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IDENTIFICATION AND PREDICTION OF COASTLINE CHANGES IN BANYUWANGI REGENCY DUE TO CLIMATE CHANGE USING GRASS QGIS

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ABSTRACT

Banyuwangi Regency has a coastline of 175.8 kilometers, stretching from Meru Betiri National Park to Baluran National Park. Coastline changes occur due to human activities, abrasion and sedimentation due to climate change and global warming. Research to identify and predict changes in the coastline of Banyuwangi Regency due to climate change using GRASS QGIS in 2025. The results of predictions of shoreline changes in Banyuwangi Regency are located in Pang Pang Bay, Muncar District and Tegaldelimo District. In Banyuwangi Sub-district on Cacalan Beach, Cemara Beach and Marina Boom Beach, and on the southern coast of Banyuwangi in Purwoharjo District, namely Grajagan Beach, and in Pesanggaran District on Red Island Beach. Recommendations for mitigating shoreline changes with sandy and swampy beach types in addition to the application of ecotourism principles are also the implementation of wind barriers, mangrove rehabilitation, seawall construction, or TetraPOT. Vegetative and mechanical conservation efforts are a strong combination in natural and artificial defense from marine abrasion attacks.

Keywords: coastline; GRASS QGIS; climate; conservation, coastal Banyuwangi.

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INTRODUCTION

The coastline is the boundary where the sea and land meet at the time of the highest tide. Banyuwangi Regency has a coastline of 175.8 kilometers, stretching from Meru Betiri National Park to Baluran National Park. The southern coast of Banyuwangi is directly adjacent to the Indian Ocean and to the east it is directly adjacent to the Bali Strait. From the length of the coastline, many marine tourism destinations have sprung up.

Banyuwangi tourism has a significant impact on the community's economy and makes Banyuwangi Regency quite famous among domestic and foreign tourists. Pulau Merah Beach, Bangsring Underwater, Cacalan Beach, Mustika Beach, Teluk Hijau, are some of the popular tourist attractions. However, some of these beaches are experiencing sea water erosion (abrasion). An example is Cacalan beach which experienced abrasion of -18.11 meters or -2.59 meters / year starting from 2011-2018 (Saikhun, 2019).

Coastline changes often occur as a result of several factors. Starting from various kinds of activities that occur in the area around the coastline to changes that occur due to global climate change. Global climate change causes rising sea levels that have the potential to submerge and narrow land areas. There are at least two kinds of shoreline changes. First, the shoreline is regressing, this is usually called abrasion. Meanwhile, if the coastline is further protruding into the ocean, it is called sedimentation or accretion due to the accumulation of erosion carried by river flows.

Research related to shoreline changes has at least been investigated by (Meranti et al., 2014; Nugraha, Karang and Dharma, 2017; Saikhun, 2019; Alimuddin and Aryanti, 2020; Hidayah and Apriyanti, 2020; Isdianto et al., 2020; Kusumaningtyas, 2020 ; Nadyaratri, 2020; Laksono and Hidayah, 2021). This study analyzes and simulates shoreline changes in Banyuwangi Regency in 2010 and 2021 using GRASS on the QGIS platform. GRASS GIS (Geographic Resources Analysis Support System) is a Geographic Information System (GIS) software used for geospatial data analysis and management, image processing, producing graphics and maps, spatial and temporal

modeling and visualization. Grass GIS can be in the form of raster data, vector topology, image processing and graphics.

The purpose of this study is to identify and predict changes in the coastline of Banyuwangi Regency due to climate change using GRASS QGIS. It is hoped that this research can detect changes in Banyuwangi's coastline and provide recommendations for shoreline conservation efforts so that tourism activities will remain sustainable.

RESEARCH METHODS

The study sites are located along the coastline of Banyuwangi Regency, from the coast of Meru Betiri National Park to Baluran National Park.

Figure 1. Banyuwangi Regency Coastline

The data collection of this study includes primary data and secondary data, which are described as follows:

a. Primary data: primary data collection is obtained directly from the field by direct observation to the study site, in the form of documentation of shoreline conditions, ground checks or field surveys. A field survey was conducted to see the existing condition of the research area.

b. Secondary data: secondary data in the form of Banyuwangi Regency RBI Map data, Google Earth images in 2010 and 2021.

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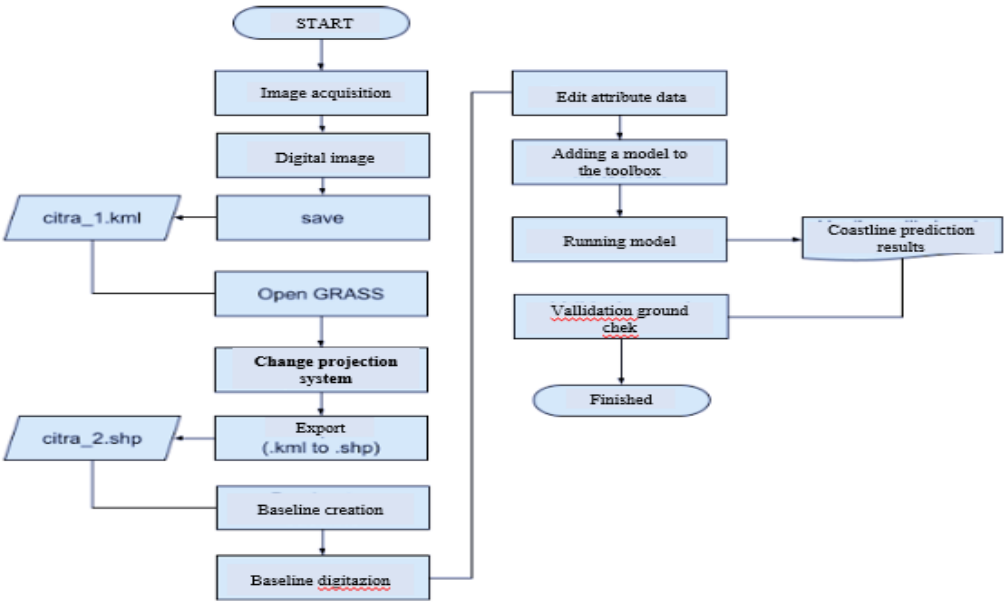
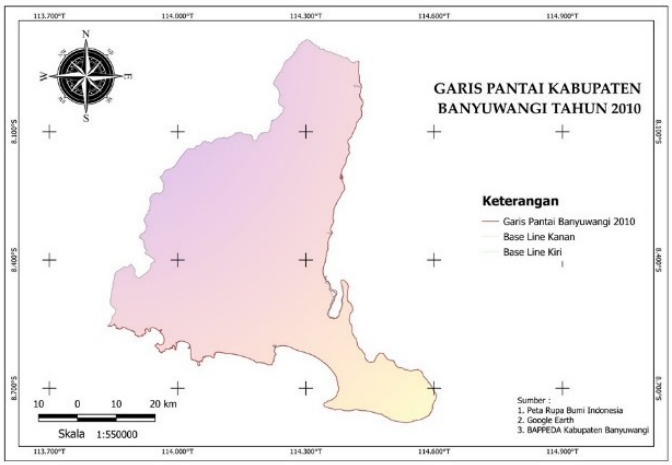


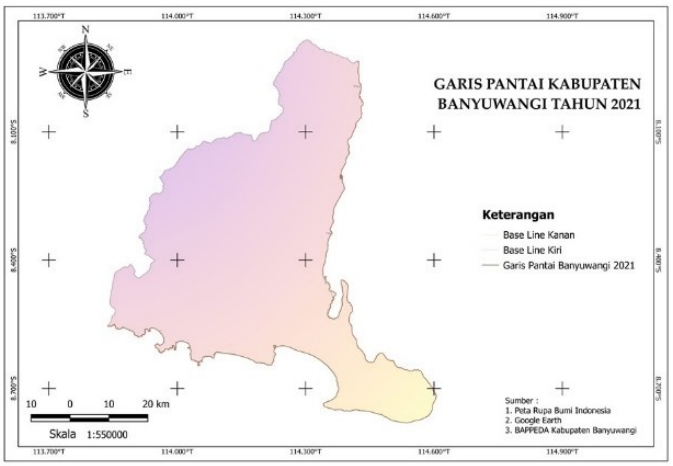
Figure 2. Modeling Flowchart With Grass QGIS

RESULTS AND DISCUSSION

The results of digitizing the coastline of Banyuwangi Regency from the history of Google Earth imaging in 2010 and 2021 can be seen in Figure 3 below.



(a)



(b)

Figure 3. Banyuwangi Regency Coastline Map (a) in 2010 and (b) in 2021

Figure 3 shows that the changes in coastlines in 2010 and 2021 or for 11 years are not very significant because from the comparison of shoreline changes only a few areas experience changes in coastlines such as the coastal areas of Purwoharjo, Tegaldlimo, Muncar, and Banyuwangi sub-districts. To see the predicted shoreline change model in 2025.

For prediction of changes in the coastline of Banyuwangi Regency using Google Earth imaging and the help of Grass QGIS, it can be seen the prediction of the results of the percentage change and the area of the coastline experiencing changes in the coastline. As can be seen in the following prediction results maps.

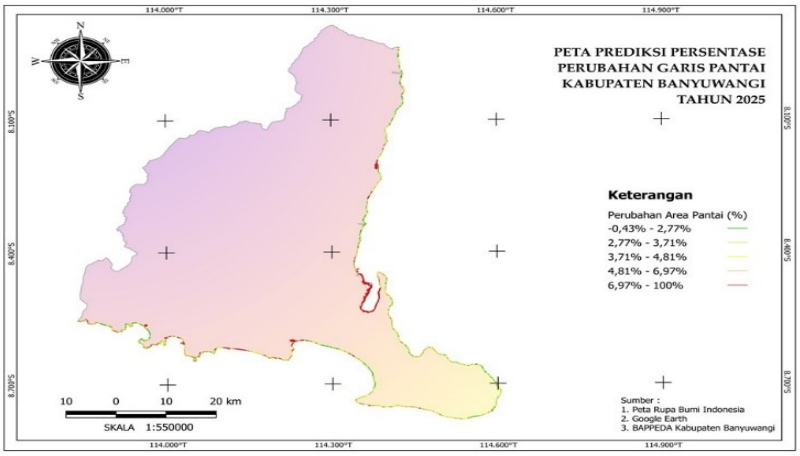


Figure 4. Prediction Map of the Percentage of Changes in the Banyuwangi Regency Coastline in 2025

In Figure 4 it can be seen that in 2025 the coast in Banyuwangi Regency is predicted to occur an abrasion process of 0.43% - 2.77% in coastal areas with green color. While in red color there is a sedimentation process of 6.97%.

In Figure 5, it is known that there is a predicted change in the coastal area in 2025 of 174.2 – 1672.12 m2 along the green coastline. The largest area change is located in the coastal area of Pang-Pang Bay in Muncar District.

Furthermore, to predict the risk of shoreline change in Banyuwangi Regency, it can be seen in Figure 6. This map of shoreline change risk prediction is a map as a reference base for early detection of

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coastal change disaster mitigation efforts due to abrasion and accretion/sedimentation processes as a result of global climate change or climate change. due to global warming. This coastline change risk map is mapped for a 5 year period from 2021.

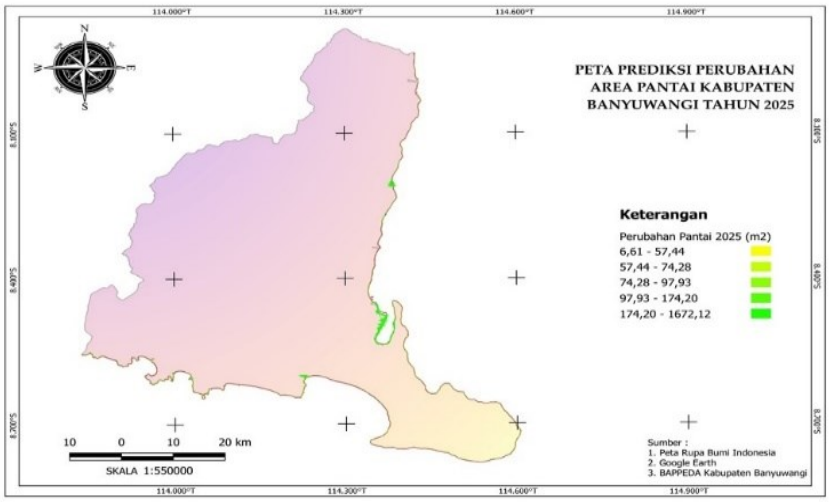

Figure 5. Prediction Map of Banyuwangi Regency Beach Area Change in 2025

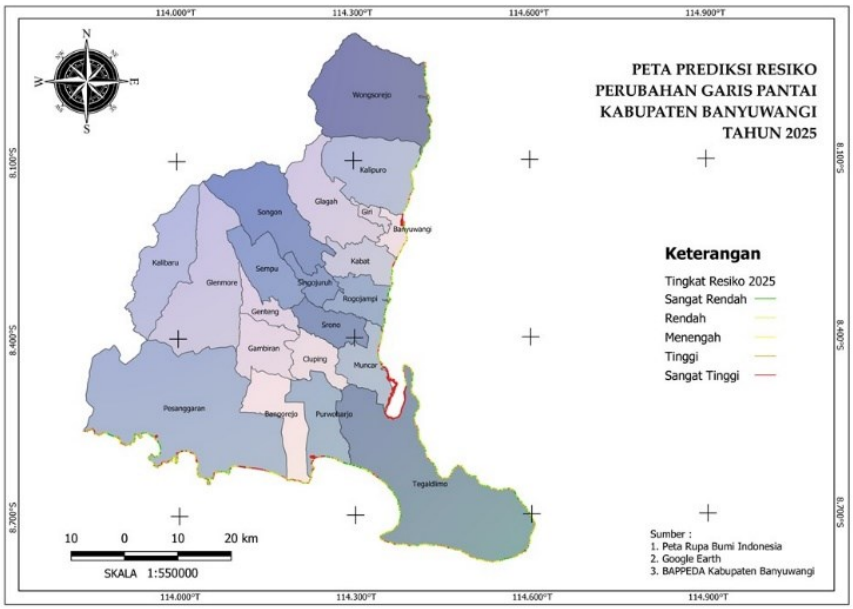

Figure 6. Risk Prediction Map of Banyuwangi Regency Coastline Change in 2025

Based on Figure 6, it can be seen that basically the predicted results of shoreline changes in 2025, it turns out that the areas affected by climate change due to abrasion and sedimentation processes include the coastal zones:

a. Pang Pang Bay area which is included in the Muncar District and Tegaldelimo District.
b. The sub-districts of Banyuwangi are Cacalan Beach, Cemara Beach and Marina Boom Beach.
c. Purwoharjo sub-district, namely on the coast of Grajagan, and in Pesanggaran sub-district on the coast of Pulau Merah.

Indirectly, if you look at the red zoning of the coastline changes according to the prediction results, that on average it is located in the areas where tourism is located. So shoreline changes in this area are caused by three possibilities:

a. The presence of sediment loads due to erosion in the upstream area due to changes in land use
b. Development activities and the impact of human activities in coasta l areas
c. Due to the impact of global climate change and global warming, it is supported by extreme sea currents in the Bali Strait and high waves of the Indian Ocean on the South Coast of Banyuwangi.

Based on the results of the prediction of the risk of shoreline changes in Banyuwangi Regency, the area that has a very high risk is the Pang Pang Bay area which is included in the Muncar District and Tegaldlimo District. The coast of Pang Pang Bay is dominated by land cover in the form of aquaculture (ponds), settlements, mangroves, most of the fields, and heterogeneous forests. The shoreline changes in this area are caused by two possibilities; the first is the result of sediment loading due to erosion in the upstream area so as to form a land or delta as shown in Figure 7 and the second is the development of ponds for fish and shrimp farming activities.

Figure 7. Location of Pang-Pang Muncar Bay Sedimentation

Changes in the coastline of the Muncar and Tegaldlimo areas are more dominated by aquaculture activities. After the permit for cultivation area expires, ponds tend to be abandoned without any conservation efforts and restoration of land cover functions as they should, especially in the Tegal Pare area.

In addition to Muncar and Tegaldlimo sub-districts, the risk of shoreline changes also occurs in Banyuwangi sub-district, namely Cacalan beach, fir beach and Marina beach, Purwoharjo sub-district on Grajagan beach, and Pesanggaran sub-district on Pulau Merah beach.

Neighbors of Cacalan Beach in Banyuwangi District are Rejo Beach and Sari Beach. According to (Yuniartik et al., 2021), Sari Beach is one of the locations that has the potential for mangroves in the Banyuwangi Sub-district, it is still a coastal line from Rejo Beach and Cemara Beach. According to (E W Setyaningrum et al., 2020), in Cemara Beach, there are about 11 types of mangroves whose density is still lacking. Whereas around it there is a pond, as well as a landing place for turtles to lay eggs. In relation to the living conditions of coastal communities, one of the important aspects of strengthening mangrove conservation is to involve and seek support from local communities. The existence of the Mangrove area is expected to reduce sedimentation.

Based on (Setyaningrum et al., 2019), making strategies in environmental aspects include preventing environmental pollution due to industrial waste, preventing damage to coastal ecosystems, controlling erosion, and sedimentation. In addition, in the form of strengthening regulations and law enforcement; development and awareness raising of human resources; infrastructure improvement; and institutional development of the management area. He added (Setyaningrum et al., 2020), in

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developing ecotourism at Cemara Beach, making an attraction by crossing the river using a boat or called mangrove tracing, where the river facilitates mangrove trees with a path to the river and sea or estuary. Followed by (Setyaningrum et al., 2021), that in managing mangroves into ecotourism by building mangrove paths, making garbage traps so that garbage from the sea does not enter the river, and vice versa at high tide. Sustainable coastal development is the thickening of mangrove density by planting mangroves from nurseries and creating hardware on the beach in the form of tetrapods as beach protectors from sea abrasion.

Figure 8. Damage to Cemara Beach due to Abrasion

As can be seen in Figure 8, that Cemara Beach is exposed to abrasion of 70 meters from a length of 1000 km, the beach sand disappears. A number of efforts have been made, such as replanting cypress trees or installing geronjong or dams to block waves. But the results are not optimal. This abrasion is caused by the estuary in the south turning north, and because it is blocked by piles of sea sand so that the current leads to Cemara Beach.

Figure 9. Marina Boom Beach Changes in 2011 and 2021

Meanwhile, Marina Boom Beach was formerly known as THR (People's Amusement Park) and is now a tourist destination with significant changes in terms of its development. The dock construction was carried out by PT Pelindo Property Indonesia, a subsidiary of PT Pelindo III. If viewed from the satellite image, it can be seen that the coastline changes as a result of these development activities are shown in Figure 9.

The large current changes in the Bali strait, either leading from north to south or vice versa, cause eddies around the Marina Boom beach area. This results in the erosion of coastal areas. In addition, the lack of vegetation cover due to the relatively new development of the area around the coast can

make Marina Boom beach a very high risk level. Grajagan Beach is actually a bay, the current of the big waves swirling towards the saplings then erodes the shore around the pelawang (where fishing boats enter and exit).

Changes in the coastline of the southern region, especially on Pulau Merah Beach, Pesanggaran District, are more caused by large wave currents because they are directly opposite the Indian Ocean. Large currents also hit the Red Island area because they are both directly opposite the Indian Ocean. But not only that, tourism activities and also mining activities in the Tumpang Pitu area are also a factor causing changes in the coastline in the southern Banyuwangi region.

From the various problems in coastal areas that are prone to abrasion and accretion due to climate change, several recommendations and conservation efforts to prevent and minimize changes in coastlines in the Banyuwangi Regency area include:

Application of Wind Barrier

Windbreak plants such as shrimp pine and sea pine (Figure 10) can be used for coastal conservation activities. Shrimp spruce has the characteristics of slender and pointed leaves. This plant can grow in extreme conditions such as in coastal areas and can reach a height of 6 meters. Sea fir is a type of fir from the Casuarina group. This plant also has other names, namely Australian pine and Beach she-oak. Sea fir can not only be used as a wind barrier, it can also be used to resist abrasion, it can even be used to improve the microclimate around coastal lands (Hajadi, 2017).

(a) (b)

Figure 10. Application of Wind Barrier (a) Shrimp Fir (b) Sea Fir

Mangrove Rehabilitation

This mangrove rehabilitation is a long-term investment of 4-5 years or more, mangrove rehabilitation can be a new source of income for the community, if managed into ecotourism. Mangrove rehabilitation activities cannot be carried out instantly, because planting mangroves at the age of 1-2 years has not many benefits, but at the age of 5 years or more, the benefits will be very large for the community.

According to (Surayya, Kusmana and Sundawati, 2020), mangrove rehabilitation activities can be carried out in the following stages:

a) Rehabilitation planning: team building, goal formulation, and funding.
b) Making mangrove nurseries: nursery planning, nursery preparation, seeding, making planting media, germination, weaning, nursery maintenance, transportation selection, administration, and nursery organization.
c) Mangrove planting: planting planning, land preparation for planting areas, planting techniques, and planting activities.
d) Mangrove maintenance: weeding, replanting, thinning, control of damaging factors, and pruning.

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e) Monitoring and evaluation of mangrove growth: monitoring and evaluation of growth incidentally and continuously.

Figure 11. Mangrove Rehabilitation Activities at Cemara Beach Banyuwangi

Conservation of artificial coral reefs along the coastline

Conservation of artificial coral reefs can be implemented by making artificial reefs placed along the coastline, not only as a place to protect marine life but also as a barrier to waves and sea abrasion.

From experience (Abdurrahman As'ad, Erwanto and Fauqho, 2020), Bangsring Village is one of the areas located in coastal areas that have common problems such as other coastal areas, namely the damage to coral reefs caused by several factors, namely natural factors and human factors. . The handling carried out by the surrounding community is still not optimal so that it has an impact on the decline in the diversity of marine biota. Conservation is a solution in handling damaged coral reefs into coral reefs that have high selling value, not for exploitation but for balancing marine ecosystems through artificial coral reefs in the form of a tetrapod puzzle in the form of a four-legged triangular pyramid as shown in Figure 12. Also previously by (Erwanto and Masluha, 2019), making coral reefs as breeding grounds for fish and as island protectors from abrasion and sea erosion, an Artificial Temple Reef made from bagasse ash that is environmentally friendly will be placed on the coast of Tabuhan Island as shown in Figure 13.

Figure 12. Implementation of Marine Park Conservation at Bangsring Beach (Abdurrahman As'ad, Erwanto and Fauqho, 2020)

Figure 13. Implementation of Artificial Temple Reef at Bangsring Beach as a Conservation of Marine Biota and Marine Abrasion (Erwanto and Masluha, 2019)

Coastal protection buildings such as Krib, Groin, Jetty, and Sea Wall with river stone masonry construction, wire gabions, concrete buis masonry, and other construction models.

Groin or Krib is a coastal protection building to overcome the problem of erosion and sedimentation. The difference is that the Groin building is perpendicular to the beach, while the groin building is parallel to the shoreline. The groynes resist waves and seawater abrasion processes and places sediment deposition along the coast. Based on the shape, it can be divided into: straight type, T type and L type. Generally, groyne or groyne construction consists of materials such as steel, concrete, stone and wood. Specifically, the distance between groynes and sandy beaches ranges from 2 to 3 times the length of the groynes.

A coastal safety wall or Sea Wall is a coastal building that is built parallel to the coastline that separates the land from the sea, to protect the land against abrasion due to waves. Conventional coastal protection walls can be in the form of gabion, sheet pile, stone revetments, wood or can be made of concrete masonry.

While the Jetty building is a coastal protection building that is shaped straight towards the sea and is located on both sides of the river side which serves to reduce the siltation of the channel by river sediment.

Making a Tetrapod (Four Legs) as a Breakwater

Tetrapod is a concrete structure that has four sides with the shape of each side like a cylinder. Its function is to protect the land from erosion caused by ocean waves. The rock arrangement has four sides and is installed irregularly along the coast so that the land has artificial protection and the land on the shore is safe.

The Tetrapod model as shown in Figure 14 can be modified into a four-legged TetraPOT design with a POT function by inserting plant seeds in pots, then randomly distributed along the shoreline. The applied TetraPOT will eventually lock into each other to create a durable marine defense of growing trees and roots that help keep the blocks in place. As plants grow inside and out from TetraPOT, their roots will be intertwined and gradually become a natural marine defense. The design not only prevents soil erosion, but also helps protect and create natural habitats. This is not only defense, but also ecosystem.

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Figure 14. Tetrapod Mold Model

TetraPOT is a combination of artificial sea defense and natural sea defense developed by Sheng-Hung Lee from Taiwan and Wan Kee Lee from Malaysia. TetraPOT is a sustainable marine defense system made of concrete, organic matter and plants (Figure 15). TetraPOT is applied by placing plant seeds in biodegradable pots, then randomly distributed along the shoreline. The applied TetraPOT will eventually interlock to create a durable marine defense of growing trees and roots that helps keep the blocks in place. As plants grow inside and out from TetraPOT, their roots will be intertwined and gradually become a natural marine defense. Their shape and placement will allow the TetraPOTs to interlock with each other and form a structure. The design not only prevents soil erosion, but also helps protect and create natural habitats. This is not only defense, but also ecosystem.

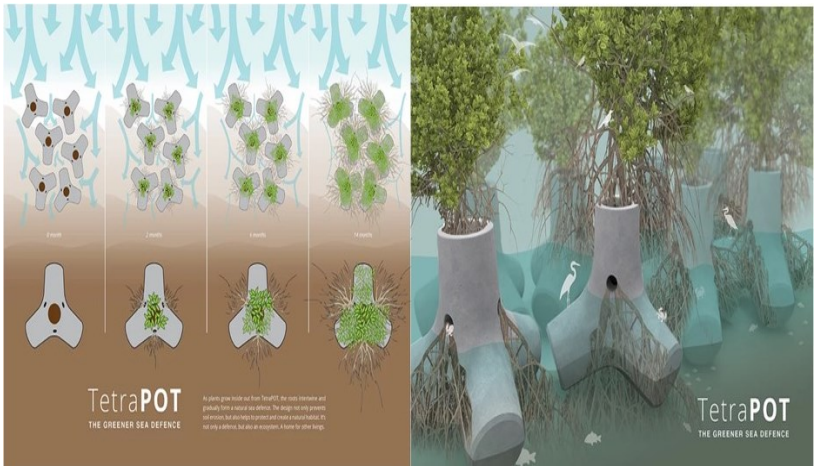

Figure 15. TetraPOT design

CONCLUSION

The results of predictions of changes in the coastline of Banyuwangi Regency in 2025 or for the next 25 years and 50 years, due to climate change from the impact of abrasion and sedimentation processes are in the coastal zone of the Pang Pang Bay area which is included in the Muncar District and Tegaldelimo District. Then in Banyuwangi District, namely Cacalan Beach, Cemara Beach and

Marina Boom Beach, and on the southern coast of Banyuwangi it is in Purwoharjo District, namely Grajagan Beach, and in Pesanggaran District on Red Island Beach. Recommendations for mitigating shoreline changes with sandy and swampy beach types in addition to the application of ecotourism principles are also the implementation of wind barriers, mangrove rehabilitation, seawall construction, or Tetra POT. Vegetative and mechanical conservation efforts are a strong combination in natural and artificial defense from marine abrasion attacks.

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