Mapping the abrasion on Sederhana Beach, Muara Gembong, Bekasi, West Java province for the coastal mitigation purpose

F Y Prabawa¹*, D Purbani¹, S S Sukoraharjo¹, M H Jayawiguna¹, H Triwibowo¹

¹ Marine Research Center, The Republic Indonesian Ministry of Marine Affairs & Fisheries, Jakarta, Indonesia
*Corresponding author: jeromeviril2019@gmail.com

Abstract. Sederhana Beach is located in the waters of Muara Gembong, Bekasi Regency, West Java Province, northeast part of Jakarta Bay. The observation data in 2018 showed the morphology of the damaged coast and the massive fallen mangrove vegetation. Loss of land and mangrove populations has a major impact on the economic and environmental aspect. How to mitigate the impact of abrasion? This study aims to map the type of sediment, sediment distribution and its depositional environment, to obtain a correlation with the type and direction of currents causing abrasion. The results would become the base for determining the appropriate actions to overcome further abrasion, in an integrated coastal area planning program. Seabed sediments were taken using a grab sampler, megascopic descriptions and analysis of the depositional environment off sediments were held on site. The results are plotted onto a map, to determine the distribution of sediments. Sediment types found are: coarse sand, clay, sandy clay, medium-fine sand, and silt. 75% of the study area is: scattered sandy clay, mostly covering the coastline to the north. This is a common phenomenon because the mainland of research location is dominated by mangrove vegetation. The Coarse sand took 20% of the research location. An interesting phenomenon is: the coarse sand reaches the coast directly adjacent to the mangroves, where 5% of silt is found outside this coarse sand zone. The presence of coarse sand on the shoreline with mangrove vegetation indicates that the main current that triggers abrasion is longshore current, moving parallel to the coastline, namely northeast - southwest. So, the recommended steps that can be taken in mitigating further abrasion at Sederhana Beach is the construction of a current breaking structure that is perpendicular to the coast line

Keywords: Seabed sediments, sediment distribution, abrasion, longshore current, coastal hazard mitigation

1. Introduction
The waters of Muara Gembong and its surroundings are part of the Jakarta Bay, included in the administrative of Bekasi Regency, West Java Province. The research location is on Muara Gembong District’s coastal waters 67.8 km from Jakarta capital city, and 53.9 km north of Bekasi City. Every year there is shrinkage of land caused by abrasion and large waves that are estimated to reach 1-2% of the potential of land or equivalent to 100-200 ha. The largest shrinkage occurred in Muara Gembong District [1]. Since 1976 the area of mangrove forests has decreased by 55% and most of it has changed to become fishponds (increased to 35%). The land conversion has resulted in shoreline changes and the biggest erosion occurred in the Pantai Bahagia village with an erosion rate of 15.46 m/year and lost an area of 330,460 Ha. As a result of massive land use changes from mangrove forests to fish ponds, there is a change in the coastline [2,3]. The loss of 3 villages around the coast of Muara Gembong and the relocation of the fish auction sites (TPI) for 3 times in recent years are the other evidence showing that strong abrasion is hitting on study location [4]. Abrasion is a problem that threatens the coastline, damages ponds, rice fields that are located on the beach peripheral, and also threaten buildings that are directly adjacent to sea water [5].
Changes in the coastline that occur in the coastal area can be in the form of erosion of the beach body (abrasion) or the addition of a beach body (sedimentation or accretion). These processes occur as a result of the movement of sediments, currents and waves that occur and interact with coastal areas directly, also it can occur due to anthropogenic factors, such as human activities [6]. For that it needs to be analyzed the abrasion process that occurs in study location, and the alternative beach structure countermeasures so that the damage of the abrasion does not increase. There are researches that recommend types of beach structures as a mitigation effort, such groin, sea wall [6], and [7] concluded that break water is the suitable one for the mitigation at Muara Gembong beach. But, firstly is a break water structure the most suitable for this study location? Moreover, those structures are resulting the deposit of sands on the coast. In fact: research location’s water is used to be a mangrove zone. Mangrove needs biological mud subtract for living, and most of the mangrove substrate there has perished. So, the construction of the beach structures such groins, sea walls, break waters would not enough. It is needed a plan concept for coastal mitigation, that could reduce the impact of the abrasion, also could restore mangrove zone as well.

What type of structural mitigation intervention suitable to implement on the research location? The research area is bordering the Java Sea, while in Jakarta Bay, there are dozens of rivers, which many of their estuaries drain sediments to the bottom of the coastal sea. The nature condition of research location affects the supply, type, and distribution of sediment in the study area, that could be used to trace the type and direction of sea water agent that causing the abrasion on research location. This study aims to mapping the abrasion, using Sedimentology approach, by determine the type of sediment, sediment distribution and its depositional environment. The results of this study could support the planning and implementation of the existing integrated coastal management program, in the form of the recommendation for the appropriate land use, spatial planning purposes and mitigation from the abrasion.

2. Tools and Methods
   2.1. Location Determination

![Figure 1. Map of the research location in Muara Gembong, Bekasi, West Java Province, Indonesia.](image-url)
The main research location geographically, is located at 5° 57' 1.0'' – 6° 2' 24.5'' South Latitude and 107° 1'29.6'' – 107° 5' 59.6'' East Longitude. (Figure 1). District of Muara Gembong is included in the Citarum River watershed, which flowing trans provincial region [2].

2.2. Data Collection

Data collection from primary sources: measurement and sampling on site, then secondary data was used from reference study: papers, newspaper, reports, internet sources etc. In addition, this research sampling was held at the end of 2018, and the study was continuously conducted during 2019. Research and sampling of seabed sediments was carried out in the waters of the Muara Gembong area to the north, there was the Sederhana Beach area, then further north again was Kuntul Estuary which was still quite dense with mangrove vegetation, and continued to the north again from the Somblem Estuary to Besar Estuary which was increasingly dense and old mangrove vegetation. Sederhana Beach land is dominated by shrimp ponds [4-7], so the shape is in the form of a stretch of pond, which has minimal vegetation, the origin of this area's habitat is mangrove forest.

Sediment collection is carried out using a grab sampler with the planned and attempted sediment location points being representative, this sampling is then plotted into a work map. Field operations are carried out using boats, and a “global positioning system” device. The grain size analysis was carried out by wet sieving for grain sorting, then megascopic description was carried out at the in-situ location [8]. The nomenclature of sediment grain size is classified according to [9]. The triangular diagram is divided into one class, for sediments containing sand, namely based on the proportion of the percentage of sediment without gravel, namely the proportion of the percentage of sand to the ratio of silt and clay.

2.2.1 Regional Geology

According to [10], the lithology of Muara Gembong District is dominated by sedimentary rocks, in the form of deposit loss material. About 40% of the lithology is loose sediment originating from the floodplain (Qaf), in the form of clay and soil with fragments of gravel and micro-organisms of vegetation, occupying the interior. The next 35% of the research sites are covered with swamp sediment (Qsd) which dominates the coastal area, in the form of humus clay, peat clay, silt, and thin layer of peat, micro-organisms of vegetation from mangrove forest substrates. 5% of the lithology of young river deposits (Qa), was found at the mouth of the Gembong River which borders the coast of the Sederhana Beach’s Pond area to the north, in the form of sand, mud, gravel and greed.

The remaining 20% consists of shallow marine deposits (Qnd), located in the northernmost region which is directly adjacent to the Java Sea, in the northwest, which is the northernmost arm of the Muara Gembong Bay. The lithology is interference between sand, silt, clay and a thin layer of tuff, containing shells. The research location is in the northern part: Gembong River Estuary or Muara Gembong, Sederhana Beach, Muara Kuntul, Muara Somblem and Muara Besar, located in the lithology area of Qsd, Qa. And in the southern part, namely Muara Blacan, it is in the Qnd lithology area deposition environment.

The area around Muara Gembong is geomorphologically located in the lowlands in one watershed (Citarum River Basin) composing material in the form of surface sediment [11]. Surface lithology of Muara Gembong are autochton deposits that was formed on the same surface location [12]. The lithology of Muara Gembong is dominated by lose material sediment, that is formed from the depositional environment, form residual deposits that occurred by the intensive chemical weathering process, especially for tropical regions with high rainfall. In these conditions most of the rock will produce soil that loses. The topography of the wetland area in Muara Gembong ranges from 1 to 4 m. The widest silting area is located south of Muara Gembong to Muara Tawar [13].
2.3. Data process
The obtained data was compiled and analyzed, developed using Microsoft Words and Excels tabulation, sampling sediment results were plotted on spatial map using Arc GIS 10.3 software, design and simulation was drafted as additional work. The data is plotted on a map to get the gradation of sedimentary zones by type. Then the analysis was carried out by compiling the map and the information on the results of the analysis with the facts from the observations at the location. Finally, data and information are used to determine the type and direction of the main destructive sea water agent of the abrasion. The information obtained is then being formulated to support the design of appropriate coastal disaster mitigation from the impact of abrasion.

2.4. Analysis
The analysis was performed qualitatively descriptive. Its analysis involving a comparative and synthetic work, and finally constructing a conceptual model and action plan recommendation. The grain size analysis was carried out in megascopic way, to determine the type of sediment, while the results of the analysis plotted on the sediment distribution map were to determine its distribution on the coast and seabed surface. From the distribution of existing sedimentary textures, it can be seen the relationship between current dynamics and clastic grain transport [8]. The other side, [9] provides an example of grain size analysis data that has been plotted on a map. In the range of coarse sand and gravel the law of impact is binding in terms of deposition or mode of erosion (force to lift). [9] designed the method to determine the type of sediment from the results of the grain size analysis, based on the grain size measurement. A geological study of the research area was also carried out to support data collection, analysis of sediment types and their origin, also their deposition environment as well.

3. Results and Discussions
3.1 Sediment Profile

Figure 2. Map of Sediment Types at Sederhana Beach Muara Gembong
Figure 2 shows the sediment sampling plot of study location. Based on the results of the megascopic in situ description of the grab sample, the sediment nomenclature in the study area was found to be of the following types of sediment: Coarse Sand, Clay, Find Sand, and Silt, as shown in figure 3. The distribution of coarse sand is found in three places, namely Muara Kuntul, Muara Gembong, Muara Besar out and the outer waters area which is 500 meters out from the coast of the study area.

More than 75% of the study area is of Clay - Sandy Clay sediment type, mostly covering the coastline of Muara Blacan Bay in the southern part of Muara Gembong – Muara Gembong - Muara Kuntul - Muara Besar area in the north. Coarse sand is found randomly on Sederhana Beach in the north of the Gembong River estuary, Muara Gembong Village, north to Muara Kuntul, Muara Somblem area in the north, to the Muara Besar area.

Coarse Sand was found to reach the coast directly adjacent to mangroves in the land zone, the area is approximately 20% of the research waters area, in the outer waters of the 500 meter zone coarse sand lithology dominates, 5% of the research location is occupied by silt, in the form of spots that are randomly located in Muara Blacan in the southernmost part of the study site and Muara Kuntul in the
north. Sediments of this type are generally transported from other places by ocean currents, and accumulate at the study site [20].

The data from all of these samples support the hypothesis that strong abrasion is occurring in the study area. Strong abrasion hits the Sungai Gembong estuary area in Muara Gembong Village, Sederhana Beach to the north, Muara Kuntul to the north, and the Muara Besar area to the north of the sampling location. The northernmost peninsula of Muara Gembong Bay is recorded to experience accretion [14,15]. At the southernmost bay, The Blacan estuary (Muara Blacan) is otherwise relatively untouched by sea abrasion. Observational data shows the damaged coastal morphology and massive fallen mangrove vegetation confirms the evidence of strong abrasion hitting those locations. Loss of land and mangrove populations will certainly have a major impact on economic valuation, this is detrimental to all parties: the local government and community members [16]. If it is not anticipated, then the loss will continue and get bigger every year. Not to mention the loss of the environmental sector and the retreat of regional land and sea administrative boundaries.

From the results of the classification of lithological types of seabed sediments [17] starting from the southernmost area, namely Muara Blacan Bay, the Muara Blacan area is not entered by currents. This is evidenced by the finding of the majority of the mud sediment lithology of mangrove substrates adjacent to the Silt sediment lithology spot [18]. Mangrove substrate mud is commonly easily eroded by currents, and Silt is the smallest lithology below the size of Clay [19], its depositional environment is an area with no currents, so that micro-grains can be deposited [20,21]. So, the Silt and the integrity of mangrove river flow and its thick substrates area coming from numerous mangrove estuaries in Muara Blacan Bay is protected from any ocean current.

Next, clay was found to dominate the bottom waters of the research area, starting in the southern area of the border of Muara Gembong and Muara Blacan, Sederhana Beach in the north, continuing to the north namely Muara Kuntul, Muara Somblem and ending in Muara Besar. Lithology of seabed sediments Clay at the research site in several spots mixed with biomass in the form of parts of plants such as leaves, twigs, rotting roots, marked by some dark brown clay. This condition is common with respect to the terrestrial environment, all of which are mangrove forests [21]. Mangroves live in both marine and land transition zones with biomass and muddy substrate lithology. This mud consists of plant biomass and clay from the mainland, which is transported through rivers, and enters the sea. The clay originating from land comes from the zone of flood deposits and young river deposits in the upstream direction.

3.2 Abrasion

From the survey results, both the sediment sampling method and the observation method at the research site confirm and prove that there is very strong abrasion in the study area. The results of the sediment survey prove that strong abrasion hit the shoreline of the Muara Gembong area such as Sederhana Beach and its surroundings, in the north namely Muara Kuntul and Muara Besar. From the observations, Muara Somblem has a relatively small impact on abrasion, as evidenced by the findings of clay and silt lithology samples mixed with mangrove substrates that are still intact and undisturbed by currents at the shoreline boundary of mangrove forests.

Muara Blacan to the south of Muara Gembong and the large bay in front of it is relatively untouched by the abrasion and event any currents. The areas worst affected by abrasion are: the Muara Gembong, towards north: Muara Kuntul delta, and Muara Besar. Evidence of abrasion from the scientific field of Sedimentology is found in the lithology of coarse sand and medium sand in the mangrove area which normally has a sedimentary lithology of clay mud and silt. Figure 4 shows the abrasion pictures:
The strongest abrasion hit the Muara Besar area, the northernmost research area, and the Gembong River Estuary. Observational data shows the damaged coastal morphology and massive fallen mangrove vegetation confirms the evidence of strong abrasion hitting the study location (Figure 4). The Blacan estuary in the southernmost part is relatively untouched by sea abrasion. Loss of land and mangrove populations certainly has a major impact on economic valuation, this is detrimental to all parties: the local government and community members [22]. If it is not anticipated, then the loss will continue and get bigger every year [23]. Not to mention the loss of the environmental sector and the retreat of regional land and sea administrative boundaries.

The impact of the abrasion on the research site is exacerbated by other factors, according to the results of interviews, namely the occurrence of sea sand extraction around the site, and the continued decline in the area of mangrove forests due to changes in land function into ponds, etc. There are several spots in the research area that are contaminated with industrial and household waste. This can also endanger the preservation of the natural environment and its biota, and can also harm humans by degrading health levels. If it is not addressed immediately, the abrasion will continue to be strong, and the area of fallen mangroves will continue to decrease, land will decrease, and the impact will be the retreat of the administrative boundaries of the local area due to the retreat of the shoreline at the research location marked by mangrove vegetation on the coast that is in direct contact with the sea. Because the measurement of regional boundaries and national boundaries is carried out from the outer shoreline.

Figure 4. Spots of the abrasion in research location, with pictures
3.3 Longshore current

Figure 5 shows a unique pattern was found on site, namely the lithological distribution of the coarse and fine sand side by side that fills the space at the shoreline border, in the form of direct contact with the terrestrial transitional boundary marked by mangrove and Nipa palm vegetation.

![Figure 5. Longshore Current is causing the abrasion on the Sederhana Beach Muara Gembong](image)

Unique here because the surrounding waters start to the south of Muara Blacan in the form of a wide bay, to the north at Muara Gembong, further north at Muara Kuntul, continue to the north of Muara Somblem and to the north, Muara Besar is a mangrove habitat. This means that the bottom sediment lithology of the waters is ideally mud, it can be clay or silt, and the mangrove substrate that is in the form of mud with plant residue biomass. Especially found in areas parallel to the contact between the sea and land boundaries (shoreline).

As shown in the Figure 6, the position of the Coarse Sand sediments marked in yellow extends parallel to the shoreline, and most of them are in direct contact with the land overgrown with mangroves. In general, the direction of the sand sediment zone is northeast – southwest, parallel to the shoreline north of Muara Gembong – Muara Kuntul – continuing north to Muara Somblem and Muara Besar. Except at the Muara Gembong gate, the northern part of the sand sediment spreads to the west, this can be interpreted as the condition of the still strong river discharge flowing from the Gembong River that exits its estuary, so as to suppress the spread of sand sediment transported by longshore currents coming from north east. The pattern of water flow on the coast is influenced by regional ocean currents in the North coast and tidal currents in the West. Meanwhile, the pattern of water flow in the plains is influenced by the presence of the Citarum watershed and its tributaries and the topography of the wetlands [2,11].
These findings indicate a strong abrasion is working in the area, controlled by primary sea water agent: longshore current, rather than the waves [24-26]. The wave turned to longshore current while arrive at shoreline water [27,28]. Then the current entering the shoreline boundary, moving parallel to the shoreline, while carrying sands [29,30]. In Sederhana Beach the current has reaching directly the mangroves, land, and then eroding land, uprooting mangrove trees and others [23,26,31]. The existence of sands on shoreline boundary is undeniable evidence of the role of longshore current as an agent controlling the abrasion on study location. This could occur because there is not enough mangrove forest left, as the impact of the transformation of land use to ponds area [2,4,12,31].

The lithology of course and fine sand sediments in the study area is estimated to reach more than 20%. This number can be analyzed as one of the additional factors that supports the evidence that the study site experienced strong abrasion. The mangrove estuary area is normally covered by 90% of mud substrate sediments [27-30], both clay and silt are a correlation of the dominance of mangrove forest land types at the research site. In fact, the sediment in which is a typical of the neritic sea was found on the mangrove estuary, namely medium sand and coarse sand [21,23,31], and in a larger percentage the extent. The study of geological maps also shows the lithology of the mainland around the study area is away far from marine sediment formations that have a lot of sand content [10], meaning that this fact leads to the origin of sand sediments on this location was transported from the sea bottom area [17,24,26,27,32].

### 3.3.1 Coastal Mitigation Methods

There are 2 types of coastal mitigation in this study, to discuss: construction of beach structures and mangrove plantation. Several types of beach structures are shown in figure 6:

- **Groins, Revetment, Bulkhead**

![Figure 6. Illustration of Groins, Revetment and Bulkhead. Picture taken from [33].](image)

Groins [A] could stop the longshore current because its structure is perpendicular to shoreline. So, this type of beach structure is suitable to implement in study location Pantai Sederhana Muara Gembong. Revetment [B] also suitable to build in study location, its function to reduce the velocity of the erosion. [C] Bulkhead and sea wall are more similar to revetment, but bulkhead has the advantage as a dam that could hold the soil from land area not to fall into the sea water [33,34]. Bulkhead is already built-in study location, in simple construction using the material such as: timber and bamboo (figure 7).

Recently, this type of technic is called Hybrid Engineering or HE. Various location in Java Island is using the HE, especially those on northern part of the island [35]. The main idea of the HE that northern Java people have been implementing recently is that the HE is cheap technology and not comprehensive. People could build any revetments, bulkheads from simple material such as timber and bamboos. Figure 7 shows the bulkhead built by shrimp farmer at Muara Gembong Beach to mitigate their ponds from the...
impact of the abrasion. On the other part of country, the island people are commonly building their adaptation structure to for mitigation purpose such as the break water, groin, sea wall using dead corals and rocks [36,37]. In Indonesia, this HE is still a good option to choose in hazard mitigation efforts.

![Figure 7. Traditional Abrasion Retaining Supporting Coastal Structure Bulkhead at the Research Site](image1)

Figure 7. Traditional Abrasion Retaining Supporting Coastal Structure Bulkhead at the Research Site B. Break water [private documentation]

[7] recommended breakwater as the suitable beach safety structure for Muara Gembong beach. This study will assess this theory, by using simple simulation and then a comparison work. Figure 8A shows a beach with breakwater, and figure 8B illustrates the sediment movement on this area. On 8A, it is shown sand pattern forming back dune sand behind the breakwaters. But the spaces between breakwaters are void, so wave still could erode the shoreline [35,38]. Figure 8B shows the existence of longshore currents that move parallel to the shoreline. This current could not be stopped by the breakwaters, eroding land area in the shoreline. So, the breakwater only structure is not suitable, not fully functioned to stop or reduce the impact of the abrasion that uprooting trees and buildings, changing the shoreline boundary moving backward inland area, that coming from longshore current [39].

![Figure 8. A) Illustration of Break Water B) Break water’s impact on beach](image2)

Figure 8. A) Illustration of Break Water B) Break water’s impact on beach. Picture taken from [40]
3.3.2 Recommended Mitigation Method

Based on the fact that the shoreline of Sederhana Beach is badly damaged by abrasion, it is recommended that every proposed conservation area is always equipped with human engineered coastal structures [2,6,7,40]. This plan is purposed to protect the coastal area in the location that will be recommended as a core zone [33], maintain the shoreline in its coordinates [34], and also protect the neritic waters [34,41] area. Moreover, the design of this study adds a plantation zone for mangrove cultivation, by armor ing the area to protect it from waves and currents. So that this green zone could meet the ideal conditions for the growth of mangrove seedlings which will later be planted for green belt replantation. This is called a transformation from grey to green construction [42,43,44]. However, it is recommended the need for technological intervention as the main initial effort in the coastal abrasion disaster mitigation program, namely the construction of coastal structures that resist the abrasion, as well has a function to the restoration of the area.

![Figure 9. A] box-shaped beach armor structure combination of break water and groin [B] illustration of mangrove plantation to fill the inner spatial of the box-shaped armor structure. Picture [A] taken from [45], picture [B] taken from [46].](image)

This study recommends a combination of the concept: beach safety structures and mangrove zone. Groins or jetty are suitable for perpendicular beach structure, combined with continuously form break water that all those structures are combined into a box-shaped form. This box-shaped beach structure mitigation form is more similar to the breakwater box form for port area [45]. Figure 9 displays the sample pictures. In 2018, the increase in sea area of 1,397.8 hectares indicates the occurrence of abrasion in Muara Gembong District [47]. Farmers substitute the dyke ponds that are eroded by abrasion by a net to border their ponds, so they can proceed farming. Farmers also mitigate their pond area by the revitalization of farm: better construction of the farm, farm’s operating system, and the farm management. The pond which was rehabilitated allocated 40% of the total pond area became a mangrove zone [48]. But the mangroves could not function as protectors from abrasion. So, it is needed a better solution to preserve the environment and run the economy sustainably.

This box-shaped form is recommended to be located far most to west at the precious local beach ridge that is presently drowned. At the far north their boundary is continuing to northern part of Muara Besar, at the far south the boundary is at southern part of the estuary of Muara Gembong (Figure 12). Beach nourishment [49], the replacement of the substantial local natural material to advance the shoreline seaward, is a sustainable option to mitigation of shoreline recession. There are guidelines for design purpose, and improved procedures are required to conduct the construction to ensure the project will resulting less impacts. Sediment will lost from the original location of a beach nourishment are by several mechanisms and pathways [49,50]. The construction of new shoreline structures of study area...
that advanced seaward for example; will have both advantages and also disadvantages, for human and for nature as well. People of Muara Gembong for example, will have their land back, the land that presently submerged in sea water because of the abrasion. This study recommends the allocation of green zone for mangrove plantation purpose. See Figure 10.

Figure 10. Design of Mitigation Structure Muara Gembong at Sederhana Beach

Mangrove plantation for conservation purpose, silvofishery, mangrove for disaster mitigation, mangrove zone for tourist site, etc are several options to implement in Muara Gembong land rehabilitation future project. [51]. Or it is also called mangrove zone restoration, reforestation. The project could be done in lower cost, by implementing Hybrid Engineering principles. This is the design concept for coastal mitigation purpose, that could reduce the impact of the abrasion, in the same time it could restore mangrove zone as well.

4. Conclusion
The research location: Sederhana Beach in Muara Gembong Village and the northern area is Muara Kuntul, then the northern area is Muara Somblem to continue to the north namely Muara Besar experiencing severe abrasion. The main current that causes abrasion is the longshore current which leads northeast – southwest. It is characterized by coarse sand sedimentary lithology which is found to form a long line in the direction of the shoreline, along the coast from Sederhana Beach, to the north to Muara Besar estuary. Therefore, it is recommended that coastal abrasion disaster mitigation efforts by intervening the construction of coastal structures in the form of retaining wave currents are Groins, combined with continuous Break Water that built seaward back to the original or ancient shoreline, forming closed circuit as common port. This structure formation would be best to be combined with the plantation of mangrove formation inside the zones. The zone inside the closed circuit will be filled
naturally with mangrove substrate mud coming from the estuaries around. And later, this zone would become a mangrove plantation zone, mangrove restoration, rehabilitation, or it is called also: reforestation of mangrove. The design and the implementation are better to be based on sustainability principles, and implementing Hybrid Engineering technology as well to minimize the negative impacts.

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