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Design of Integrated Coastal Defense and Renewable Energy Power Plant for Mundu Bay Sustainable Development Based on Shoreline Management Plan

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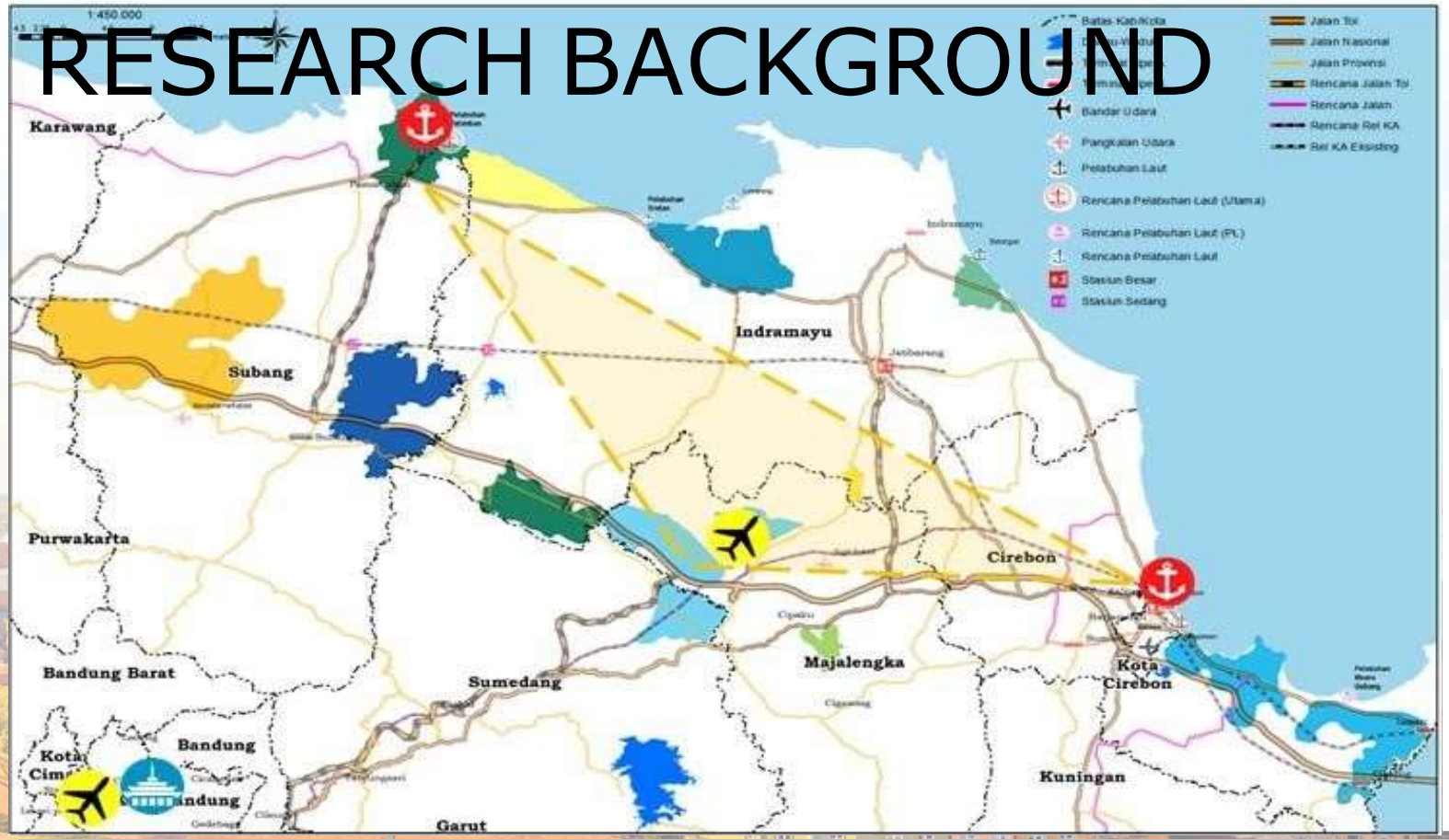
RESEARCH BACKGROUND



Industrial area in west Cirebon
source: cirebonpower.com

Cirebon flood 2021
source: news.detik.com

Cirebon is a part of the **"Segitiga Rebana"** that has been proposed to be **the largest special economic zone** in Indonesia. Cirebon Regency is mostly **planned to be industrial area (**Regional Spatial Plan of Cirebon Regency 2018-2038). However, it has **potential risk of flood, high waves, erosion & abrasion.** Source: West Java Province

MUNDU BAY COASTAL AREA

WHY?

The research area is the Mundu Bay that consist of 3 district (Mundu, Astanajapura, and Pangenan), 29 km shoreline length, Total area 93,17 km2.

Mundu Bay part of "Segitiga Rebana" and directly adjacent to the city of Cirebon which has high development pressure.

Mundu Bay locates in an active sediment cell with the middle-high risk natural hazard risk such as flood, erosion and abrasion.

Mundu Bay is the ideal area for the case study of Integrated Coastal Defense and Renewable Energy Power Plant Based on Shoreline Management Plant.

PROBLEM & SOLUTION

Ideally Mundu Bay has its coastal defense, however they do not have it.

There is no buffer zone or structural protection for the coast that damage the human and built environment on the land.

The insignificant coastal defense create a higher risk of flood disaster and it potentially create disadvantages for the coastal community.

It makes the more dynamic abrasion, erosion, and sedimentation of the coast.

Integrated Coastal Defense and Renewable Energy Power Plant

Based on Shoreline Management Plan will be one of the solution for Mundu Bay Sustainable Development

RESEARCH OBJECTIVE

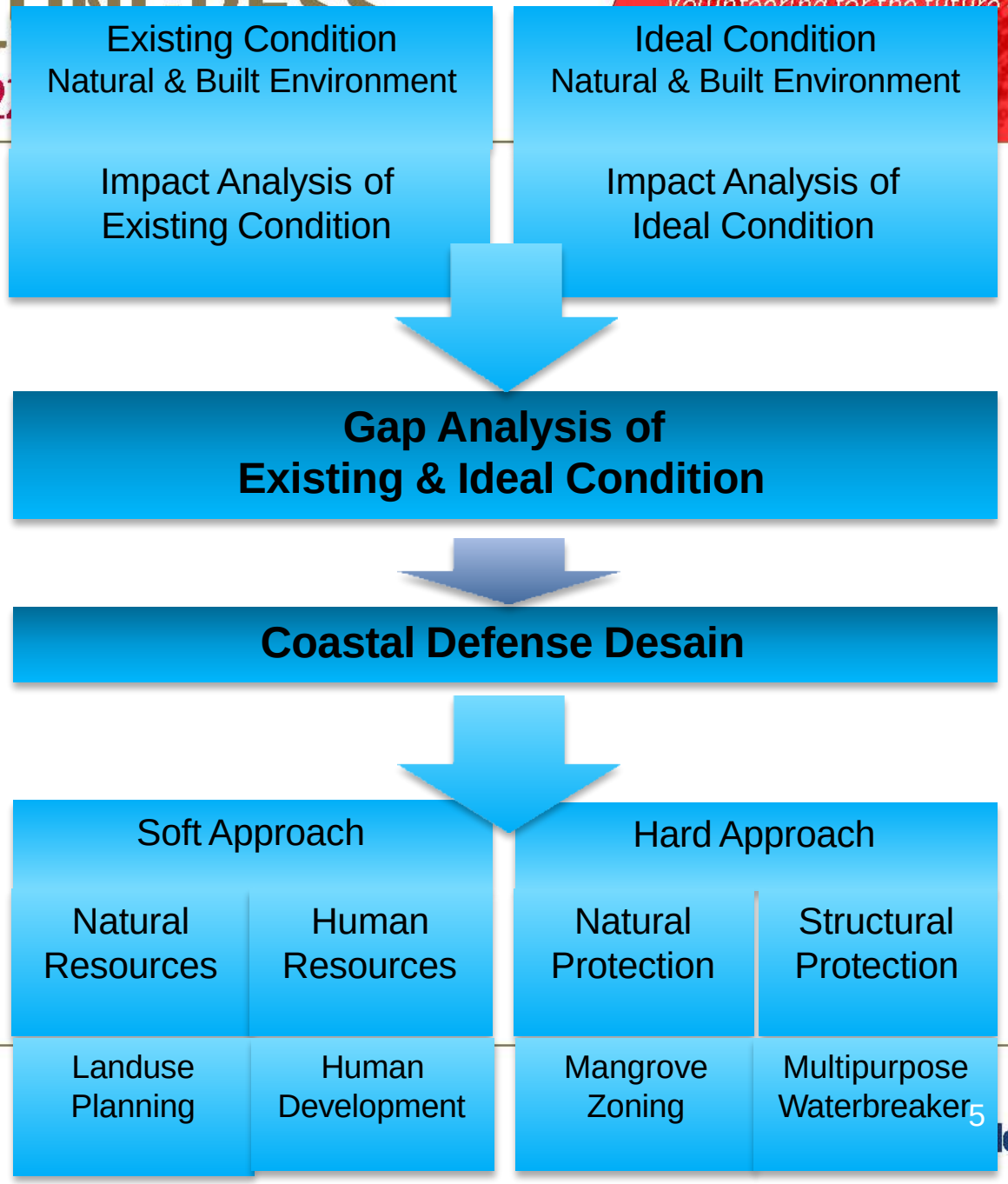
1. To identify the existing condition of coastal process, natural environment, built environment and coastal defense, in Mundu Bay coastal area.
2. To analyze impact of the existing condition of Mundu Bay coastal area.
3. To design the Integrated Coastal Defense and Renewable Energy Power Plant for Mundu Bay Sustainable Development Based on Shoreline Management Plan

RESEARCH METHOD

A shoreline management plan (SMP) is a large-scale assessment of the risks associated with coastal processes and helps to reduce these risks to people and the developed, historic and natural environment.

<u>Four key components of SMP:</u>

- the coastal processes,
- the coastal defences,
- land use and the human and built environment,
- the natural environment.




The West of Wales Shoreline Management Plan
source:www.royalhaskoningdhv.com


The coastal defense along Cirebon Coastal area is still not optimal. That is why the Cirebon coast especially the eastern is a dynamic coast because of the abrasion and sedimentation process.

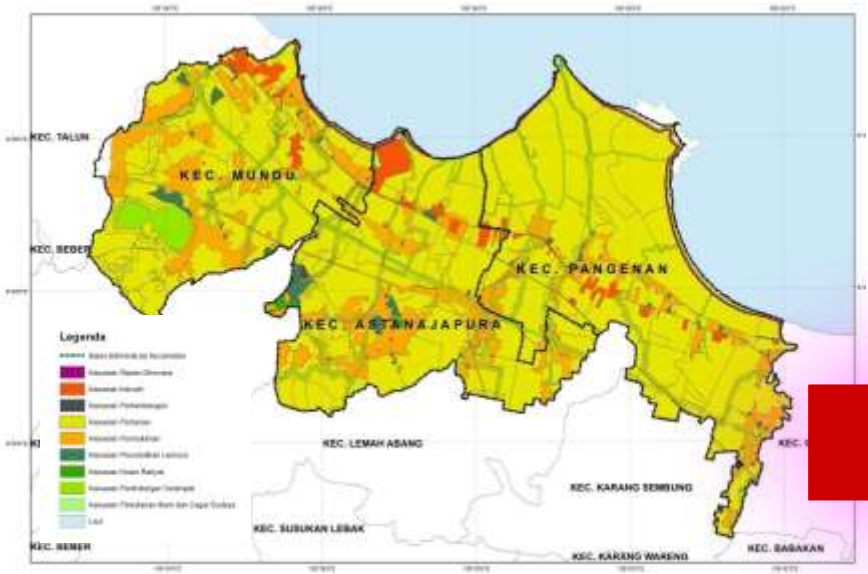
COASTAL DEFENSE BASED ON SHORELINE MANAGEMENT PLAN (SMP)

Shoreline Management Plan is the **most suitable method to develop the coast of Cirebon** because it has a complete mixture of coastal defense, coastal processes, development of built environment, and protection of natural environment. The aim of a shoreline management plan is to provide the basis for sustainable coastal defence policies within a coastal cell and to set objectives for the future management of the shoreline.

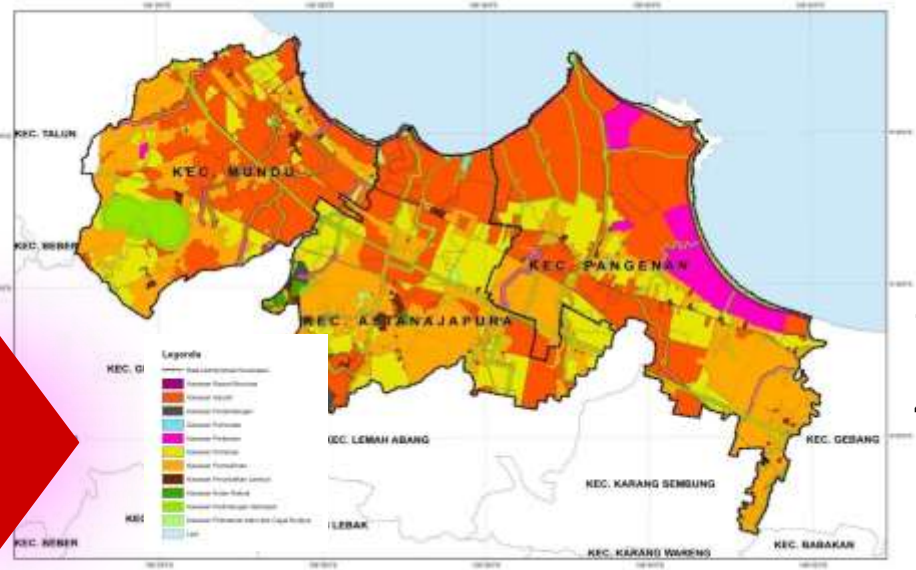
There are already coastal defences and other coastal structures (such as ports and harbours) on many shorelines. It is important to assess how these defences affect coastal processes. How effective they are and their residual lives will affect future coastal changes. Many defences will need major work in the future if existing defence standards are to be maintained or improved. Operating authorities should make sure that a programme is in place for regularly inspecting all defences. These surveys should provide up-to-date information on the location and type of existing defence structures, together with an assessment of their condition, performance and residual life. Operating authorities should be recording this information in the national flood and coastal defence database. SMP studies should use this data base

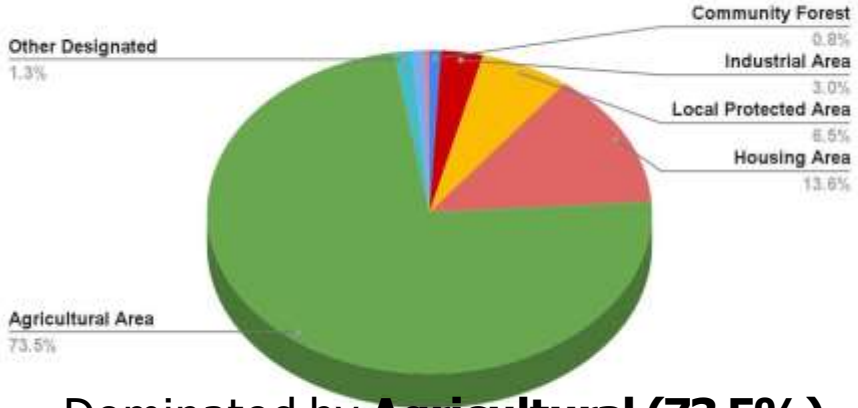
LAND USE CHANGES OF MUNDU BAY DEVELOPMENT

Existing Land Use Map
(Cirebon Regional Spatial Plan 2018-2038)

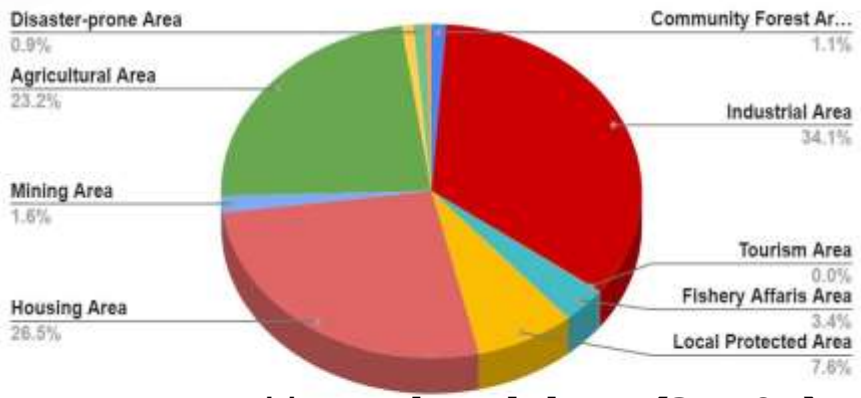


Land Use Planning Map
(Cirebon Regional Spatial Plan 2018-2038)





Dominated by **Agricultural (73,5%) and Housing area (13,6%)**



Dominated by **Industrial rea (34,1%) and Housing area (26,6 %)**

Environmental Impacts;

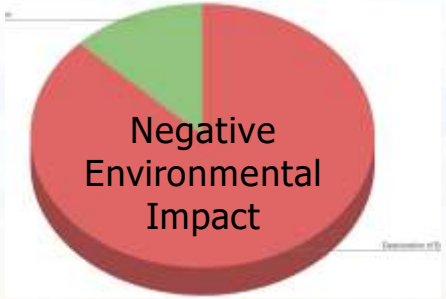
1. Reduced Water Catchment Area
2. Insufficient water supply
3. Pollution, Liquid and Solid waste production.
4. Increase the natural hazard risk (flood, erosion, abrasion).

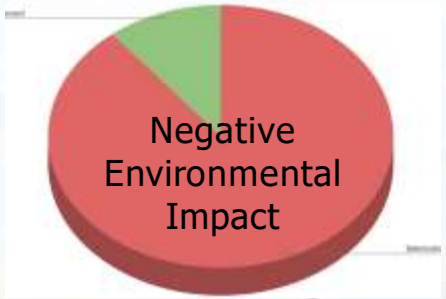
Proposed Solution;

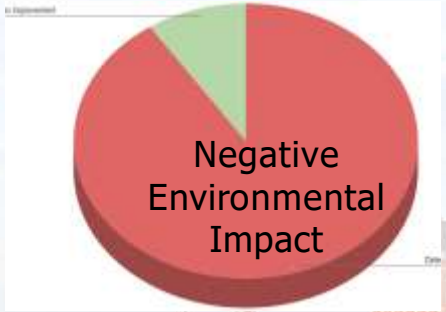
1. Shallow & Deep Infiltration well
2. Proper drainage system.
3. Natural coastal defense (mangrove plantation).
4. Structural water breaker.
5. Multipurpose water breaker for renewable energy power plant.

SOCIAL IMPACT OF LAND USE CHANGES of MUNDU BAY DEVELOPMENT

Mundu District	Astanajapura District	Pangenan District
Positive	Positive	Positive







Cirebon Regency Spatial Planning (2018-2038), shows that most of the area being converted to industrial area which has the very low environmental functions.

Most of the Mundu, Astanajapura, Pangenan areas will be **converted into industrial areas** so that their environmental function will decrease.

The conversion of land from agricultural to industrial areas causes various environmental impacts such as reduced catchment areas and reduced groundwater reserves, increased surface water flow and increased potential for flooding, increased volume of pollutants, both solid waste and liquid waste.

Design of Integrated Coastal Defense and Renewable Energy Power Plant

Shallow & deep infiltration wells is proposed for water resource management;

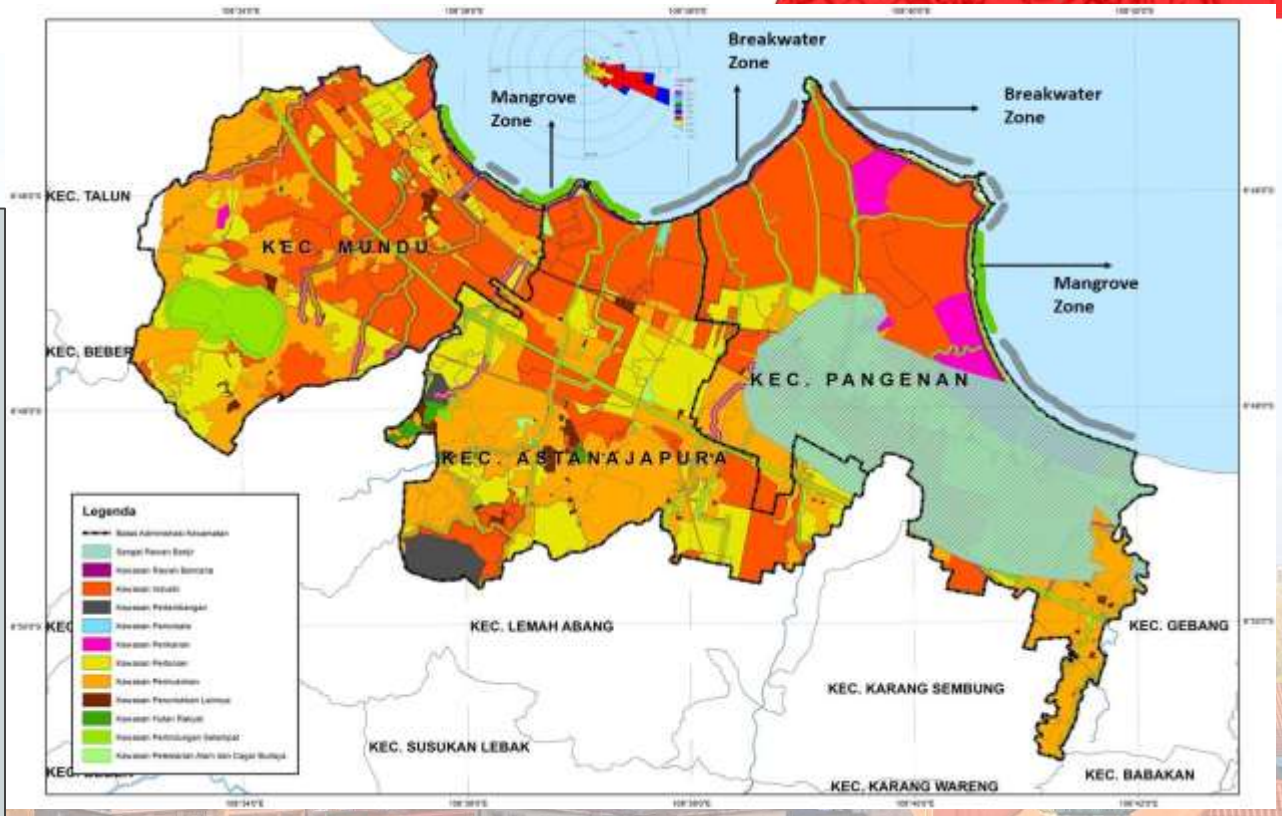
Shallow Infiltration Well

1. Ground water level >0.5 m
2. Located on flat land and at least 1 m from the building foundation.

Deep Infiltration Well

1. Preferably in land subsidence areas or inundation areas
2. Groundwater level drop in critical condition
3. Ground water level >4 m
4. Not close to the river.

BATU MAYOR REGULATION NUMBER 21 YEAR 2015 CONCERNING DEVELOPMENT WELLS AND BIOPORI

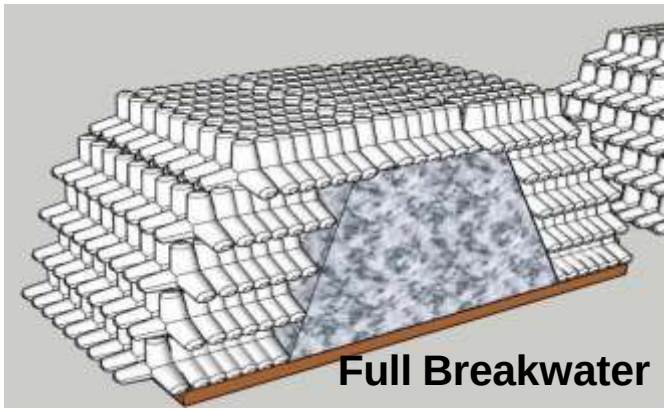


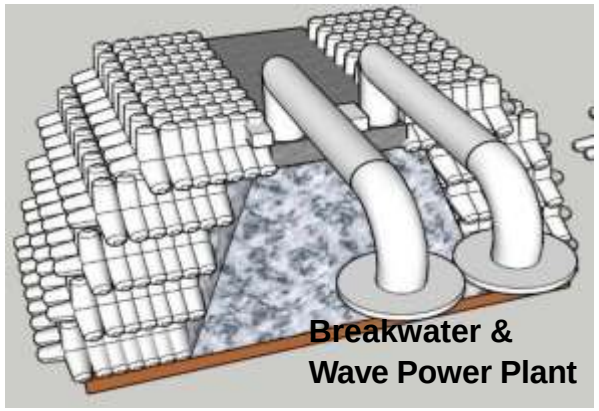
Multipurpose breakwater is proposed for the natural hazard risk (flood, erosion, abrasion) reduction.

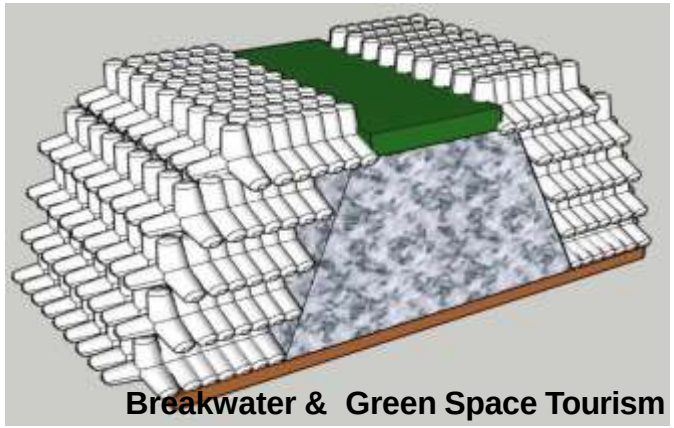
Breakwater zone is placed in area with high wave potential based on annual wave direction. Wave direction follows windrose, thus from the annual data, the wave direction is towards the southeast. Other than that, estuary is placed groin/breakwater in order to prevent sedimentation in downstream.

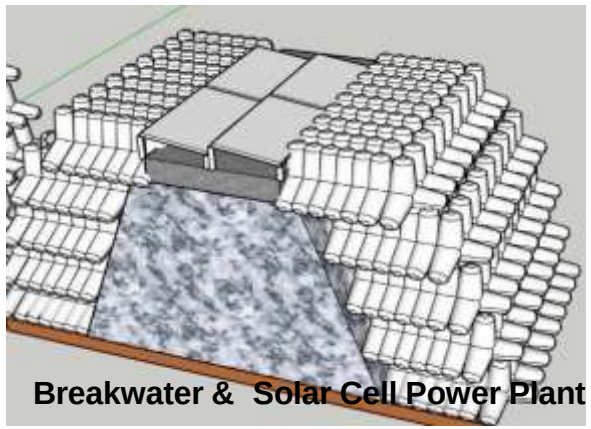
Mangrove zone is placed in areas close to residents so that it can be used as mangrove tourism.

Design of Multipurpose Breakwater for Renewable Energy Power Plant









Breakwaters
are constructed to reduce wave forces in the water area behind the structure. The wave force is reduced through a combination of reflection and dissipation of incident wave energy.

Benefit
- Solutions in dealing with coastal damage due to high abrasion and erosion.
- Preventive action in dealing with the risk of flooding that occurs in the Mundu Bay area as an area with high economic value because it is designated as an industrial area.

Innovation
The breakwater investment cost which is quite large is economical due to the use of breakwater as a renewable energy power plant, and green space tourism.

Multipurpose Breakwater for Renewable Energy Power Generation to break waves and prevent sedimentation, erosion and abrasion and power plant sites. Effective Length : 200 meters, Width : 4 meters, Stone Type : tetrapod

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Renewable Energy Potensial of Mundu Bay Solar,Wind, Wave,and Tidal Data

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Energy production:

Input rate of solar panels around 1000 Watts /m2, 15-20% efficiency. 1square meter in size, produce around **150-200W in good sunlight.**

Given the average capacity factor for small wind turbines, a 10 kW turbine will produce roughly **14,892 kWh per year**.

cirebon3 - Notepad

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Nilai Elevasi-elevasi Penting (cm):

Highest Water Spring    (HWS ) :    53.18, Jml. Kejadian :      1
Mean High Water Spring  (MHWS) :    45.77, Jml. Kejadian :    458
Mean High Water Level   (MHWL) :    41.77, Jml. Kejadian :   7720
Mean Sea Level          (MSL ) :    31.48, Jml. Kejadian : 162936
Mean Low Water Level    (MLWL) :    19.82, Jml. Kejadian :   7747
Mean Low Water Spring   (MLWS) :    15.08, Jml. Kejadian :    458
Lowest Water Spring     (LWS ) :     7.23, Jml. Kejadian :      1


 Nilai elevasi-elevasi penting diikatkan pada MSL (cm):

Highest Water Spring    (HWS ) :    21.70, Jml. Kejadian :      1
Mean High Water Spring  (MHWS) :    14.29, Jml. Kejadian :    458
Mean High Water Level   (MHWL) :    10.29, Jml. Kejadian :   7720
Mean Sea Level          (MSL ) :      .00, Jml. Kejadian : 162936
Mean Low Water Level    (MLWL) :   -11.66, Jml. Kejadian :   7747
Mean Low Water Spring   (MLWS) :   -16.40, Jml. Kejadian :    458
Lowest Water Spring     (LWS ) :   -24.25, Jml. Kejadian :      1

Tunggang pasang :     45.95 cm
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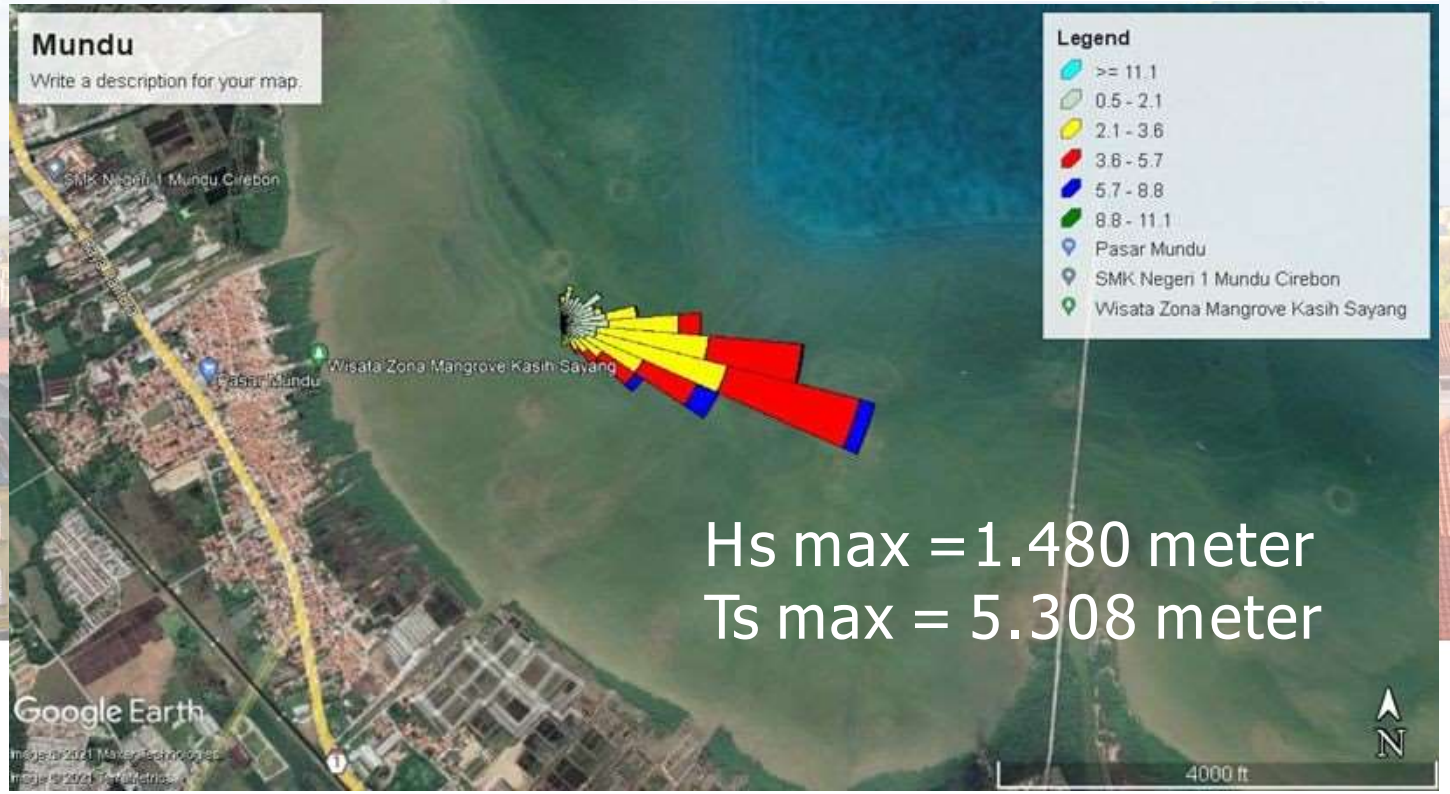

Hs max =1.480 meter

Ts max = 5.308 meter

Calculation of Breakwater Design

$$Lo = \frac{gT^2}{2\pi}$$

$$Lo = \frac{9.81 \; x \; 5.308^2}{2\pi} = 43.989 \; meter$$

Slope in mundu bay, m = 0.02

$$\frac{Ho'}{gT^2} = \frac{1.48}{9.81 \; x \; 5.308^2} = 0.005$$

$$\frac{Hb}{Ho'} = 1.1$$

$$Hb = 1.1 \; x \; Ho'$$

$$Hb = 1.1 \; x \; 1.48 = 1.5 \; meter$$

$$Ybr = \frac{1.923}{0.01} = 192.3 \; m$$

To make a perfect salient we use

$$\frac{Yb}{Ybr} = 0.55$$

$$Yb = 0.55 \; x \; Ybr = 0.55 \; x \; 192.3 \; m = \mathbf{105.77 \; meter}$$

To make a subdued salient, we use Lb/Yb = 1.2

$$\frac{Lb}{Yb} = 1.2$$

$$Lb = 1.2 \; x \; Yb = 1.2 \; x \; 105.77 = 123.3 \; meter$$

To make distance with other breakwaters (Lg)

$$\frac{Lg \; x \; Yb}{Lb^2} = 0.55$$

$$Lg = \frac{0.55 \; x \; (123.3)^2}{105.77} = \mathbf{79 \; meter}$$

CONCLUSION

1. The existing regional spatial planning (RTRW) 2018-2038 of Cirebon Regency will increase the natural hazard risk, such as flood, abrasion, erosion, sedimentation that threat the coastal community. The land use changing become industrial area will increase the natural hazard risk and cause other problems of waste, water and energy demand, human resources, and social impact.
2. The Integrated Coastal Defense and Renewable Energy Power Plant Based on Shoreline Management Plan will be one of the solution of for Mundu Bay Sustainable Development. The proper land use planning, water and wastewater management, sewerage system and groundwater artificial recharge will be the comprehensive solution to fulfill the water demand of Mundu Sustainable Development.
3. The multipurpose breakwater for renewable energy power plant will be the solution to minimize the natural hazard risk of flood, erosion and abrasion instead of to fulfill the water demand of Mundu Sustainable Development.
4. The Integrated Coastal Defense and Renewable Energy Power Plant, the breakwater construction costs which are quite expensive can be compensated with the economic benefits that can be generated by the power plant and green space tourism built on the breakwater.

FUTURE RESEARCH

1. Further research is needed to determine the dynamic characteristics of the coastal area of Mundu Bay, determine the environmental impact and natural damage and the solution that can be applied to overcome the existing problems.
2. Detailed data on the potential of renewable energy in the study area, including the potential for solar, wind, wave and tidal energy is needed to to optimize the use of existing resources.
3. Feasibility study and detailed engineering design for the construction of the breakwater in the study area is needed to implement the ideas that have been made in this research.

REFERENCES

[1] A. D. Siswanto and W. A. Nugraha, "Permasalahan Dan Potensi Pesisir Di Kabupaten Sampang Sampang'S Coastal Problems and Potentials," *J. Kelaut.*, vol. 9, no. 1, pp. 1907–9931, 2016.

[2] G. Barbaro, "Management and protection of coastal area, the importance of coastal processes during the planning phase," *Air, Soil Water Res.*, vol. 6, pp. 103–106, 2013, doi: 10.4137/ASWR.S12868.

[3] N. J. Cooper, P. C. Barber, M. J. Bray, and D. J. Carter, "Shoreline management plans: a national review and engineering perspective," *Proc. Inst. Civ. Eng. - Water Marit. Eng.*, vol. 154, no. 3, pp. 221–228, 2002, doi: 10.1680/wame.2002.154.3.221.

[4] B. R. Crawford, "Factors Influencing Progress in Establishing," 2004.

[5] E. Harris, "Assessing the level of integration between coastal risk management and town and country planning on the coast," pp. 2–97, 2018.

[6] I. H. Agustina, "STUDY OF FLOOD-PRONE AREAS IN BEKASI REGENCY," vol. 21, no. 2, 2021.

[7] D. Sunyowati, "Penataan Ruang Laut Berdasarkan Integrated Coastal Management," *Mimb. Huk.*, vol. 20, no. 3, pp. 425–442, 2008, doi: 10.20303/jmh.v20i3.246.

[8] E. SUTRISNO, "Policy of the Cirebon Regency Regional Government in Land Procurement for Landfill," *Ra J. Appl. Res.*, vol. 07, no. 11, pp. 2627–2631, 2021, doi: 10.47191/rajar/v7i11.02.

[9] S. Narayan *et al.*, "The effectiveness, costs and coastal protection benefits of natural and nature-based defences," *PLoS One*, vol. 11, no. 5, pp. 1–17, 2016, doi: 10.1371/journal.pone.0154735.

[10] F. C. Details and O. Road, "Flooding in the City & County of Swansea."

[11] D. A. Ramesh and A. S. Vel, "Methodology of Integrated Coastal Zone Management Plan Preparation – Case Study of Andaman Islands, India," *J. Environ. Prot. (Irvine,. Calif).*, vol. 02, no. 06, pp. 750–760, 2011, doi: 10.4236/jep.2011.26087.

[12] C. Coelho, P. Narra, B. Marinho, and M. Lima, "Coastal management software to support the decision-makers to mitigate coastal erosion," *J. Mar. Sci. Eng.*, vol. 8, no. 1, 2020, doi: 10.3390/JMSE8010037.

[13] Mike Sweeney, "City and County of Swansea Local Flood Risk Management Strategy," no. July, pp. 1–70, 2013, [Online]. Available: http://www.swansea.gov.uk/media/1336/Affordable-Housing-Viability-Study-July-2013/pdf/Affordable_Housing_Viability_Study_July_2013.pdf.

[14] M. dan S. T. Knight, "Koleksi Dokumen Proyek Pesisir," 2003.

[15] L. A. Klumb-Oliveira and R. D. Souto, "Integrated coastal management in Brazil: Analysis of the National Coastal Management Plan and selected tools based on international standards," *J. Integr. Coast. Zo. Manag.*, vol. 15, no. 3, pp. 311–323, 2015, doi: 10.5894/rgci531.

[16] N. Of, "Ft Nl Y," no. July, 2014.

[17] Y.-J. Lan and T.-W. Hsu, "Planning and Management of Coastal Buffer Zones in Taiwan," *Water*, vol. 13, no. 20, p. 2925, 2021, doi: 10.3390/w13202925.

[18] M. Angelin, Y. Nurita, and S. Dewi, "Desain dan Konstruksi Pemecah Gelombang dengan Sisi Miring Design and Construction of Sloping Breakwater," vol. 1, no. 2, pp. 106–120, 2020.

[19] K. Kaplan and H. E. Pape, "Inasmuch As," pp. 213–222, 1950.

[20] G. Elchahal, P. Lafon, and R. Younes, "Design optimization of floating breakwaters with an interdisciplinary fluid-solid structural problem," *Can. J. Civ. Eng.*, vol. 36, no. 11, pp. 1732–1743, 2009, doi: 10.1139/L09-095.

[21] A. Sebastian, S. S, and J. Thuvassery, "Design of floatable monolithic breakwater structure to ensure tranquility in port and harbor basins," *Int. J. Eng. Technol.*, vol. 7, no. 4.5, p. 736, 2018, doi: 10.14419/ijet.v7i4.5.25072.

[22] R. D. Carver and R. R. Bottin, "Reef breakwater design for Burns Waterway Harbor, Indiana, U.S.A.," *J. Coast. Res.*, vol. 13, no. 4, pp. 1267–1281, 1997, doi: 10.1016/S0967-0653(98)80813-2.

[23] B. Abayomi, I. A. Rapheal, B. M. Olaitan, and L. City, "Performance Comparison of Carbonized and Un- Carbonized Neem Leaves Briquette," vol. 7, pp. 150–53, 2021, doi: 10.46654/ij.24889849.