SUITABILITY EVALUATION OF SPACE UTILIZATION BASED ON ENVIRONMENTAL SUSTAINABILITY AT THE COASTAL AREA OF BUNGUS BAY IN PADANG CITY, INDONESIA

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ABSTRACT: This study aimed to evaluate the suitability of space utilization conducted in the coastal area of Bungus bay. The research was conducted through field survey with a spatial approach using Geographic Information System (GIS) in order to know the suitability of area allocations which were served as a protected zone, utilization zone, and special zone. The results showed that zone II covers an area of 232.9 ha with a score of 48,4 and zone II covers an area of 136,2 ha with a score of 23 was not-suitable served as utilization zone, and zone III covers an area of 539.9 ha with a score of 61 was suitable served as utilization zone. Management alternative for not-suitable category in the protected zone at location 8 can be managed by the establishing of coast protection, establishing of stilt house, and the improvement of roads connected to the main road; On the utilization zone of location 11, location 12, location 18, and location 23 can be managed by relocating the settlement as far as >100 m from the coast, establishing of coast protection, establishing of stilt house, and improving roads connected to the main road; On the special zone of location 1 can be managed by relocating the distance limit of ship track and activity, making of settling ponds for waste discharging, and establishing stilt house; and on the special zone of location 25 can be managed by relocating the distance limit of ship track and activity, making of settling ponds for waste discharging, and dust suppression (wetting) during coal loading, and unloading.

Keywords: Space Utilization, Suitability, Geographic Information System (GIS), Coastal Area, Bungus bay

1. INTRODUCTION

Construction progress that makes use of protected zone as a new area significantly results in overlapping, and irregular space utilization [1]. [2] explain that oblitrable space utilization can decrease both economically and ecologically the value of existing ecosystem utilization if it is not properly managed. [3] explain that have similar and synergistic utilization nature are used to be located in the same space while an oblitrable space utilization is used to be separately categorized as black zone (potentially deadly for other areas). However, if the black zone area has been built, buffer zone should be applied as an operational requirement of the area.

Based on Regulation of the Ministry of Marine and Fisheries of the Republic of Indonesia No. 23/PERMEN-KP/2016 concerning "Management of Coastal Areas and Small Islands", then a coastal region in required to have a protected zone which is the protection zone in which there is a preservation zone and a buffer zone [4]. [5] added that utilization zone is a zone that is managed intensively and consider its environmental carrying capacity such as coastal boundary, river boundary, and special zone for fast growing area.

The factors that be an obstacle in realizing the coastal area in suitable with the Regulation of the Ministry of Marine and Fisheries of the Republic of Indonesia No. 23/PERMEN-KP/2016 because of policy at the Regional of Regulation No. 4/PERDA/2012 who does not actionable with Regulation No. 27/UU RI/2007 concerning "Management of Coastal Area and Small Islands" [6], and an action plan to secure the coastal ecosystem environment that seemed to let the growth of industry sector in the area that is allocated as a zone of fisheries and tourism. Factor of space irregularities and factor of planning that is economy-oriented has changed the environmental setting in the coastal area of Bungus bay as the area of fisheries and tourism become the region of the industry. In accordance with the policy of areas set out in "Development Master Plan of Regional Tourism Padang City Year 2008-2017" [7], that the concept of the development strategy of development in the coastal area of Bungus bay prioritized for tourism development.

The purpose of this study is to determine the suitability of space utilization in the coastal area of Bungus bay so that happens the balance between the environmental carrying capacity with the ability of space that can be utilized in a sustainable.
2. RESEARCH METHOD

2.1 Research Locations

The research was conducted in the coastal area of Bungus bay residing on the sub-district of "Bungus Teluk Kabung" of Padang City and geographically located at coordinates of 100°22'23" - 100°29'13"E and 0°59'1" - 1°5'44"S.

Based on research [8], the coastal area of Bungus bay has the coastline with length ± 21.050 m, long of bay 5.418 m, and has a surface shape which tends to be rounded with a surface area 1.384 ha. Research location of covers the mainland area of bay and limited by the ridge of the hill where major rivers and tributaries entirety of empties into the bay.

Mapping of research location in the coastal area of bounded (buffers) with a distance 500 m from coastline towards of the mainland, and towards of the sea [9]. Width of research location in the coastal area of Bungus bay (buffers 500 m) is with the area of 980.19 ha of coastline to the waters (sea and river), and 911.13 ha of coastline to the mainland (Fig.1). The coastal area of Bungus bay is a functional area covers waters, foreshore, and mainland.

Fig. 1 Map of Research Location

2.2 Determinations Location of Field Survey

The determination of survey location was based on the location’s high accessibility, and its representability of allocation classes of existing area, so that the information could be quickly and easily collected. The determination was done at the validated locations in the field. The locations represented a proportion of 10 % protected zone, 60 % utilization zone, and 30 % special zone [10].

Based on the three zones division, the zone is bordered by 2 main river flows located in Bungus bay coast whose names are Batang Bungus rivers and Batang Cindakir rivers. Further information regarding survey location spots are presented in the Table 1.
Table 1 Field survey location at the coastal area of Bungus bay

| Zone | No | X  | Y   | Area Allocation          |
|------|----|----|-----|--------------------------|
|      |    |    |     | special port             |
| I    | 5  | 655380 | 9885528 | contamination of waters  |
|      | 6  | 656038 | 9885436 | artificial conservation  |
|      | 7  | 656783 | 9885512 | settlement               |
|      | 8  | 656394 | 9885814 | natural conservation     |
|      | 9  | 656792 | 9885252 | artificial conservation  |
|      | 10 | 657225 | 9885338 | agriculture (rice field) |
|      | 11 | 657208 | 9884851 | settlement               |
| II   | 12 | 657364 | 9883704 | agriculture (rice field) |
|      | 13 | 657301 | 9883127 | settlement               |
|      | 14 | 656375 | 9883513 | natural conservation     |
|      | 15 | 657550 | 9882416 | agriculture (rice field) |
|      | 16 | 657372 | 9881754 | special port             |
|      | 17 | 657001 | 9881228 | settlement               |
|      | 18 | 656337 | 9880995 | agriculture (rice field) |
|      | 19 | 656458 | 9882445 | contamination of waters  |
| III  | 20 | 656444 | 9881233 | natural conservation     |
|      | 21 | 655699 | 9881541 | natural conservation     |
|      | 22 | 654587 | 9880813 | natural conservation     |
|      | 23 | 653745 | 9882196 | contamination of waters  |
|      | 24 | 652690 | 9880914 | special port             |
|      | 25 | 652151 | 9882279 | contamination of waters  |

2.3 Data Analysis

2.3.1. Suitability of Biophysical Parameters

Biophysical parameter based suitability analysis of space utilization is the information value of an ecosystem from an ecology in an area including the state and condition found while conducting the survey.

Table 2 Biophysical parameters of space utilization based on environmental sustainability

| Zone | Allocation | Parameters | Number | Weight | Score |
|------|------------|------------|--------|--------|-------|
|      | natural    | there is endemic | 2      | 2      | 4     |
|      |            | there is no endemic | 0      | 0      | 0     |
|      | coastal    | 100 - 200 m from highest tidal point to the land | 2      | 2      | 4     |
|      |            | 0 - <100 m from highest tidal point to the land | 0      | 0      | 0     |
|      | river      | 100 - 200 m at the left and the right side of main river, and 50 m at the left and right side of the creek located outside of settlements. | 2      | 2      | 4     |
|      |            | 0 - <100 m at the left and the right side of main river and 50 m at the left and right side of the creek located outside of settlements. | 0      | 0      | 0     |
|      | artificial | there is coast protection | 2      | 1      | 2     |
|      |            | there is no coast protection | 0      | 0      | 0     |
|      |            | there is no seawater intrusion | 2      | 1      | 1     |
|      |            | there is seawater intrusion | 0      | 0      | 0     |
|      | coastal disaster-prone | there are no abrasion and accretion | 2      | 1      | 1     |
|      |            | there is abrasion and accretion | 0      | 0      | 0     |
|      |            | there is no land subsidence | 2      | 1      | 1     |
|      |            | there is land subsidence | 0      | 0      | 0     |

*Table 2 continued to next page
| Zone                              | Allocation | Parameters          | Number | Weight | Score |
|----------------------------------|------------|---------------------|--------|--------|-------|
| SALINITY (‰)*                    | 15 – 25    |                     | 2      | 3      | 6     |
|                                  | 10 - 15 and 25 - 35 |                     | 1      | 3      | 3     |
|                                  | <10 or >35 |                     | 0      | 0      | 0     |
|                                  | 28.5 - 31.5 |                     | 2      | 3      | 6     |
| TEMPERATURE (°C)*                | 26 - 28.5 and 31.6 - 33 |                 | 1      | 3      | 3     |
|                                  | <26 or >33 |                     | 0      | 0      | 0     |
|                                  | 4.0 - 7.0  |                     | 2      | 5      | 10    |
| DO (mg/l)*                       | 3.0 - 4.0 and 7.0 - 12.0 |             | 1      | 5      | 5     |
|                                  | <3 or >2   |                     | 0      | 0      | 0     |
|                                  | 7.6 - 9.0  |                     | 2      | 5      | 10    |
|                                  | 4.0 - 7.5  |                     | 1      | 5      | 5     |
|                                  | <6.0 or >9.0 |                  | 0      | 0      | 0     |
|                                  | >6.0       |                     | 2      | 3      | 6     |
| SULFIDE (mg/l)*                  | >4 - 5.9   |                     | 1      | 3      | 3     |
|                                  | <20 and >60 |                   | 0      | 0      | 0     |
|                                  | <0.01      |                     | 2      | 3      | 6     |
| SULFIDE (mg/l)*                  | 0.01 - 0.02 |                   | 1      | 3      | 3     |
|                                  | >0.02      |                     | 0      | 0      | 0     |
|                                  | <0.005     |                     | 2      | 5      | 10    |
| NITRATE (NO₃-N) (mg/l)*          | 0.004 - 0.002 |                 | 1      | 1      | 5     |
|                                  | >0.001     |                     | 0      | 0      | 0     |
|                                  | >2000 - 3000 |                   | 2      | 2      | 4     |
|                                  | 1000 - 2000 |                   | 1      | 2      | 2     |
|                                  | <1000 or >3000 |               | 0      | 0      | 0     |
| there are a buffer for agricultural lands and river >50 m | 2 | 1 | 2 |
| there are no a buffer for agricultural lands and river >50 m | 2 | 0 | 0 |
|                                  | 5.5 - 7.4  |                     | 2      | 3      | 6     |
| TOPOSOIL’s pH (0 - 30)           | 4.0 - 5.4 and 7.5 - 8 |             | 1      | 3      | 3     |
|                                  | <40.0 and >8.5 |                  | 0      | -      | 0     |
|                                  | beach ridge |                    | 2      | 2      | 4     |
|                                  | alluvial plain |                | 1      | 2      | 2     |
|                                  | backswamp   |                     | 0      | 0      | 0     |
| located on non flood-prone areas | 2          | 2                  | 4     |       |       |
| located on flood-prone areas    | 2          | 0                  | 0     |       |       |
| do not settle on the beach border, wetland crops, and irrigation | 2 | 3 | 6 |
| settle on the beach border, wetland crops, and irrigation | 2 | 0 | 0 |
|                                  | <200       |                     | 2      | 3      | 6     |
|                                  | 200 - 500  |                     | 1      | 3      | 3     |
|                                  | >500       |                     | 0      | 0      | 0     |
|                                  | >100       |                     | 2      | 3      | 6     |
|                                  | <50        |                     | 0      | 0      | 0     |
|                                  | <50 people/ha |                 | 2      | 2      | 4     |
| population density              | 50 - 100 people/ha |             | 1      | 2      | 2     |
|                                  | >100 people/ha |                 | 0      | 0      | 0     |
| do not settle on the locations of flood disaster, abrasion/accretion | 2 | 1 | 2 |
| settle on the locations of flood disaster, abrasion/accretion | 2 | 0 | 0 |
|                                  | 2          | 2                  | 4     |       |       |
| FLOW (cm/Sec)                    | 2 - 1      |                     | 1      | -      | 3     |
|                                  | <1         |                     | 0      | -      | 0     |

*Table 2 continued to next page
### 3.1 Suitability of Space Utilization

The results of scoring algorithm in a the spatial in the coastal area of Bungus bay (Table 4) at a zone I with an area of 232.9 ha showed category of *not-suitable* for utilization zone with a score of 48.4 and zone II with an area of 136.2 ha showed category of *not-suitable* for utilization zone with a score of 23. This means of value mentioned be on a 0 - <60 showed that this space is not worth as utilization zone, and can be allocated for a protected zone or special zone; zone III with an area of 539.9 ha showed *suitable* for space utilization with a score of 61. This means of value mentioned be on a >60 - 80 showed that space this of supportive, and decent as utilization zone, However, need to be considered.
certain requirements if want to be developed as the same zone. Zone of area that be used for protected zone, utilization zone, and special zone as the zone of space utilization be on a minimum limit. Area which is the center of industrial activity, and economy are in a zone of space utilization with a radius 3.5 and 7 km from the center of sub-district showed the category is not-suitable, this is because space location residing in the coast border and river has no vegetation as buffer zone of the good one [12].

### Table 4. Results of scoring algorithm of space utilization suitability

| Zone | Location | Allotment | Score | Category      |
|------|----------|-----------|-------|---------------|
| 1    | Port of Fisheries Bungus | special   | 35    | 10,5          |
| 2    | Labuhan Tarok       | utilization | 5     | 3             |
| 3    | Labuhan Tarok       | utilization | 20    | 12            |
| 4    | Sako Beach          | protected  | 4     | 0,4           |
| I    | Waters of Fisheries Bungus | special | 35    | 10,5 not-suitable |
| 6    | Sako Estuary        | protected  | 4     | 0,4           |
| 7    | Primary School/SD No. 01 | utilization | 18    | 10,8          |
| 8    | Primary School/SD No. 018 | protected | 4     | 0,4           |
| 9    | Carolina Estuary    | protected  | 4     | 0,4           |
| Total|           |           | **129** | **48,4**    |
| 10   | Talawi              | utilization | 11    | 6,6           |
| 11   | Pasa Laban Beach    | utilization | 6     | 3,6           |
| II   | Cindakir Beach      | utilization | 14    | 8,4 not-suitable |
| 12   | Cindakir Estuary    | utilization | 6     | 3,6           |
| 13   | Cindakir            | protected  | 8     | 0,8           |
| Total|           |           | **45** | **23**       |
| 15   | Batung Beach        | utilization | 12    | 7,2           |
| 16   | Port of Pertamina   | special   | 27    | 8,1           |
| 17   | Labuhan Cino        | utilization | 12    | 7,2           |
| 18   | Labuhan Cino        | utilization | 5     | 3             |
| 19   | Batung Waters       | special   | 27    | 8,1           |
| III  | Kabung Cove         | protected  | 12    | 1,2 suitable  |
| 20   | Kaluuning Cove      | protected  | 14    | 1,4           |
| 21   | Pandan Cove         | protected  | 14    | 1,4           |
| 22   | Waters of Buo Cove  | utilization | 20    | 12            |
| 23   | Port of Steam-electric power station in Sirih Cove | special | 19    | 5,7           |
| 24   | Waters of Steam-electric power station in Sirih Cove | special | 19    | 5,7           |
| Total|           |           | **181** | **61**       |

Source: Data analysis, 2016.

Development activity of industry, settlement, and other activity with no regard to quality of the environment through of mangrove conversion activity on the coastal boundary, and river boundary at the location 2, location 3, location 6, and location 8 in Labuhan Tarok cause a decrease in the function of the space on the coastal environment. Conditions this makes the coastal area in Bungus bay disaster-prone of coastal that can harm society in aspects of agriculture and settlement, such as sedimentation which can hamper sea transportation and abrasion that threaten land and access roads the coastal area in Bungus bay. [13] add, limited of mangroves as a buffer zone between zone that are not synergistic (harming each other) brings the influence against a decline in waters quality and coastal environment. As for the map of utilization space suitability in the coastal area in Bungus bay can be seen in Fig. 2.

### 3.2 Evaluation of Space Utilization

The based on scoring algorithm results for the space utilization zone and the focus activity in the coastal area of Bungus bay with a suitable, and not-suitable category is shown in Table 5. Where, conditions are space utilization on the zone I, and zone II be on a minimum limit so that is not optimal and could damage other areas through various activity.

According to [14] zone of space utilization in the coastal area can be grouped according to the similarity of the characteristics physical, biology, ecology, and economy of that are determined based the activity grouping that is synergistic, and separate from activity that contradicts with criteria certain so that this zone can defend the sustainable value.
3.2.3. Buffer Zone

Allocation and distribution of this zone are needed, especially in the area whose activity could potentially have an impact on another area, so the value of other zone become a declined. Buffer zone in the coastal area of Bungus bay of allocation a space determination distributed on a special port activity that potentially contaminates other area. Almost all of space utilization is prone to cause problems inter of the zone a that not yet has a buffer zone, only agricultural land that has a buffer zone.

According to [15] minimum width of the buffer zone 7.6 m plus 0.6 m for each of slope 1% between the water surface with the mainland. Besides a role in the ecology of protective function as a buffer zone to protect the quality of water masses, water pollution and slow down the run-off, so that sedimentation can be reduced. As for the width a alternative zone can be seen in Table 6 and map of space utilization alternative in the coastal area of Bungus bay can be seen in Fig. 2.

The activity of special port in location 24, and location 16 has a big impact toward the mariculture at location 19, and location 23. [16] add turbidity of the waters during the rainy season led to lower the Dissolved Oxygen (DO) content in the waters so that process of photosynthesis is inhibited, and causing of death on aquatic biota, especially fish.

Development activity in the coastal area of Bungus bay that not suitable with one another can lead to adverse impacts on the surrounding environment. To overcome of the impact that a occurs need management of the environment, both ecologically and through the policy of revision "The Spatial Planning and Regional of Padang City and West Sumatra Province" so that this area can be utilized in a sustainable manner.

Tabel 5. Width of space utilization zone category

| Zone   | Allocation | Width (ha) | suitable | 55.84 | 297.15 |
|--------|------------|-----------|----------|-------|--------|
| I      | special    | 26.15     | -        | -     | -      |
| II     | protected  | 27.11     | 1.98     | -     | -      |
| II     | special    | 34.2      | 11.85    | -     | -      |
| II     | utilization| 87.0      | 307.62   | -     | -      |
| II     | protected  | 19.2      | 46.32    | -     | -      |
| II     | utilization| 78.4      | 9.21     | -     | -      |
| total  | value      | 287.16    | 181.03   | 641.08|

Source: Data analysis, 2016.

The based on the results of research which refer to the Regulation of the Ministry of Marine and Fisheries of the Republic of Indonesia No. 23/PERMEN-KP/2016, the coastal area of Bungus bay can be grouped in 3 zone representing the characteristic of a space utilization area for utilization zone, protection zone, and buffer zone.

3.2.1. Utilization Zone

Zones this serves as the main zone for the activity of fishing, agriculture, settlement, tourism and other activity are still in touch or mutual support inter the space utilization in the coastal area of Bungus bay in the allocation this zone consists of 2 sub-zone i.e 1) utilization zone constitute a area or a zone in its activity constitute a zone or a similar activity could support another zone, and does not cause problems on the other zone. zone this consists of a group of mariculture, fishing industry, settlement, and agricultural area of 230.65 ha; and 2) special zone constitute a zone that in its activity could adversely affect the other space, so that need is done effort protection against the other space with adjusting the placement of zone this on a certain space a that utilized as big as possible for these activity. In addition, the placement of vegetation as a buffer zone between regions should be applied in the zone.

3.2.2. Protected Zone

Zones this serves as a zone of protection because it has a great diversity of ecosystems therein. For protection zone is allocated amounted 201.46 ha, effect land clearing on a large scale at the location 8, and 6 in Sako Estuary - Labuhan Tarok for the construction of Crude Palm Oil (CPO) amounted 79 ha causing damage to coastal ecosystems conditions, and vulnerable to coastal disasters. Protected zone at location 8, and location 6 covers an area of 35.45 ha become damaged by mentioned land clearing. Width of protected zone other such as coastal boundary, and river boundary continue to experience the decrease in extents, so it needs to be optimized.
Environmental management on an allotment zone in the coastal area of Bungus bay based on the value that is in the category *not-suitable* as the utilization zone for agriculture such as in location 8, and location 18. As for the actual environmental management to be a condition of potential environment in the coastal area of Bungus bay i.e management for *not-suitable* category on the special zone in location 1 caused due to the high of sedimentation which resulted in disruption of the transport ship in port and prone to flooding. Environment management is carried out by the drainage system repair, establishing of coast protection, and establishing of stilt house on a limit coastal settlement. The denseness of port activity on a location mentioned affect towards water pollution Cd, Cr+6, and Pb for overcoming of the problem with relocation the limit distance of ship track and activity and making of settling ponds for waste discharging.

Environment management for *not-suitable* category on the protected zone in location 8 a result of land clearing for the development of palm oil mill in which there are settlement, and adjacent to agricultural and location 18 which a prone to flood. For overcoming the problem with establishing of
coast protection, establishing of stilt house, and improving roads connected to the main road.

Environment management for not-suitable category on the utilization zone in location 11, location 13, and location 12 a result of abrasion and flood disaster that resulted in destruction the physical building of settlement and agricultural land. For overcoming of the problem with relocating the settlement as far as > 100 m from the coast, establishing of coast protection, establishing of stilt house, and improving roads connected to the main road, relocate the settlement from the river as far as >50 m and, establishing of coast protection.

Environment management for not-suitable category on the special zone in location 16 has the natural habitat of mangrove and agricultural of wetlands from water pollution Cd, Cr+6, and Pb are with relocating the distance limit of ship track and activity, making of settling ponds for waste discharging. Need to socialize with the community regarding the determination of law regarding the protection of coastal ecosystems, especially of taking of mangrove wood.

Environment management for not-suitable category on the special zone in location 23 that constitute the location of the fish hatchery, and mariculture. On location of coastal boundary, there is settlement either owned by government or settlement and communities, where the location such settlement are vulnerable to flood disaster. Management to be undertaken i.e with establishing of coast protection.

Environment management for the not-suitable category on the special zone in location 25 that dealing directly with the high seas/mouth of the bay and the location of ship crossings. Environment management to be undertaken, namely with relocating the distance limit of ship track and activity, making of settling ponds for waste discharging, and dust suppression (wetting) during coal loading, and unloading.

4. CONCLUSION

The analysis of suitability the space utilization based a biophysical parameters in the coastal area of Bungus bay shows the category is not-suitable for space utilization in the zone I with a score 48.4, and only on a zone III which shows the category is suitable with a score 61, this indicates the existence of Steam-electric power station in Sirih cove on the zone III does not lower the quality environment in the zone. The condition of each zone which is used for protected zone, utilization zone, and special zone as the zone of space utilization is at a minimum. This is because the location of space that utilized residing on a coastal boundary, and river boundary without owning vegetation as a good buffer zone, so it needs to be developed mangrove revegetation efforts with good as the utilization zone, protection zone, and buffer zone amounted 83.90 ha. And socialization with the public and stakeholders towards a logging activity of mangroves in the coastal area of Bungus bay.

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