A Study of Dynamic Spatial Model Zonation-Based Land Suitability for Sustainable Management of Ambon's Coastal Area

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Abstract

The sustainable management of coastal resources with zonation-based using dynamic spatial approach aims to study how the relationship between dynamic approach and land suitability and land carrying capacity can be used to evaluate sustainable management of coastal area in Ambon. This research was conducted in 4 districts around coastal area of Ambon. The result of this research proves that the land suitability of coastal area in Ambon is in the category of S2, with N score = 61,1% which is the area that can be developed with particular conditions such as spatial utilization control and regional structuring. Dynamic relationship model is carried out based on four main studied indicators which are covered land sub model, ecology sub model, economy sub model, and social sub model. The alteration rate of forest covered land during 2005 - 2015 was decreasing as large as 71,6 ha, opened land as large as 94 ha, mixed garden as large as 184 ha, meanwhile the settlement area was increasing as large as 355 ha. The dynamic model result explains that the alteration rate of forest covered land for the past 10 years from 2005 – 2015 was decreasing as large as 71,6 ha, opened field as large as 94 ha, mixed garden as large as 184 ha, meanwhile the settlement area was increasing as large as 355 ha. Covered field sub model describes that the change of covered field is highly influenced by 2 (two) aspects that are the aspects of land economic value and the society's income from other sectors. The result of this research is expected to be a consideration of Ambon's government in attempting construction plan.

Keywords: Model ; dynamic spatial; zonation; Ambon.

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1. Introduction

Integrated and sustainable management of coastal area is an iterative and evolutionary process to create coastal area development optimally and sustainably. Coastal area resources have a large potential both biological and non biological resources. However, up until now the utilization rate is still far from its best possibility and sustainability. Instead, those resources are irresponsibly used, stolen, and degrading. There are numbers of factors causing this degradation of coastal area resources which at the end result on potential resources failure in giving eternal advantages for ecosystem continuity and human kind's prosperity [1,2,3,4].One of the causes is the rapid of population rate inhabiting coastal area which increase the threat toward the existence of coastal resources. The effect is massive coastal resources exploitation especially in attempts of extending allocation area that is possible to urge on economic growth [5,6,7]. From the aspect of sustainable resources availability, a development without noticing conservation aspect will only decrease the ability of coastal resource itself in supporting service function for long term ecosystem balance in coastal area [8,9]. Ignorance toward coastal area spatial, destructive utilization, unclear policies regulating coastal resources management, and less involvement of the society will cause coastal resources management less than optimal [10,11]. Another problem that is critical regarding management of coastal area in Ambon is the imbalance of land utilization which implies to land usage unsuitability in coastal development. This causes interest conflicts amongst stake holders who have particular interests in coastal area. Mountain area exploitation for settlement area expansion that is uncontrolled can cause several problems such as flood and landslide, coastal area expansion by reclamation without considering marine resources preservation, and the implications of coastal and marine ecosystem and resources damages [12,13,14,15]. Regional development plan including human activities in any level of coastal and sea utilization through spatial plan and marine zonation in any stages of development have been carried out to determine sustainable development plan strategy and marine environment conservation and also to minimize conflicts amongst users of marine and coastal resources in any regions such as in England [16,17,18,19,20,21], Scotland [22], Canada [23], [24], China [25], Baltic Sea [26], South Africa [27], and Ambon, Indonesia [28,29]. The approach of sustainable management of coastal area integrally is not only to pursue short term economic growth but also to guarantee the economic growth so that it can be perceived equally and proportionally by the stakeholders. It is also to preserve carrying capacity and coastal environment quality so that the development takes place sustainably [30, 31]. Dynamic spatial model land usage change based on this research is one of systemic approaches that aim to evaluate the land usage change and land suitability using dynamic model which measures environment and economic quality, and impacts on social and economic lives of the society, and also regional income that will be evaluated toward management of coastal area in Ambon. The result of these calculation and analysis will be used as considerations to develop a management recommendation that is appropriate with result analysis of land suitability zonation-based. The scenarios that are developed through system improvement are pessimism scenario, moderate scenario, and optimism scenario.

2. Material And Method

This research was conducted in Ambon, Maluku province focusing on 4 districts which are districts of Nusniwe, Sirimau, Teluk Ambon Baguala, and Teluk Ambon. The used samples based on this research consist of 30 villages and sub districts to represent those 4 districts. The research was conducted from August 2014 until

February 2015. The primary data was obtained from direct survey in research area by giving questionnaires to 359 respondents for zonation valuation. The method of data analysis was done by using spatial method approach through image data evaluation Landsat 7 year 2003, 2013 and Landsat 8 year 2015. Land suitability analysis according to the approach is based on the Law No. 1 year 2014 about coastal and small islands management [31] and the Law No. 7 year 2004 about water resources [32]. Dynamic modeling analysis is using power sim for land usage sub model toward land suitability of Ambon's coastal area.

3. Result

a.   The Result of Problems Analysis in Coastal Area of Ambon

The analysis that has been done based on the Law No. 1 year 2014 aims to examine whether the coastal area of Ambon is proper to be developed by considering the characteristics of the area, conservation area allotment, utilization area (agriculture, fishery, and settlement) also particular port area. It was measured by the suitable approach based on particular criteria according to the Law. Then, scoring and weighting processes were done. One of the coastal areas of Ambon and its characteristics and problems is explained as follow;

1. Inhabitant settlement, public facilities (market and bus station), government and non government offices, hotel, military and police facilities, PLN facilities (National Electricity Company), shopping centre and mall, health facilities (hospital), the main road is too close to the coastline and located in coastal border,
2. River mouth covering by sediment and waste which causes pollution and flood,
3. The loss of mangrove, seagrass, and coral caused by the coast sedimentation, petroleum waste disposal activity in water area, and soil erosion.
4. The change of land use because of coast reclamation for common interest which triggers erosion and abrasion.
5. There are 3 large rivers flowing in coastal area SWPPP I, which result in large amounts of waste from household, office activities, hotels and markets in which it is disposed along the river flows causing sedimentation and water pollution.
6. Slum and irregular areas located in Wainitu, Waihayong, Batumerah, and Tantui which cause quality disruption of aquatic environment.
7. Landslides and floods.

Figure 1: Problems in Unit Area of Coastal Protection and Observation 1 (SWPPP I)

b.   The Result of land Suitability Based on the Approach according to Law No. 1 year 2014 about Management of Coast and Small Islands.
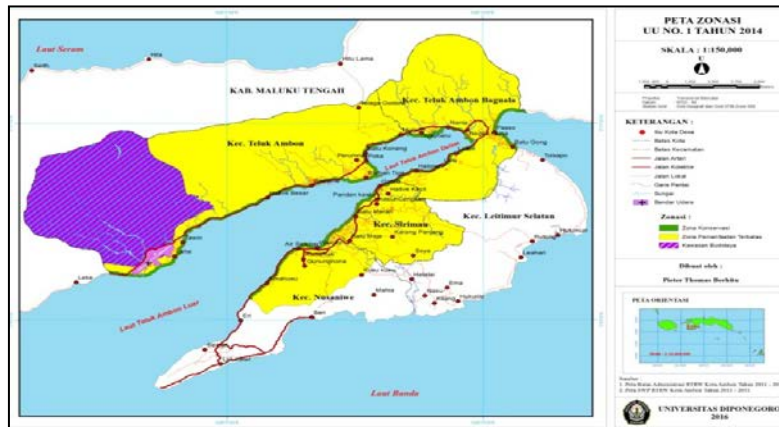
Figure 2: Zonation Map Based on the Approach of Law No. 1 Year 2014

The zonation based on the law is focused on preservation and cultivation area which is regulated technically in coastal spatial planning guidance from Ministerial decree No. 34 year 2002. Preservation zoe according to the Law, coastal area is directed to areas that have protective function such as national strategic area, conservation area, and coastal preservation area. Several criteria that can be used to determine spatial use suitability zone, for instance coastal border, disaster prone area, settlement, and coastal dynamic. The obtained scores are timed by score weight that is formulated as: N = (Preservation Score x 10%) + (Usage Score x 60%) + (Particular Score x 30%).

N = (Preservation Score x 10%) + (Usage Score x 60%) + (Particular Score x 30%)

  = ((20) x 10%) + ((64) x 60%) + ((49) x 30%)

  = 2% + 38,40% + 14,7%

  = 61,1% (Eligible to develop in certain conditions)

According to the calculation based on Law No. 1 year 2014 approach, it is obtained that the eligibility number is 61,1%. Referring to this number, it can be considered that coastal area of Ambon is included into category (S2), that is an area that can be developed in certain conditions such as spatial use control, spatial use control for settlement, office centre, educational institutions, business development, functional shift area, pollution control, sedimentation, abrasion and erosion, spatial control related with coastal ecosystem damage, intake of C minerals, etc.

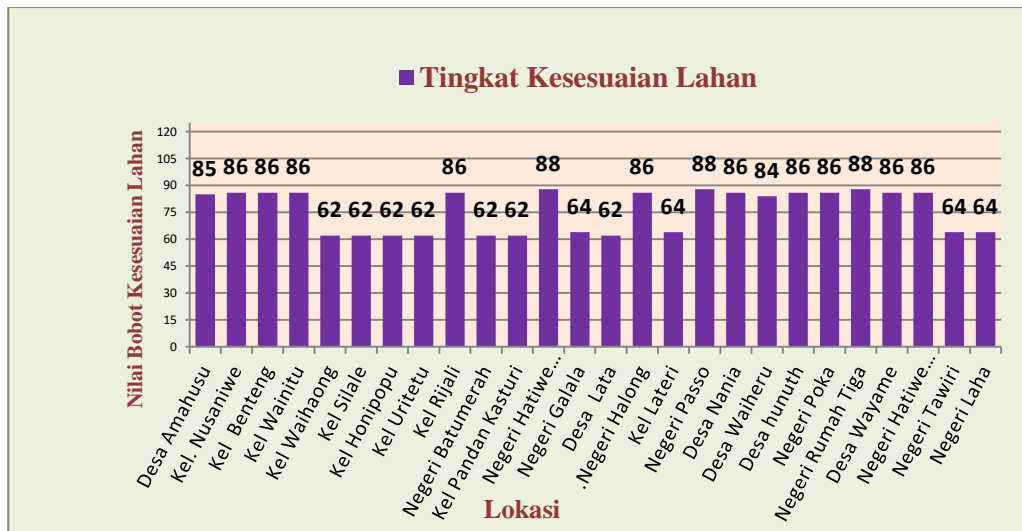c.   The Result of Land Suitability Based on Law No. 7 Year 2004 Approach Regading Water Resources

Figure 3: Distribution of Land Suitability of Ambon's Coastal Area

From the above figure, the distribution of land suitability of Ambon's coastal area is as follow;

- Land suitability level with score > 80 – 100, category S_1, it is significantly suitable to use whereas this area is worth and eligible to be developed in 15 locations or 57,69%. It is identified in: Amahusu village, Nusaniwe sub district, Benteng sub district, Wainitu sub district, Rijali sub district, Hatiwe Kecil village, Passo village, Nania, Waiheru, Hunuth, Rumah Tiga village, Wayame village, Hatiwe Kecil village.

- Land suitability level with score ≥ 60 – 80, category S_2, this area is suitable to use. It is eligible to be developed in certain conditions which is found in 11 locations or 42,31%. The locations are: Waihayong sub district, Silale sub district, Uritetu sub district, Hunipopu sub district, Batumerah village, Pandan Kasturi sub district, Galala village, Lata village, Lateri sub district, Tawiri village, and Laha village.

- For conservation zone (marked in green). Activities included into this zone according to RTRW of Ambon are more focused on protection and security along coastal area of Ambon, it is natural coast conservation program by mangrove plantation and preservation toward coastal border as well as conservation forest.

- Restricted use area (marked in purple) which is restricted zone related to cultivation activities that are developed.

- Utilization area (marked in yellow), it can be developed for crops agricultural and plantation, settlement or real estate by considering land suitability and possible impacts.

d.   Land Use Model Approach
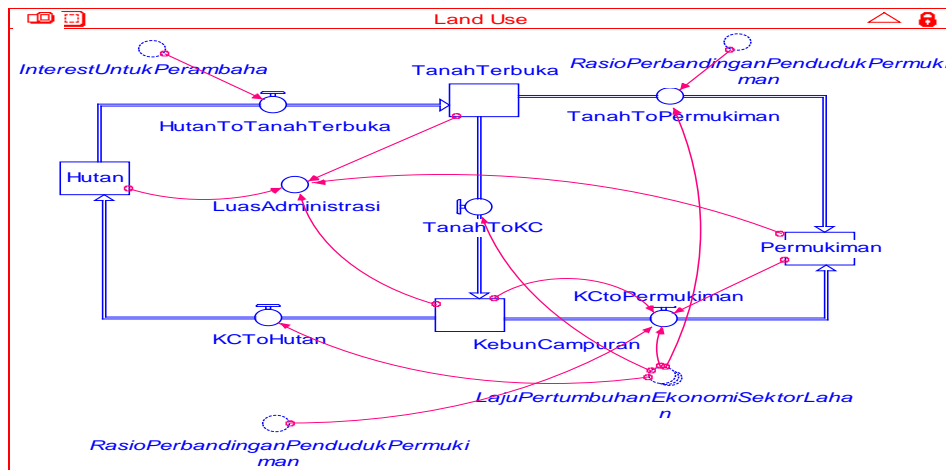
Figure 1: Land Use Model

System model that is developed based on this study aims to abstracting management and land use model of coastal area in Ambon by referring to the result of multi dimensional sustainable analysis using MDS also zonation analysis based on Law approach. There are numbers of activities in coastal area of Ambon including settlement construction that follows the rate of population growth and economic infrastructure which finally lead to covered land changing. Covered land changing, in one hand, critically affects to coastal physical change such as erosion rate, sedimentation and abrasion rate which result in ecological damages including marine biota habitat, settlement area, and tourism area.

e.   . Land Use Alteration Sub Model

Covered land alteration model of coastal area in Ambon was conducted based on the approach of image map data analysis landsat 7 year 2003, 2013, and Landsat 8 year 2015, illustrated initial form of covered land in Ambon as follow as can be seen in Table 1 which illustrates the area of covered land for forest, opened land, settlement, and mixed garden.

Tabel 1: Covered Land of Ambon

Year	Tutupan lahan (Ha)			
	Forest	Opened land	Settlement	Mixed Garden
2003	14,839.00	1,540.00	1,852.00	10,624.00
2013	14,781.72	1,472.10	2,110.68	10,490.50
2015	14,767.40	1,455.12	2,175.35	10,457.13

From Table 1, it is calculated the alteration rate based on image data. Image data that is used is image of covered land alteration from 2003-2013. Alteration number is then calculated to become the rate by dividing the alteration number with time interval from 2003 – 2013 that is 10 years. The rate of alteration can be seen in Table 2 as follow.

Tabel 2: The Rate of Covered Land Alteration of Ambon

2003		2013				
Covered land	Area	Cloud	Forest	Mixed Garden	Seetlement	Opened land
Fores	14,839	0	0	-24.54	0	-71.16
Mixed Garden	10,624	0	24.54	0	16.36	0
Settlement	1,852	0	0	-16.36	0	-13.04
Opened land	1,540	0	71.16	0	13.04	-
Jumlah 2013		0	95.7	- 40.9	29.4	-84.2

Based on Table 2, the next step is to construct a prediction model by using the following equation;

Forest (t) = Forest(t - dt) + (KCTo Forest – ForestToOpenedLand) * dtINIT Forest = 14839INFLOWS:

KCToHutan = if Laju Pertumbuhan Ekonomi Sektor Lahan [Laju Incom ekebun]>1 then 2.96/5 else 0

OUTFLOWS:

HutanToTanahTerbuka = if time>2016 and Interest Untuk Perambahan=1 then 0.2*7.16+7.16 else 7.16

Kebun Campuran(t) = Kebun Campuran (t - dt) + (Tanah ToKC – KC ToHutan – KC to Permukiman) * dtINIT Kebun Campuran = 10624

OUTFLOWS:

Land To KC = if Rate of Economic Growth on Land Sector [Garden Income Rate] >1 then 0.56/5 else 0

Land To Settlement = if Rate of Economic Growth on Land Sector [House Income Rate] >1 or Ratio of Inhabitant Settlement Comparison =1 then 13.04+(0.2*13.04) else if Rate of Economic Growth on Land Sector [House Income Rate] >1 or Ratio of Inhabitant Settlement Comparison= 0 then 13.04 else 0

Administrative Area = Forest + Mixed Garden + Settlement + 1254 + Opened Land

Based on the above equation, it can be seen that the alteration of covered land is significantly influenced by 2 (two) aspects, they are land economic value and the society's income from other sectors. If the society's income in non-forest sector is smaller than Regional Minimum Wage of Ambon, thus the society will tend to move to natural resources exploitation which has no economic value as well as forest has

f.   The Simulation Result of Covered Land Model
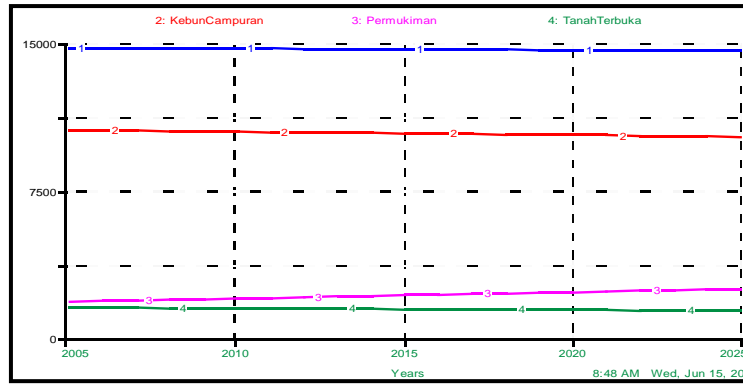
Figure 2: Land Use Mode

Tabel 3: Simulation Result of Covered Land Sub Model

Year	Tipe Tutupan Lahan			
	Forest	Opened land	Settlement	Mixed Garden
2005	14,839.00	1,540.00	1,852.00	10,624.00
2006	14,831.84	1,531.51	1,884.34	10,607.31
2018	14,744.49	1,431.09	2,272.36	10,407.07
2019	14,735.90	1,424.03	2,304.69	10,390.38
2020	14,727.30	1,416.98	2,337.03	10,373.69
2021	14,718.71	1,409.92	2,369.36	10,357.00
2022	14,710.12	1,402.86	2,401.70	10,340.32
2023	14,701.53	1,395.81	2,434.03	10,323.63
2024	14,692.94	1,388.75	2,466.37	10,306.94
2025	14,684.34	1,381.70	2,498.70	10,290.26

According to Figure 2 and Table 3, coved land sub model explains that; from 2005 until 2025, it is seen that the area of covered area of forest, mixed garden, and opened land is decreasing every year. The model simulation result describes that the area of forest has decreased for ±11 years since 2005 up until now in 2016 in as large as 71,6 ha. The prediction up to 2025, the area of forest will be decreasing ± 155 ha. The area of opened land has decreased since 2005 until 2016, which is 11 years as large as 94 ha. The prediction until 2025, there will be a decreasing of opened land area as large as 159 ha. The area of mixed garden has decreased since 2005 until 2016 as large as 184 ha. The prediction up until 2025 says that the area of mixed garden will be decreasing as large as 301 ha. The area of settlement has increased since 2005 until 2016 which is 11 years as large as 355 ha. The prediction says that up until 2025, the area of settlement will be increasing to 485 ha.

4. Conclusion

Based on the result of this research, it can be concluded that in sustainable management of coastal area in Ambon by using Law No. 1 year 2014 management approach, the eligible number is 61,1% and the whole area of Ambon's coast is categorized into category (S2), that is an area that can be developed with certain conditions,

for instance land use control, land use control for settlement, office centre, and educational institutions. The score of land suitability level based on the approach of Law No. 27 year 2004 regarding water resources is > 80 – 100, in category S_1, in which it is considerably suitable to use because these areas are worth and eligible to be developed. These areas consist of 15 locations or 57,69%. Land suitability level which the score is $\geq 60 - 80$ includes category S_2, in which these areas are proper to use as well. They are worth developing with certain conditions. These areas including 11 locations or 42,31%. There are four types of zone, they are a) conservation zone, b) restricted utilized zone, c) utilized zone, and d) particular zone. The result of dynamic modeling for covered land sub model explains that from 2005 to 2025, it is known that the area of covered land of forest, mixed garden, and opened land decrease every year. The area of forest decreases for as large as 71,6 ha, opened land decrease for 94 ha, mixed garden decreases for 184 ha, meanwhile the area of settlement increases during 11 years for as large as 355 ha. The result of this research is expected to be a consideration for the government of Ambon in the efforts of developing sustainable construction of coastal area.

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