Spatial Evaluation on Wetland Conversion Pattern in Surabaya and Surrounding Areas

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Abstract: - Government and public awareness in maintaining and protecting the wetland ecosystem has increased recently. This was actualized by the applicable acts or regulations for the conservation of wetland ecosystems. However in reality, since the last two decades, wetland ecosystem in the world has become the most endangered ecosystem due to wetland drainage, pollution and over-exploitation being conducted in various countries. This condition is not appropriate with the Ramsar Convention policy which has been agreed by many countries especially those countries which have ratified this convention. Like in other countries, the existence of Indonesia wetlands area also threatened since they still become target of economic activities and also development. The uncontrolled of wetlands conversion can cause the extinction of those ecosystems. The conversion of wetland ecosystems are also occurred in the artificial wetland such as rice fields and ponds. In general, the conversion of agricultural areas are occurred in the fertile agricultural land which have a good technical irrigation channel. Those areas are converted into residential, industrial and infrastructure. The objective of this research is to explain the spatial phenomena of the evaluation of wetland conversion in Surabaya and surroundings by using the multi-temporal analysis. From the result of the research, it was stated that there are 1.722,68 km2 of wetland ecosystem (76.51% of the total area 2.251,62 km2). Those wetlands consist of fluvial landform (1.302,54 km2) fluvio-marine landform (386,14 km2) and marine landform (34.00 km2). The conversion patterns of those areas are various and controlled by the type of landform.

Key-Words: - wetland ecosystem, artificial wetland, conversion pattern, spatial evaluation

1 Introduction

1.1. Problem Identification

Wetland ecosystems continue to get pressure in the form of conversion to other uses by reason of utilizing these ecosystems have economic value. In the ecological perspective as described by Dugan (1990), Maltby and Immirzi (1996), ignorance of conservation, conversion of wetlands for reasons of utilizing the ecosystem for the better. This is one that encourages wetland ecosystem continues to occurrence anthropogenic pressure tends to increase both the number and intensity. Gardier, (1994), Joes et.al., (1995) in Spencer et.al., (1998) asserts that wetlands are the most damaged ecosystems, estimated to have gone to 50 percent of original wetlands in the world. Even Erez, at.al (2002), showed that the degradation of wetlands have been headed for conflict of interest. Therefore a very serious effort in the management of wetland ecosystems in a broad sense is a natural wetland ecosystem and wetland ecosystem of non-natural, very important to manage immediately.

Some evidence about the destruction of wetland ecosystems in the world as described Maltby, (1986) and Dugan (1990) that, conversion of wetlands that has lasted for centuries in various parts of the world have destroyed millions of hectares of wetlands, particularly in industrialized countries. Draining wetlands ecosystem massive progress with the reason to reduce flood hazards, improve sanitation, and for the development of agricultural land. For example, in the United States in the period between the 1950s and 1970s, 87 percent of the lost wetlands used for agriculture, 8 percent for urban development, and 5 percent for other development. French state has lost as much as 40-80 percent of wetlands. New Zealand estimated more than 90 percent of natural wetlands have been destroyed since the arrival of the emigrants in Europe, and until now drying continues. Philippines, 6 percent of mangrove area lost during the 60 years from 1920 until 1980. In

Brazil most of the estuarine wetlands have been degraded due to pollution.

World public awareness about the ecological functions of wetland ecosystems is increasing, this is reflected in the rate of decline in land conversion symptoms including wet on both natural ecosystems and non-naturally to other uses. National Land Agency of Japan (2000), reported that in 1970, there has been conversion of 8.5 million hectares of land area while in the year 1999 decreased to only 4.9 million hectares. But in Indonesia the other hand, precisely at that period both the natural conversion of wetlands (swamps, mangrove forests) and man made wetlands (ponds and rice fields) to the increasing use of other symptoms. Based on data RePPPRroT (1985) in Poniman, et al, (2006), area of wetlands in Indonesia approximately 41,706,105 hectares or about 20 percent of the land area. In the period 1985-2003, as proposed by Haryani (2003), Indonesia has done the conversion of wetlands more than 50 percent, so that current wetland area of 22.158 million hectares, or stay about 10 percent of the total land area.

Wetlands, especially the mad man (rice fields, freshwater ponds and brackish water) in Java Island has been converted to other uses, with the highest growth rate compared to other islands of Indonesia. Kustiwan (1997), explained that in the period between 1983 to 1994 technical irrigated agricultural lands that are ecologically located in wetland ecosystem on the north coast of Java had been converted to other uses in an area of 104 581 hectares, equivalent to 35.58 percent. Another study conducted by Pakpahan et al, (2006) that the conversion of farmland to other uses in Java, an area approximately 23 140 hectares per year. Housing sector, industry, and infrastructure that most land conversion, approximately 16.500 hectares per year or 44.23 percent. Results of analysis Pakpahan et al (2006) that the conversion of land per province in Java, five-year period between 1981-1986, shows the East Java Province has the largest conversion of 43.947 hectares or 8.798 hectares per year. Central Java Province 40.327 hectares or 6,721.2 hectares per year. West Java Province 37.033 hectares or 7,406.6 hectares per year, and the Special Region of Yogyakarta 2.910 hectares or 223.8 acres per year.

1.2. Objectives

Objective of the studies are: (1) Evaluation of spatial phenomena of land use changes in Gresik, Surabaya and Sidoarjo in the period: (a) before the year 1965, (b) between 1965-1985, (c) 1985-2005 and (d) after the year 2005, (2) evaluation of spatial patterns of wetland conversion process in Gresik, Surabaya and Sidoarjo,

1.3. Teoritical Approach

Conversion of wetlands on the landscape ecology perspective is not simply the issue of depreciation of land but rather the disorders (disturbanches) ecosystem. Conversion of land that did not pay attention to the physical properties and processes that occur in wetland ecosystems raises new problems. This adds another problem if associated with the management and spatial planning. Degradation of wetland ecosystems in Indonesia can not be separated from policy planning and management space that becomes the central issue of land conversion in Indonesia. Actually, the long history of planning and space management in Indonesia has been quite a while through various regulations and legislation.

Lately, the use of spatial metrics to analyze the spatial dynamics of the phenomenon has become very popular as an attempt to understand and study the landscape characteristics mainly due to the pattern of land use change (Turner 1987, Turner 1988; Wu 1998; Jennerette and Wu 2001). Danoedoro (2010) considers that the paradigm morfo-quantitative spatial science paradigm of remote sensing is growing due to the emergence of spatial analysis problems that can not be solved by the spectral approach and landscape morphology approach. Such approaches have been developed and dominated the research-based remote sensing image. Spectral paradigm become the backbone in the development of mapping methods of digital image-based geographic phenomena. The development of remote sensing-based analysis of this other than as a result of technological development is also emphasized by spatial problems more complicated. A fundamental question that must be critically examined is why the problems of spatial heavier, one of which is about the conversion of land that is not in accordance with established plans, it emerged at the time the technology is well developed.

Issues of land conversion is a complicated issue, as described by Danoedoro (2000) brought to land conversion has side dimensions of spatial, temporal and functional. Landscape fragmentation base on ecological perspective (landscape ecology) is the form of new problems that arise due to uncontrolled land conversion. Landscape fragmentation on wetland ecosystems either natural or man madel are not a simple problem.

Focused on the background of the problem this research is to understand the structure of the phenomenon of conversion of non-natural wetlands (rice fields and ponds) in the tropical coastal areas. This research was conducted in Surabaya, Gresik and Sidoarjo, the following considerations: (1) the study area have different characteristics, namely as an industrial town of Gresik, Surabaya, trade and governance, while Sidoarjo is a city that still has bases of agriculture and fisheries; (2). study area experienced minimal bentanglahan change process, namely from a natural wetland ecosystem is converted to wetland / pond, and now turned into a residential, industrial and infrastructure. The techniques used in this study is the analysis and synthesis of multi-temporal data period (1) before 1965, (2) between 1965-1985, (3) between 1985-2005 and (4) after the year 2005. Mutli-temporal spatial data were used to analyze the development trend of settlement or wake region (buildup area), using quantitative analysis method (spatial metric analysis), as a basis for determining the structure and design the spatial fragmentation bentanglahan fragmentation on wetland ecosystems.

2 Data and Methode

2.1. Study area

The location of this research is part of lowland ecosystem in East Java with the regime influence the development and dynamics of the Solo and Brantas River. Naturally, this region is influenced by the fertile volcanic material as the basis for intensive agriculture. In addition this region also has hinterland region very susceptible to denudation and erosion, which results in every rainy season will receive an overflow of water and sediment are very big into the Java Sea and the Strait of Madura, which form the development of river delta Solo and Brantas. Base on administrative boundery which a research location is Gresik, Surabaya and Sidoarjo, east Java, Indonesia and while the astronomically located between 112°22’39,00”- 112°52’39;00” east longitude and 06°50’9;00”- 07°35’39;00”; south latitude as shown in Figure 1.

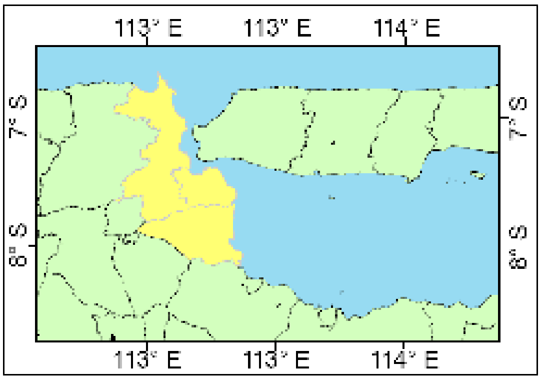

Figure 1. Location of Study

2.2. Data

This study using satellite imagery Landsat ETM +, ASTER and ALOS by the consideration that the two kinds of spatial resolution was relatively high (15 and 30 m) to describe the variety and fragmentation of existing land use in Surabaya and surroundings. In addition, Landsat ETM, ASTER are relatively easy to obtain, as well as covering the spectral channels that are sensitive to the phenomenon of land cover on land. The three types of imagery will also be evaluated using different kernel sizes, to obtain information about the optimal size for evaluating the level of observation of land fragmentation in the study area.

3 Result and Discussion

3.1. Wetland Ecosystem landform

Wetland Ecosystem landform study area can be classified into two major groups, namely non-wetland and wetland. Wetland ecosystem characterized by three units of unit landform ie. fluvial origin (F), marine origin (M) and fluvio-marine origin (FM), table.1.

Table.1. Units of landforms Gresik, Surabaya and Sidoarjo based on the origin of the process

NO	Landform Unit	Area	
		%	km2
1	Marine (M)	1,51	34,00
2	Fluvial (F)	57,85	1302,54
3	Fluvio-Marine (FM)	17,15	386,14
	Wetland	76,51	1722,68
4	Structural (S)	5,05	113,67
5	Denudasional (D)	18,44	415,26
	Non Wetland	23,49	528,94
	Total	**100**	**2251,61**

Description: The results of analysis of landforms map of Surabaya, Gresik and Sidoarjo, which comprises units of marine origin of landforms (M), fluvial origin landform (F), fluvio-marine origin landform (FM), the structural origin of landforms (S) and denudational origin of landforms (D)

Based on Table 1 shows that the landforms that are included in the wetland area of 1722.68 km2 or 76.51 of the total study area is of 2251.62 km2. Wetlands consist of fluvial landform is the most widespread is equal 1302.54 km2, fluvio-marine landform of 386.14 km2 and marine landform 34.00 km2, see figure 2.

Furthermore, when analyzed further by using the administrative boundary map can be explained as follows: First, the Sidoarjo area of 728.70 km2, is almost entirely a wetland ecosystem that is equal to 99.46%. Wetland ecosystem in Sidoarjo, which is at the origin marine landforms of 3.71 km2 or 0.51%, which is located in an area of fluvial origin betuklahan 552.97 km2 or equal to 75.88% and are located on fluvio-marine origin of landforms covering 171 , 82 km2 or equal to 22.58%. Second, the city of Surabaya area of 339.32 km2, consisting of non-wetland ecosystem area of 67.83 km2 or 19.99% while the wetland ecosystem or an area of 271.48 km at 08.01%. Wetland ecosystem in the city of Surabaya is at the origin of landforms marine unit area of 7.11 km2 or 2.10% and which is at the origin fluvial landform units covering an area of 221.56 km2 or 65.30%, and are on fluvio-marine landform unit an area of 42.81 km2 or equal to 12.62%. Third, an area of 1093.89 km2 Gresik Regency, consisting of non-wetland ecosystem area of 461.10 km2 or 42.15% while wetland area of 632.78 kilometers or 57.85%. Wetland ecosystem in Sidoarjo regency was at home yesterday landform unit area of 26.89 km2 or 2.46%, and that is at the origin fluvial landform units covering an area of 473.71 km2 or 43.31%, and are on fluvio-marine landform unit an area of 132.18 km2 or equal to 12.08%.

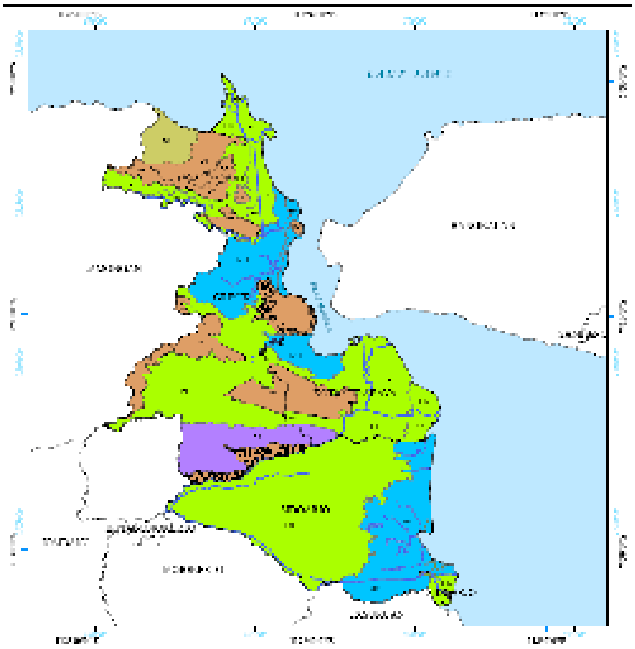

Figure 2. Map of landforms units in the study area based on the origin of the process

3.1. Land Use Changes

Analysis of land use change on wetland ecosystems are divided into three sources of data for analysis, namely (1) using the extracted data from the land use map of the AMS, Jog and RBI, (2) using the extracted data from Landsat MSS 1972, 1982, and in 1985, (3) using landsat TM data + 1994, 2003 ETM +, and ASTER 2006. Analysis of changes in land use was used to determine rates of change: (1) in the period before 1965 is by using the AMS data and jog and other sources, (2) in the period between 1965 to 1985 using Landsat MSS data, (3) on period between 1985 to 2005 by using TM landast 1989, 1994, 2000, 2003 and use the map RBI Indonesia in 1994, (4) after 2005 using Aster 2006.

Results of analysis of land use changes based on the table 2.a, 2b, 2c, can be viewed on the diagram per district in figure 3a.3b da 3c.

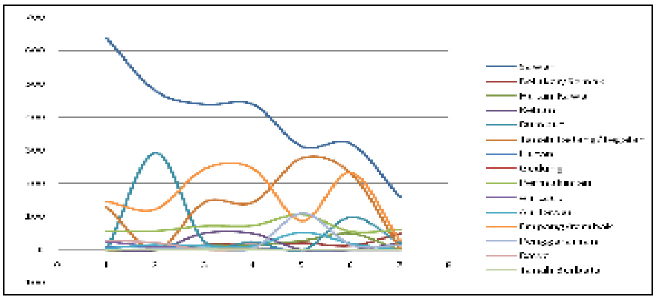

Figure 3a. Land Use Changes Gresik District 1954-2008

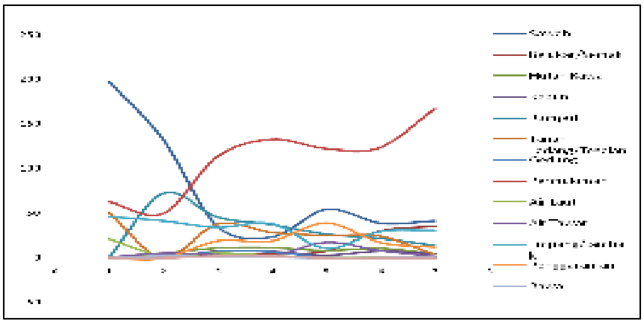

Figure 3b. Land Use Changes Surabaya District 1954-2008

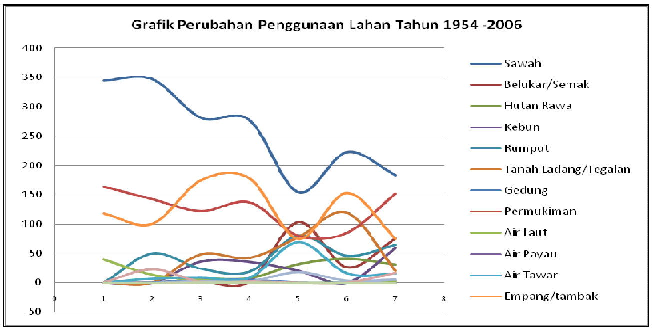

Figure 3c. Land Use Changes SidoarjoDistrict 1954-2008

4 Conclusion

Conversion of wetlands is a complex phenomenon resulting from the dynamic interaction between landscape ecology and the increasing demands of society. Land conversion has resulted in a large expanse of land use into smaller units and surrounded by other land use such as home or residential areas, causing disruption in the continuity of land uses in this case the rice fields and ponds. This is also a result of changes in ownership patterns where a large area of rice fields or ponds are divided into smaller areas.

Land Use Changes in Surabaya and its surrounding area changed dramatically between 1985 and 2005. Related to urban land cover increased in the area. This increase occurred in both large and regional compact patch small areas that cause fragmentation of the landscape .Housing and industrial development is an important determinant in the spatial configuration of land cover changes in the study area. This study shows an approach to remote sensing and geographic information systems analysis combined in a comprehensive landscape ecology to understand the relationship between changes in land cover and wetland ecosystems in Surabaya and its surrounding (Gresik and Sidoarjo district). The time period of analysis and more detailed field data still must be tested again. In addition the study also needed to build a stronger relationship between the character dynamics of the process of urbanization on wetland ecosystem in the area.

This research is very important as a basis for studying the effects of conversion of land fragmentation process, especially when associated with the environmental risk for urban areas due to changes in agricultural land and fisheries functions not just as a production function with a low exchange rate should be viewed as a space teratpi capable of providing environmental services. Therefore the study of land fragmentation, especially on wetland ecosystems is the next research agenda.

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Table 2a Land Use Changes Gresik District 1954-2008

Path Group I	Path Group II	JOG (1954)	AMS (1959)	MSS (1985)	TM (1994)	TM (2003)	ASTER (2006)
Agriculture	Rice Field	638,392	478,998	438,914	310,793	320,258	159,117
Open Green Spase	Shrub/Bush	0	0	16,552	21,877	13,638	48,889
	Swamp forest	0	0	15,928	28,988	49,924	0,938
	Gardens	0	0	50,921	0	0	20,684
	Grasslands	0	293,07	25,119	0	98,97	21,872
	Dray land/Ferm dry land	129,529	0	143,448	276,228	229,706	3,35
	Forest	10,943	10,138	7,024	0	0	0,013
Built Up Area	Buildings	0	0	3,241	0	0	0
	Settlements	57,376	57,482	72,686	106,688	55,325	61,199
Water	Sea water	25,684	10,274	1,428	0,118	1,299	0
	Fresh water fish Pond	5,263	17,668	13,677	52,626	20,651	0,588
	Salt water Fish Pond	145,904	123,026	244,032	87,038	233,482	27,862
	Salt pond	0	2,694	4,651	110,694	15,168	13,784
	Marshes	28,681	22,598	0,919	0	0	0

Table 2b. Land Use Changes of the Surabaya City 1954-2008

Path Group I	Path Group II	JOG (1954)	AMS (1959)	MSS (1985)	TM (1994)	TM (2003)	ASTER (2006)
Agriculture	Rice Field	197,841	132,417	35,09	54,587	39,28	41,601
Open Green Spase	Shrub/Bush	0	5,183	11,187	8,237	10,819	4,514
	Swamp forest	0	0	7,657	2,915	7,762	4,307
	Gardens	0	72,401	45,576	26,63	21,755	14,032
	Grasslands	50,793	0	38,338	25,283	24,482	3,707
Built Up Area	Buildings	0	0	6,812	0	0	0
	Settlements	62,818	49,839	113,692	122,428	123,82	167,529
Water	Sea water	21,553	2,162	5,505	0,019	0,068	0,129
	Fresh water fish Pond	0,416	5,078	3,141	17,308	7,891	1,323
	Salt water Fish Pond	45,939	41,439	34,369	10,588	29,565	30,726
	Salt pond	0	0	19,286	39,763	17,5	12,267
	Marshes	0	1,942	0,989	0	0	1,598

Table 2c. Land Use Changes of the Sidoarjo District 1954-2008

Path Group I	Path Group II	JOG (1954)	AMS (1959)	MSS (1985)	TM (1994)	TM (2003)	ASTER (2006)
Agriculture	Rice Field	345,031	347,412	281,483	154,464	222,735	183,566
Open Green Spase	Shrub/Bush	0	0	1,713	102,842	26,025	74,934
	Swamp forest	0	0	6,903	31,491	40,329	30,888
	Gardens	0	0	36,203	20,74	0	59,544
	Grasslands	0	49,637	24,202	79,999	46,145	64,149
	Rice Field	0	0	47,873	77,176	119,106	19,912
Built Up Area	Buildings	0	0	5,231	0	0	0
	Settlements	164,178	142,899	122,364	80,431	85,39	152,479
Water	Sea water	40,063	13,628	4,597	0,003	0,011	3,161
	Branckish water	0	0	0,277	0	0	0
	Fresh water fish Pond	0,416	7,065	8,918	68,99	16,298	15,691
	Salt water Fish Pond	118,199	100,685	174,699	74,739	153,207	74,96
	Salt pond	0	0	2,125	17,827	3,267	5,115
	Marshes	0	22,996	1,218	0	0	16,461