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Double Master Degree Program on Integrated  
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## Proceedings

### INTERNATIONAL SEMINAR-WORKSHOP ON “INTEGRATED LOWLAND DEVELOPMENT AND MANAGEMENT”

THEME:

THE ROLE OF AGRO-ECO-EDU PROGRAM THROUGH  
MULTISTAKEHOLDERS PARTICIPATION ON THE SUSTAINABILITY OF  
LOWLAND DEVELOPMENT AND MANAGEMENT



PALEMBANG CITY – BANYUASIN DISTRICT  
SOUTH SUMATRA - INDONESIA  
MARCH 18 – 20, 2010

Published by : Faculty of Agriculture, Sriwijaya University  
ISBN No. : 978-979-25-8652-7



# ECOSYSTEM SUNGAI Sumi & Dinar-2010

*by* Dinar Da Putranto

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**Submission date:** 15-Mar-2019 10:44AM (UTC+0700)

**Submission ID:** 1093652207

**File name:** ECOSYSTEM\_SUNGAI\_Sumi\_Dinar-2010.pdf (752.64K)

**Word count:** 3657

**Character count:** 19411

## ANALYSIS SPATIAL OF RIVER ECOSYSTEM CASE STUDY: PALEMBANG, SOUTH SUMATRA

Sumi Amariena Hamim<sup>1</sup>, Fachrurrozie Sjarkowi<sup>2</sup>, Totok Gunawan<sup>3</sup>, Dinar Dwi Anugerah  
Putranto<sup>4</sup>, F.X. Suryadi<sup>5</sup>

- 1) PhD student, Sriwijaya University, Lecturer Indo Global Mandiri University, Palembang, South Sumatera Indonesia;
- 2) Professor Agricultural Faculty of Sriwijaya University, Promotor, Palembang, South Sumatera Indonesia;
- 3) Professor Geographic faculty of Gadjahmada University, Co Promotor, Yogyakarta, Indonesia;
- 4) Lecturer Engineering Faculty of Sriwijaya University, Co promotor, Palembang, South Sumatera Indonesia;
- 5) Senior Lecturer Land and Water Development, UNESCO-IHE Delft, the Netherlands;

### ABSTRACT

The Palembang city has environmental problems, where the topographical conditions are relatively flat and low in relation to the sea level. At present, the relationship city-river has degraded the Palembang river ecosystem. There is a high population growth, density urban development which is concentrated along the river and next to that lack of infrastructure conditions that produce negative consequences for the city environment like flooding and inundation problems.

River ecosystems is one particular type of natural ecosystems located within urban areas. The processes of river ecosystem are performed within the river ecosystem structure that composed of two kinds of elements: the dynamic of hydrological conditions and the stable physical ones. Both of them present in the ecosystem in different sizes and shapes, which surround and contain the water body. The stable physical components of the river ecosystems are the basis for identifying their dimensions and structures of river ecosystems. Using the classification of the topography, geomorphology, soils and land use, river ecosystems can be analyzed and understood easily in the spatial term.

In this paper, the spatial approach landscape ecology, land unit concepts were applied to identified river ecosystems in Palembang. The stable physical components of Palembang river ecosystem were derived from both topographic map scaled 1:1000 and a low-resolution digital elevation model (DEM) by using Geographic Information Systems.

As the result, the application of spatial approach will allow the identification and mapping of the components of a ecosystems, finding how the topographic, geologic, geomorphologic and Land Use characteristics interrelated and contribute to the spatial definition of the river ecosystems.

**Key words :** Landscape ecology, land unit concept, river ecosystem

### INTRODUCTION

River ecosystems is one particular type of natural ecosystems located within urban areas. River ecosystems have suffered the major negative impacts of urban consumption. Those impacts have had negative consequences in the human health, the urban-ecologic balance and the city image (Smeets, 2004). The processes of river ecosystem are performed within the river ecosystem structure that composed of two elements: the dynamic of hydrological conditions and the stable physical ones. The river ecosystem are composed by two elements: the dynamic hydrological and the stable physical ones. The dynamic hydrological element is water and the climate components (precipitation, evaporation, temperature). The stable physical elements are composed of land (topography, geomorphology, and soils) and vegetation, both of them present in the ecosystem in different sizes and shapes, which surround and contain the water body (Lant, 2004).

Corresponding Author : dwianugerah@yahoo.co.id

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The study area, Palembang is one of the cities that has environmental problem where the topographical conditions are relatively flat and low in relation to the sea level. At present, the relationship city-river has degraded the Palembang river ecosystem. There is a high population growth, the land use change, which has led to change on the hydrology of the area, the resulting floods occur afterwards. The changes are (and use patterns, such as urbanization, road construction and unplanned building distribution and structures, paved surface in urban area have assumed to produce significant effects 3- the Palembang sub river flow, in combination with climatic factor. Especially, the effect of sea level rise and next to that lack of infrastructure conditions that produce negative consequences for the city environment like flooding and inundation problems.

The remote sensing and GIS technology are used to provide physically of river ecosystem's. GIS approach used in this study to identify the condition of spatial ecology of the river system in land mapping units that contain components of the river ecosystem. In river ecosystem management, land mapping unit based on land use type will change, the type of land use to run off value. Management information systems of land allocation to reduce the flooding risk in Palembang. This requires integrating thematic elements of land use for city evaluation, hydrology and hydraulics analysis to see the condition of river ecosystems to effort the urban drainage management and flood mitigation.

In this study, the spatial approach landscape ecology, land unit concepts applied to identify river ecosystems in Palembang. River ecosystem dimensions structures are based on the stable physical components of the river ecosystems. Palembang ecosystem river is divided into sub-river systems. The stable physical components of the sub river system are extracted from two sources: topographic map scaled 1:1000 and contour-based 0.25 m and 5m resolution DEM by using GIS. The mapping of the components of a given ecosystems, finding how the topographic, geological, geomorphologic and land use characteristics interrelated and contribute to the spatial definition of the river ecosystem.

## **MATERIALS AND METHODS**

### **Study Area**

This study focuses on Palembang sub river system, that the water will flow to Musi River. Study area was divided into 18 sub river system. Every sub river system divided into some sub river systems. The area study is located between 2°52' to 3°5' South Latitude and 104°52' East Longitude with the mean height 5 m above sea level. covering an area approximately 219.19 km<sup>2</sup> (Fig. 1). There are differences area river sub systems between this study and the previous study. Delineation the river systems in this study based on its flow patterns and extracted contour 0.25 m and resolution DEM by using GIS. The differences area of river systems are shown in Table 1.

### **Methodology**

Concepts, theories and approach such as Landscape ecology, Thematic land use were applied for analysing ecosystem river condition. The landscape ecology is used for describing the main characteristic of hierarchical wholes from organism and society to the earth as a total system. It does so by combining the system approach with methods developed by geography for describing tangible tract of land (Zonneveld, 1989). The spatial approach will be useful to understand the river and urban functionality and their interactions, while the methods for describing land condition will allow the mapping of the natural structure and urban ecosystems. The main characteristic of the thematic approach is analysis different landscape components that is used to make a synthesis.

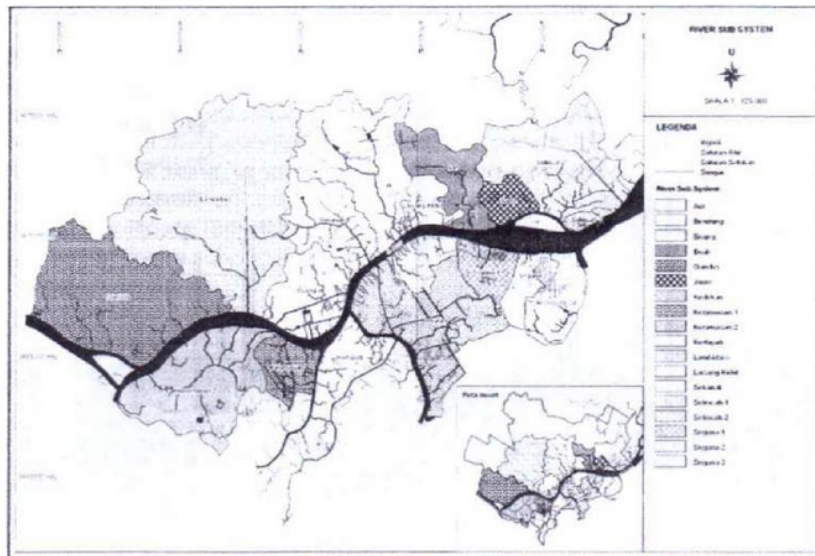


Fig. 1 Palembang River Sub Systems

Table 2. Comparison of Area River sub system with previous study

Sub Sistem Sungai	Area (km <sup>2</sup> )			
	JICA 2003	Bappeda 2004	BWSS VIII 2008	Sumi 2009
Gandus	23.94	23.94		28.67
Gasing	52.11	52.11		
Lambidaro	50.52	52.09		65.25
Boang	8.67	8.67		9.69
Sekanak	11.39	11.39		10.39
Bendung	19.19	22.59	15.4	19.60
Lawang Kidul	2.34	2.86		2.57
Buah	10.42	10.82		9.92
Juaro	6.86	6.86		3.45
Batang	5.58	5.59		
Selincih	4.83	4.83		11.42
Borang	71.21	72.09		
Simpang Nyiur	22.85	22.85		
Sriguna	4.91	4.91		
Aur	6.58	6.58		
Kedukan	9.32	10.99		
Jaka Baring	37.06	37.61		
Kertapati	25.08	25.09		
Keramasan	30.09	32.88		

The results a set of thematic maps /that are analyzed independently according to the component one wants to study. The application of overlay techniques allow looking for the spatid associations and relationships between the different themes. The synthesis is achieved km composite maps. (Antrop, 2000). The application of this approach is based on the concepts behind the Land Unit approach. This concept has been developed by Zonneveer (1989). This concept will allow the identification and mapping of the componenets of a given ecosystem, finding out how the topograpic, geologic, geomorpholgic and vegetator characteristics contribute to spatial definition of the ecosystem river.

Corresponding Author : dwianugerah@yahoo.co.id

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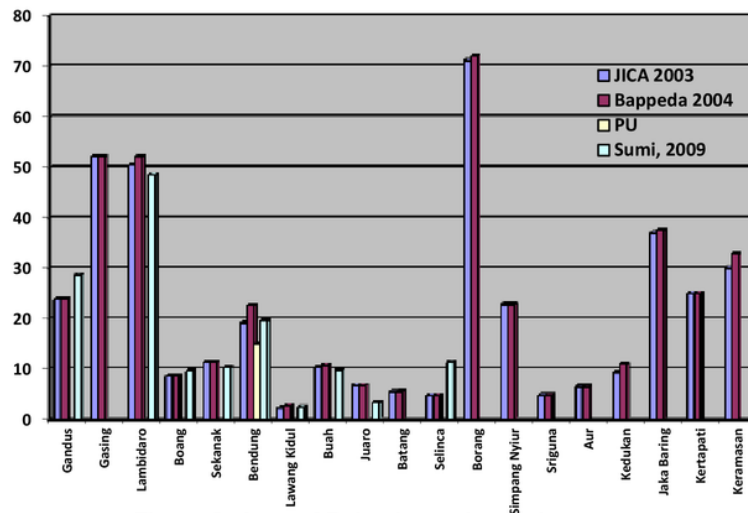


Figure 2. Area of Palembang river sub system

In this study, the sub river system as a unit analysis is delineated based on drainage network and flow pattern. The Drainage network and flow pattern are obtained by generating Digital Elevation Model (DEM). It was created from Palembang topographic maps scaled at 1:1.000 as a result of the interpretation aerial photograph scaled at 1:5000 with digital techniques stereophotogrametry in 2004. The topographic maps were registered using UTM Projection (WGS 84, zone 48 S), which is the national coordinate system of the topographic maps. DEM generated from contours of 25 m intervals are 5 m resolution in flat areas, using the Hydrology toolset in ArcGIS. The precision of the DEM affects the accuracy of extracted drainage networks in urban area.

After generating DEM, Morphometric characteristics of sub river system such is bifurcation ratio, drainage density, stream frequency, texture ratio, basin relief ruggedness number and time of concentration can be defined too. After generating DEM error of sink and peaks removed in order to eliminate discontinuities in the drainage network in sub river system. Flow direction was calculated for each pixel using the filled DEM. Flow Accumulation was calculated from the flow direction grid. Each pixel was assigned a value equal to the number of pixels drained through a given pixel in the flow accumulation. The topography of study area is relative flat, then the extracted drainage network in floodplain area was modified manually due to insufficient DEM resolution. The Strahler method is used to classify the drainage network into different orders. Study area was divided into 18 sub river system. Every sub river system divided into some sub river systems. The morphometric characteristic parameters for each drainage network lies carried out at every sub river system (Fig 4).

### Result and discussion

Rivers in Palembang present similar geographic characteristic with a "V" shape. The hydrography of river sub system shows a dendritic shape, where the main river is the result of the confluence of minor rivers. The stable physical condition of the Palembang River Ecosystem are analyzed through topography, geomorphology, geology, vegetation.

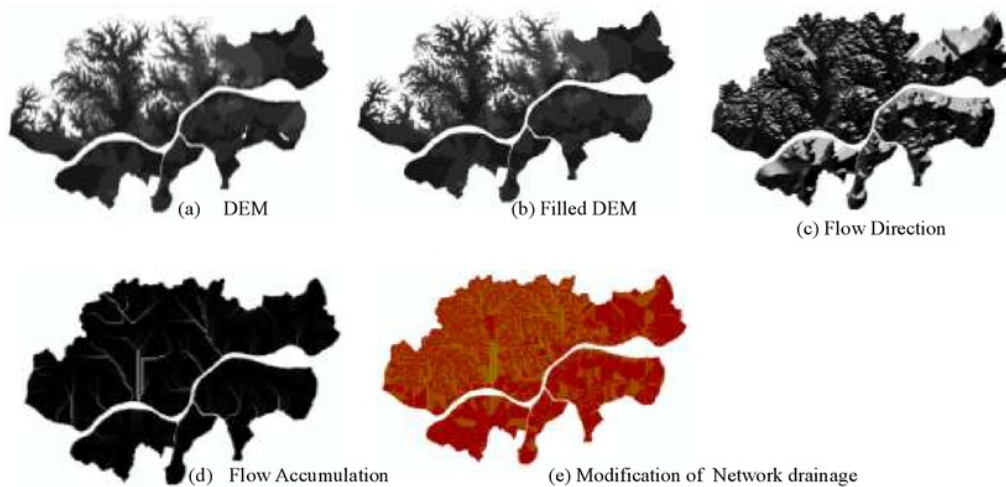


Figure 3. Extracting drainage network from DEM

### Morphometry characteristics of river sub system

The river sub system morphometry pattern are using to predict or describe geomorphology process. That has been used to predict flood peaks, to assess sediment yield, and to estimates erotion rates (Baumgardner, 1987 and Gardiner 1990 in Miller 7002). Every basin possesses a quantifiable set of geometric properties that define the -ear, areal and relief characteristics on watershed, known as the basin morphometry.

Linier morphometric such as bifurcation ratio (Rb), which is defined as the ratio of the slumber in the next higher order to the number in the next higher order using Strahler ordering. The <sup>8</sup> number of streams in the first highest order is a good approximation of Rb. That is range between 3 and 5 for watersheds when the influence of geological structures on the drainage network is <sup>7</sup> glible (Verstappen, 1983, in ozdemir 2009).

The areal morphometric, Drainage density (Dd) shows the landscape dissection, run potential, infiltration capacit<sup>5</sup> of the land, climatic conditions and vegetation cover of the basin (Verstappen, 1983). On the one hand, The Dd is a result of interacting factors controlling the surface runoff. On the other hand it is self influencing the output of water and sediment from the drainage river sub system. In the area study Dd range between 1.05 to 2.8<sup>4</sup> km/km<sup>2</sup>.

The stream frequency (FS) analysis of the drainage network derived DEM. Comparatively river sub system, Bendung highest values. Then are followed by river sub systems, Lambidaro, Boang, Buah respectively (Table 3)

A third group parameters are relief morphometric, that indicated the vertica dimension of drainage river sub systems. The texture ratio (T), The highest T values fo drainage network are found in river sub system Lambidaro followed by sub river syster Bendung, Gandus, Boang. These result reveal that the T values depend on the underlying geology, infiltration capacity and relief aspects of the river sub system.

Basin Relief (Bh) and measures of basin slope as hydrologic parameter. The HITBh value indicates the gravity of water flow, low infiltration and high runoff conditions. The High Bh are found in Gandus river sub systems. The longitudinal dimension of rive<sup>r</sup> sub systems in Palembang determines an original length profile. The slope is relative) flat about 0 % to 3 %. The slope of river in study area are shown in Figure 5. <sup>6</sup>

The time concentration (Tc), is the time to taken by water to travel from the most distant point of sub<sup>6</sup> river system to its outlet. The highest Tc in Lambidaro river sub system. Represent the greatest length in time for water to travel from the most

distant point to its outlet.

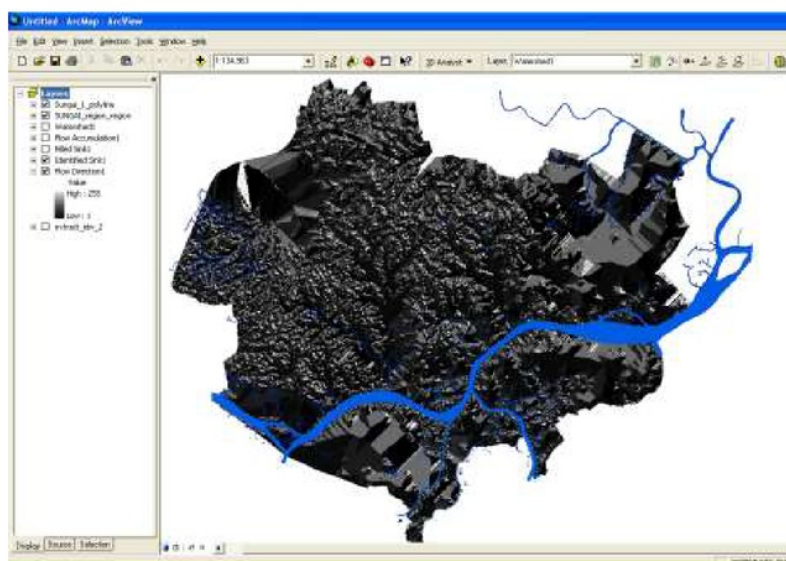


Figure 4. The Slope of Palembang river sub sistem

Table 3a Morphometric of Palembang Sub Basin

No	Sub Basin	n1	n2	n3	n4	Total	Length	Area
1	Bendung	25	21	4		50	17,11	19,60
2	Boang	10	4			14	6,05	9,92
3	Buah	6	5			11	6,69	9,69
4	Gandus	15	4			19	19,62	28,67
5	Juaro	2				2	2,03	2,57
6	Lambidaro	47	19	34	1	101	46,41	48,62
7	LawangKidul	1				1	1,21	3,45
8	Sekanak	5	2	2		9	8,15	10,39
9	Selincih	5	2			7	5,26	11,42

Table 3b Morphometric of Palembang Sub Basin

No	Sub Basin	Perimeter	Rb			Dd	Fs	T	Bh	Rn	Tc	C
			n1	n2	n3							
1	Bendung	36,41	1,19	5,25		1,15	2,55	0,69	24,50	23,35	53,13	0.7
2	Boang	23,30	2,50	0,80		1,64	1,41	0,43	24,75	23,11	16,01	0.63
3	Buah	17,75	1,20	1,25		1,45	1,14	0,34	19,75	18,30	19,62	0.69
4	Gandus	35,36	3,75			1,46	0,66	0,42	35,75	34,29	53,78	0.63
5	Juaro	10,41				1,27	0,78	0,19	5,75	4,48	8,00	0.66
6	Lambidaro	56,94	2,47	0,56	34,00	1,05	2,08	0,83	27,75	26,70	159,56	0.66
7	LawangKidul	12,12				2,85	0,29	0,08	14,75	11,90	3,07	0.28
8	Sekanak	24,13	2,50	1,00		1,28	0,87	0,21	19,50	18,22	24,72	0.7
9	Selincih	20,10	2,50			2,17	0,61	0,25	2,00	-0,17	35,89	0.57

Corresponding Author : dwianugerah@yahoo.co.id

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### Vertical Dimension of Palembang sub river system: geology (Soils) and Vegetation (Land use type)

The variables of vertical dimension of the ecosystem river are: Geology (soils) and vegetation (land use type), from which geology specifically soils is considered more relevant with the ecosystems physical stability. In general, the soil created from clay and sand clay. Stratified condition of soil divided into three parts: alluvium and swamp is located in along the Musi River and especially the swamp is in eastern and western part is about 28.05%; middle side of Palembang, has clay rock 46.8% and clay sand 12.2% which is waterproof, spread on northern and southern part; bottom side of Palembang, spread on centre of Palembang with long line pattern from south west to south east formed as an anticline combination.

The second variable of the vertical dimension is vegetation or land use type. The combination of socio-economic activities and the city's growth process gives as a result the current land use pattern of the urban area. As a spatial expression of the performance of the urban activities, this variable provided a good perspective about the city's dynamics and in some way provides a good idea of the intensity of the use of space. Non urban is about 55% such as swamps, rice field, forest, household and commerce, industry is about 31.22 % and water body is about 7.8 %. The pattern distribution of Palembang river sub systems land use type as shown in Fig 6.

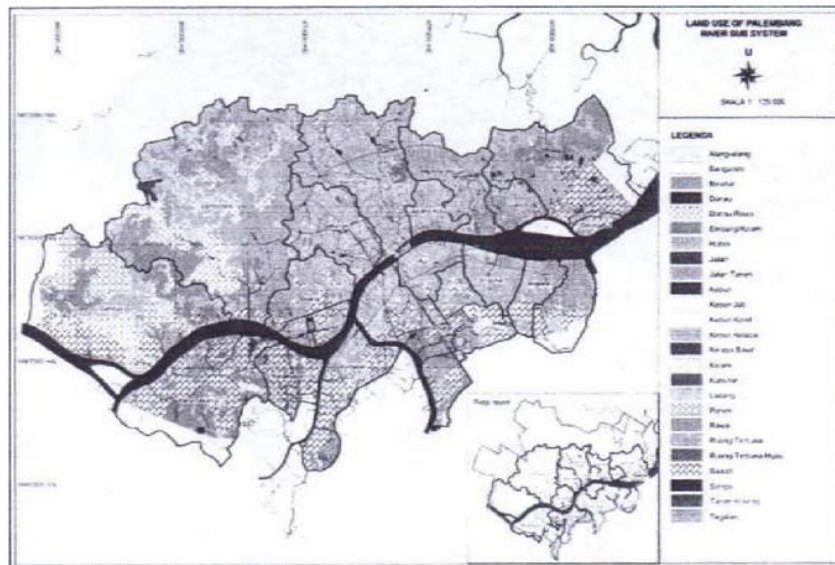


Figure 5. Distribution Land use of Palembang river sub system

### Conclusion

Based on the result of this research it can be concluded that land use ecology and land thematic unit approach can <sup>2</sup> used to identify an analysis characteristic river ecosystem. It also can be used to understand the influence of the sub river system to flooding on the main channel, morphometric parameters of drainage

Corresponding Author : dwianugerah@yahoo.co.id

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network must be considered along with their hydrological characteristic. Besides, the characteristic of river ecosystem such as relief, infiltration, land use type and drainage density by using overlay technique can be used to predict the surface run off in that area of advance study.

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