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

Sumi Amariena Hamim', Fachrurrozie Sjarkowi[2], Totok Gunawan[3], **Dinar Dwi Anugerah Putranto[4]**, F.X. Suryadi[5]

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 Indonesi;
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 tow in relation to the sea Level. At present, the relationship city-river has degraded the Palembang river ecosystem. There is a high 'ovulation growth, density urban development which is concentrated along the river and next to that lack of infrastructure conditions that produce negative consequences for the c¦ty environment likes flooding and inundation problems.

River ecosystems is one particular type of natural ecosystems located within urban real. The processes of river ecosystem are performed within the river ecosystem s.-nacture that composed of two kinds of elements: the dynamic of hydrological conditions Ind the stable physical ones. Both of them present in the ecosystem in different sizes and zapes, which surround and contain the water body. The stable physical components of t°le 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, ¯e'er 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 !lembang river ecosystem were derived from both topographic map scaled 1:1000 and a - resolution digital elevation model (DI=M) 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 topographyc, 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 consumptior- Those impacts have had negative consequences in the human health, the urban-ecologic balance and the city image (Smeet, 2004). The processes of river ecosystem a-¨1- performed within the river ecosystem structure that composed of two elements: **tit** 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. Tit dynamic hidrological element is water and the climate components (precipitaticr. evaporation, temperature). The stable physical elements are composed of **lac** (topography, geomorphology, and soils) and vegetation, both of them present in the ecosystem indifferent sizes and shapes, which surround and contain the water body (Lant. 2004).

Coresponding Author : dwianugerah@yahoo.co.id

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 **av** structures, paved surface in urban area have assumed to produced significant effects 3- the Palembang sub river flow, in combination with climatic factor. Especially, the effec of sea level rise and next to that lack of infrastructure conditions that produce negat--s 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 identified 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 sourced: 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, geolog[i]c. 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^2 (Fig. 1). There are differences area river sub systems between this study and the previous study. Deliniation 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 Table1.

Methodology

Concepts, theories and approach such as Landscape ecology, Thematic land **int** were applied for analysing ecosystem river condition. The landscape ecology is used for discribing the main characteristic of hierarchical wholes from organism and society to the earth as a total systems . 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 ther river and urban functionality and thee interactions, while the methods for describing land conditon will allow the mapping of tne natural stucture and urban ecosystems. The main characteristic of the thematic approact is analysis different landscape components that is used to make a synthesis.

Coresponding Author : dwianugerah@yahoo.co.id

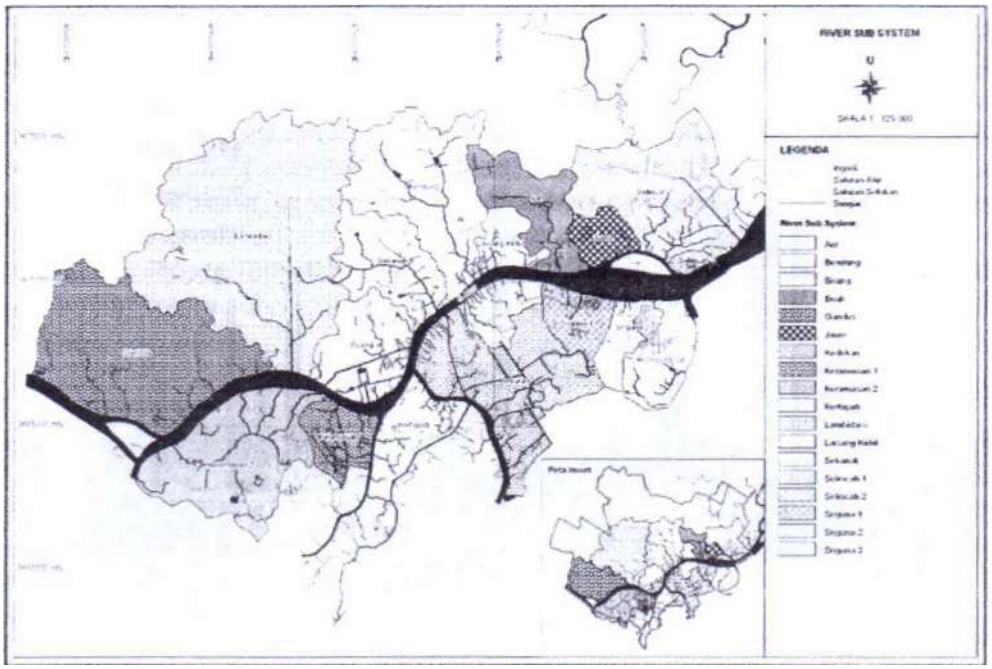

Fig. 1 Palembang River Sub Systems

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

Sub Sistem Sungai	Area (km^2)			
	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		
Selincah	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 beetween 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 vegetatior characteristics contribute to spatial definition of the ecosystem river.

Coresponding Author : dwianugerah@yahoo.co.id

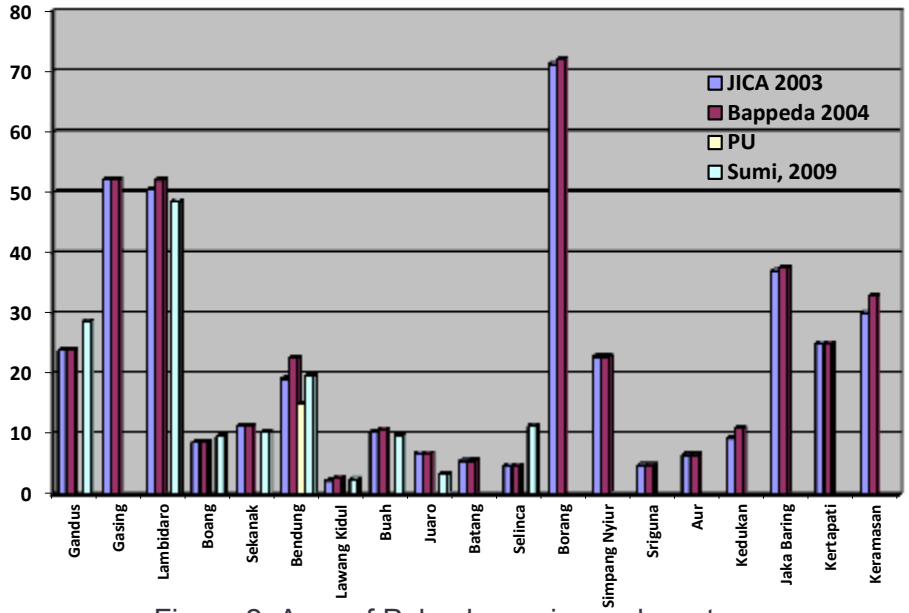

Figure 2. Area of Palembang river sub system

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 topograpic 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 0.25 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 ietwork in sub river system. Flow direction was calculated for each pixel using the filled DEM. Flow Acummulation 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 *letwork* 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 parametesr 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. e hydrography of river sub system shows a dendritic shape, where the main river is the ult of the confluence of minor rivers. The stable physical condition of the Palembang .er Ecosystem are analyzed through topography, geomorphology, geology, vegetation.

Coresponding Author : dwianugerah@yahoo.co.id

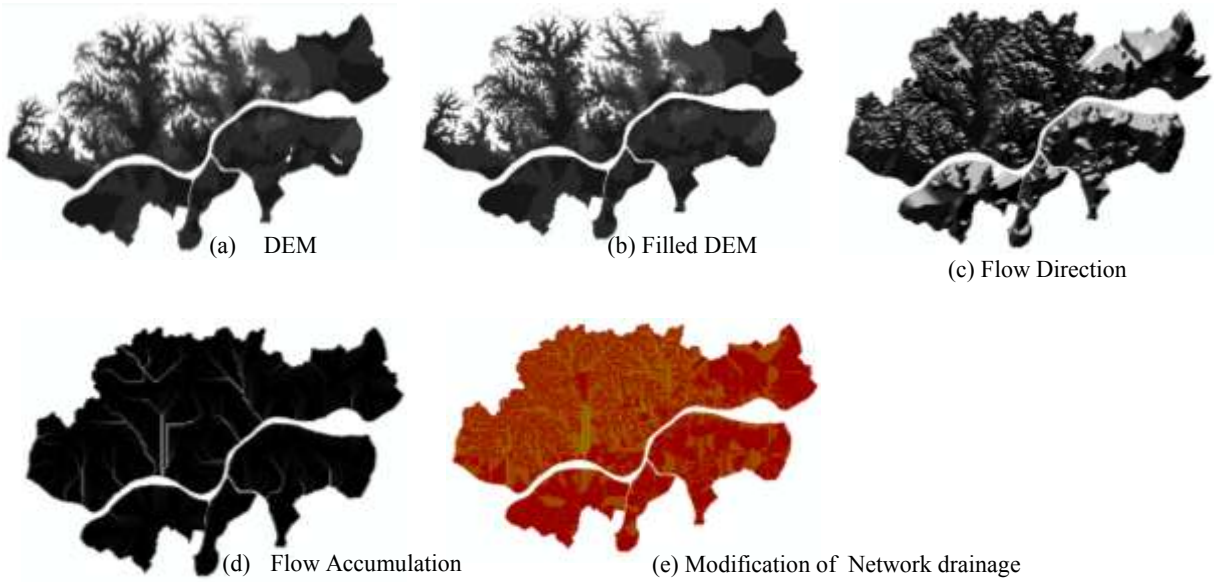

Figure 3. Extracting drainage netwok from DEM

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 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 neglible (Verstappen, 1983, in ozdemir 2009).

The areal morphometric, Drainage density (Dd) shows the landscape dissection, run potential, infiltration capacity 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 wate- and sediment from the drainage river sub system. In the area study Dd range betwee- 1.05 to 2.85 km/km^2.

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^r 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 underlyinc 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^r sub systems in Palembang determines an original length profile. The slope is relativel) flat about 0 % to 3 %. The slope of river in study area are shown in Figure 5.

The time concentration (Tc), is the time to taken by water to travel from the most distant point of sub 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

Coresponding Author : dwianugerah@yahoo.co.id

distant point to its outlet.

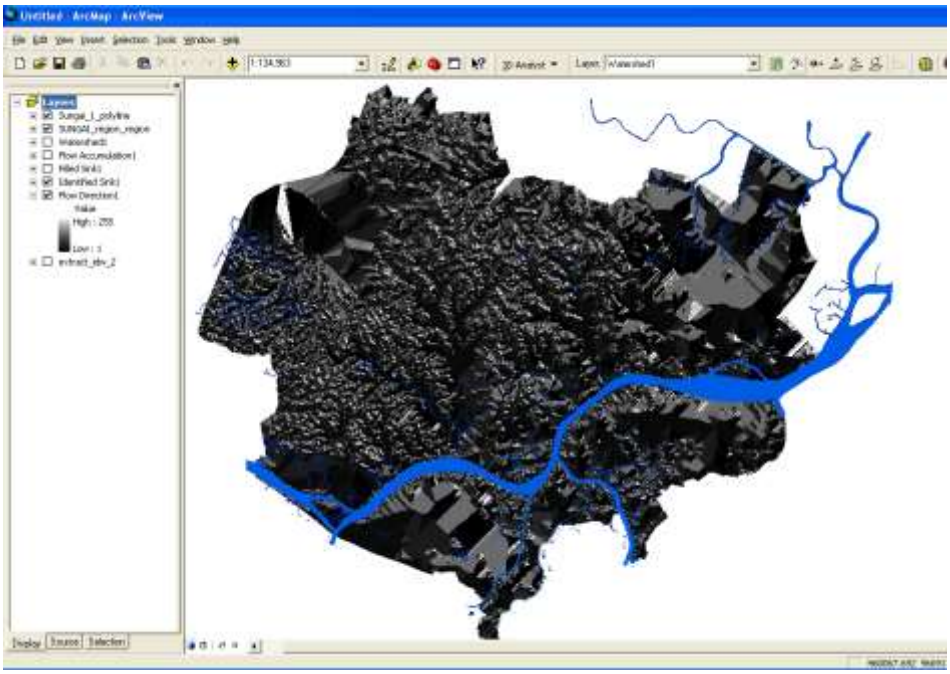

Figure 4. The Slope of Palembang river sub sistem

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
i8	Sekanak	5	2	2		9	8,15	10,39
9	Selincah	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
	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
	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	Selincah	20,10	2,50			2,17	0,61	0,25	2,00	-0,17	35,89	0.57

Coresponding Author : dwianugerah@yahoo.co.id

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.

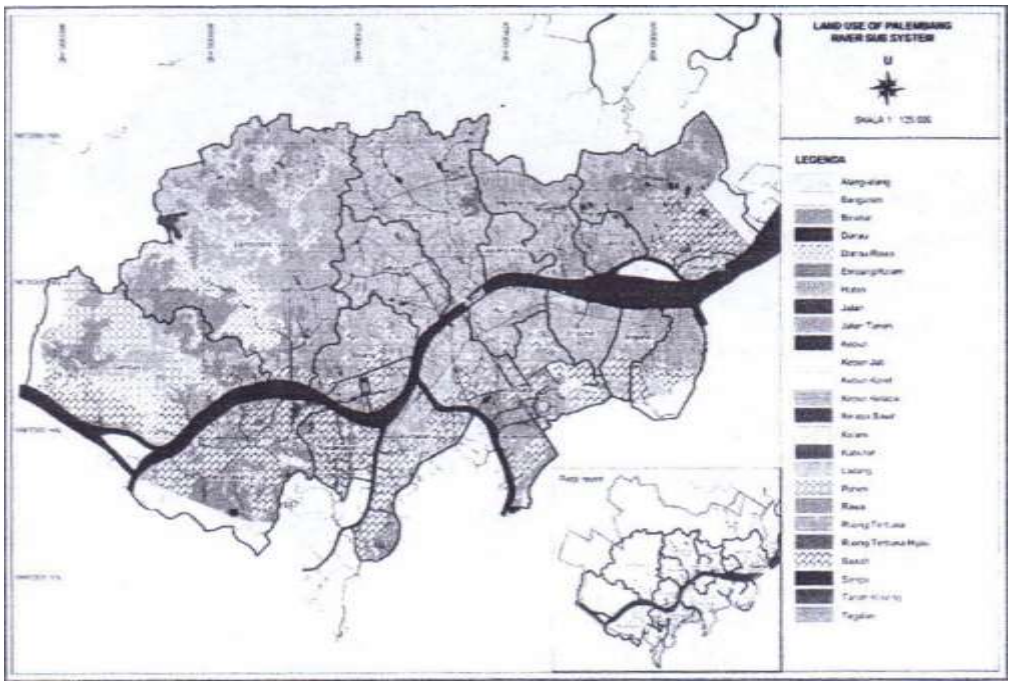

Figure 5. Distribution Land use of Palembang river sub system

Conclusion

Based on the result of this research it can be concluded that land use ecology and land thematic unit approach can be 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

Coresponding Author : dwianugerah@yahoo.co.id

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.

References

Black, P.E., 1991. *Watershed Hydrology.* Prentice-Halt, Inc. New Jersey, USA

Brooks, K.N., Ffolliot, P.F., Gregersen, H. M. and DeBano,L.F., 1997. *Hydrology And The Management Of Watersheds 2nd Edition.* Lowa State University Press

Butler, *D* and J.W. Davies, 2004. *Urban Drainage.* Spon Press, London UK.

Chay Asdak, 2004. *Hidrologi clan Pengelolaan Daerah* Aliran Sungai. Gadjah Mada University Press, Yogyakarta.

De Groot, R. S. W, Mathew A.; Boumans, Roelf M. J, 2002. A *Typology For The Classificatio, Description And Valuation Of Ecosystem Functions, Goods And Services.* Ecological Economics.

Gregory, ICJ and Walleng D. E., 1973, *Drainage Basin Form and Process,* Edward Arnold, London

Gunawan, T, 1993. Interpretasi Foto Udara untuk Pendugaan Limpasan Permukaan Menggunakan Pendekatan Bentang(ahan, Maka(ah pertemuan fimiah ke-3 Masyarakat Penginderaan Jauh (M.APIN), Yogyakarta

Hamim, S., Putranto, DA., Juliantina I., 2008. *River Ecosystem Within Urban Area (Case study: Palembang),* ICERT , Penang, Malaysia.

International Association of Environment (IAE), 1982. *Role Of Water In Urban Ecology.* Urban Ecology 4.

Japan International Cooperation Agency (JICA), 2003. *The Study On Comprehensive Water Management Of Musi River Basin in the Republic of Indonesia.*

Jessica Pineda Z., 2005. *Maintenance Of River Ecosystems Within Urban Areas, Thesis, International Institute For Geoinformation Science And Earth Observation Enschede.* Urban Planning *And* Land Administration, Netherlands.

Lant, C. L. K., Steven E; Beaulieu, Jeffry; Bennet, David; Loftus, imohy; Nickow, John, 2004. *Using GIS-based ecological-economic modelling to evaluate policies affectin agricultural watersheds,* Ecological Economics.

Leopold, L.B., et.al. 1964, *Fluvial Processes in Geomorphology,* W.H. Preeman and Company, San Fransisco

Linsley, Ray K., *et.al.,* 1949., *Applied Hydrologu,* McGraw Hill Book Company, Inc. NewYork, London

Makel, J. F. M., 1970, *The Use* of *Aerial Photograph in Geology Mapping,* ITC, Netherlands

Miller, Ritter, Kochel, 2002., *Process Geomorphology,* 4th edition, Mc. Graw Hill, New York, London.

Ozdemir, H., Bird, D., 2008. Evaluation of Morphometric Parameters of Drainage Networks Derived From Topographic Maps and DEM In Point Of Floods. *Environment Geol Vol (2009) .56:1405-1415,* Springer.

Seyhan, E, 1979. *Application of statical method to Hydrology,* institute of Earth Sciences, Free University, 1007 Inc. Amsterdam, Netherlands

Skidmore, A.K., 2002. *Environmental Modelling Using Remote Sensing and GIS.*

Coresponding Author : dwianugerah@yahoo.co.id

London, Taylor and Francis.

Skidmore, A.K., 1997. The World Apart, *ITC Journal,* p: 17-20. Netherlands.

Smeets, P., harms, *W.,* van Mansfeld, M. Van Susteran, A., van Steeketenburg, M., 2004. *Metropolitan Delta Lanscapes Planning Metropolitan Landscapes: Concepts, Demands and approaches,* Wageningen, DELTA series 4.

Suripin, 2004. *Sistem Drainase Kota yang Berkelanjutan.* Andi Offset, Yogyakarta,
Indonesia.

T. Tingsanchali, S.H. Nguyen, 2004. *Development Of Flood Simulation And Inundation Model For Vu Gia-Thu Bon River Basin.* Central Vietnam School of Engineering and Technology, Asian Institute of Technology, Thailand.

Wiens, J. A., 2002, *Riverine Landscapes: Taking Landscapes Ecology Into The Water. Freshwater Biology.*

Zevenbrgen C., 2008, Challenges In Urban Flood Management: Travelling Across Spatial And Temporal Scales, *Journal Compilation,* Blackwell Publishing, Ltd.

Zonneveld, I. S, 1989. *The Land Unit-A Fundamental Concept In Landscape* Ecology *and Its.*

Coresponding Author : dwianugerah@yahoo.co.id