ISSN 0024-9521
IJG Vol. 41, No. 1, June 2009 (93 - 101)

INDONESIAN JOURNAL OF GEOGRAPHY

THE LANDUSE CHANGE RELATED TO THE INCREASE OF PEAK DISCHARGE OF PENGABUAN CATCHMENT, JAMBI, INDONESIA

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ABSTRACT

Catchments area is an ecosystem unit formed by several components influencing each others. Hence, if one of the components changes, it will influence the others. The objective of this study is to prove the influence of land use change on the increase of the flood discharge with the case study of the catchments area of Pangabuan River, Jambi Province. The decline of secondary forest area occurred from 1665.38 km² in 1989 to 632.42 km² in 2007. A software simulation program for rainfall-runoff HEC-HMS was used to simulate the increase of the river flood discharge (i.e. sub-catchments area A is from 2677 m³/second in 1989 became 2988.3 m³/sec in 2007). Based on the land use change from 1989 to 2007, the study predicted the increase of flood discharge by 3148.50 m³/sec in 2015. Conservation of the Pengabuan catchments area is needed to minimize the land use change, i.e. primeval forest and secondary forest, primarily in upstream region where large primeval and secondary forests are found.

Keywords: land use changing, peak discharge, HEC-HMS

INTRODUCTION

Catchments area is an area which is topographically separated by mountains patching and releasing rain water to be channeled to the sea through the main river [*Asdak,* 2005]. Catchments area is an ecosystem unit which is formed by a-biotic, biotic, and culture components. These environmental components are formed by several factors relating to and influencing each others [*Borman* and *Likens,* 1969]. Hence, if one of the components changes, it will influence the other components which in turn will change the condition of ecosystem of the catchments area. Negative effects raised by catchments area components change which is not compatible with resistance of catchments areas are dryness and flood [*Ashagrie et al.,* 2004].

The damage of the resistance function of the catchments area is a dominant factor resulting in dryness and flood [*Maryono,* 2007]. The catchments area with low resistance is identified by change of land use from rain-patching area with low surface flow coefficient (run off coefficient) (in which most of rain water is sunk into the earth) becoming open land with high run off coefficient (in which most of rain water becomes surface flow). The low resistance of catchments area can be observed through its increasingly lesser forest area, and larger, critical land.

The Pangabuan catchments area which is mostly located in Tanjung Jabung Barat Regency, Jambi Province, is about 4,022.353 km^2. Its main river is Pengabuan River, also called as Tungkal River which flows directly to Berhala strait. The phenomenon of land use change also intensively occurs in the catchments area of Pengabuan. Therefore, it needs to be studied whether the land use in this catchments area is compatible with the resistance of the catchments area itself. In the end of 2007, the increase of water debit in the catchments area of Pengabuan resulted in flood in several places in Tanjung Jabung Barat Regency [*Radar Tanjab,* 2008]. The decrease and the lack of forest area in Pengabuan may be one of the factors affecting increase of surface water (runoff) in that area. Therefore, this study focused on the influence of land use change on the Pengabuan catchments area, especially the influence on flood events.

Response of land use change to flood, river discharge change and water level increase can be simulated using a software program [*Griend,* 1978]. In this research the software of HEC-HMS (free software) was used. HEC-HMS is a model of rain-flow with distributed parameter, so that the change of determiner factors of surface flow can be approached more accurately.

THE METHODS

The satellite map analysis conducted in this research used temporal/multi-date approach. This multi-temporal approach is a research using image processing of digital remote sensing of different periods, i.e. Landsat ETM+ year 1989, 1995, 2000, 2004 and 2007. This multi-temporal approach method was conducted by comparing appearance in each year to know the land use change. To know the further land use change, overlay method was employed. This method was carried out by overlaying the classification result from two different-period data to estimate the land use area change.

In this analysis, Landsat ETM+ with 7 channels and composite 543 was used. It might be able to differentiate land covered by vegetation and uncovered land, i.e. land covered by water body, building or without cover. This was chosen to meet the classification of land use needed to do simulation of the catchments area response to flood. To support the accuracy in the land use interpretation and land change, ground check in several sample points was performed and some secondary data such as the map of existing land use and the administration map of Pengabuan catchments area were used. In this research the HEC-HMS software was used. The procedure of HEC- HMS model usage is provided in Figure 1.

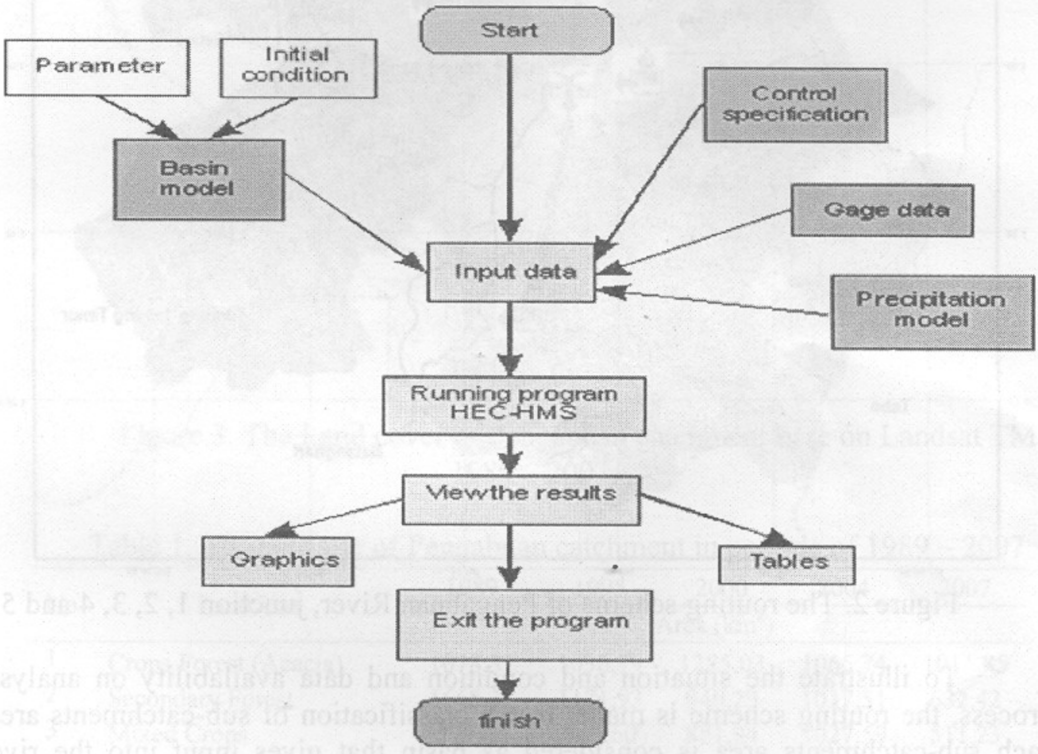

Figure 1. Scheme of usage procedure of HEC-HMS mode

The runoff volume is truly influenced by rainfall, land covering, land usage, and humidity, which is often expressed by using Curve Number (CN) parameter [*Skaggs* and *Khaleel*, 1982] where the value is influenced by the land use and land/soil type. For a watershed consisting of several types of soil, the value of CN composite can be estimated using weighted method. Besides, the value of CN is influenced by hydrological condition and soil type. Hydrological condition can be poor, fair, and good, depending on the amount of land covering in the watershed. The poor condition may mean that the area of land covering is less than 50%, fair condition: 50% to 75% and good condition has land covering area more than 75%. Poor, fair, and good conditions also can be related to the land slope, where poor condition is for land with slope > 25%, fair is in between 15% to 25% and good is <

15%.

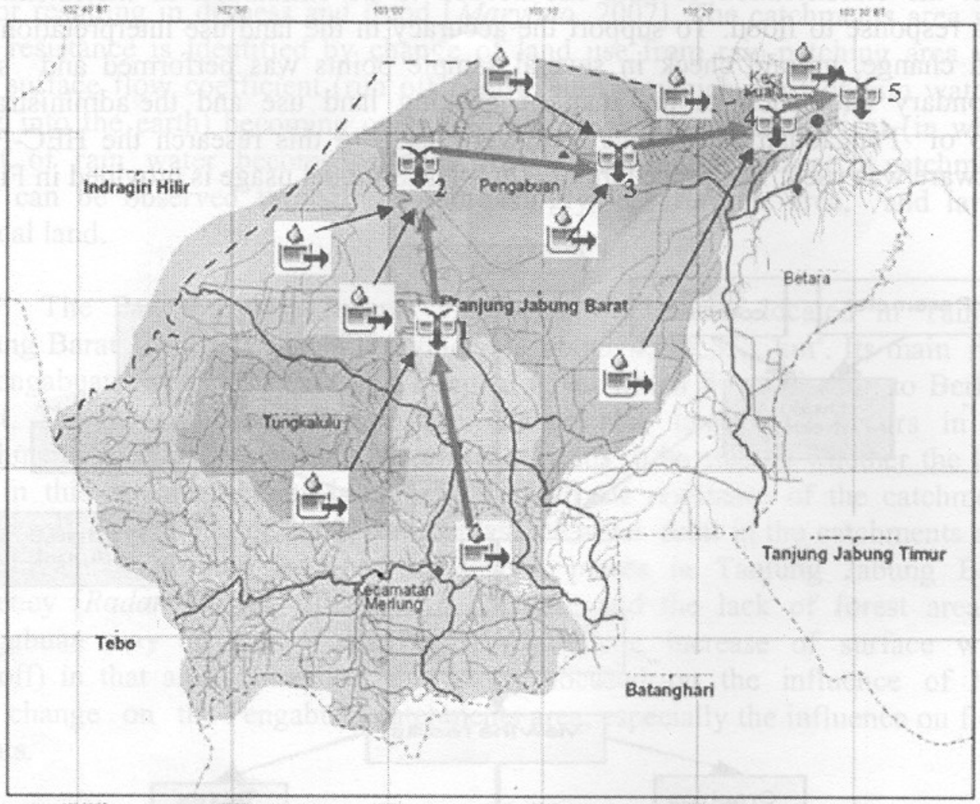

Figure 2. The routing scheme of Pengabuan River, junction 1, 2, 3, 4 and 5

To illustrate the situation and condition and data availability on analysis process, the routing scheme is made. In the classification of sub-catchments area, each sub-catchments area is considered as basin that gives input into the river system, as can be seen in Figure 2.

RESULTS AND DISCUSSION

Analysis of Land Usage Changing

The analysis of land use change is conducted by doing overlaying process between the map of land use resulted from the interpretation of Landsat 1989, 1995, 2000, 2004 and 2007. Figure 3 shows image of Landsat from 1989 to 2007. The result of overlaying the map of multi-temporal land use is then used to analyze its land cover change. The standard of measurement of land use change in this research is presented in km^2. Land use change can be either width addition (+) or width reduction (-).

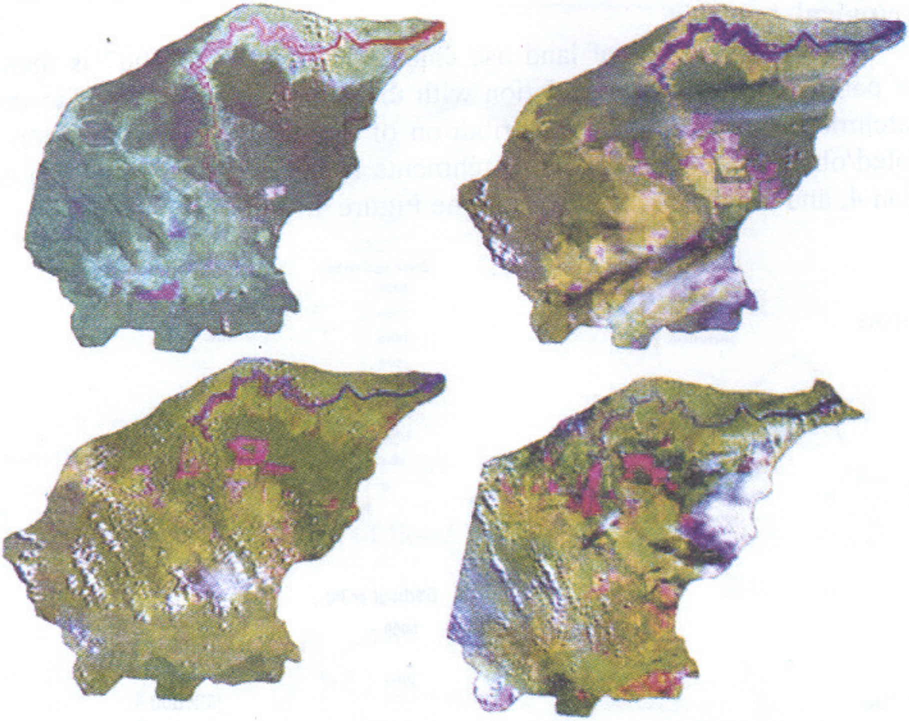

Figure 3. The Land cover of Pengabuan catchment base on Landsat TM 1989 – 2007

Table 1. The land use of Pengabuan catchment in periode of 1989 – 2007

No	Land Use	1989	1995	2000	2004	2007
		Area (km^2)				
1	Crops Forest (Acacia)	1078,37	1036,79	1285,03	1065,74	1011,85
2	Secondary Forest	1665,38	1171,93	940,29	1037,51	632,42
3	Mixed Crops	599,42	746,60	881,94	1027,59	511,23
4	Open Land	27,90	219,43	184,31	127,81	349,11
5	Plantation	0,00	48,04	59,02	96,16	710,82
6	Residence	2,57	2,57	2,57	2,57	4,29
7	Rice Field	112,60	126,43	84,18	65,48	67,87
8	Rice Field mixed with Hard Crops	473,70	478,32	516,13	552,94	547,25
9	Bushes	15,85	145,65	22,30	0,00	140,80
	Total	3975,79	3975,78	3975,78	3975,79	3975,64

From Table 1 can be seen that some land uses decrease and increase significantly and some others are static, for example land use of secondary forest. In the graph, the trend of area change of secondary forest decreases, while the cultivation area increases every year.

Hydrological Analysis

The analysis result of land use change from 1989 to 2007 is then used as one of parameters in flood simulation with the same rain as an input to the model, i.e. catchments area mean rain distribution of 100 years. The simulation result is controled/observed in several sub-catchments (junction 1, junction 2, junction 3, junction 4, and junction 5) as shown in the Figure 4.

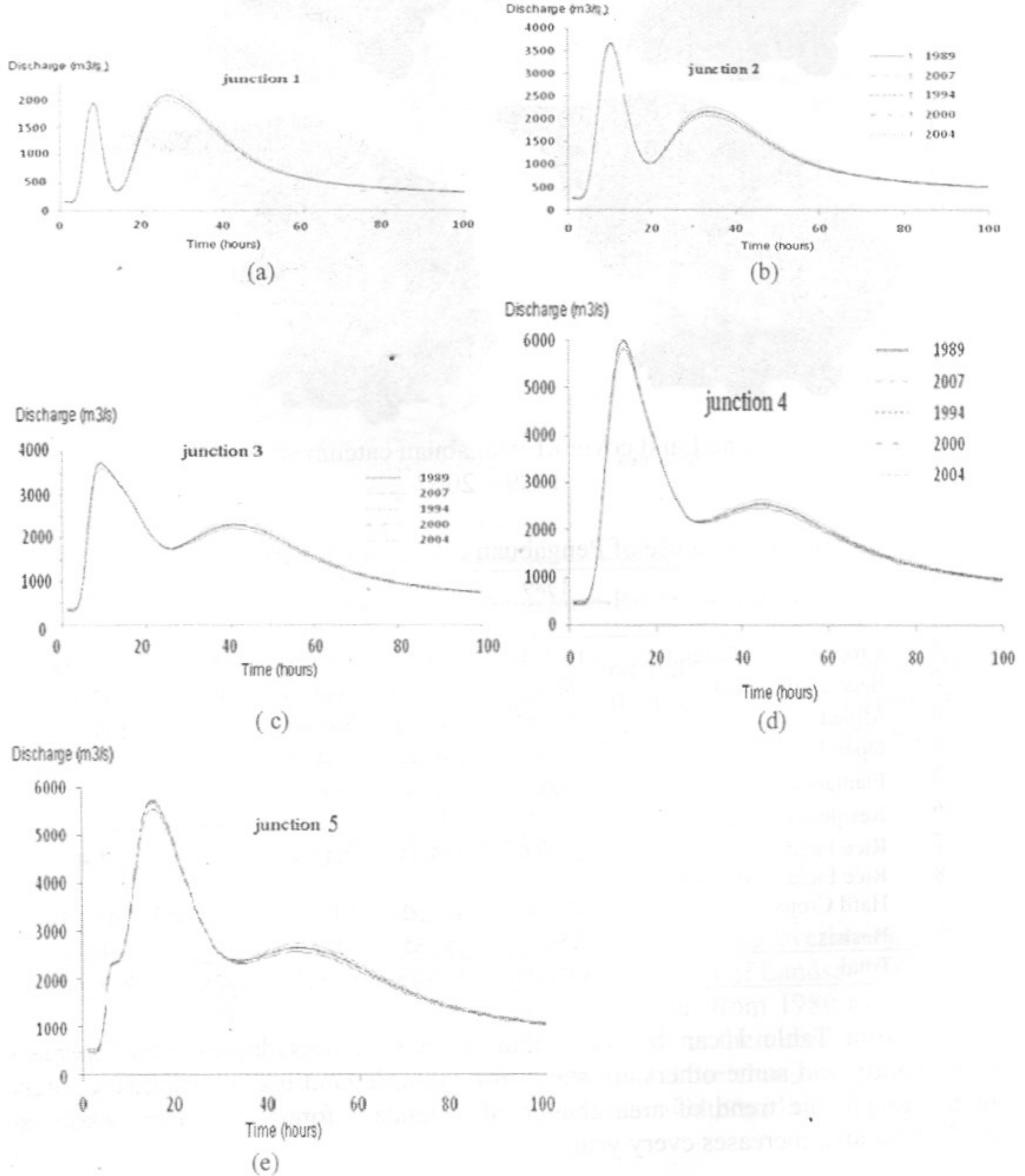

Figure 4. Flood hydrograph in junction 1, 2, 3, 4 and 5 (a, b, c, d, and e)

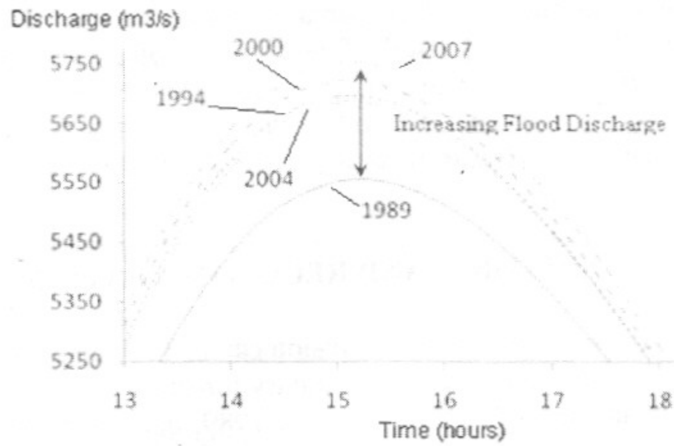

Figure 5. Detail of flood hydrograph in junction 5

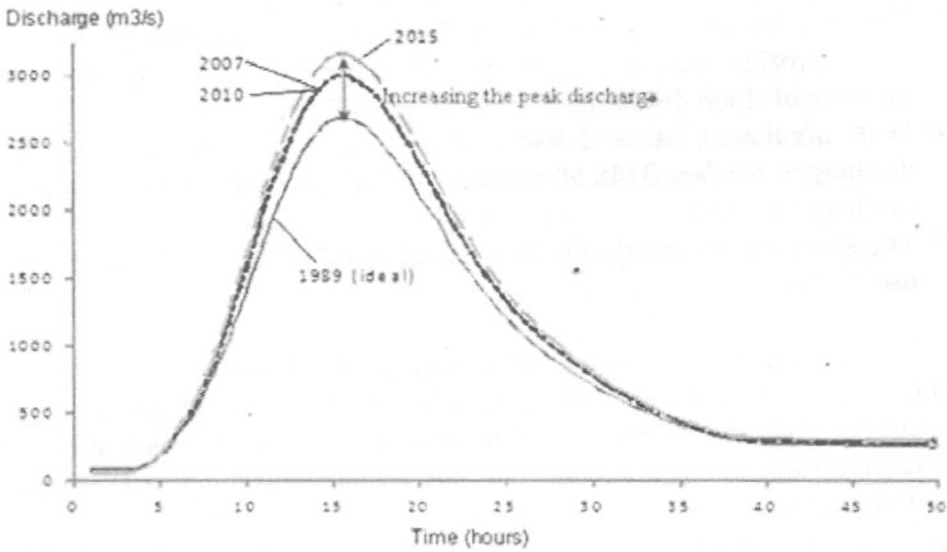

Figure 6. Hydrograph of simulation result in 2015 (as a consequence of the decreasing trend of primeval forest)

In Figure 4 (a, b, c, d, e) show the change of flood discharge in some controlling sites (junction) in Pengabuan catchments area. The land use change influenced the change of flood discharge. The land use change, in which primeval forest/secondary forest was converted to production forest, resulted in the change of flood discharge. It can be seen that from 1989 to 1994 significant changes occurred as the result of logging of forest area by community or firms. Various efforts were been made in 2000 for reforestation, but it was difficult to do. However, the logging or cleaning of forest area largely in 2007 resulted in the increase of flood discharge as shown in Figure 4.

Whereas to predict how the land use condition and hydrological condition in 2015 will be, an assumption that forest area decreases with the same trend in 1989 to 2007 was used. It is obtained that the forest area is 406.26 km^2 or only 10.10% of the entire catchments area of Pengabuan. Based on the prediction of the land use condition in 2015, the increase of flood discharge will reach 3148.50 m^3/sec, or there is an increase about 160.20 m^3/sec compared with the discharge in 2007 (see Fig. 6).

CONCLUSION AND RECOMMENDATION

From discusion above, some conclusion can be drawn as follow:

1) Reduction of primer forest and secondary forest areas in the catchments area of Pengabuan reached 1666.38 km^2 in 1989, decreasing by 632.42 km^2 in 2007.
2) In 2007, the largest land use was crops forest (Acacia), i.e. 1011.85 km^2 or 25.16% of the entire Pangabuan catchments area.
3) The land use change from 1989 to 2007 gave influence on runoff occurring in catchments area of Pengabuan. All control point simulations show the increase of flood discharge from 1989 to 2007.
4) With prediction of land use condition in 2015, the increase of flood discharge reaches 3148.50 m^3/sec, or about 160.20 m^3/sec from flood discharge in 2007.
5) The study shows clearly the increase of flood discharge caused by the land use change.

The recommendation base on this study can be drawn as:

1) Conservation of the catchments area in upstream with reforestation or forest conservation should be done to increase retention in upstream area. Further, reforestation also addresses to the catchments area of central and downstream areas.
2) Land use which minimizes direct runoff and heightens retention and water conservation in the catchment area should be arranged.
3) Components of natural retention in the river area, along the river flood plain and river body should be increased by growing plants or re-neutralizing the damaged river flood plain.
4) The erosion of the river banks should be handled by involving technology of eco-engineering using local vegetations.
5) The function of the area of wetland or natural polder along the river corridor from the upstream to the downstream should be enhanced to store water.
6) Various alternatives should be obtained to develop natural conservation ponds along the river sites or in the possible locations either in the urban-residence area or outside the urban area. These natural retarding basins

function to avoid flood.

7) Besides that eco-hydro-technical solution, socio-hydraulic approach as a part of eco-hydraulic should be implemented by continuously promoting society's awareness of their role in overcoming flood.

ACKNOWLEDGEMENT

The authors would like to thank to an anonymous reviewer for improving the manuscript.

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