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Geospatial Analysis of Land Use Change in Way Kuripan Watershed, Bandar Lampung City

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Abstract— *The purpose of the study is to analyze land use and land cover change impact on Way Kuripan discharge. Six scenarios of land use and land cover changes at Way Kuripan watershed area of 53.54 km² was developed based on geospatial analysis with Geographic Information System. Peak discharge is calculated by using rational method. From the six scenarios simulation, scenarios 1, 2, 3, and 4 maintained the protected areas of 80.15%. Land use and land cover changes done by changing areas from vacant land and agricultural areas to be residential, industrial and government office areas. From the analysis, peak discharge of scenarios 1, 2, 3, and 4 change slightly which are between 11.19% and 23.46%. These results are in contrast to scenarios 5 and 6, in which scenario 5 keep the protected areas about 53.35% while in scenario 6 left the protected areas around 30%. Those protected areas changed into residential areas. The result showed that in scenario 5, the peak discharge changed about 66.29%. While in scenario 6, it changed about 107.19%. It can be concluded that the existence of protected areas in Way Kuripan Watershed was very important role to reduce the peak discharge values.*

Keywords— land use and land cover change, peak discharge, GIS, Way Kuripan watershed.

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1. INTRODUCTION

Development in andar Lampung City now requires spatial planning management that provides optimal benefits, harmonious and friendly to the environment. Unfortunately changes in watershed land use dominantly influence on the flood discharge. This phenomenon also occurs in Way Kuripan Watershed. The watershed has an area of 53.54 km². Its upstream is at Mount Betung. Way Kuripan river is one of the rivers that pass in Bandar Lampung City which flow into Lampung Bay. Its watershed has an important role to catch the water.

Unfortunately, Way Kuripan Watershed current conditions have experienced changes in land use from undeveloped areas to developed areas which causes less water infiltration to the ground

. Instead of infiltrate to the ground, rainwater flow to the surface as runoff. Thereby it increases flood discharge. Quantifying how changes in land use affect the hydrological response at the river basin scale is a current challenge in hydrological science [1].

Research on the impact of the change of vegetation on the water balance at catchment scale has been subject to extensive observation and modelling across the world for many years [2]. There are several evidences that changes in land use have influenced the hydrological regime of various river basins. These impacts can be significant in small basins [3]. It is, however, more challenging to quantify the impact of land use change on the rainfall-runoff relations for large basins where the interactions between land use, climatic characteristics and the underlying hydrological processes are often more complex and dynamic [4].

The land use changes not only cause flooding, but also may create landslides and droughts. As mentioned above that, the land use changes have important role in watershed discharge fluctuation, it is interesting to conduct the study about the impact of land use changes on its discharge. Completed by the advance of computer program which support well for geospatial analysis, the study used Geographic Information System (GIS) as the base of the discharge analysis. The impact of land-use changes on recharge and discharge areas has been assessed using hydrological models within a Geographic Information System (GIS) framework [5]. The study was conducted to determine the impact of land use changes on Way Kuripan Watershed using geospatial analysis or often called Geographic Information Systems (GIS) so that the analysis can estimate the value of discharge based on physical parameters of land.

2. METHODS

The experiment was conducted on Way Kuripan Watershed in Bandar Lampung City. The primary data in this study was rainfall station Ground Control Points (GCPs) which were obtained using Global Positioning System (GPS). These points then plotted on the map coordinates which were overlaid to watershed map or base map.

Secondary data on the study includes: (1) a river map which was obtained by screen digitations with reference of google earth map, and (2) topographic maps to form watershed map, (3) land use maps. Land use map was based on RTRW Bandar Lampung in 2010 and RTRW Pesawaran in 2011 and (4) precipitation data. In this research, three types of analysis were done; (1) hydrologic analysis, (2) spatial data analysis, and (3) sensitivity analysis of land use by stack overlapping outcomes of thematic maps using Geographic Information Systems (GIS).

Such works of sensitivity analysis was done by first identifying the flow coefficient (C) on the land use map based on each region land use, and then calculating the area of each land use changes scenarios (A) to get the value of discharge (Q) which calculated using rational method.

3. RESULTS

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Based on topographic map processing to form Way Kuripan Watershed, it was found that Way Kuripan Watershed consists of four rivers; Way Kuripan, Way Simpang Kanan, Way Simpang Kiri, and Way Betung. Overlaid by administrative map, it was found that Way Kuripan watershed pass through five districts in Bandar Lampung City, including Kemiling, Tanjung Karang Barat, Teluk Betung Utara, Teluk Betung Barat, dan Teluk Betung Selatan. Way Kuripan Watershed also passed three districts in Pesawaran, including Padang Cermin, Way Lima, dan Gedong Tataan. Way Kuripan Watershed has an area of 53.54 km^2.

Land cover data of Way Kuripan watershed was based on data from Bandar Lampung Spatial Plan 2010 and Pesawaran Spatial Plan 2011. From the establishment of land cover data, it was obtained that there were nine different types of land cover in Way Kuripan Watershed: (1) 80.15% of protected areas, (2) 0.19% tourism areas, (3) 0.02% general service areas, (4) 11.69% vacant lands, (5) 0.63% regional trade and services, (6) 0.27% government offices, (7) 6.29% residential areas, (8) 0.34% of agricultural areas, and (9) 0.42% of the area roads. The Existing land use map in Way Kuripan Watershed can be seen in Figure 1.

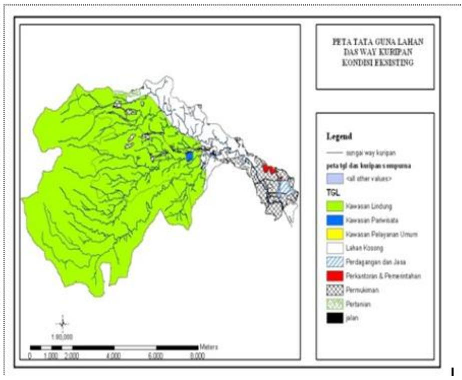

Figure. 1 Existing Way Kuripan Watershed Land Use Map

From Global Positioning System (GPS) data, rainfall station positions were plotted into Way Kuripan base map. The study areas are between rainfall stations and are fully affected by rainfall recorded by the stations.

In the study, three nearby stations rainfall data were used. Determination of rainfall station areas effecting the watershed was calculated using Thiessen Polygon Method and was done in GIS (Figure 2.). From the polygon, it was known the percentage of rainfall areas which influence at certain extent of the territories in each watershed. Rainfall intensity (I) used in the calculation is 40% of 90% rain falls within one day. Table I shows the correlation between return period (T) and rainfall intensity (I).

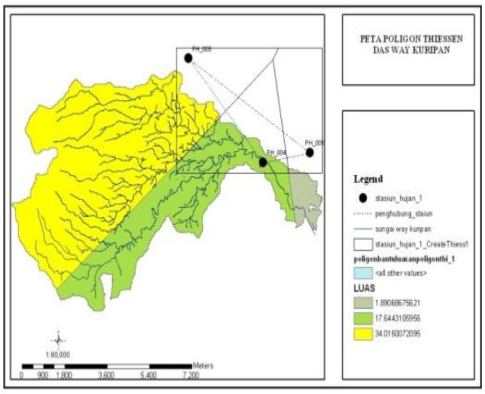

Figure. 2 Thiessen Polygon Map on GIS

TABLE I
CORRELATION BETWEEN RETURN PERIOD (T) and RAINFALL INTENSITY (I)

T	I
2	29.61
5	32.19
10	33.65
25	35.31
50	36.43
100	37.49
200	38.48

The values of peak discharge at the Way Kuripan Watershed due to changes in land use were implemented in simulations with several scenarios of land use changes (sensitivity analysis). The scenarios are: (1) Scenario I: change of 11.69% vacant land cover into the

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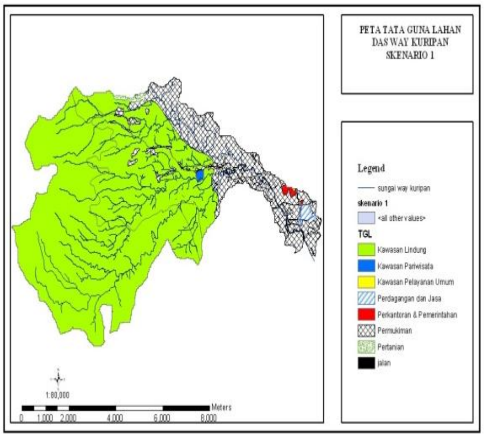
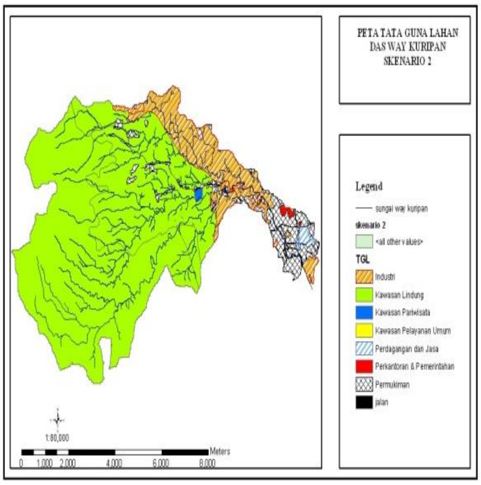
residential areas, (2) Scenario II: changing agricultural areas 0.34% and 11.69% vacant land into an industrial areas, (3) Scenario III: changing agricultural areas 0.34% and 11.69% vacant land into an office areas and government offices, (4) Scenario IV: change most of the protected areas in Bandar Lampung at 7.12% and 11.69% of vacant land into residential areas, (5) Scenario V: change all the protected areas in Bandar Lampung (26.80%) to the residential areas and vacant lands change of 11.69% to the region and government offices, (6) Scenario VI: change all the protected areas in Bandar Lampung and most protected area in the Pesawaran district (50.54%) amounted to the residential area, then convert the vacant lands of 11.69% to the region and government offices. Figure 3 until Figure 8 shows the six scenarios done in the study. Each type of land use in Way Kuripan Watershed has different flow coefficient. The protected area has C value of 0.20; area of tourism has C value of 0.60; public service has C value of 0.70; vacant land has C value of 0.40; regional trade and services have C value of 0.80; areas and government offices have C value of 0.85; settlement area has C value of 0.65; agricultural region has C value of 0.30; industrial estate has C value of 0.70; and the roads area has C value of 0.90. The calculation of peak discharge using the rational method. The formula is:

$$Q = 0,278\ C\ I\ A \quad (1)$$



(a)



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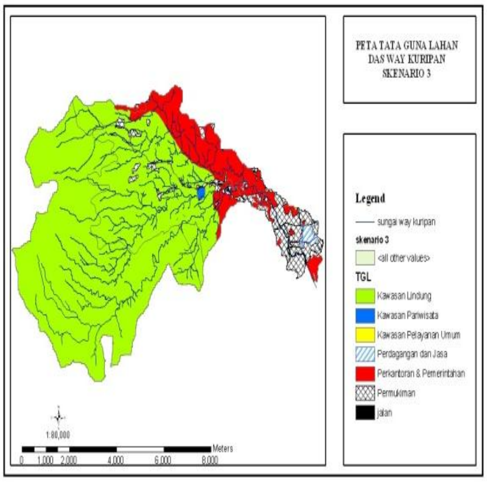

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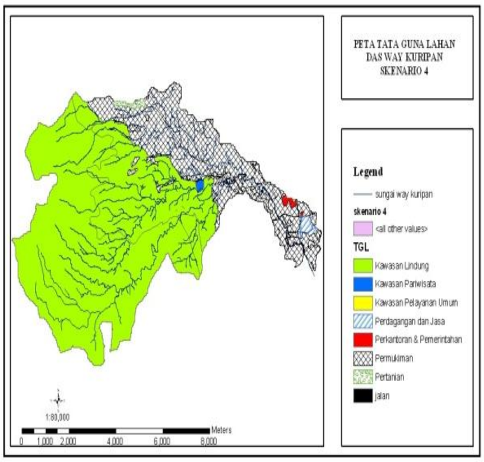

(d)

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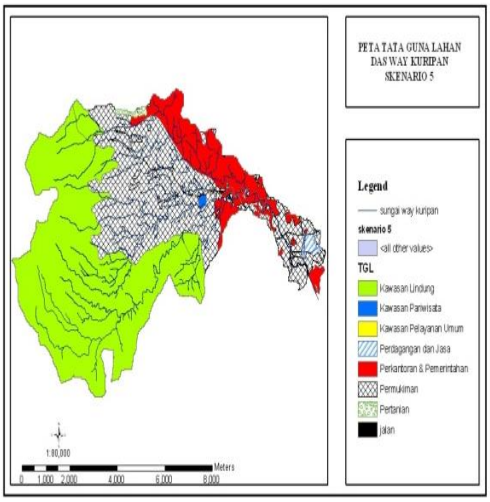

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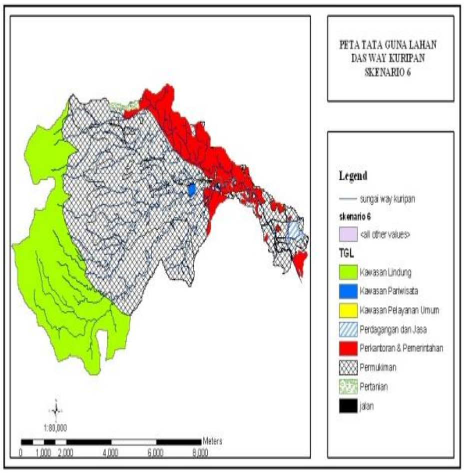

(f)

Figure 3. Scenarios of Land Use Changes of Way Kuripan Watersheds, (a) scenario 1, (b) scenario 2, (c) scenario 3, (d) scenario 4, (e) scenario 5, and (f) scenario 6

TABLE II
RECAPITULATION EFFECTS of LAND USE CHANGES for WAY KURIPAN WATERSHED DISCHARGE

T	Discharge (m^3/det)						
	Existing Condition	I	II	III	IV	V	VI
2	115,15	128,03	133,86	139,16	142,16	191,48	238,58
5	125,19	139,19	145,54	151,30	154,55	208,18	259,39
10	130,89	145,53	152,16	158,19	161,59	217,66	271,20
25	137,34	152,70	159,65	165,98	169,55	228,37	284,55
50	141,71	157,56	164,74	171,26	174,94	235,64	293,61
100	145,80	162,10	169,49	176,20	179,99	242,49	302,08
200	149,67	166,41	173,99	180,88	184,77	248,88	310,10
%	Changes	11,19	16,25	20,85	23,46	66,29	107,19

From Table 2, it was found that the presence of protected areas in the Way Kuripan watershed has very important role to reduce the peak discharge. By maintaining the existing of protected areas, it is predicted it will potential to avoid downstream flooding. In scenario 1, 2, 3, and 4 land use changes on protected areas is not significant so that the peak discharge values are not too large. It was very different from the scenarios 5 and 6, there were an extreme increase of peak discharge, due to the watershed protection in scenario 5 left only 53.35% and in scenario 6 left only 30%.

4. CONCLUSIONS

Based on hydrology analysis, it was found that the rainfall pattern of Bandar Lampung City was distributed to 40% in the first hour, 40% in the second hour, 15% in the third hour, and 5% in the fourth hour, it is very different from the pattern of rainfall by Van Breen in Java Islands.

By maintaining 80.15% of 53.54 km^2 overall Way Kuripan Watershed, it provides enough space for rain water infiltration, and may reduce the potential for flooding in the downstream area of Bandar Lampung City.

From the simulation of scenarios 1, 2, 3, and 4 in which the protected areas were maintained 80.15% of the watershed and simulation consisted the changes of: vacant land and agricultural areas function turned into residential areas, industrial areas, and the government offices. It was retrieved that peak discharge increase in

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not too large values, it was between 11.19% -23.46%.

Contrary results obtained from simulations using scenarios 5 and 6 in which the protected areas on the scenario 5 of 26.80% and the protected areas on scenario 6 of 50.54%, its function transformed to be a region settlements. And it was obtained an increase of extreme peak discharge. In scenario 5 it increases by 66.29% and in scenario 6 around 107.19%. It can be concluded that the existence of protected areas is important to minimize flooding in the Way Kuripan watershed.

Using GIS in geospatial analysis of land use changes on Way Kuripan watershed make the system analysis process becomes more effective, efficient, and easy to understand.

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