# LANDUSE AND LAND COVER CHANGE (LUCC) A CASE STUDY IN INDONESIA

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***Abstract***
*The Land use and Land Cover Change (LUCC) case study aimed to develop an operational methodology using Remote sensing and GIS technology for monitoring LUCC over time; and to identify and analyze the driving force behind LUCC. The study area selected upper Citarum Watershed as its basic unit of analysis to systematically and uniformly collect physical and sosio-economic information. There are significant variations of the pattern of changes at sub-district level. In some sub-districts, agricultural land together with settlement increased considerably, whereas forest area decreased. In other sub-districts, forest and settlement areas both increased, whereas agricultural land decreased. In the regression analysis, percentage change in the number of school pupils and number of industry establishment were factors that were found to be highly and significantly cause increased in the settlement area.*

## 1. INTRODUCTION

The IBGP-START Regional Workshop was covered in Chiang Mai Province, Thailand during 21-25 March, 1994. The general theme of workshop was to focus on identifying and developing relevant methodologies for a study on global land use and land cover changes. Each country member (Indonesia, Thailand, Malaysia and Philippine was participated on discussion on the development of methodology and the development of conceptual framework for analyzing land cover change as guideline for case study in each country. The case study was conducted since 1995 and finished at the end of 1996, the Indonesian case study selected the upper Citrus watershed as its basic unit of analysis to systematically and uniformly collect physical and sosio-economic information.

To chose Upper Citarum as the case study area because of in this area especially in the low land area leis some industrial sites and exist a huge reservoir; the Saguling reservoir.

The main objectives of this study are; to develop an operational methodology for monitoring land use and land cover change, to recognize the driving force and other things that are related to the impact of land use and land cover changes, and to identify parameters that can be used as control parameters to manage the watersheds.

Land use and Land cover changing which caused by both of physical processes naturally and /or human activities are playing an important role. The effect of physical may slowly change and sometime very difficult to assess. Human activities are more readily distinguished. The degradation of a tropical rain forest and climate changes are good example of effect from land use and land cover changes within a global scale.

Data for the analysis have been generated or gathered from the interpretations of satellite imageries of MSS 1984 and TM 1996 for changes in the land use and land cover. Data on socio-economic, population and demographic factors, and other driving force factors were gathered from the secondary sources through field works.

Data and information on the district and municipality level were published on per sub-district (kacamatan) level. The unit of analysis used, therfore, was the sub-district. For that reason, changes in the land use and land cover as generated by RS & GIS have to be matched with socio-economic data.

This paper is part of LUCC case study, focused on the socio-economic and human dimension in land use cahanges relationship. Therefore discusion in this paper focused on to develop model on socio-economic and land use-land cover change relationship.

## 2. METHODOLOGY

The model will utilize GIS techniques to elaborate satellite data and other thamatic information to find a conclusion result about land use and land cover changes in the watershed areas. First, multitemporal satellite data ( MSS 1984 and TM 1996) classified by using classification techniques such as maximum likelihood, to get land use changes from 1984 to 1996. The land use-land cover type will divide into six patch ; 1) Evergree, 2) Decidious, 3) Upland agricultural, 4) Paddy, 5) Settlement, and 6) Industry. Second, at the same time driving forces toward land use and land cover change will be evaluated by investigating socio-economic and physical aspects that are assumed to have close relationship to land use and land cover changes.

The methodology for multitemporal classificaton describe on figur 1. And the multiple regression model of socio-economic to investigate human dimension driving force in land use and land cover changes describe as follow:

$$LC\,j = a + bP + cEd + dCI + eEcn + fPly + gTD + er \quad (1)$$

LC = Lan cover and j = 1,...6 are the six patches, and suggests changes across time,
P = population or demographic indicator or proxies,
Ed = Educational proxies,
CI = Cultural indicators or proxies,
Ecn = Economic indicators or proxies,
Ply = Policy variable or any other proxies,
TD = Indicators for technology advancement or orientation.

## 3. THE STUDY AREA CHARACTERISTIC

Upper Citarum watershed is located in mountainous area of western part of Java, and approximately width of the area is about 25,000 sq km. Geographically, the area is stretch of 107 15' E – 107 60' E and 6 40' S – 7 15' S. The upper Citarum watershed poses the uppermost of Citarum watershed. This watershed cover 7 sub watershed, those are: (see figure 2.)

1. Citarik
2. Ciwidey
3. Cikapundung
4. Cisangkuy
5. Cihaur
6. Ciminyak
7. Cirasea

Administratively, upper Citarum watershed bilongs to four regencies namely Bandung Municipality, Bandung Regency, Cimahi Administrative city, and Sumedang Regency. While each sub watershed of upper Citarum belongs to several districts that those districs subordinated by regency ( see figure 3).

## 4. RESULT AND DISCUSSION

On figure 4, 5 and 6, shown that the land use-land cover changes overtime 1984 to 1996. During 1984-1996, in the study area, water bodies have increased mostly for the construction of the Saguling Reservoir. Agricultural land had been reduced substantially from 93,249 in 1984 to 52,213 hectares in 1996. Likewise, forest area decreased from 99,278 in 1984 to 78,284 hectares in 1996. Settlement and/or industrial sites, however, increased considerably; i.e., from 34,376 to 85,444 hectares in 1996. In addition, the transitional forms of land use; grass/brush land and open land, increased also quite considerably, from about 14,000 to about 33,400 hectares in 1996 ( see Tabel 1).

Table 2. shows that change in the open land is positively and strongly correlated to the change in the area for settlement/industry and the area of grass land. In addition, change in the area for settlement/industry is also positively and strongly correlated with the change of the area of grass land. This may suggest that, to some extent or to some proportion, the open land and grass land are part of the settlement or industrial areas.

As expected, three major land use variables are negatively correlated to each other; but none of the coefficients are significantly different from zero. This possibly suggest that, in reality, there is no consistent policy in the local land use policy. For example, in one time, some agricultural land may be taken and converted into settlement or industrial areas but, in another time, it was forest land that converted into settlement or industrial area. Or perhaps, some agricultural land have been planted to tree crops and aerial photo interpretation may resulted that the tree crop farms seen as forest area. As have been mentioned, in some cases (sub-districts), forest land have increased but, at the same time, agricultural land was reduced.

Quantitative analysis performed had been limited only to correlation and regression analysis. The multiple correlation analysis performed for changes in the land use show strong and significant correlation analysis only between changes (increases) in settlement, open land and grass land. The multiple correlation analysis amongst the socio-economic and human dimension variables indicated that population growth, percentage change in population density, and growth of the number of households were strongly and significantly correlated each other; all in positive signs. Also, growth in the number of households was significantly and positively correlated with growth rate of school pupils had a strong and significant correlation with population growth and percentage change in population density; in the opposite direction, however (see Tabel 3).

Through Graphic 1, where land-use changes were observed by sub-district areas, some interesting changes are revealed. In some districts, increase in the settlement or industrial areas have sacrificed forest land, whereas in other sub-districts, agricultural land have to be given up for the new settlement or industrial sites. There are also cases, or sub-districts, where increase in settlement and agricultural land can take place together and sacrificing forest land. On the other hand, in some other sub-districts, increase in forest land have taken place and sacrificing agricultural lands; or, perhaps, agricultural land have been converted into forest or tree crops area. In general, however, in almost all sub-districts, agricultural land have decreased considerably.

## REFERENCE


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2. Pong-in Rakariyathan, Phd, *Socio-Economic and Human Dimension in Land Use and Land Cover Changes. A Case Study in Thailand,*, June 1996
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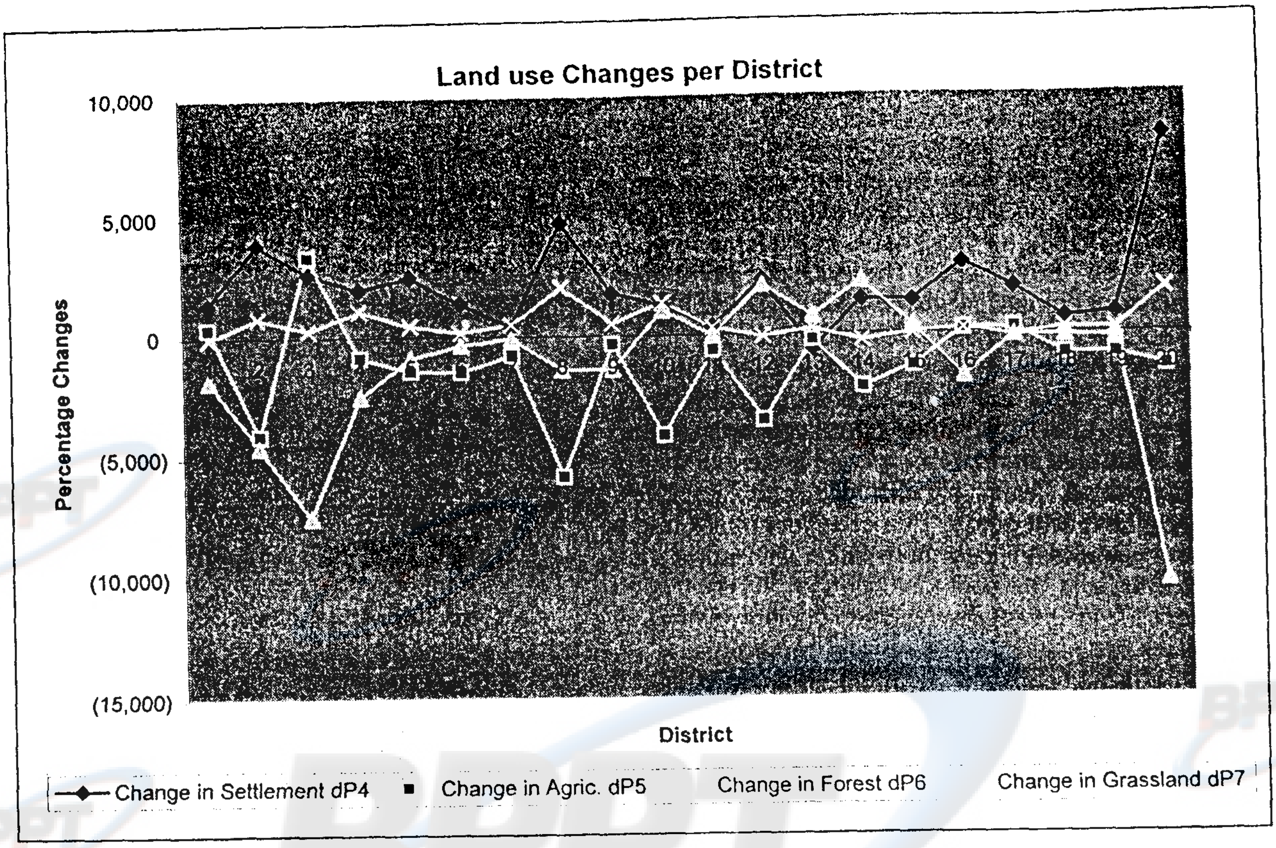
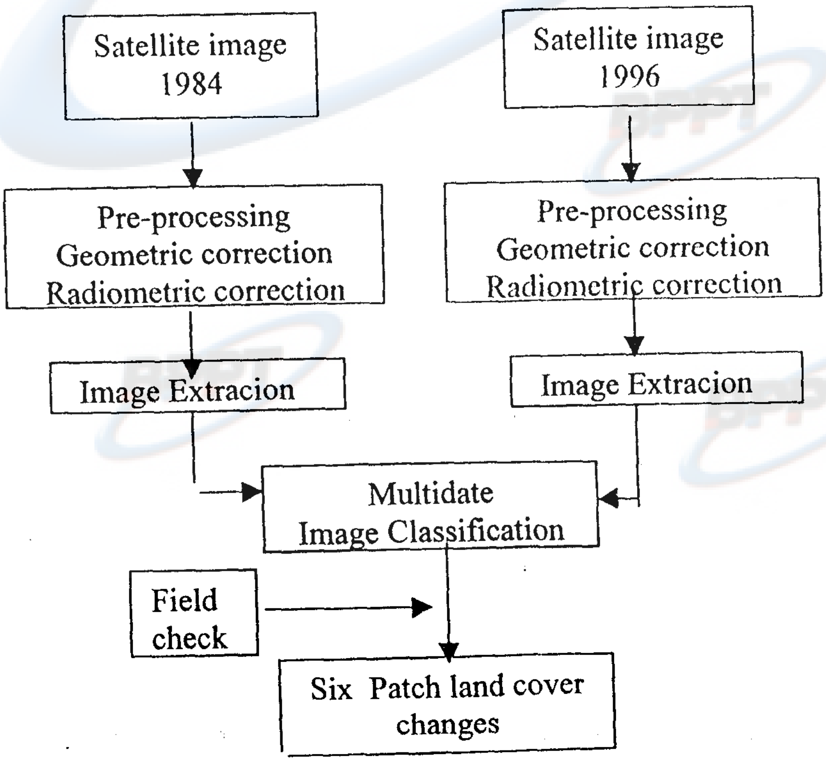



**Graphic 1. Land-use Changes per District in the Study Area, 1984-1996**




gure 1. Image Classification

**Table 1. Changes in Land-use in the Study Area, 1984-1996**

| PATCH | 1984 | | 1996 | | Change *) | |
|---|---|---|---|---|---|---|
| | Ha | % | Ha | % | Ha | % |
| 1. Water body | 355 | 0.14 | 3,887 | 1.50 | 3,532 | 994.93 |
| 2. Clouds/shadow | 18,100 | 6.97 | 6,269 | 2.42 | -11,831 | -65.36 |
| 3. Open land | 4,459 | 1.72 | 15,248 | 5.88 | 10,789 | 241.96 |
| 4. Settlement/industry | 34,376 | 13.25 | 85,444 | 32.93 | 51,068 | 148.56 |
| 5. Agriculture | 93,249 | 35.93 | 52,213 | 20.12 | -41,036 | -44.01 |
| 6. Forest | 99,278 | 38.26 | 78,284 | 30.17 | -20,994 | -21.15 |
| 7. Grass land | 9,688 | 3.73 | 18,140 | 6.99 | 8,452 | 87.24 |
| Total | 259,505 | 100.00 | 259,484 | 100.00 | -20 | |

Source : Result of RS classification and GIS compilation.
Note : *) - means decrease, and increase otherwise.

**Table 2. Matrix Correlation Coefficient of Land-use Variables**

| Land-use Variables | dP3 | dP4 | dP5 | dP6 | dP7 |
|---|---|---|---|---|---|
| 1. Open Land, change (Ha), dP3 | 1.0000 | | | | |
| 2. Settlement/Industry, Change (Ha), dP4 | 0.7834 | 1.0000 | | | |
| 3. Agriculture, change (Ha), dP5 | -0.3315 | -0.2419 | 1.0000 | | |
| 4. Forest., change (Ha), dP6 | -0.4547 | -0.2738 | -0.4693 | 1.0000 | |
| 5. Grass land, Change (Ha), dP7 | 0.7767 | 0.6419 | -0.3192 | -0.3122 | 1.0000 |

**Table 3. Matrix Correlation Coefficient of Socio-Economic and Human Dimension Variables**

| Socio-Economic Variables | X1 | X2 | X3 | X4 | X5 | X6 | X7 |
|---|---|---|---|---|---|---|---|
| 1. Population growth (%/Y), X1 | 1.000 | | | | | | |
| 2. Change in Pop. Density, %, X2 | 0.937 | 1.000 | | | | | |
| 3. Change in Dep. Ratio, %, X3 | 0.215 | 0.221 | 1.000 | | | | |
| 4. Growth rate of pupils, %/Y, X4 | 0.402 | 0.371 | 0.035 | 1.000 | | | |
| 5. Change of pupils, %, X5 | -0.693 | -0.631 | -0.420 | 0.046 | 1.000 | | |
| 6. No. Households, growth, X6 | 0.745 | 0.761 | 0.372 | 0.554 | -0.406 | 1.000 | |
| 7. No. of industry (units), X7 | 0.292 | 0.226 | 0.000 | 0.375 | -0.046 | 0.256 | 1.000 |

Human Dimension Maps (IGBP)

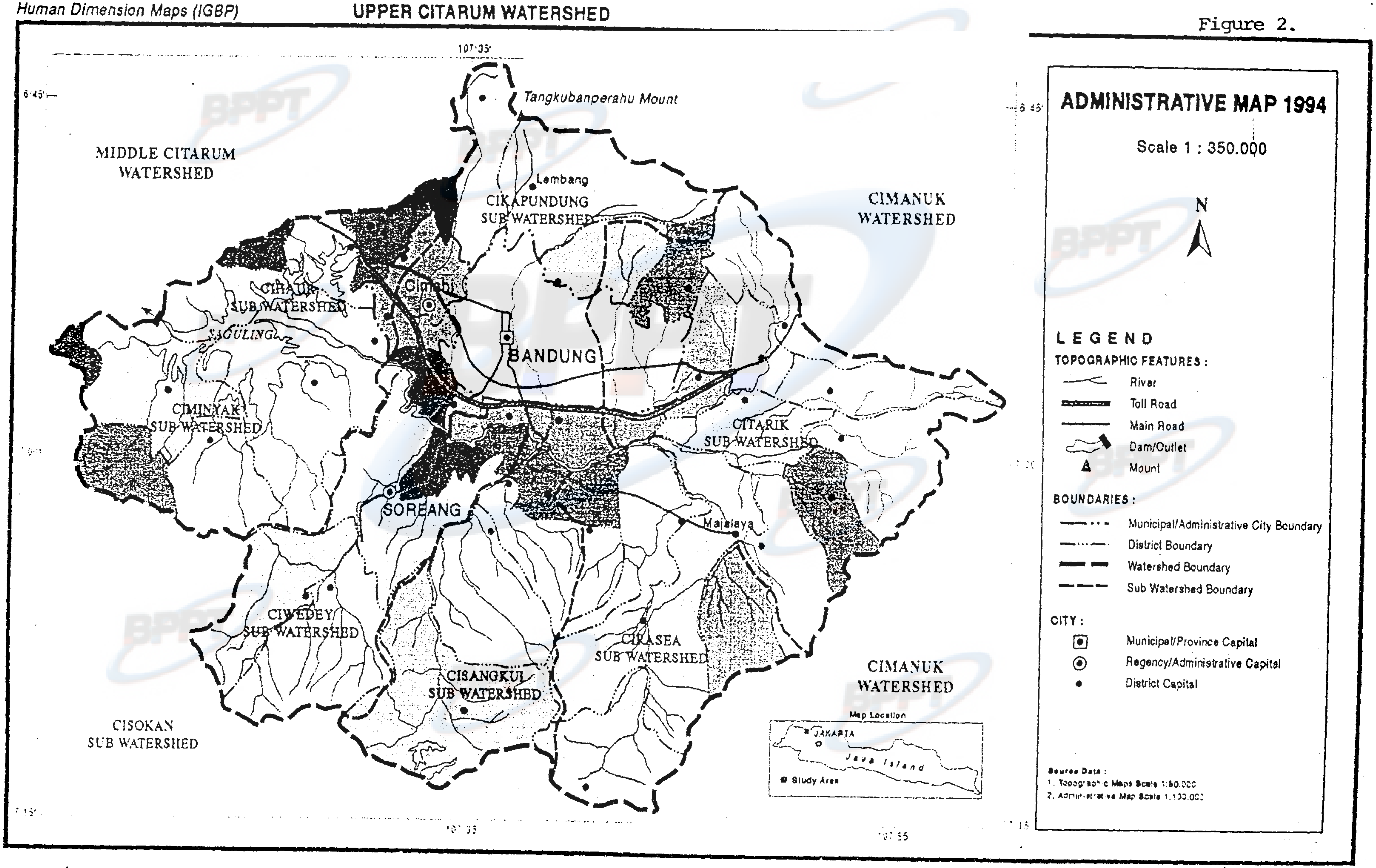
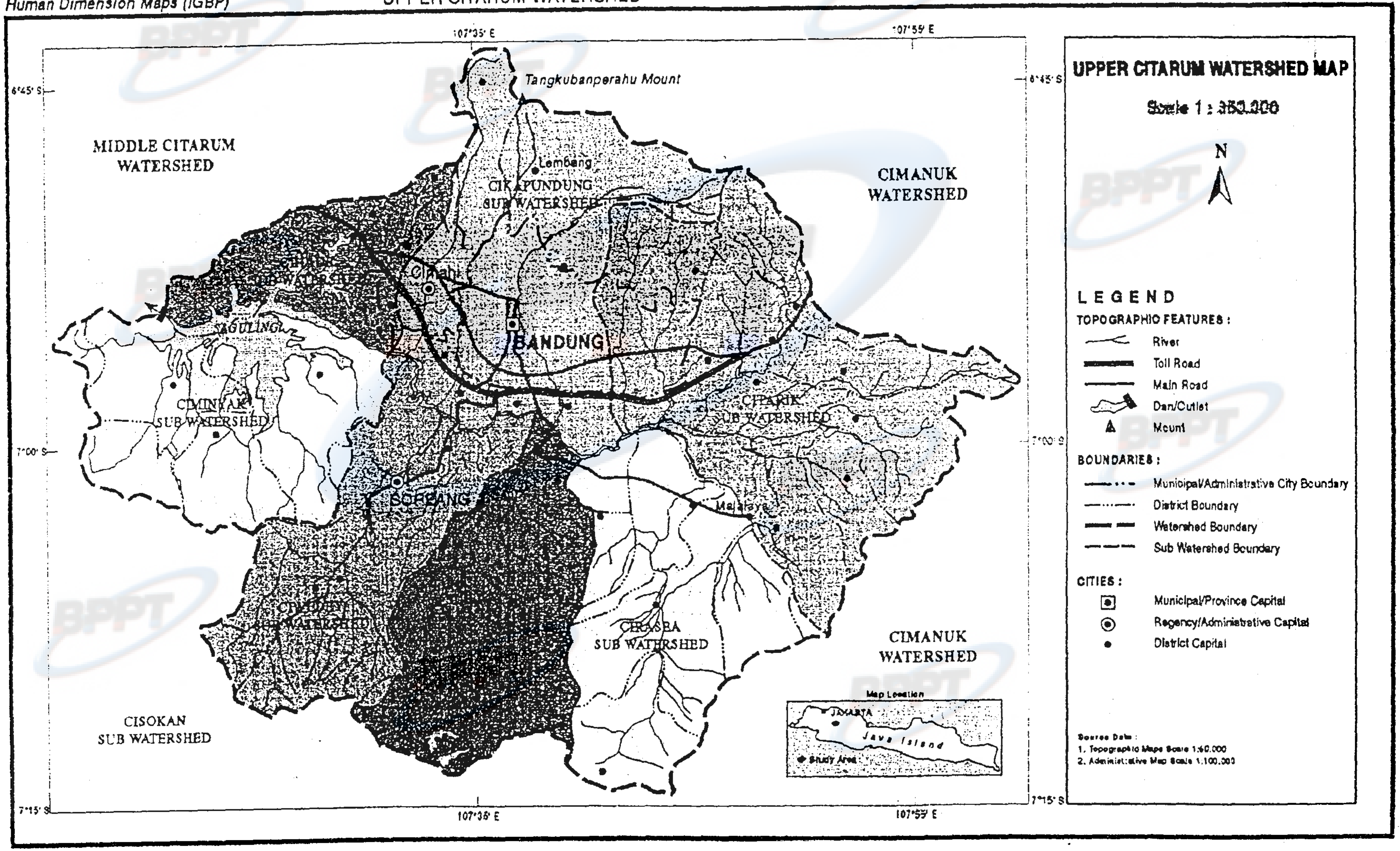


Figure 3.



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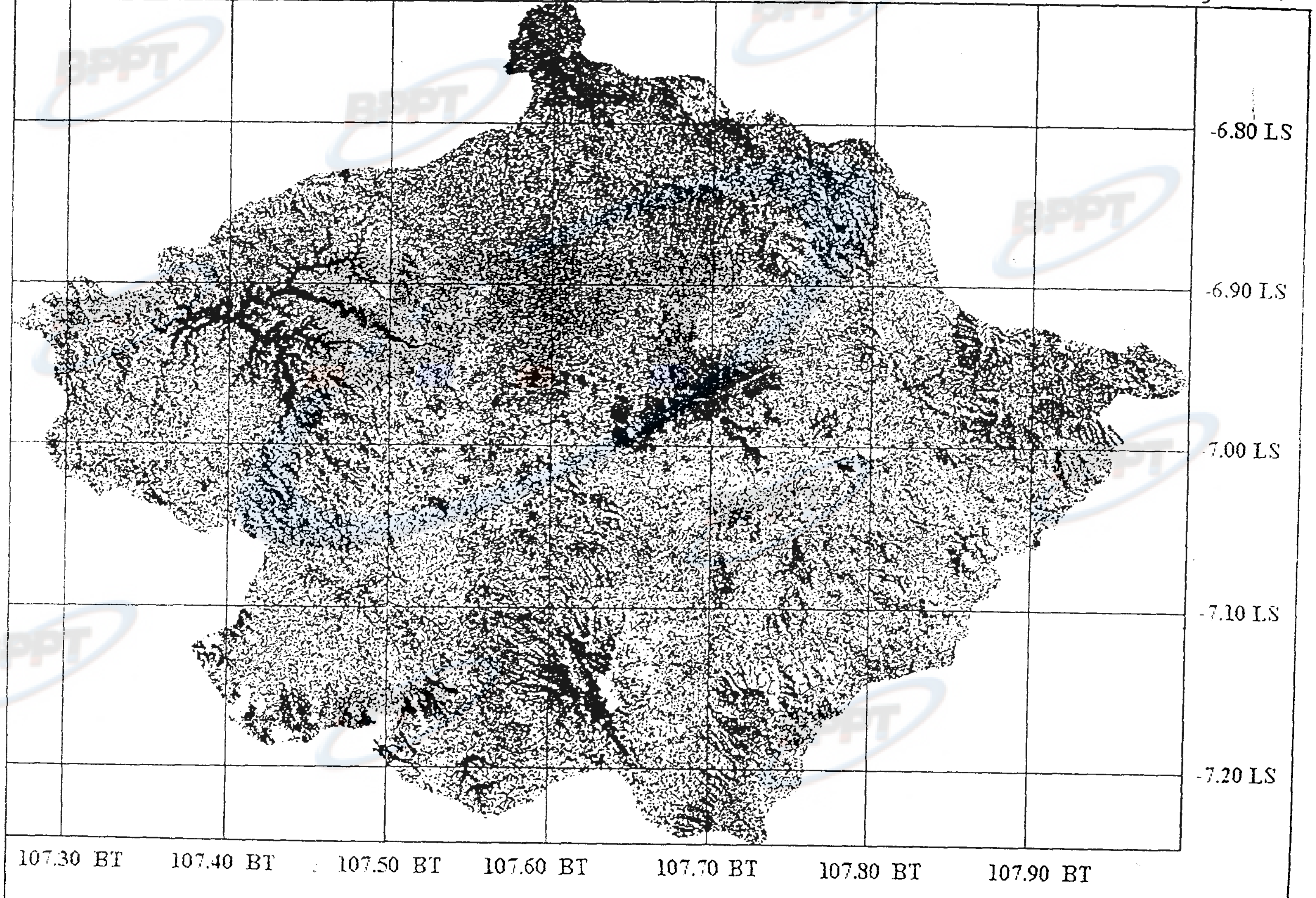
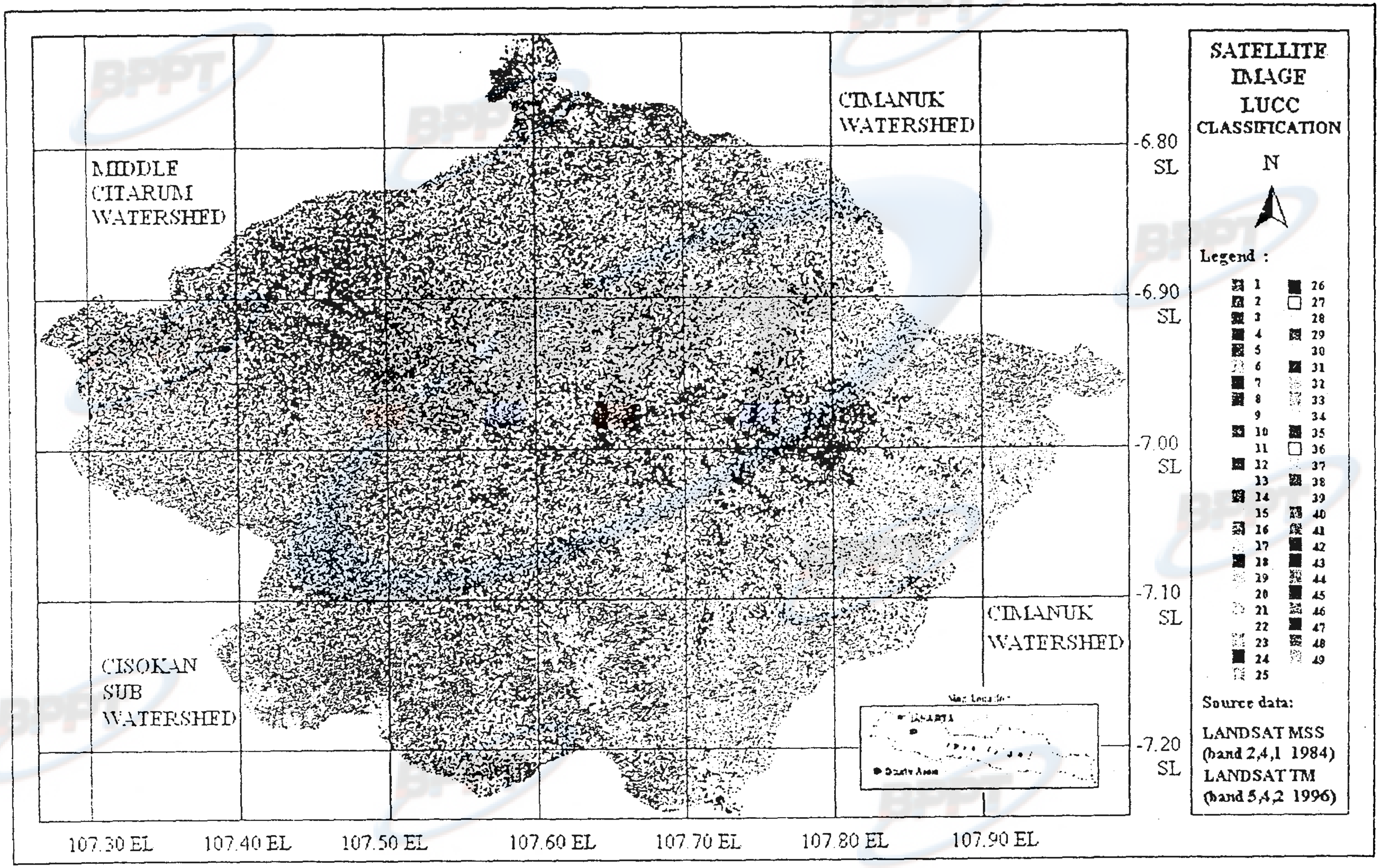
UPPER CITARUM WATERSHED, WEST JAVA, INDONESIA
( LANDSAT TM 1996 RGB COMPOSIT BAND 5,4,3 )

Figure 4.



*Satellite Image Maps (IGBP)* **UPPER CITARUM WATERSHED** Figure 6.



UPPER CITARUM WATERSHED, WEST JAVA, INDONESIA
( LANDSAT MSS 1984 RGB COMPOSIT BAND 2,4,1 )

Figure 5.