Study on Land Resources Based on Agro-Ecological Zones in Bandung District, West Java - Indonesia

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Abstract

Study of land resources in Bandung Regency has been conducted during the period of 2010 to know the potential and constraints for the development of the agricultural sector. Agroecology zone used for grouping of commodities that can be developed in an area corresponding to the condition of the land. The method used in this study is analyses of several thematic maps, there were topographic map, soil map, and climatic map. On some of these maps produce various agro-ecological zones as the initial development of the agricultural sector. Further studies conducted on the actual land use to know whether it is in accordance with ZAE generated. Paired T test statistic used in the determination of the direction of this. Results showed Bandung Regency has 4 (four) regions agroecological zones, namely Zone I to 1,396.9 Ha protected area, Zone II to plantation (annual crops) area of 71,437.34 hectares, a Zone III area of 35,714.07 hectares for Agroforestry and Zones IV for crop area of 64,114.83 ha. The availability of land for agricultural development in Bandung District is an area of 66,118.918 hectares, according to Agra-ecological zones.

Keywords: land resources, Agroecological Zone, Bandung Regency, Geographical Information System

Introduction

Most of Bandung Regency region is mountainous. Among the peaks are: The northern side there are Mount Bukittunggul (2,200 m), Mount Tangkubanperahu (2,076 m) on the border with Purwakarta. (Both are now included in the West Bandung regency). While in the south there Patuha (2,334 m), Mount Malabar (2,321 m), and the volcano (2,262 m) and Mount Guntur (2,249 m), both on the border with Garut.

Potential agricultural and plantation in Bandung Regency is large enough to include food crops, vegetables, fruit plantations and land use in a mountainous area of protected forest, production forest, forest and plantation tour while in the foothills area used for cultivation horticulture (especially vegetables).

Agroecology is the grouping of land area based on the physical conditions of a region that is almost the same environment in which the diversity of plants and animals cannot be expected to differ markedly (Adnyana, *et al*. 1999). The main components of Agroecologyare: climate, slope, and soil property; that supporting plant growth. Sustainable agricultural systems will be realized only if the land used for farming systems appropriate manner appropriate management. If the land is not used properly, will rapidly declining productivity and ecosystems become threatened. Appropriate land uses in addition to ensure that the land and the natural benefit to the user in the present, also ensure that this natural resource for future generations. Taking into account the state of Agroecology, land use and production systems in the form of options right plants can be determined.

Agricultural production and environment became optimum is achieved if land is used appropriately and in a manner appropriate management. Application of the technology package of farming systems should be based on an assessment of agro-ecological zones (ZAE) more thorough so as to facilitate the planning and management of the plant (Amien, 2000). Agro-Ecological Zoning (ZAE), as implemented in the study (FAO, 1996), define zones based on a combination of soil, landform and climatic characteristics. Very important parameters, namely climate conditions, edaphic and crop management systems where the plant grows. Each zone has a similar combination, constraints and the potential for the use of land, which serves as the focus of recommendations designed to improve the situation existing land use, either through increased production or by limiting land degradation.
Using Geographic Information Systems (GIS) have been used for the determination of a number of major crop agroecological zones in nine major regions of Asia, Africa and America in relation to the dry weight of the harvest (Shivakumarand Valentin, 1997). Application of GIS in the zoning commodities has also been carried out by Bhermana et al, (2004), which is to collate and analyze commodity zoning area in Kandul North Barito Regency, Central Kalimantan.

Efforts to provide the data and information resources, including natural resource information database of land as the district is one of the important aspects that need attention in order to support various agricultural development programs to be implemented.

The availability of data and information ZAE will help determine how and proper land use, so that agricultural production be obtained and the optimum preservation of land resources is maintained.

The study was conducted with the aim of:(a) compile the data and information about the state of the physical environment (climate, soil, topography) Bandung Regency region into a data base, (b) determining agroecological zone Bandung regency using the Geographic Information System approach, (c) determine the zoning of commodity agriculture based on agro-ecological zone of each region.

Material and Method

Site Study

The study was conducted in Bandung Regency, situated at 107^{o} 22'- 108^{o} 50' East Longitude and 6^{o} 41'-7 ^{o}19 ' South Latitude is located in the plateau region. Total area of Bandung regency 172,296.316 Ha. Limit administrative area of Bandung Regency (Figure 1)is:

- The northern side is bordered by West Bandung Regency, Bandung and Sumedang;
- The eastern border with Sumedang and Garut regency;
- Next to the southern border with Garut and Cianjur;
- Next to the western border with West Bandung Regency, Bandung and Cimahi.

Morphology mountainous of region with an average slope between 0-8%, 8-15% and above 45%, Bandung Regency is influenced by a tropical monsoon climate with an average rainfall of 1,500 mm to 4,000 mm per year. The temperature ranges between 12 ^{o}C to 24 ^{o}C with humidity between 78% to 70% of the rainy season and the dry season.

Interpretation of Data and Spatial Analysis

The method used in this study was data interpretation and spatial analysis (Balitbangtanak, 1991). This type of data consists of the thematic maps:land use, slope (contour), soil type, and climate data (rainfall and air temperature). The resulting data were arranged in the form of digital spatial data and information, then do the compilation and analysis of data using the ArcGIS 9.3 software.

ZAE division based on differences in climate and slope class. The climate data used are air humidity and air temperature. Humidity of an area distinguished by the number of dry months in a year, which is a month that has an average rainfall <60 mm, with the distribution of climatic zones according Agussalim *et al*, (2000).
The data on land resources in the form of a digital layer that consists of four sub-zones, namely the slope sub-zone, soil sub-zone, and sub-zones of air temperature and air humidity, further in-overlay-right combination to get the cell data that have physical characteristics that were relatively homogeneous by using GIS technology. The next analysis phase is the preparation of ZAE maps, conducted through the editing process and reclassification of a table's data. Digital maps were used in the preparation ZAE slope class maps, land use maps, maps of soil type and climate maps.

Actual Land Use Analyzed by AEZ

Studies of actual land use by Agro-ecological zone (ZAE) intended to determine how large the deviation of actual land use that occured, so it is known that land use is appropriate and not appropriate according to Agra-ecological zones. To compare the actual existing land use with land use by Agro-ecological zone, an analysis by two-sample t test of paired one-way (one-tailed tests). The value of **t** can be formulated as follows, according to Steele and Torrie (1995):

$$t_{calculated} = \frac{\overline{Y}_1 - \overline{Y}_2}{s_{y_1 - y_2}}$$

where:

$\overline{Y}_1$ = Averagebrood ofland usebyAgra-ecological zone

$\overline{Y}_2$ = Averagebroodd ofexistingland use(actual)

s^2

$s_{y_1 - y_2}$ = standard error of the mean $\sqrt{\frac{2s^2}{n}}$ = Standard deviation

$$s^2 = \frac{\Sigma \overline{Y}_1^{\,2} - \left(\Sigma \overline{Y}_1\right)^2 / n + \Sigma \overline{Y}_2^{\,2} - \left(\Sigma \overline{Y}_2\right)^2 / n}{2(n-1)}$$

N= total polygonsobserved

If $\mathbf{t}_{calculated} > \mathbf{t}_{table}$ or significance<0.05 according to the type of land use, it means that actual land use is significantly different with agroecological zones, or vice versa if $\mathbf{t}_{calculated} < \mathbf{t}_{table}$ or significance> 0.05 then not significantly different (same).

Results and Discussion

Agroecological zoning implemented by first making scoring against each of the components of the physical environment. Based on the results of overlay maps of topography, drainage maps, maps of humidity and temperature maps, there were obtained four (4) agro-ecological zones AEZ (Table1 and Figure 2). Agroecological zones with agriculture or forestry system specifications in Bandung Regency detailed, as follows:

- Zone I: zones with slopes> 40%, the type of land use for forestry.
- Zone II: the zone with 16-40% slope, type of land use for plantation.
- Zone III: 8-15% slope zone, the type of land use for Agroforestry.
- Zone IV: zone slopes <8%, the type of use of agricultural land to dry land.

Zone I

Zone I is the type of land use zones for protected areas (conservation). The region covers an area with a height of more than 750 m above sea level, has an area of 1,396.9 hectares with a total area of Bandung regency. Zone I consists of 4 (four) subzona is subzona with symbols Ibx1 covers an area of 626.42 hectares, the cool-temperate zone with humid moisture, soil type and Entisols Andisol with good drainage, while the slope class> 40% is land with steep slopes . Subzona Ibx2 with an area 451.17 hectares, it has a kind of soil subzona Ultisol and Inceptisol with poor drainage. Subzona Iby1 has an area of 318.52 Ha with moisture rather dry. Subzona Iby2 with an area of 0.79 hectares with poor drainage. Zone I is mostly found in the southern part of Bandung Regency and located on the plateau. Zone I is largely contained land use primary forests and plantations, but there are a land use shrubs, fields and settlements.

Conditions of land with very steep slopes and high rainfall resulted prone to erosion that can result land degradation and environmental damage. In consideration of the level of vulnerability of environmental degradation is high enough, then the land use in Zone I should be addressed as a protected area, it is contained in the Forestry Act. 41 of 1999.

Zone II

Zone with an area of 71,070.518 hectares this is the type of land use zone plantation / cultivation of annual crops / fruits. In Bandung District, there are 6 (six) subzona is subzona IIbx1 with extensive 35,511.30 Ha, subzona IIbx2 area of 26,361.5 hectares, covering an area of 1,662.24 ha subzona IIay2, covering an area of 4,944.25 ha subzona IIby1, with an area of 2,494.21 subzona IIby2 Ha and subzona IIay1 with an area 90.53 Ha. This Subzona distinguished based on soil moisture, temperature and soil type regime views of its drainage. The second zone covers the whole of sub-district in Bandung with a total area of 71,437.34 ha of the total area of Bandung regency. Based on the data of land use zone II there are land use primary forests, secondary forests, fields, plantations, rice fields and settlements.

Use directives for the cultivation of plantation crops or perennial crops with conservation farming systems. Planting without tillage, minimum tillage and the use of cover crops under annual crops help prevent erosion that can lead to degradation of land quality and environmental damage. This zone can be directed to the use of annual crops with crop commodities cocoa, coffee and rubber. This zone can also be directed to the utilization of limited production forest, with the principles of environmentally sound management (Karel and Hendrik, 2010). Silvicultural systems (selective logging, planting) can be applied in a manner consistent forest management and sustainable given the condition of the land is still relatively vulnerable to erosion.

Zone III

This zone is a zone with land use directives agroforestry. Zone III has an area of 35,714.07 ha and memilikidanau / situ measuring 58 hectares. Based on the temperature regime, moisture regime and drainage, there are 6 (six) subzona in Bandung Regency is widely IIIbx1 subzona 18,960.88 hectares, an area of 12,045.93 hectares subzona IIIbx2, subzona IIIay2 is 720.53 ha, covering an area of 2,362.67 ha subzona IIIby1, subzona IIIby2 subzona IIIay1 covering an area of 1,450.41 and 75.41 Ha. This zone is most likely in an area with an altitude> 750 m ASL in Bandung Regency. Zone III there is a land use pepper / moor the largest, followed by plantations, settlements and fields.

In this zone can be directed choices of crops such as peanuts, soybeans, sweet potatoes and cassava can be planted between the types of annual crops or perennial crops or crops of cocoa, coffee, rambutan and others as plant remains. Although the level of vulnerability to erosion hazard is lower than Zone I and II, but for the long-term dangers still exist so it needs proper treatment. Conservation farming systems still need to be applied in this zone is minimal tillage, terracing and a choice between the right kind of soil will greatly assist in preventing erosion and increase soil fertility in particular kinds of legumes (Rahim, 2000).

Zone IV

This zone is a zone with land use directives for both dryland agriculture and horticulture crops lowlands. Zone IV is a broad area of 64,114.83 hectares of Bandung regency. There is a lake / situ measuring 316.72 hectares located in District Pangalengan and Ciwidey. In this zone there are 6 (six) subzona by moisture regime, temperature regime and soil drainage, which IVbx1 area of 13,510.14 hectares, an area of 15,752.23 hectares subzona IVbx2, covering an area of 15,932.24 IVay1 subzona Ha, with an area of 8.958 subzona IVay2, subzona IVby1 area of 2,837.52 and 5,751.63 Ha subzona IVby2 area. Based on the data of land use in this zone there is a land use field / moor, fields, settlements, gardens and a small proportion of primary forests and secondary forests(Table 1).
Referring to the national agricultural programs, the relatively flat land with the condition is more geared for food crops to strengthen national food security. Ecologically commodity that can be developed in the Bandung Regency of paddy rice, corn, potatoes, cucumbers, cassava, peanuts, upland rice. In addition to food crops and vegetables, plantation crops such as cocoa, coffee and tea, cloves potential to be developed especially in the southern part of Bandung Regency.

Existing Land Use and Recommended Land Use by AEZ

Alosimageanalysis resultsobtainedland useareain site study shown in Table 2 and Figure 3.Based on thistableabove, theland usetype was dominated by rice field of 43,862.686Ha, followedbyplantationsandprimary forestthat of38,135.67Ha andof 34,999.718Haconsecutively.

Zone I developed agricultural system is a system of forest cover and forest protection forest production. Forest conservation areas and serves as a buffer to maintain the environment and water management.

The slope of the land in this zone is the danger of erosion and deterioration / degradation which is a real threat to agriculture in the humid tropics steep slope. Zone II is a zone that uses the land for intensification monoculture plantations with annual crops or mixed farms, plantations and fruit. In addition, zone II can be used for conservation efforts. Zone III directed to agro-forestry, farming systems (Agroforestry) or cultivation hall, which is planting crops in conjunction with annual crops. Zone IV is the zone of direct farm system is for food crops and seasonal crops.

Study the actual land use and land use by Agra-ecological zone aims to determine how large deviations based on actual land use ZAE. The study was conducted through analysis using ArcGIS 9.3 software, then continued with the test T. Irregularities in land use agroecological zones can be known through overlaying agro-ecological zones with the actual land use, in order to obtain area (Ha) of land use which are not appropriate based on the zone Agroecology (Table 3).

The deviation of the actual land use on agroecological zones feared could have an impact on the physical and socioeconomic aspects. Agroecology zone dividing the main zones based on a slope, with the aim to facilitate the farmers to manage their land mainly related to soil and water management, technology factors, and considering the conversion factor.

Statistical analysis through T test, $T_{calculated}$ in the study area was 2,075 while the $T_{table}$was 1.761 with a 95% confidence level, it means the actual land use was significantly different compared with land uses according to agro-ecological zones. Land use deviation in this region was 60%. The same results observed in some regions in West Java Province, eg. Purwakarta Regency of 65 % (Alemina, 2004), Cirebon Regency of 42 %, (Rohmawati, 2006), and Sumedang Regency of 50 % (Ferryanny, 2007).

Urbanization and industrialization are the factors that greatly affect the dynamics of the land use. Growth and development of the city of Bandung, and smooth transportation have increased land conversion in Bandung regency. Development of this area without following the directives of agroecological zones so that existing land use agroecological zones intersect with those areas especially in the southern part of Bandung Regency.

Based on administrative boundaries, such changes largely occurred in the District Banjaran, which is the area with the densest population in Bandung Regency. As the area adjacent to downtown and transfortasi fairly smoothly from the city of Bandung, Banjaran quickly turned into residential and industrial areas.

Irawan (2005) suggested that the conversion of the land is part of a development activity can not be avoided. During the rapid population growth and economic activity is still ongoing, inevitable conversion. Economic development will require that land be used for the construction of facilities transfortasi and other public facilities as well as the need for land for non-agricultural activities such as industrial and trade areas.

Studies of AgroecologcalZone have been applied almost all over Indonesia. In the area there are 5 zones Agroecology Papua is allocated as agricultural land is protected area Zone I to Zone II for plantations, agroforestry Zone III, Zone IV and Zone V crops earthy peat swamps or wetlands for agriculture and aquaculture (Karel *et al*, 2010).

Based on the studyPrasetyo *et al* (2011), System development zone Agroecology Semarang District, characterizing a region up to the village level, both soil and climate conditions that can recommend a suitable cultivated farming systems and agricultural commodities are suitable to be cultivated. Research Syafruddin, et al. (2004), define the concept of competitive commodities using Agroecology Zone in Central Sulawesi obtained seven main zones, four farming systems and several types of alternative crops that can be developed in the region of Central Sulawesi.

Conclusion

- In accordance with the results of the spatial analysis based on the Geographic Information System approach in determining agroecological zone Bandung Regency, it can be concluded that the area of Bandung Regency has four agro-ecological zones, namely Zone I to 1,396.9 Ha protected area, Zone II to plantation (annual crops) covering an area of 71,070.518 Ha, Zone III area of 35,714.07 hectares for Agroforestry and Zone IV for crop area of 64114.83 ha.
- Land use that's notappropriate to AEZ in Bandung Regency was 60%.

- The availability of land for agricultural development in Bandung District is an area of 66,18.918 hectares, according to Agra-ecological zones. Development of commodities for each zone is determined by the characteristics of the land.

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Table 1: AEZ distribution in Bandung Regency

No.	AEZ	(Recommended) Land Use	Area (Ha)	(%)
1	I	Forestry	1,396.901	0,81
2	II	Plantation	71,070.518	41,25
3	III	Agroforesty	35,714.067	20,73
4	IV	Food crops	64,114.829	37,21
Total			172,296.316	100,00

Note: result of maps overlayed: slope, temperature, air humidity, and soil drainage (2014).

Table 2: Actual Land Use in Bandung Regency

No	Land Use Type	Area (Ha)
1	Primary forest	34,999.72
2	Secondary forests	384.945
3	Gardens / Plantations	38,135.67
4	Field / moor	21,107.45
5	field	43,862.93
6	Shrubs / Thicket	14,654.69
7	River / Lake / Reservoir / Situ	563.644
8	Pond / dam	18.303
9	Woke / Settlement	18,568.97
Total		172,296,316

Table 3. Deviationof ActualLand Useonagroecologicalzonein Bandung Regency

Agroecological Zone	Land Use	Area (Ha)	Note
I	Primary forest	1,180.62	appropriate
	Secondary forests	1.21	appropriate
	Gardens / Plantations	38.991	not appropriate
	Field / moor	10.102	not appropriate
	field	2.833	not appropriate
	Shrubs / Thicket	148.913	not appropriate
	Woke / Settlement	0.00012	not appropriate
II	Primary forest	28,612.64	not appropriate
	Secondary forests	332.405	not appropriate
	Gardens / Plantations	16,092.33	appropriate
	Field / moor	10,656.55	not appropriate
	field	4,536.09	not appropriate
	Shrubs / Thicket	10,137.06	not appropriate
	River / Lake / Reservoir / Situ	3.543	not appropriate
	Woke / Settlement	935.11	not appropriate
III	Primary forest	4,358.61	not appropriate
	Secondary forests	40.041	not appropriate
	Gardens / Plantations	11,012.31	appropriate
	Field / moor	6,849.86	appropriate
	field	7,155.95	not appropriate
	Shrubs / Thicket	2,874.25	not appropriate
	River / Lake / Reservoir / Situ	41.043	not appropriate
	Woke / Settlement	3,206.99	not appropriate
IV	Primary forest	814.788	not appropriate
	Secondary forests	8.567	not appropriate
	Gardens / Plantations	10,991.13	not appropriate
	Field / moor	3,590.68	not appropriate
	field	32,164.42	appropriate
	Shrubs / Thicket	1,535.14	not appropriate
	River / Lake / Reservoir / Situ	519.049	not appropriate
	Pond / dam	18.303	not appropriate
	Woke / Settlement	14,426.80	not appropriate
	Total	172,296.32	
		Ha	**%**
	appropriate	67,300.74	39.06
	not appropriate	104,995.57	60.94

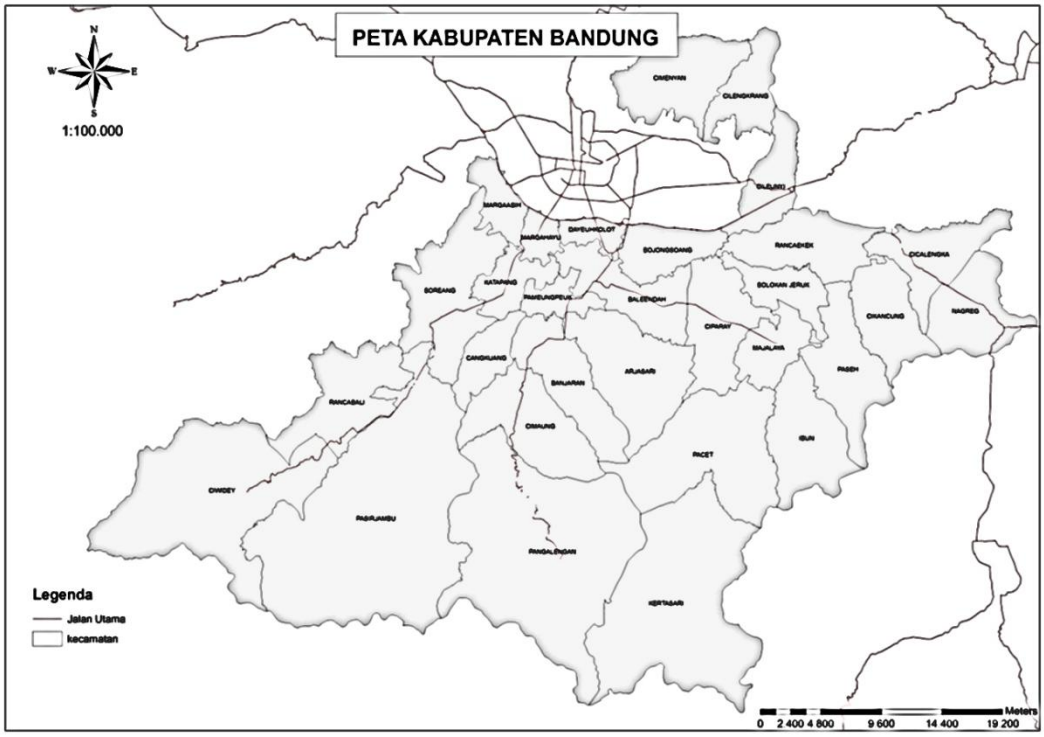


Figure 1.SiteStudy (Bandung Regency)

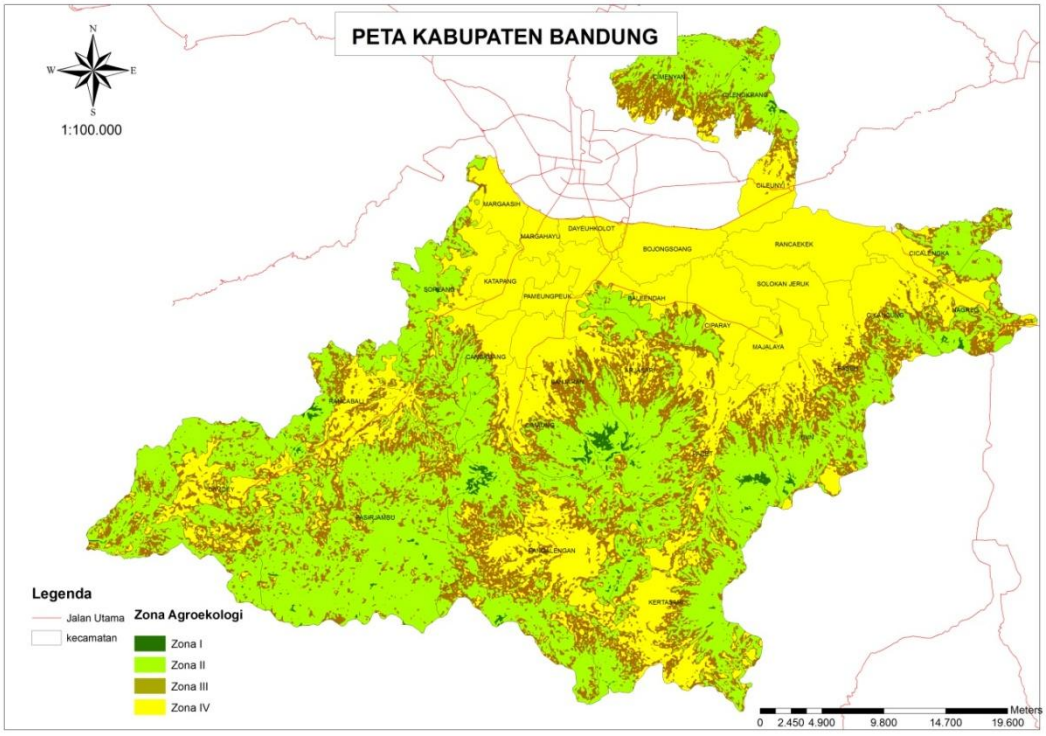
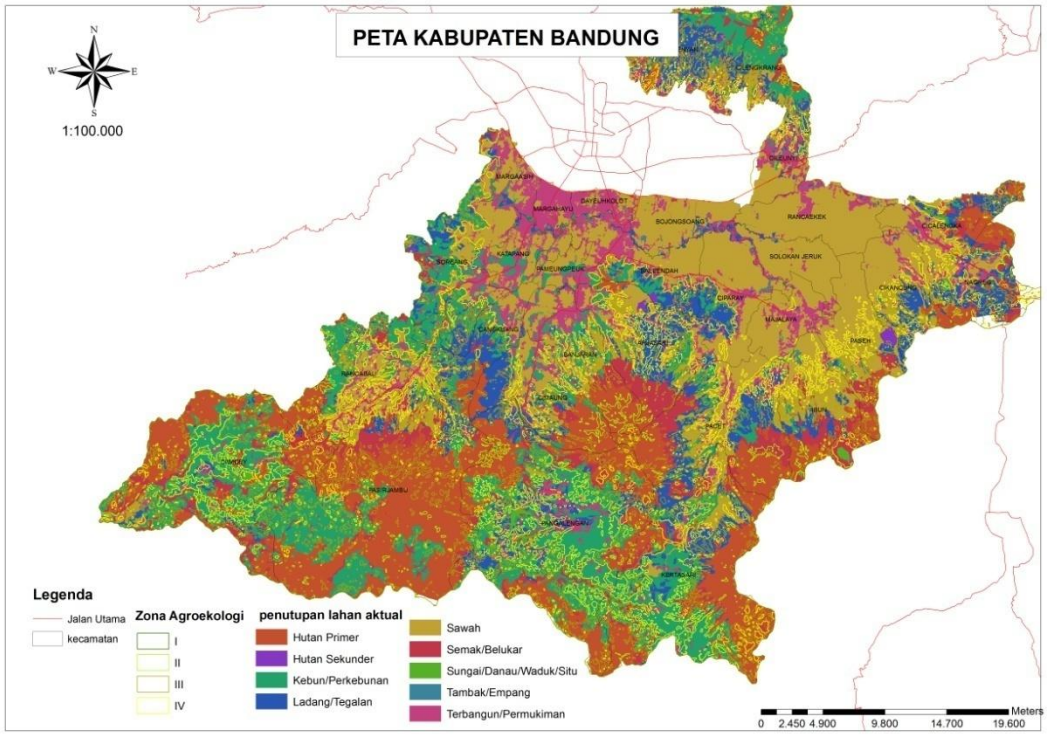


Figure2. Agro-ecological Zone Map of Bandung Regency

Figure 3.Actual Land Use in Bandung Regency



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