# DISTRIBUTION OF NATURAL RESOURCES AND POPULATION DENSITY IN THE MERAPI VOLCANO AREA

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## ABSTRACT

*The objective of this research is to study spatial distribution of natural resources and their relation to population density of the Merapi volcano area. Survey method was used in this research, and started by thematic map and remote sensing imagery interpretation; fieldwork was carried out to check the interpretation result and to observe the actual natural resources in the sample areas were determined by purposive sampling. Population density data were collected by secondary data from sub-district. Descriptive, qualitative approach was used to data analysis and landform unit was used for evaluation of the natural resources..*

*The findings of this research are: i). spatially the natural resources potency varies according to landform unit, and each landform unit has specific natural resources potency, ii). the availability of the natural resources in the landform unit has closed relationship to the population density, high and enormous of natural resources usually followed by densely populated, iii). the high densely populated area not always influenced by the existing of the natural resources but also by the functional of the area.*

***Key words: natural resources , Merapi volcano, population density***

## INTRODUCTION

### Background

Indonesia has been known as the most volcanic country in the world (128 volcanoes are still active). Most people view that volcanic areas are covered by fertile soil, high populated, and at high risk on natural disaster. The such people's opinion should be supported by actual data.

Comprehensive natural resources potency data on the volcanic ecosystem should be known if we want to achieve sustainable development. Natural resources are the whole bio-geophysical environmental components which potentially supported the human lives or all substances in the nature that can be used to fulfil the needs of human lives ( Katili, 1983).

Availability of the natural resources in certain area are depended on the ecosystem type. The ecosystem type can be analogue as a kingdom, where within the system every component has interrelationship and interdependently, and as a holistic arrangement of environmental components, influences each other to maintain the balance, stability and the productivity of the human environment (UULH,1997).

This research is carried out in the Merapi volcano as unity of ecosystem. Generally most people know Merapi volcano from his hazard. Some research of the Merapi volcano were focused on the volcanic activities, the hazard and the disaster. The natural resources potency of the volcano do not know precisely and completely, and of course the carrying capacity to support the human lives are still in a question. The natural resources of the Merapi volcano have been used for centuries, and the population density tend to increase, even though the natural disaster in any time can occur. Based on secondary data and field observation there are variation on the spatial distribution of the population density of the volcano.

In relation to the previous phenomena a research question arise whether the variation of the spatial population density is related to the natural resources potency or in another question is there any relationship between the natural resources potency and the population density. The question is needed to know pushing factor of the population to live in the danger area from volcanic hazard.

**Objective of the Study**

The main objective of this study is to know the spatial distribution of the natural resources and population density and their relationship of the Merapi volcano, while the objectives in detail are as followed:

1) to study the natural resources potency and their spatial distribution of the Merapi volcano;
2) to know the population aspects ( the number and the spatial distribution) as consumers of the natural resources; and
3) to study the interrelationship between natural resources and the population density of the Merapi volcano.

**Benefit of the Study**

Scientific benefit of this study is a integrated geographical research model which syntheses the natural resources and the human resources of the volcanic ecosystem. In respect of benefit to society: availability of basic data for natural resources of the volcano ecosystem. The such as data are important to compose strategic planning for natural

resources management in correlation to the human resources. This study can also be used as an example for natural resources evaluation study of the others volcanic ecosystem in Indonesia.

**Literature Review**

Study on interrelationship between human live, natural resources and the human environment is important, because if the exploitation of natural resources and the environment for human live do not take care to their characteristics the quality of the natural resources and their environment will deteriorate drastically (Verstappen, 1983; Dietz, 2000). Natural elements which can classified into natural resources composed of: land, mineral and mining substances, flora and fauna, water, air and energy ( Katili, 1983; Dietz, 2000). This study will stress on selected natural resources, namely: land, mining, water and land use ( to represent the flora and fauna).

The spatial and temporal data of the natural resources are needed for regional development; the data can be obtained by remote sensing techniques using: aerial photographs, satellite images or another images (Verstappen,1983; Van Zuidam, 1985; Lillesand and Kiefer, 1979). Each remote sensing image has different capability for obtaining natural resources data, such as geologic, geomorphologic, soil, hydrologic and land cover (Mekel, 1974; Verstappen,1983; Van Zuidam, 1985; Lillesand and Kiefer, 1979).

Landform is one of the objects in the geomorphologic study formed by interaction between lithological types and geomorphic processes (Thornbury, 1953; Summerfield, 1991). Landform unit can be used to identify the natural resources, it influences the soil type distribution (Gerrard, 1995), and also influences the groundwater characteristics (Walton,1970; Brown,1995).

The natural resources and environment are dynamic in nature, in any time will change the quality as well the quantity; the changes of the natural resources and the environment have shifted, formerly dominated by nature and then dominated by human activities (Messerli et al., 2000). The human influences to the changes of the natural resources and environment in the Merapi volcano have occurred for centuries and tend to deteriorate the environment. According to Sutikno Bronto (Anonym, 2001) Merapi volcano has gave, being and will give advantages to the population if view from economic aspects. The sand and the stones from Merapi explosion have high potency as construction materials; every day not less than 3000 miners with 15 backhoes and more than 750 trucks to exploit the materials. The human activities to mine the volcanic material in the Merapi volcano give impression that the storage of the sand and stone resources have high potency. Environmental impacts due to the exploitation of the material construction has been identified, and supposed have high risk to the people who live near by the mining sites and in the lower slopes.

The inhabited population in the Merapi volcano has beneficial from the natural resources, but some part of them have high risk to the natural disaster. The condition influence the population distribution. Spatially the population distribution in the Sleman district varies, toward upper slope the population density decreased (Pemda Sleman, 1992).

The literature review give theoretical framework that the natural resources availability in an area are interrelated and interdepended. The natural resources task in this study are land resources, surficial material (sand, gravel, stones), water resources and land use. Landform unit which characterized by relief, lithologic and geomorphic processes has relationship to the other natural resources component, and can be used for identification and evaluation as well. The natural resources are dynamic, rapidly changes due to natural factors as well as human factors, but mostly activated by human activities. The spatial distribution of the population in the Merapi volcano will adapt to the availability of the natural resources and the risk of the natural disaster.

## THE RESEARCH METHOD

Survey method is used in this research, there are two variables will be collected and analysed, i.e. natural resources and population density. The natural resources variables are limited to land, surficial material, water and land use.

The natural resources data are collected through thematic maps and remote sensing images interpretation. The thematic maps that are used are of topographical, geological hydrogeological and reconnaissance soil type maps, and the remote sensing images consist of colour infrared aerial photographs and Landsat TM. Aerial photographs and Landsat images interpretation are proposed to obtain geological, geomorphologic , hydrological and land use data. The obtaining of the hydrological data from remote sensing images used landform unit approach. The result of the images interpretation are presented in preliminary maps. The preliminary maps are used for field work to revise the maps and to determine the sample areas for detail observation. The samples area are selected by purposive sampling. Landform unit, variation of remote sensing features are considered to select the samples area. Observation on the samples area are proposed to collect bio-geophysical field data which consist of: landform unit characteristics, slope, material composition, geomorphic processes, land cover and hydrological condition. The field bio-geophysical data are used to evaluate the land capability classes, water resources and mining material resources of the landform units. Qualitative evaluation of the natural resources of the landform units are based on final thematic maps.

The population data are collected from secondary data per sub district in 9 districts within the Merapi volcano area. The secondary population data are classified into population density. The population density data then are plotted into administrative map to compose the population density map of the sub districts.

The spatial distribution of the natural resources which represented by the landform unit map and the spatial distribution of the population density is overlaid using geographical information system. The spatial distribution of the natural resources and the population data is analysed descriptively.

## RESULTS AND DISCUSSION

### Natural Resources Potency

Landform unit is used as framework to evaluate the natural resources potency in the Merapi volcano area. Thematic map, remote sensing images interpretation and field work, genetically most of the study area consist of volcanic origin and in small part composed of fluvio-volcanic origin. The Merapi volcano is strato volcano, and the landform units consist of: crater, lava dome, volcanic cone, volcanic slope, volcanic foot, volcanic foot plain and fluvio-volcanic foot plain. The area distribution of the landform units are presented in Figure 1, and the characteristics of the landforms unit are described in Table 1.

**Table 1. Characteristic of the landform units in the Merapi volcano area**

| Landform unit | Relief | Rock type | Geomorphic processes | Characteristic |
|---|---|---|---|---|
| Crater | Depression, steep slope | Lava, pyroclastic | Eruption | Depression, fill hot water |
| Lava dome | Hilly | Lava, Pyroclastics | Pushing by lava when active and collapse | Lava and pyroclastic near by the crater very labile, lava collapsing, nue ardente |
| Volcanic cone | Mountainous | Lava and pyroclastics | Volcanic and mass movement | Upper most of the volcano, very steep slope, bare land, rocky surface, labile, recharge area |
| Volcanic slope | Hilly to mountainous | Intercalation of lava and pyroclastics | Volcanic, mass movement erosion | Steep slope, shrubs – forest covered, partly dry land, springs belt, deep valley, recharge area |
| Volcanic foot | Undulating | Pyroclastic, sand | Volcanic, mass movement, erosion | Gentle slope, dry land and rice field, settlement, springs belt, high potency of ground water and surface water |
| Volcanic foot plain | Flat to gentle | Sand and fluvial sediment | Erosion and deposition | Rice field and settlement dominant, springs, good ground water conditions |
| Fluvio volcanic foot plain | Flat | Fluvial deposits fluvial | Deposition and lateral erosion | Settlement dominant, rice field, good ground water condition, some time flooding |
| Lahar field | Undulating to rolling | Lahar deposits | Deposition and erosion | Rough surface, rocky and stoniness, dry land to bare land, sources for surficial material. |
| Lava field | Undulating to rolling | Lava deposits | Deposition, lava flow and lava collapsing | Rough surface, rocky and blocky; located in upstream, sources for constructional materials. |

The landform units characteristics in Table 1 can be used to estimate the natural resources potency. The variation of relief mountainous to flat can indicate rock types, distribution of surface water and ground water and geomorphic processes. Rock types of the landform units can be used: to estimate the ground water potency, to identify of construction material (surficial material) and their characteristics.

To simplify the discussion of the natural resources potency of the Merapi volcano, the landform units in the Table 1 are grouped into five units, namely: volcanic cone, volcanic slope, volcanic foot, volcanic foot plain and fluvio volcanic foot plain. The grouping of the landform unit is based on the slope morphometry, and in fact the slopes of the Merapi volcano relate to the characteristic of the material composition and the geomorphic processes. The characteristics of the five landform units are used to estimate the relative potency of the Merapi volcano's natural resources (Table 2).

**Table 2. Characteristics of the land, mining materials, water and land use resources of the Merapi volcano area**

| Landform unit | Area (ha) | Water resources (represented by annual precipitation in mm) | Land resources ( represent by land capability classes) | Mining material resources | Agricultural land use |
|---|---|---|---|---|---|
| Volcanic cone | 1.129 | 1.734 | VIII | Lava, pyroclastic | Bare land and shrubs |
| Volcanic slope | 9.464 | 1.406 | VI-VII | Lava, pyroclastic | Forest and dry land |
| Volcanic foot | 21.604 | 1.550 | III-IV-V | Lahar, stones, gravel and sand | Dry land, rice field and settlement |
| Volcanic foot plain | 74.658 | 1.186 | II-III | Sand and gravel | Rice field, settlement |
| Fluvio volcanic foot plain | 92.250 | 1.328 | I-II | Sand and fluvial deposits | Rice field, settlement |

Based on the Table 2 can be estimated the specific and the competitiveness of the natural resources in each landform unit. The volcanic cone unit generally has limiting natural resources, even though the precipitation is high but poor in water resources, because of the high porosity of the material and very steep slope. The volcanic cone is the main sources of constructional materials, due to the steep slope the material can not exploit directly, but by natural processes the material moving down by lahar flow or lava collapsing. In any time the constructional material increase by volcanic activities or mass movement processes.

Transition between the volcanic cone the volcanic slope is marked by break of slope from very steep slope into steep slope. The slope changes are followed by the material

composition and the geomorphic processes, as consequences of the changes a spring belt occur in this transition zone. The high precipitation and raising spring belt, the water resources potency in the volcanic slope are sufficiently to support biotic life. The volcanic slope covered by very huge pyroclatic materials; the materials can be managed for constructional materials.

The volcanic foot and the volcanic foot plain have high potency on land, water, constructional materials resources. Due to the gentle to flat slope, thick soil, and high available of water the volcanic foot and the volcanic foot plain unit have been used for agricultural land and settlement. Even though the units have high potency of constructional materials, the materials are at risk to exploit because the land have been cultivated or occupied for settlement.

The land capability classes in Table 2 can be used to evaluate the land resources for agricultural purposes. The landform units who have land capability on I-IV class are suitable for agricultural land; land capability on V-VI class are suitable for plantation; land capability on VII class are suitable for grass land and limiting productive forest; and land capability on VIII class for conservation forest.

**Population Aspects**

The population size, the population density and the spatial distribution of the population will be discussed. The number of population of nine districts and 93 sub-districts in the Merapi volcano area: 4.680.621 persons (2001's data). The population density per sub-district are divided into three classes:

1. First class : > 8697 persons/km$^2$ : high;
2. Second class : 8697 – 1557 persons/km$^2$: medium;
3. Third class : < 1557 persons/km$^2$ : low.

The population density data of the area are plotted in the administrative map become population density map (Figure 2). The sub-districts with first class population density: Ngemplak (Sleman district), most of the sub-districts in Yogyakarta and Surakarta municipality). The first class (high) of population density in the Merapi volcano area are located on volcanic foot and volcanic foot plain. The large parts of the volcanic foot plain have the second class (medium) of population density, in special case they have the first class because of the function and development of the area (such as urban or real estate area).

The third class (low) of population density are located on the volcanic foot and volcanic slope; while on the volcanic cone there is no settlement at all, beside poor in natural resources, very danger to volcanic disaster and prohibited by regulation.

**Natural Resources and Population Density**

The previous data on the natural resources characteristics, which used landform unit for the frame work for evaluation, and spatial data of population density can be used to discuss their relationship. Relatively the natural resources potency can be estimated trough relief, slope, material composition, land capability, water resources and land use data from Table 2.

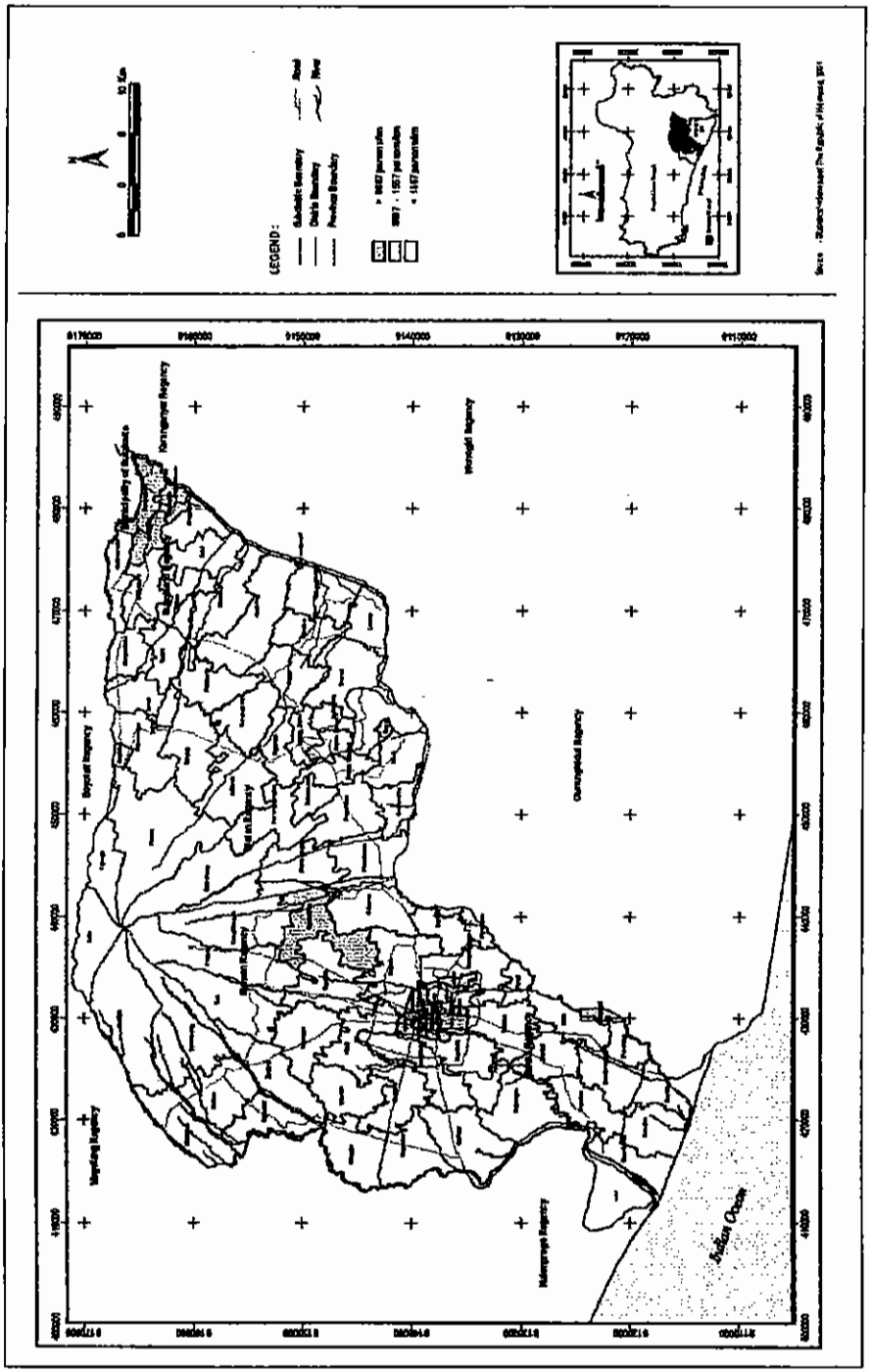


Figure 1. Landform Unit of the Merapi Volcano Area

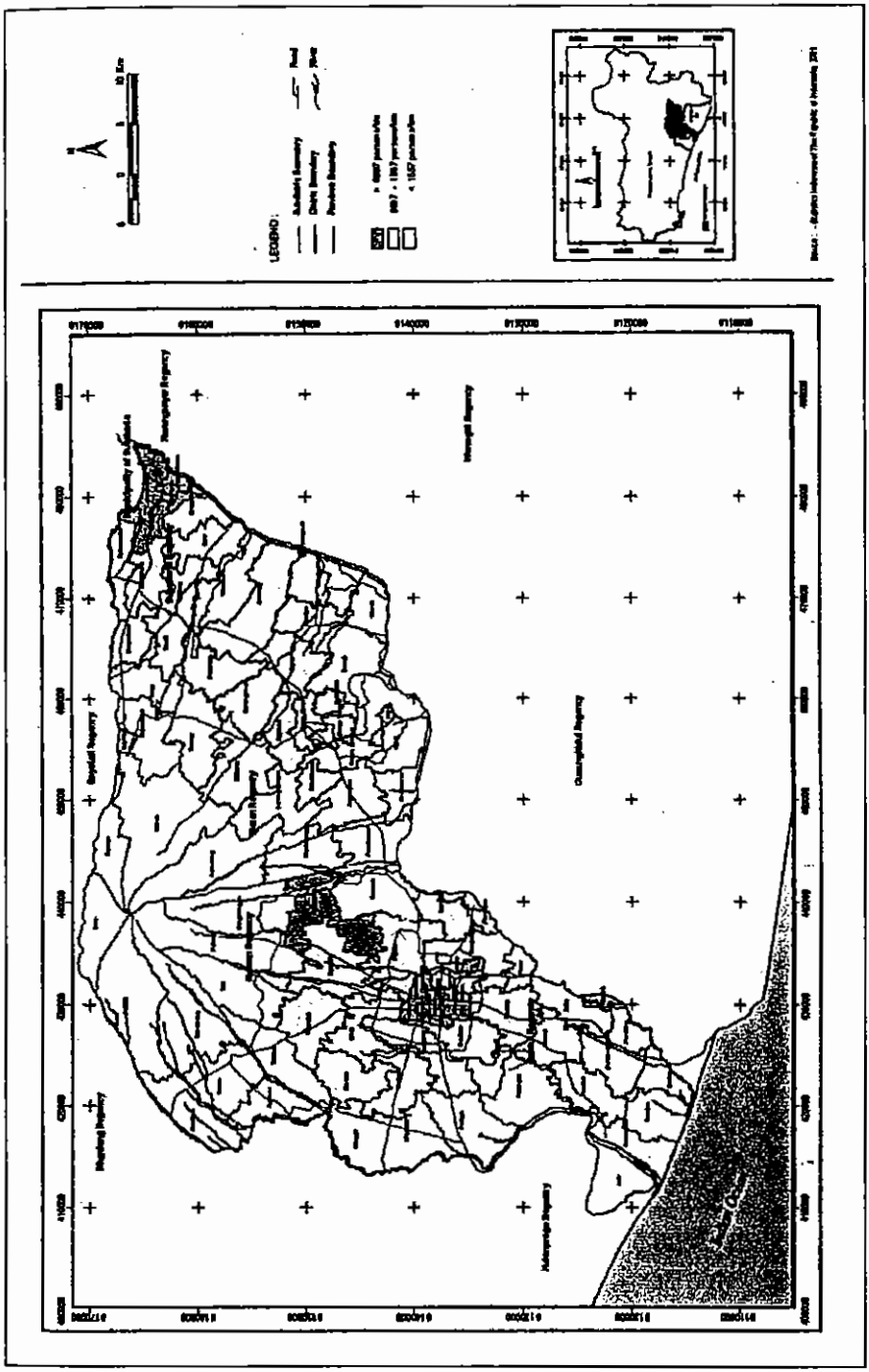

**Figure 2. Population Density of the Merapi Volcano Area**

The estimation of the relative natural resources potency is distinguished into three, namely: high, medium and low (Table 3). Synthezing of landform unit (Figure 1) and population density (Figure 2) will give idea to know interrelationship between the natural resources potency and the population density as summarised in Table 3.

**Table 3. The relative natural resources potency and the population density in the Merapi volcano area**

| Landform unit | Area (ha) | Relative natural resources potency | Population density class |
|---|---|---|---|
| Volcanic cone | 1.129 | Low | Low |
| Volcanic slope | 9.464 | Medium | Low – medium |
| Volcanic foot | 21.604 | Medium-high | Low – medium |
| Volcanic foot plain | 74.658 | High | Medium – high |
| Fluvio volcanic foot plain | 92.250 | High | Medium – high |

Interrelationship between the natural resources and the population density can be interpretive from Table 3. The low natural resources potency of the landform unit will coincide with the low population density. The such interrelation actually are very rough, highly generalization, and need detail bio-geophysics data to refine the result. The water resources are based only on the annual precipitation, even are located in a landform unit will have very dusting the available of the water resources, as example landform unit that is located in the rainfall shadow will have poor water resources. The volcanic foot plain and the fluvial volcanic foot plain have high potency in natural resources, and high population density. It means that the natural resources potency act as withdrawal forces for human life.

## CONCLUSION

1) Spatially the natural resources in the Merapi volcano varies according to the landform unit, each landform unit posses specific and competitiveness of natural resources; factors to determine the relative potency on natural resources are relief, slope, material composition, geomorphic processes and precipitation. All the factors are also to be considered as site selection for human activities.

2) The high population density in the Merapi volcano mostly are located on volcanic foot plain and fluvio-volcanic foot plain; it means the availability of the natural resources in the landform units have real interrelationship to the population density, highly and completely of the natural resources in the landform units will have high population density.

3) The highly populated density not only depended on the availability of the natural resources in the landform unit, but function and level of the development program are also have a great influences.

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