ANALYSIS OF POPULATION DENSITY DISTRIBUTION WITH IMAGE SATELLITE

Ketut Wikantika[1,2], Farid M. Rahman.[1], Andri Hernandi[2], Hadi, F.[1,2]

[1]Expertise Group on Remote Sensing and Geographical Information Science
[2]Center for Remote Sensing
Faculty of Civil Engineering and Environment, Institut Teknologi Bandung
Jl. Ganesha 10 Bandung (40132), Indonesia
Telp. 022-2530701 Ext. 3644, Fax. 022-2530702
Email : ketut@gd.itb.ac.id

ABSTRACT

Current demographic data from Badan Pusat Statistik (BPS) is only calculated and displayed based on administrative boundary without knowing the actual density. This make the derived information is not complete, tend to be homogenuous and is not represent the real facts. In the regional planning, demographic aspect is one of the most important aspect because planning is basically for and by the citizen itself. Remote sensing technology currently provide alternative solution on the problem of time-series spatial data. The excellence of remote sensing which can provide continuous data can be utilized to study population distribution on certain area. This research studies the role of remote sensing to analyze the population distribution in several villages in Bandung with Quickbird satellite images. The method in this research is land use density according to least square principles. The output of this method is a new thematic map which describe population density distribution on a more informative map and have the ability to represent the actual condition.

Keywords: distribution, population density, *land use density*, least square principles

1. INTRODUCTION

Data on current population density from Badan Pusat Statistik (BPS) is only calculated and displayed based on administration area. Due to this condition, the information is not complete, tend to be homogeneous and visually not represent the real condition. While in the planning of an area or city, demographic aspect is one of the important components because planning is designed for and by the citizen itself.

Every steps taken by the government during the development process is basically to improve the citizen's wealthiness. Information on population density is one of the most important data in the regional planning. Due to this reason, there is a need to search for new techniques that produce information with a better quality.

This research utilize a high spatial resolution imagery, Quickbird, to analyze population density distribution in several villages in Bandung. Land use density method with least square principle was chosen as the research method (Min et al., 2002).

2. DATA AND STUDY AREA

Data used in this study consists of Quickbird satellite imagery acquired on August 2003, GPS point that were taken in 2004, administrative boundary with 1:25.000 scale from topographic map and Bandung statistical data of the year 2003. Six villages chosen as study case are Cipedes, Sukabungah, Pasteur, Cipaganti, Pajajaran and Pamoyanan. These six villages area assumed to represent several type of land in Bandung.

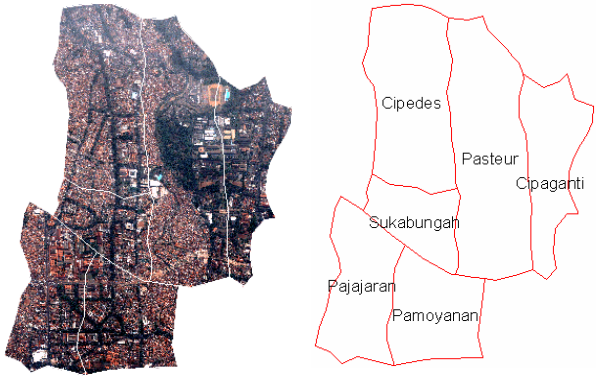

Figure 1. Quickbird satellite image (left) and village administration boundary (right)

3. METHODOLOGY

The research methodology consists of several steps:

a. Reference study, covers study on fundamental theories and methods which will be used to analyze population density distribution with satellite images.
b. Secondary data collection.
c. Data processing which includes image geometric correction, population density calculation, digitization and result displays.
d. Research analysis and publication.

Validation step is carried out by taking picture on each habitation during the field check.

4. *LAND USE DENSITY METHOD*

In this method, population density assessment is obtained from land use type. The approach method is the presentation of population density represented by the different land use type, especially land habitation type. Mathematics model which is used as the approach (Min et al., 2002)

$$\boldsymbol{P} \sum_{i=1}^{n} (A_i D_i) \quad (1)$$

where:
P = total population
A_i = size area on each landuse type
D_i = population density on each landuse type

The land use type is obtained from different of population density. The flow of this method is: first, the inhabitation and the non-inhabitation is distinguished with remote sensing imagery. Every kind of inhabitation type is distinguished in inhabitation area. The boundary of every kind of inhabitation is measured. The area of every kind of inhabitation type multiplying corresponding population density from sample is the estimation population of every kind of inhabitation type. The total sum of every kind of inhabitation type is the total population in study area.

The excellence of the land use density method is it's idea and calculation is simple; the disadvantage of the method is that the selection of sampled region is much more difficult. Is there method the population density of every habitation type is estimated but the sampled region need not be selected. In some region, there is mathematical relation among the The advantage of this method is the relatively easy calculation process, while the difficult are in choosing the sample area and whether those areas will memenuhi population density formula or not.

Further description on this method is shown in the next paragraph below. Suppose there are j regions which the population is known, j = 1,2,...,m. The population sum of every regions is P_j. There are i kinds of habitation types, i = 1,2,..,n. The population density of every habitation type is D_i, then

$$\boldsymbol{P_j} \quad \sum_{i=1}^{n} (A_{ji} D_i)$$

When several villages in the study area were sampled, the above formula is became to :

$$\begin{aligned} P_1 &= A_{11}D_1 + A_{12}D_2 + \ldots + A_{1n}D_n \\ P_2 &= A_{21}D_1 + A_{22}D_2 + \ldots + A_{2n}D_n \\ P_m &= A_{m1}D_1 + A_{m2}D_2 + \ldots + A_{mn}D_n \end{aligned} \quad (3)$$

After those equation are rearranged in matrix type is like below :

$$P = A.D \quad (4)$$

where :

$$P = \begin{bmatrix} P_1 \\ P_2 \\ \dots \\ P_m \end{bmatrix} \qquad A = \begin{pmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & & & \\ a_{m1} & a_{m2} & \dots & a_{mn} \end{pmatrix}$$

$$D = \begin{bmatrix} D_1 \\ D_2 \\ \dots \\ D_m \end{bmatrix} \qquad (5)$$

When m > n, that is, the region count known population is more than habitation type count. The least square principle is used to calculate the best population density estimation of every kind of habitation which the errors of statistical population is least.

$$D = [A^T A]^{-1} . A^T P \qquad (6)$$

5. HABITATION DEFINITION

According to the WordNet which was released by Princeton University in 2001, the word habitation has three definition, (1) the native habitat or home of an animal or plant , (2) housing that someone is living in, (3) the act of dwelling in or living permanently in a place (said of both animals and men).

Indonesia uses none of these definition for classifying its human habitations. This result in no standard classification for human habitations. While in land use method, this definition is one of the needed parameter to assess the population density. As an example, China classifies its human habitation to several types such as high building, multilayer building, simple building and compositive building. The high building indicates a building with more than 7 layers. The multilayer building indicates a building with from 3 to 6 layers. The simple building indicate a building with less than 3 layers. The compositive building indicate a building which used for business and habitation.

Based on the definition above, the way to overcome this problem is to make some assumption which is relevant to the definition and to the study area. The assumptions which were chosen are:

a) Habitation is defined only to those building used as a place for permanent stays.
b) The building is not design for a work place
c) The building is not design for temporary stay such as hotels, motels and etc.
d) The building is not design to educate people

After the habitation type is defined, the next step is to carried out interpretation of satellite image. In this research, habitation is only divided into structured habitation and unstructured habitation.

6. RESULTS AND DISCUSSION

RGB composite Quickbird satellite image was used in this study. This image was firstly geometrically corrected with 9 GCPs that were distributed evenly in the study area. The accuracy of GCPs distribution was checked by independent check points (ICP). The value of RSME from ICP shows a value of 0,5 pixel. The datum that was used in the process of rectification is WGS 84 with map projection South UTM 48. Tranformation method that was used is first degree polynomial transformation with nearest neighbor as the interpolation method.

After the data on size area of each habitation and population are obtained, the next step is the data calculation with mathematic model to assess population density. The data which will be used in this calculation is shown in Table 1.

To make the process easier and to fit the concepts of population density calculation with the chosen mathematics model, the data in Table 1 is rearranged in matrix.

Tabel 1. Data for calculation of population density

No.	Village	Area (Km2)	Habitation type	Area (Km2)	Population (P)
1	Cipaganti	0,040357548	Structured habitation	0,040357548	11664
			Unstructured habitation	0	
2	Cipedes	0,593817838	Structured habitation	0,152017917	23698
			Unstructured habitation	0,441799921	
3	Pajajaran	0,298752457	Structured habitation	0,185674304	22242
			Unstructured habitation	0,113078152	
4	Pamoyanan	0,358116354	Structured habitation	0,167232574	9309
			Unstructured habitation	0,19088378	
5	Pasteur	0,663372739	Structured habitation	0,05785	19723
			Unstructured habitation	0,60552113	
6	Sukabungah	0,382620902	Structured habitation	0,125909076	25058
			Unstructured habitation	0,256711826	
Jumlah Total		2,337037838			111694

The calculation shows that the number of population density for structured habitation is approximately 89586 people / km2, while for unstructured habitation is about 24146 people/km2. By seeing these numbers, population density for structured habitation has higher number. This is not because of the wrong data or calculation but arise as the result of calculation from least square principle. This analysis is reasonable because when the calculation is retaken in the reverse direction by using D value on the mathematical model, the total value of P and total value of Pc is nearly the same, 111.694 and 104138, 3155 people. The difference is about 7556 people or about 6,8 % from statistical data.

The foundations of population density assessment with this method is the dividing of each administrative region into several habitatation types. After that, each habitation on every administration region is further classified and united into one tipe of habitation. The number of habitation will influence the detail of information that we will have. The more class of habitation, the more class of population density that will be derived and this will result in the better quality of population density information.

By using this method, we can provide a new presentation model to describe the population density distribution. The population density is visualized not just by translating numeric data into administrative boundary but also visualized by its density on each administrative region.

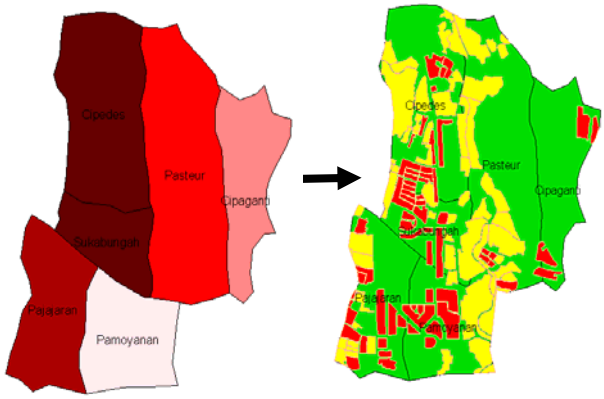

Figure 2. Conversion of
presentation model on population density

The difference between the use of previous way and this model in describing population density information is that by using land use density method the presentation is more representing the real condition.

7. CONCLUSIONS

Based on the result and analysis, there are several conclusions :

a. The population density method with land use density can not be used on low spatial resolution satellite image due to the need of detail classification process.

b. The information on population density that will be gained by this method is depended on the number of habitation classes. There is no standard habitat classification in Indonesia, so the application of this method is difficult.

c. Satellite image can be applied in the social mapping research as a data resource to calculate and to present information on condition and social characteristic of certain region.

RECOMMENDATION

There is a need to make a standard habitation classification in Indonesia. If this classification exist, it will be easier to define the type of human settlement from satellite images.

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