
PROCEEDINGS
ACRS 2018
THE 39TH
ASIAN CONFERENCE
ON REMOTE SENSING
KUALA LUMPUR
"REMOTE SENSING
ENABLING PROSPERITY"
15 - 19 Oktober 2018
Renaissance Kuala Lumpur Hotel

DASYMETRIC MAPPING METHODS FOR IMPROVING DENSITY POPULATION IN BAC TU LIEM DISTRICT

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Abstract: Usually, demographic statistics data is represented by a choropleth map or dot map. This type of representation has several limitations, in an administrative boundary the population is the same. Dasymetric method overcomes this disadvantage. The article mentions application of dasymetric mapping method to redistribute the block-group populations into a 30m grid, integrating land use, extracted from remote sensing data and census data in 2017.

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1. INTRODUCTION

Census data are usually provided by the number of totals at different scales following administrative units, almost in the form of tables. To display the spatial distribution population can easily be done using thematic mapping techniques with most of GIS packages. Thematic maps are also called choropleth maps, dots map,... Although useful and widely used, the resulting map has major limitations: (1) The choropleth map gives the impression that the population is homogenously distributed within each administrative boundary. (2) In case of dot map is displayed on the map, false impression that the distribution is the same in represented area is perceived; locating dots on map is to the certain extent a personal and subjective decision and two dot maps done by two people using the same data will rarely be identical; construction of dot maps involves tedious calculation especially when determining number of dots.

In really, population is related to other information, e.g., land use and transportation networks, housing units, that can be used to assist population interpolation. The supposition is that the above data can be integrated with census data to establish a population distribution map more accurate, the dasymetric method is the most well-known method in this category [3]. Dasymetric mapping was performed to capture the spatial variation in population density and population density change. The easiest dasymetric mapping approach with remote sensing derived land use data is a binary division approach in which land use is classified to “habitant” and “non-habitant” and census populations are simply redistributed to those populated areas [5]. The main advantage of this technique is that features such as lakes, rivers, agriculture and inhabited lands are excluded from interpolation, providing a more accurate representation of

population distribution. An improved form of this technique is multi-level technique [5]. This technique is based on land use maps classified from remote sensing images. Weighted factors are assigned to each class according to its specific population density. The weighting information assigned to each this classes is required to use prior knowledge or get expert advice. The redistribution of population from source zones (i.e., census boundaries) to target zones (i.e., populated land-use) is known as areal interpolation. Areal interpolation functions are said to preserve the pycnophylactic property (i.e., volume preserving) in that "no data is lost or created during the transformation" by using pixels as the areal units rather than administrative boundary vector, the raster shows a continuous and variable surface [2], [5].

The objective of this paper is to application of dasymetric mapping method to redistribute the block-group populations into a 30m grid, integrating land use, extracted from remote sensing data and census data in 2017.

2. AREA STUDY

Bac Tu Liem District is located along the western gateway of Hanoi, the southern bank of the Red River, which is relatively flat and fertile, with many rivers and lakes flowing (figure 1). The terrain is inclined in the direction of North West - South East, average height of 6.0m - 6.5m. The population is 320,414 people, with a density of 7,381 people / km², which is relatively high compared to the average density of Hanoi (2,279 people / km²). Population is concentrated mainly along the roads, cultural and political centres in districts and wards. The population density in the county's wards is uneven, with high population density in the east, south and decreasing in the west of the county. Highly populated wards are Co Nhue 1, 2, Xuan Dinh, Phu Dien, Phuc Dien, and low population densities, including Thuong Cat, Lien Mac and Thuy Phuong. Natural birth rate (births, deaths) 1.07% (in 2017), increased by mechanical movements in 2017 is 0.33% (transferred 2.45%, to 2.79%).

Bac Tu Liem is also a new district of Hanoi, is in the process of adjusting urban planning and renovation should make the management of the population still face many difficulties. In the district, the management of the population is very complex (many enterprises, companies are established, people from other places are concentrated, more and more inns are growing). If this problem is not resolved well, it will have a great impact on the socio-economic development of the locality, so the establishment of a population map is very necessary, creating conditions for the management as well as residential planning on the territory is more favourable.

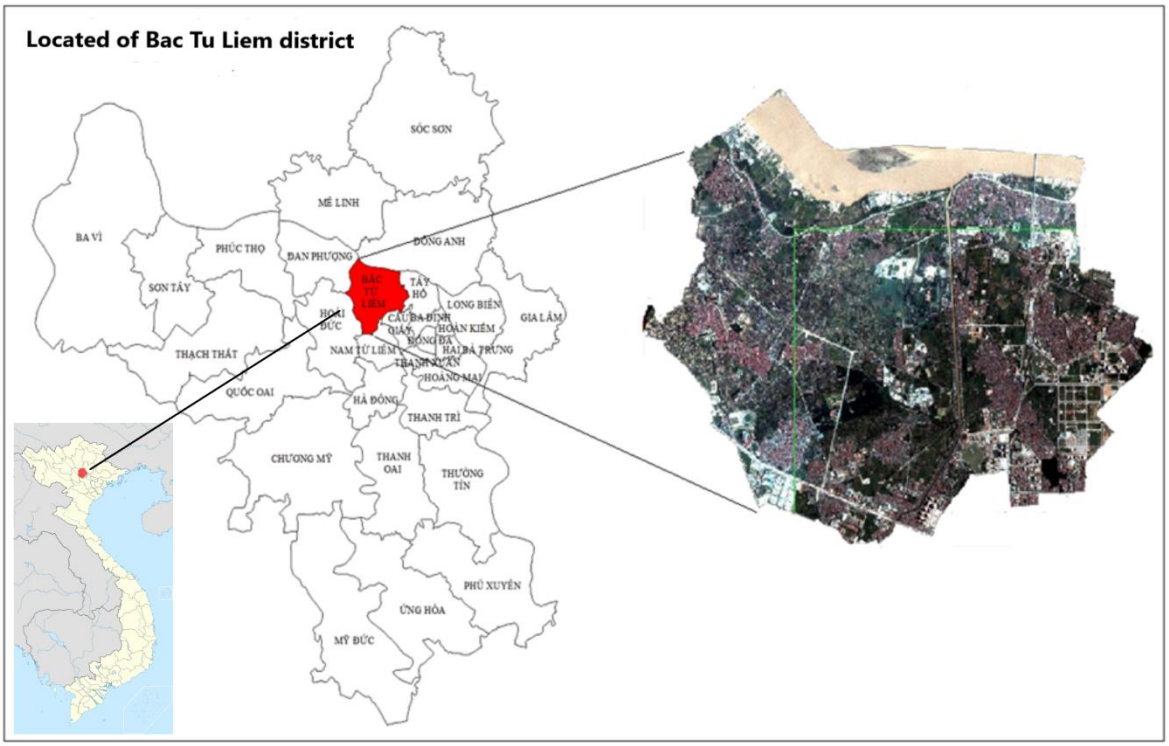

Figure 1: Location of the study area

3. DATA AND METHODES

3.1. Preparing the data

- Average census data of each wards in the Bac Tu Liem District, which is reported annually to the Population and Family Planning Center.

- Land use map of Bac Tu Liem established in 2015 from land inventory data in 2010.

- The Planet satellite imagery from Planet company, based in San Francisco, California (USA), provided by the cooperation program between Ministry of Science and Technology Vietnam and Planet Company to gain access to image data via 3 different access accounts, each account has 10 positions, support time is 30 days per account. The image acquired on 01/2017 have 3m/pixel resolution, in two scenes, was used to establish land use map in 2017.

- In addition, the topographic map in 1: 10 000 scale was updated in 2015 by the Mapping Company Limited (Department of Defence), used to establishment of geographic basis for thematic maps and reference for classification image.

3.2. Method

Langford et al. (1991) first applied multivariable regression techniques to estimate dasymetric subzone population densities, is based on the following function [1]:

$$Pi = \Sigma Pij = \Sigma Aij * Dj, (1)$$

where Pi is the total population of source zone i; Pij is the total population of land use j within source zone i (subzone ij); Aij is the total area of land use j within source zone i; and Dj is the average population density of land use j. Aij can be obtained by a GIS overlay operation of a land use map and a source zone map.

Despite the ease of implementation, dasymetric methods still suffer from the problem of a distributed assumption even in sub-areas. In other words, differences in same subzones are ignored. In order to reduce this problem, a more detailed land use classification can be made and a combination of land use types and population densities can be used effectively.

The dasymetric method is essentially divided into three steps [4]:

(1). Division of Territories into subzones with population densities homogeneous (based on ancillary data: remote sensing images / current land use maps / cadastral maps, etc.).

(2) Area interpolation is done to transform statistical data from an administrative unit into a map. This interpolation is calculated by the auxiliary data using the simple weight of the formula:

$$Pop(i,j)[D] = a_D * pw(i,j) \qquad (2)$$

Where Pop(i,j)[D] is the number of estimated people located within the area of pixel (i,j);

a_D is a constant computed for the whole district, shown in formula (3)

pw(i,j) is the weight of the current pixel.

$$a_D = \frac{Pop[D]}{\Sigma\{pw(i,j)\}} \qquad (3)$$

Where Pop[D] is the total estimated population value over the test area. In other words, the constant a_D is calculated by dividing the estimated population over the total weight in the region, the output constant a_D representing how many people in each weighted pixel.

(3) Data integration: testing is done at scale that allows for interpolation (derived from population statistics) to be compared to listed values (word syntax group of data). The use of this data allows for statistical evaluation, visualization of result maps and identification of errors.

4. RESULTS

This study using the ArcGIS dasymetric Mapping Tool developed by the U.S. Geological Survey, the population density was mapped according to the reclassified and slightly aggregated land cover types. The data were redistributed based on a combination of areal weighting and the relative densities of ancillary classes (the different land cover categories).

4.1. Land use mapping from images satellite

The land use status map serves as an important supplementary data to accurately divide the place of residence, due to the obtained data is land-use map date 2015 and image from Planet satellite 2017, so the changing areas were selected both by using the digital land use map covering and also by visually inspecting Planet images (figure 2), final check-in in terrain was needed to improve the quality of the new land-use (2017). After aggregate the data was imported into ArcMap and converted to an Esri grid file (figure 3).

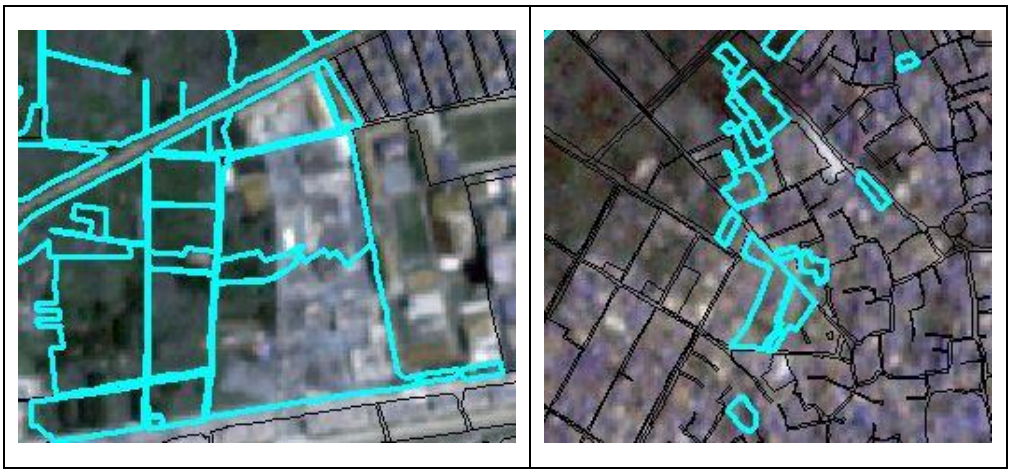

Figure 2: Update some changes of soil types on land-use map 2015 in comparison with Planet satellite images.

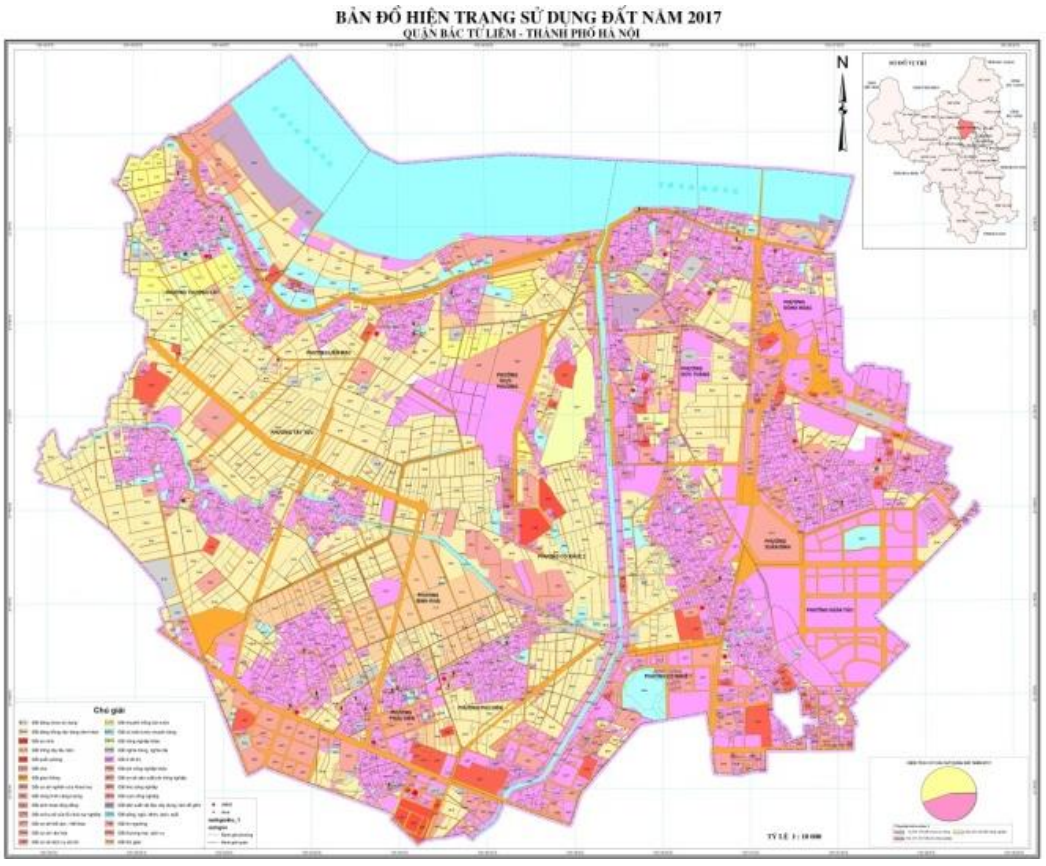

Figure 3: Land-use map of Bac Tu Liem district in 2017

4.2. Weighting of Land-use

Combine to the land use types according to land codes in suitable group for the establishment of population distribution, the groups are divided into: (1) high population density; (2) medium population density; (3) groups of cultural, educational, hospital; (4) national defence and security groups; (5) group of trade centres; (6) groups of plants and (7) water surface, transportation, ...

The calculation of the weight for 6 classes (ignoring classes determined to be uninhabited by water, etc.) using the Analytic Hierachy Process (AHP) via interviews the expert of geography and Population and Family Planning Center's in Tu Liem Bac District to build a matrix of expert opinion, calculate and check the consistent ratio to the permitted threshold (CR<0,1), the weights are as follows:

Table 1: Weighting of land-use

Group	Weight
high population density	0.47
medium population density	0.25
group of trade centres	0.14
groups of cultural, educational, hospital	0.07
national defence and security groups	0.04
groups of plants	0.03

4.3. Population map

Population distribution map of Bac Tu Liem district uses spatial analysis tools in ArcGIS to implement. The resolution of the pixel is 30m, in line with the scale of the selected map is 1: 20000, ensure the pixel read on the map when printing. The map is interpolated based on the population statistics of each ward unit and is broken down into groups of land use classes that have been grouped in the attached weighting (Table 1). The population distribution map enhances the ability to representation spatial of census data, these habitant pixels are also distinguished by the density and intensity of color shown interleaving next to zero-pixel populations where they are thought to be uninhabited (land, water, and land). use).

To evaluate the results, a statistical value of small independent urban cluster in Lien Mac and Xuan Dinh wards was compared with the statistic on the map (as a result of sum all pixels with each sub-statistic). Correlation coefficients were 0.64 (in Lien Mac) and 0.71 (in Xuan Dinh), respectively, which revealed high density population for higher accuracy in rural areas with lower density (possibly due to the bias among assigned class groups). The map is more intuitive and reflects the population distribution more accurately than the choropleth, dots map methods.

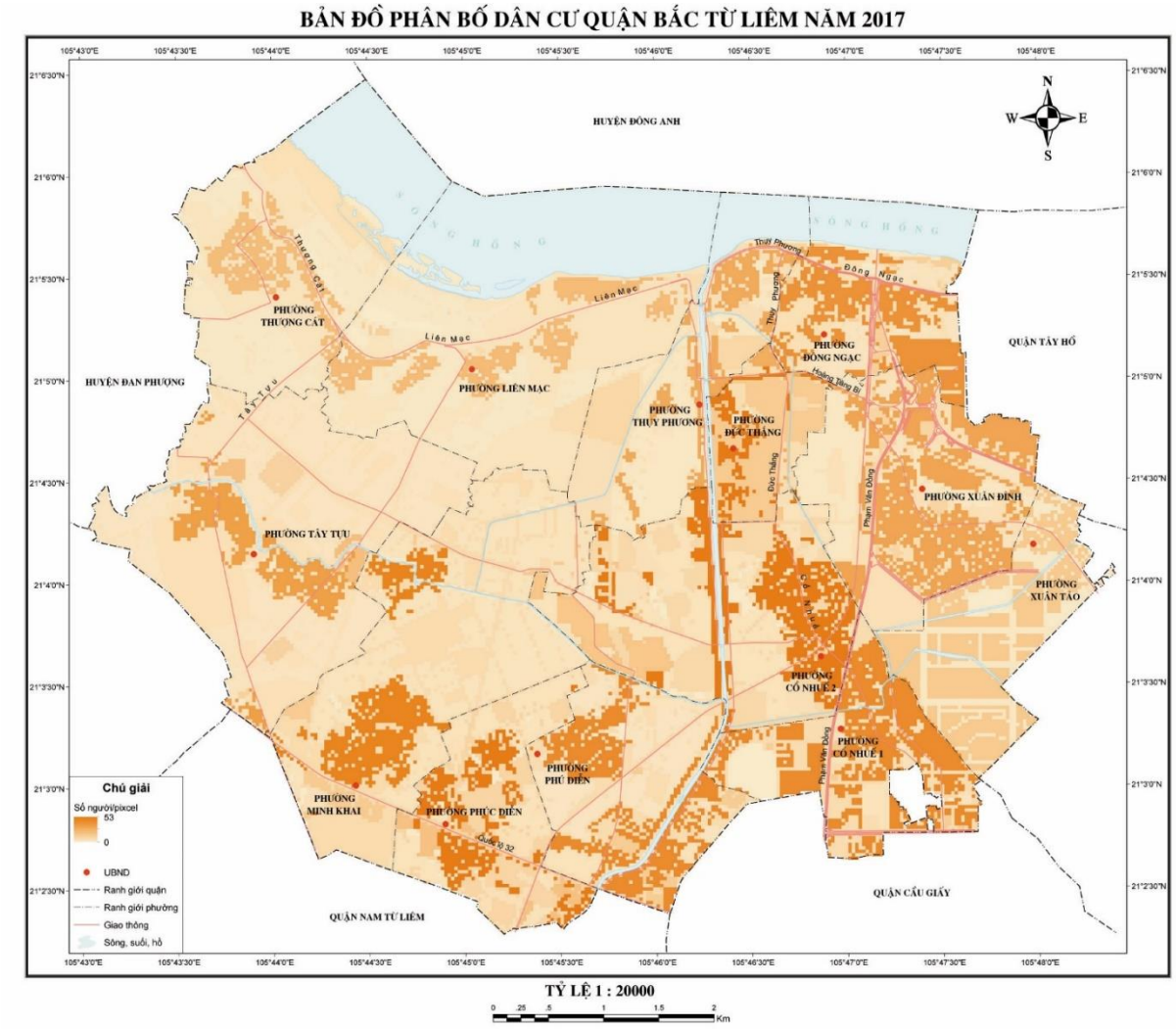

Figure 4: Population distribution map in Bac Tu Liem in 2017

5. CONCLUSIONS

Dasymetric method uses a combination of population census data and land use maps extracted from remote sensing to create a population distribution map for visual results that accurately and accurately reflects. The distribution of the population is also good in terms of population density and the relationship between population and socio-economic factors.

Using hierarchical (AHP) and dasymetric method to establish a population distribution map has limited the disadvantage of demonstrating the traditional population distribution methods, but on the other hand it has all the advantages in modern maps like the convenience of updating, editing input data sources, archiving, querying and displaying thematic information are shown on the map.

The accuracy and visibility of the method depend greatly on census data and the separation of land use into groups that are homogeneous in terms of the number of people living there, so

further research is needed. The scientific and experimental of this method is applicated well for the practical problems related to population distribution.

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