URBAN MORPHOLOGY ANALYSIS FOR THE TRENDS OF URBAN FUNCTION IN HOCHIMINH CITY, VIETNAM

[1] Le Thanh Hoa, [2] Michael Schmidt and [3] Nguyen Thi Phuong Chau [4]Le Chi Lam

[1, 3, 4] Faculty of Geography, University of Social Sciences and Humanities, Hochiminh city
10-12Dinh Tien Hoang St., Dist. 1, HCMC
Email: lthoageodept@yahoo.com; ngtpchau@yahoo.com; lechilam@gmail.com
[2] Department of Environmental Planning, Brandenburg University of Technology-Germany

ABSTRACT

The big city as Hochiminh City has many problems with population control, urban management and planning. Rapid urbanization has caused the rapid increase of built-up area with disorder of urban typologies and instability of urban-peripheral relationship. This paper discusses on the spatial development of typological process in the urbanizing City by using urban morphology analysis and fractal analysis base on remote sensing and GIS technique. The land-use map and the built-up-types map with GeoEye images of 2010 are used to identify the distribution of urban function areas.

The relationship between population, housing and urban areas is the based results to calculate fractal geometry and is used to forecast a developing direction. The analysis method for this quantitative result includes morphology analysis and spatial urban pattern analysis based on land-use and housing structures. The fractal analysis is from GIS database on City population, land-use and housing. Urban morphology in this study is to describe the City's sites such as urban built-up, non built-up, residential, non-residential, peripheral, rural areas.

The available developmental radius of built-up area in urban-peripheral model would show the rational distribution and density of urban function areas in the City. In the inelastic urban land, the increasing of built-up area makes the peripheral area narrower along with disappear of green space and open space. And the mass distribution of built-up area shows the irrational expanse of urban center. This research supports to analyze the current spatial development in Hochiminh City. And it also supports for urban planning to the stable "urban-peripheral model" of the City.

Key words: Urban morphology analysis, fractal analysis, dynamic interchange of housing types, urban function, urban-peripheral region.

1. INTRODUCTION

According to Dickinson (1968), urban Morphology is concerned with plan and built form of the habitat, viewed and interpreted in terms of its origin, growth and function. The study of urban morphology is crucial for urban planning and urbanization process in the developing countries. Analyzing urban morphology is a variable in the investigation which identifies the urban pattern, urban form and urban space components, like the trends of urban function between forms and shape.

Rapid urbanization in the high-population-growth of Hochiminh City (HCMC) has caused the problems with incomplete planning and loosing in urban management. These cause the mass of housing and disorder of urban function areas.

This research aims to analyze the urban morphology. And it also supports to identify the distribution and the current spatial development of urban function areas of the City.

2. DATA AND METHOD

2.1. Data

- Using GeoEye 2010 combine with cadastral map 1/5000 scale (Source: HCMC DoNRE) to interpret and classify the built-up map
- Using Land-use 2005 1/25000 scale (Source: HCMC DoNRE) combine with GeoEye image to interpret and update the land use map 2010
- Population census commune 2010 (Source: HCMC Statistical Office)

2.2. Method

To analyze the urban morphologies by fractal geometry based on the results of GeoEye image integration, land-use and population census, it is necessary to find the relationship between urban pattern and urban function. The relationships between population and built-up areas are the main results to calculate fractal geometry and identify the uneven changes of urban morphology. Using urban morphology tool in this study is to describe the City's sites such as urban built-up, non built-up, residential, non-residential, peripheral, rural areas.

An illustrated methodology is described in figure 1, which is interpreted from remotely sensed imagery and spatial analysis on GIS. This methodology consists of five steps: data collection from multiple sources, data processing such as image fusion and digitizing, temporal mapping, evaluation of spatial indicators and comparisons. The main quantitative analysis includes morphology analysis, spatial pattern analysis, land use structure and housing structure. Fractal geometry selected as analytical methods to describe spatial patterns in study area.

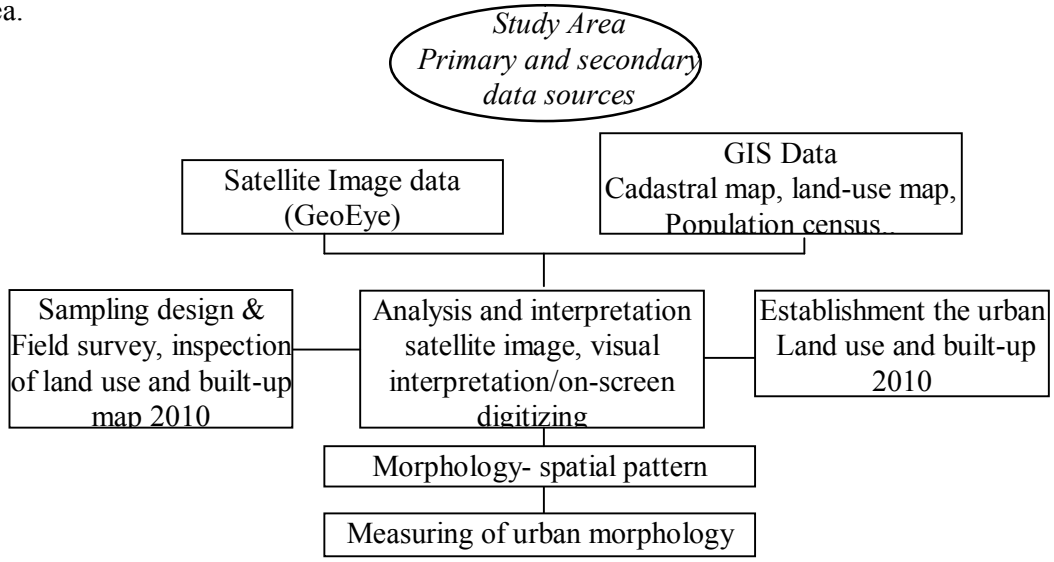

Figure 1: The general procedures in study area

2.2.1. Integration of satellite image process to update the housing, land use map

In this research, cadastral data, land-use data, and high spatial-resolution GeoEye images were used to assist the identification of training samples of different urban Land-use and built-up classes**.** After inputting into the ENVI program, GeoEye images was initially registered and ortho-rectified with projection UTM Zone 48, WGS-84 coordinates. The ground control points (GCPs) from a digital terrain model (DTM) is used to generate the base maps at 1:5000 scale. During preprocessing, the output pixel size was not changed and the

nearest neighbor algorithm was used for intensity resampling. The resulting image produces an output product that can be effectively utilized at scales of 1:5,000–1:25,000.

The interpretation keys of tone, texture, pattern, shape, size, shadow, location, GPS and 200 sampling survey in HCMC were carried out to achieve a general knowledge and covered initially 13 land-use types and 11 built-up types. This classification consists of marking the area boundaries of housing and land-use units by using the cadastral and land-use layer 2005. The on-screen digitizing is used to update attribute and spatiality of housing and land-use types 2010.

2.2.2. Morphology – spatial pattern analysis

To analysis the urban morphology is based on the raster, vector data structure of a GIS to generate graphical output such as thematic maps. Especially, micro-scale data and population census were used together for urban morphology detection. Overlay and variable analysis by using GIS technique help to identify the relationship between population and urban areas.

Analyzing the urban morphology from fractal was applied using mathematics described by Batty and Kim (1992). The fractal can be calculated by the following equation:

$$N(R) = GR^{D} \quad (1)$$

Where D is the fractal geometry measuring some the extent magnitude and N(*R)* denotes the density of occupied space at radius, *R*.

If urban areas of HCMC were subdivided into communes, fractal geometry could be calculated by using the following equation:

$$N(R) = kr^{D} \quad (2)$$

Using the natural log transforms: $D = \ln (N(R) / \ln (r)$ (3)

Where: N(R) refers the density of built-up space at radius of land-use block, and r is the expanding factor of the land-use transformation. D is the fractal dimension.

Population values of land-use block were calculated from census data at commune level. The general equation can be written as follows:

$$P_{bl} = P_{co} * U_{bl} / U_{co} \quad (4)$$

Where P_{bl} = population of land-use block; P_{co} = population communes; U_{bl} = area block areas of land-use; U_{co} = commune areas.

To estimate the residential population densities of land-use block based on the result of equation 4, it can be calculated as follows:

$$P_{RD} = P_{bl} / U_{R} \quad (5)$$

Where: P_{RD} = residential population densities; U_{R} = residential areas on land-use block (housing or footprint areas).

3. RESULTS AND DISCUSSION

3.1. Updating the built-up area and land-use map using GeoEye image

An on-screen-digitizing advance using the Envi 4.7 package was selected for visual interpretation, because the built-up and land-use areas were directly digitized from the images.

This was done by overlaying image on the built-up and land-use digital data in the map scales. The figure 2 showed the detail of land-use and built-up area updated from the GeoEye image 2010 in HCMC. The left side is original data (fig 2a). The right side is the result of visual interpretation and on-screen digitizing of land-use and built-up map.

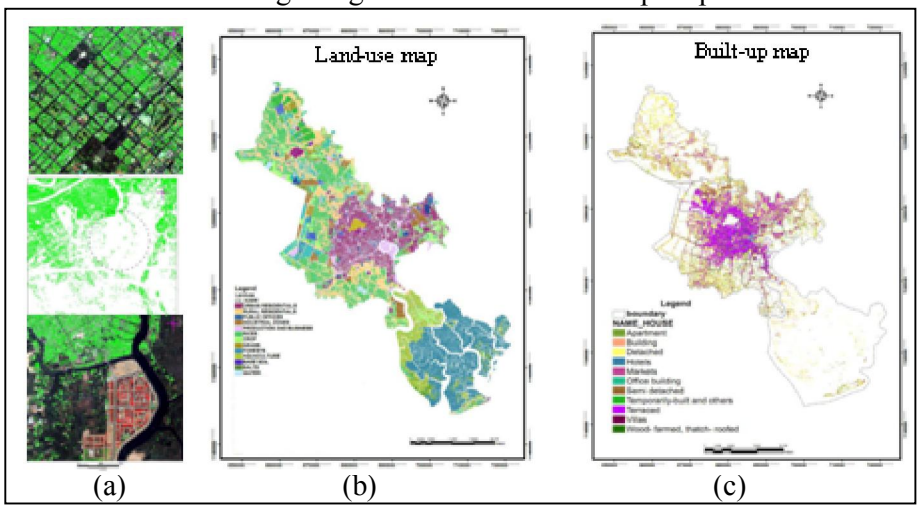

Figure 2: Integration results of land-use and built-up 2010 in HCMC

The results of spatial interpretation in table 1 and figure 2b showed the urban residential was the largest class, representing 22495.5 ha of the total land-use categories assigned, increasing 18.94% in comparison with land-use 2005. The rural residential area increases from the conversion of rice and crop classes (representing 34.47% of the change rate). On housing layer described in figure 2c, the terraced and detached houses were 89.36% of total housing in 2010. Most terraced houses are in the inert-districts (Districts of 1, 3, 7, 2…) and new urban (Binhchanh District, Binhtan District, Tanphu District, ...) While detached houses are mostly in the new Districts (Districts of 9, 12, Thuduc and Nhabe) with low density, or scattered in the old residential areas (Govap and Binhthanh Districts). The apartment has highest proportion from 2005 to 2010, mostly built in Districts of 4, 7, 11, Tanbinh, Thuduc, Binhtan, and Tanphu. During this time, there were 591 apartment buildings raised (more than 58.23 percent of total in comparison to 2005). And the built area for this typology was of course increased (about 47.68 percent in comparison to 2005). This type of housing trends to rise up rapidly in HCMC.

Table 1. Area in each land use and built-up of 2010 year

Class	Land-use types	Area (ha)	Built-up (housing) types	Area (ha)
1	Urban residential	22495.9	Apartment	166.41
2	Rural residential	10844.08	Building	28.17
3	Public office	1762.39	Detached	2872.45
4	Industry	4825.38	Semi detached	457.97
5	Production & business	10653.95	Temporarily-built and others	17.35
6	Rice	27364.85	Terraced	7154.27
7	Crop	37089.29	Villas	896.69
8	Grass	2339.31	Wood- framed, thatch- roofed	51.74
9	Forest	33032.09	**Commercial types**	
10	Aquaculture	12131.2	Markets	17.15
11	Bare soil	2189.29	Hotels	45.11
12	Salt	1327.59	Office building	130.92
13	Water	30310.05		

The Wood-framed and thatch-roofed housing typologies also trend to rise down, just - 5.03% of area. These types are easy to be seen in rural and Sub-districts and some in the low-income housing area in the inner Districts.

3.2. Fractal geometry application to analysis urban morphology

The morphology of HCM City urban was analyzed following principle from fractal geometry. Base on the equations of section 2.2.2. The table 2 and figure 3 showed the fractal geometry estimated 1.31 to 1.67 synonymous of urban expansion and high housing densities in inner city. The housing numbers in these zones are nearly the same. However, there is big difference of built-up densities among these three built-up zones A (inner city), B (urban-peripheral), and C (rural). Zone A has housing density three times higher than of zone B, and eight times higher than of zone C. But the built-up areas are in converse, the area of zone A is about three times less than zone B and eight times less than zone C. People living in the high density of housing zone A has to share smaller land urban services, otherwise, people living in larger housing area of zone C still have place for more open space and other urban services.

Fig 4 showed the population density on land-use block. HCMC is characterized by a heterogeneous structure between Districts center such as area of District 1 and other district centers. There are large differences between population densities and block areas. Some small blocks with more than 850 persons/ha were found like in District 4, 5, 6. Some high-rise buildings in large land-use blocks in District 7, 11, 10, Tan Phu and Binh Tan have high density with 450 to 600 persons/ha. The low density areas are mostly in rural with 5 to 70 persons/ha as in Cu Chi and Hoc Mon. Typical for urban peripheral is comparatively thinly populated settlements with 30-150 persons/ha as in Nha Be, Thu Duc and District 12 ... This is unreasonable with the urban density in HCMC because the principle of population density increases from the city edge to the inner city.

Table 2. Fractal geometry and housing density in HCMC 2010

Range	Zone	Area (ha)	No of housing	Housing density(ha)	LnArea	D
High	A	1721.22	260245	151	7.45	1.67
Medium	B	5413.64	268701	49	8.60	1.45
Low	C	14022.73	273131	19	9.55	1.31
Total		21157.59	802077			

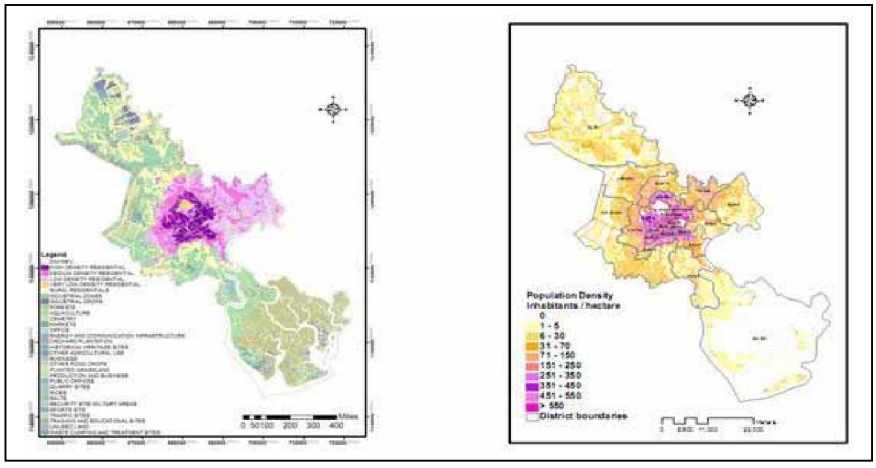

Figure 3: Built-up density on land-use **Figure 4: Population density on land-use block**

3.3. Conclusions

This paper analyses the urban morphology of the trends in the urban function areas of HCMC by high resolution data of GIS-RS and fractal geometry. The result of research shows the built-up area extended behind the northeastern and the southern parts of the City. In City center, the density is highest. Most inner Districts, house density is 50 to 61 percent of total areas. The highest density up to 81 percent is exclusively in the old Districts. In commercial District 1 and District 5, housing density is only 40 to 50 percent.

In conclusion, inner area has no more land for housing. The dynamic change in this area is just the changes from one housing type to other housing types. The open space trends to decrease for new-urban, such as Phu My Hung and Hiep Phuoc areas in District 7, Binh Trung Dong in District 2, Phu Huu in Distric 9, etc. The typical (main types) houses in this area are Terraced, Villa, and Apartment.

Fractal geometry analyzed from the micro-scale data in this research can identify the urban morphology, urban-function structures and their changes in small-scale results. It can find out the problems or uneven changes of City morphology in more details during the development process. These results can be used for City management and for City-strategies development.

4. REFERENCES

Batty, M.,and Kim, K., 1992. Form follows function: reformulation urban population density function. *Urban studies*, 29.

Batty M., Longley P., 1986. The fractal simulation of urban structure. *Environment and planning* A*,18*.

Burrough P.A. 1986. Principles of geographical information systems for land resources assessment, *Clarendon Press*, Oxford.

Conzen, M.R.G. 1968. The use of town plans in the study of urban history, *in Dyos, H.J. (ed.),* London.

Dickinson, R.E.1968. The town plans of East Anglia: a study in urban morphology. *Geography 19*.

Donnay, J.P., Barnsley, M.J. and Longley, P.A. 2001. Remote sensing and urban analysis. *Taylor & Francis*, London and New York.

Eastman J.R. 1999. Multi-criteria evaluation and GIS. *In Geographical Information Systems, volume 1: Principles and Technical issues, Longley P.A et al., John Wiley & Sons Inc*., New York.

Goodchild, M.F., and Longley, P.A., 1999. The future of GIS and spatial analysis*, In Geographical Information Systems: Principles, Techniques, Management and Applications. John Wiley*, New York.

Mandelbrot B. 1977. The fractal geometry of nature. *Freeman*, San Francisco.

Mesev, V. 1998. The use of census data in urban image classification. *Photogrammetric Engineering and Remote Sensing 64*.

Khoa, N. 2010. Urban Planning for HCMC - 2nd Essay: The Consideration and Preoccupation. *The Saigon Giaiphong News*, 28th March, 2010.

Langford, M. and Unwin, D. J. 1994. Generating and mapping population density surfaces within a geographical information system, *The Cartographic Journal*, 31.

Pacione. M, 2009. Urban geography. *Taylor & Francis*, London and New York.