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Understanding Satellite Image-Based Green Space Distribution for Setting Up Solutions on Effective Urban Environment Management †

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Abstract: Urban environments are vulnerable, as there is a change in the surface structure of the land cover. Particularly when natural vegetation cover is converted to construction land, which is covered by impervious surfaces, it increases the accumulation of solar energy. This has led to an increasingly urban environment that is becoming more severe and threatening to affect the quality of life in urban populations. Satellite images are very helpful in determining the distribution of green space. The paper presents the results of analyzing urban land cover for determining green space (GS) distribution for Ho Chi Minh City (HCMC). In 2017, the vegetation land of the old 13 urban districts accounts for only one third of the impervious surface. In contrast, in the area of 6 new urban districts there is a high percentage of urban green space, accounting for nearly twice the proportion of the impervious surface type. This shows that the old inner city area is seriously lacking GS area. Most districts have very low GS index, less than 10 m^2/person, some districts even less than 3 m^2/person. In the eastern part of the city, only District 9 has the highest GS index, and ensures a good life quality. Since then, the research has provided a number of management solutions to improve and develop the GS area, while enhancing the environment quality and the life quality for the population. The research results contribute to the effective urban management for HCMC.

Keywords: impervious surface; green space; satellite image; supervised classification; urban environment

1. Introduction

In the planning, GS is a very essential function and is considered as the lung of the city. It plays an important role in human life. However, the rapid increase in the area of impervious surface in urban areas, while significantly reducing the city's GS caused much negative impact on the quality of living environment. The expansion and increase in the density of the impermeable surface has the consequence of increasing the city's air temperature due to the thermal radiation of the concrete; increasing waste and the problem of landfill and waste disposal in high urban areas; increase flooding; Decrease in the quality and volume of groundwater due to loss of surface water absorption [1].

Ho Chi Minh City (HCMC) is the country's largest city in terms of size and economic potential as a nucleus, a driving force for socio-economic development in the south and south-central region.

However, at present, the policy of GS of HCMC has not been focused. Urban growth and government lack of necessary resources are the current weaknesses in the management and development of the quantity and quality of GS and street trees. In fact, in existing residential areas in urban districts, green systems and parks are in serious shortage. The rapid pace of urbanization in previously unplanned urban areas has spontaneously developed populations with dense populations, but lacking green spaces and public space. This leads to low quality of life and serious environmental pollution which causes many consequences for socio-economic development and affects people's life, health and morale.

This article presents the study on the status of urban distribution, using satellite data and remote sensing image processing methodology for assessment of urban environmental quality in the inner city, towards a green urban development planning in the future.

2. Methodology

2.1. Data and Image Pre-processing

The data used in this study are Sentinel-2A optical imagery, multi-spectral images with 13 spectral bands (443-2190 nm wavelengths), spatial resolution of 10 m (4 visible and near-visible bands), of 20 m (6 bands in short infrared wavelengths) and 60 m (3 bands in atmospheric study). Image was acquired on March 9, 2017 in the dry season, cloudiness in order to minimize the effects of atmospheric conditions.

Sentinel-2A is a type of satellite that provides "optical images" that are susceptible to weather conditions, especially in the rainy season, which is easily clouded by clouds. Therefore, the image should be selected in the dry season, without clouds, so that the satellite sensor can clearly see the surface. The research area is the center of HCMC, where urban areas are concentrated, with no agricultural land. In this area, where the population is crowded, the density of built-up land is high. Where the population is less, most of the land is green, provided with water from the natural small rivers inside the area. Existing bare lands are ones of construction works for new urban. Therefore, selecting the image in the dry season to assess GS for urban areas in this study may be sufficiently identifiable.

This study only extracts surface soil to evaluate urban green, so with good cloudless imagery, the atmospheric correction phase can be ignored. The images are manipulated geometrically according to the national coordinates VN2000, WGS84 datum. Image correction is less than 0.5 pixels.

2.2. Method

2.2.1. Supervised Classification

In order to evaluate the status of green distribution, the study conducted a classification algorithm with a supervised classification method in order to classify land surface entities. This is a classification method where taxonomies are established based on sampling regions, and use decision rules based on the appropriate algorithms for labeling pixels for specific coverage areas. In this research, the supervised classification method with MLC (Maximum Likelihood Classifier) has been used. This method considers each class in each spectrum channel to have a standard distribution. Pixels will be classified into the class that has the highest probability. The classification system employed in this case includes 4 main targets: water, bare land, vegetation and impervious surface. Urban and bare land are then classified into other land categories for comparison with vegetation land in the GS assessment.

Accuracy of classification is evaluated based on error matrix and norms such as overall accuracy and Kappa coefficient [2]. Overall accuracy is computed by the number of correctly classified pixels divided by the number of pixels used for classification. The high accuracy of commonly accepted classification is over 85%. Kappa coefficient (K) is used as a measure of the accuracy of image classification. It shows the basic difference between what is real about the error of

the deviation of the matrix and the total number of changes indicated by the row and column. The Kappa coefficient is usually between 0 and 1. The high accuracy of the accepted classification is commonly with K> 0.8.

2.2.2. Urban Green Space Index Assessment Method (per Capita)

Based on many researches which built urban environment quality index in Vietnam, the index "green area/capita" is an important index to evaluate environment quality and urban space [3]. This index is built to assess the quality of urban green coverage. The urban green space index (GSI) after calculation is compared with TCVN 9257:2012 [4] to evaluate the status of urban GS distribution.

3. Results and Discussion

3.1. Accuracy assessment of land cover classification

Verification points are made after classification across the study area. Each district picked up 10 samples of four types of targets in the classification system, based on the fieldwork and observed on very high resolution images of Google Earth. This field set was used to build the test set. On each target layer, the sample set ranges from 600-900 points. This sample was then compared with the classification image. The results of the classification error showed that the overall accuracy was 96.63% and the Kappa coefficient was 0.96. With this accuracy the result is reliable enough.

3.2. Distribution Status of GS

In terms of administrative units, 19 districts of HCMC consist of 13 old urban districts and 6 new urban districts. The statistical results of the area and the percentage of each land cover from the classification algorithm for 19 districts of HCMC are presented in Table 1 and Figure 1. Overall, by 2017, the vegetation type accounts for the largest proportion, with about 40.26% of the area across 19 districts. Next is the type of impermeable surface that approximates the vegetation cover with the rate of 38.68%. However, when comparing statistics between 13 old urban districts and 6 new urban districts, there is a big difference between the ratio of land cover. In particular, in the old inner city, the vegetation type only accounts for 22.62% while in the 6 new districts the area ratio is double and reached 47.39%; Contrary to the type of vegetation is the type of impervious surface, when in the six new districts this ratio only accounted for 28.79%, in the old inner city is twice as high as 63.19%. There is clearly a difference in urban development in these two areas. In general, the vegetation land of the old 13 districts in the inner city only accounts for one third of the impervious surface. In contrast, in the area of 6 new urban districts have a high percentage of urban GS area, which is almost twice in the percentage of the impervious surface type.

Table 1. Statistics of land cover by area percentage (%) of 19 districts in HCMC

Zone	Area percentage (%) to total area			
	Vegetation	**Water**	**Impervious surface**	**Bare land**
13 old urban districts	22.62	4.05	63.19	10.03
6 new urban districts	47.39	7.74	28.79	16.04
3 districts in eastern part	51.38	8.98	23.70	15.99
Whole study area	40.26	6.67	38.68	14.31

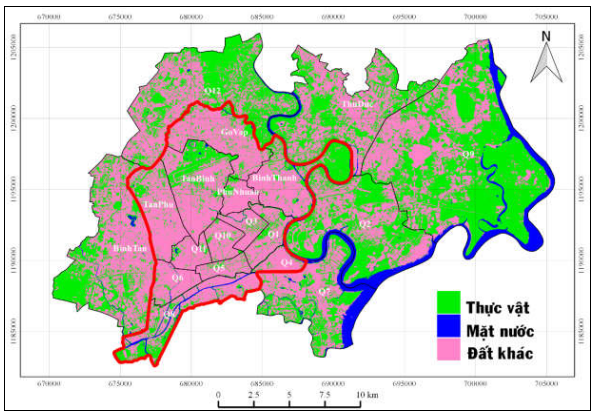

Figure 1. Land cover of 19 districts in HCMC in 2017 *(The red polyline is boundary of 13 old urban districts)*

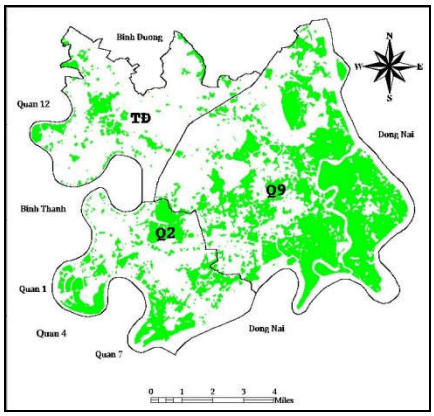

Figure 2. GS distribution of eastern part of HCMC in 2017

With focusing on the distribution of GSs, in the central metropolitan area of the city, the trees are sparse, scattered and mainly concentrated in parks. The rest is mostly built-up land. Meanwhile, the area of 6 new districts dominate the development of green areas, built-up land is not much. Specifically, in the area of 13 old urban districts, up to 8/13 districts own an area of impervious surface type occupying more than 70%. In contrast, only 3/13 districts pose an area of vegetation land about 30%, the rest has mostly about 10 - 20% of the total natural area. In the 6 new districts, most of the districts have a GS area of over 40%. In particular, 3 districts in the eastern part of the city has the largest area of vegetation, accounting for 51.38%, of which district 9 accounts for the highest rate of 57.87% in the whole study area (Figure 2).

3.3. Urban GSI and the consequences of reducing the greenary

3.3.1. The status of urban GSI in 2017

GSI has been used as an indicator of environmental quality and urban spatial planning in countries around the world. The Vietnam National standard TCVN 9257: 2012 provided that the standard rate for public green areas for special cities as HCMC ranges from 12 to 15 m^2/person [4]. According to Statistics Department, the population of the study area by the end of 2016 was 6,616,684, while the total natural area was 198,910,500 m^2. Calculated results show that the average GSI throughout the study area in the early 2017 reached about 30 m^2/person. Therefore, if considering the average for all 19 districts of HCMC, the urban GSI standard is exceeded. However, this figure is mainly due to the contribution of green area from the 6 new districts, with an index of 67.43 m^2/person, while in the old inner city GSI only 7.76 m^2/person.

The diagram in Figure 3 shows that 6 new urban districts have a total natural area of 166,763,100 m^2, five times larger than the old inner city but the population is small (2,473,179 people). So here GSI presents very high value with an average of 67.43 m^2/person. The highest GSI falls on District 9 with 227.01 m^2/person. The lowest GSI belongs to Binh Tan district with 28.46 m^2/person. Thus, all 6 new districts of HCMC have GSI value in excess of standard in TCVN 9257: 2012. Especially in the east of the city, there are 2 districts of 9 and 2 over standard of 10 times.

Meanwhile, 13 old urban districts with an area of 3,214.74 ha, but the population nearly doubled compared with 6 new districts (4,143,505 people), accounting for very low GSI, the average GSI of whole area reached only 7,76 m^2/person. Compared with the standard in TCVN 9257: 2012, only 3 of the 13 districts with an index of more than 12 m^2/person meet the specified threshold. In Tan Binh district, GSI has exceeded threshold, because of the green land of golf course at Tan Son Nhat airport, while in residential area, there is also a serious lack of green land [5]. Notably, there are districts with GSI less than 3 m^2/per person. The remaining districts ranged from 3-9 m^2/person. Thus, the area of 13 old urban districts of HCMC is lacking of green areas, not enough to ensure the

fresh environment necessary for life. While in the world, urban standards are encouraged for a healthy and safe life is to reach 20-25m²/person.

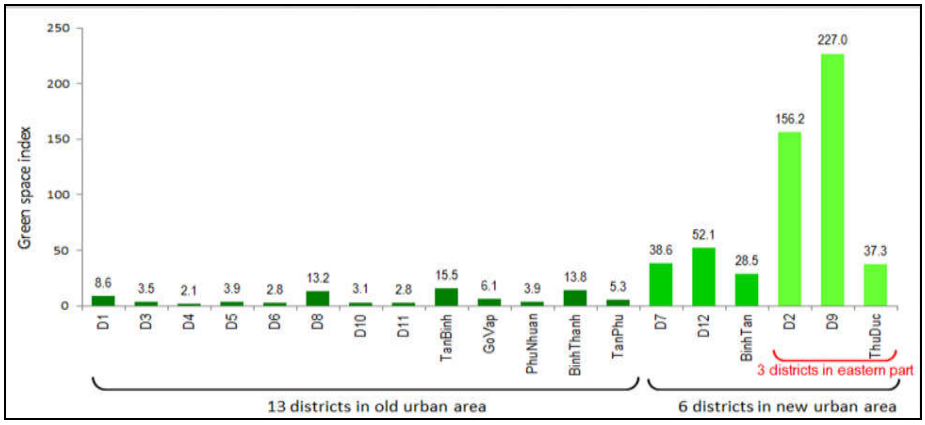

Figure 3. Status of GSI in each district in 2017

According to the Ministry of Natural Resources and Environment, urban trees play a very important role in bringing about the benefits to people, society and the environment in urban areas. Urban trees absorb the sun's heat radiation, reducing the "heat islands"; absorbing CO_2 and harmful gases in the environment, creating the GS to maintain the green landscape for the city. Trees and water in urban areas can reduce the air temperature from 3.3°C to 3.9°C when green land area reaches 20% to 50% of urban land area [6]. The combined effect of shade and evaporation can reduce the energy required for air conditioning systems by 17% to 57%, when increasing the vegetation cover by 25%. Urban trees can absorb from 40% to 50% of the solar radiation intensity. Especially, trees on both sides of the street can reduce the amount of dust in the air to the upper floors of tall buildings from 30 to 60%. An average of 1 hectare of forest or dense garden can absorb 1,000 kg of CO_2 and produce 730 kg of O_2 per day. Thus, each urban citizen needs an area of about 10m² of green trees or 25m² of grass to ensure fresh air for life.

3.3.2. The consequences of reducing the greenary in HCMC

Urbanization in HCMC with the city's expansion rate of 4% annually, is a much faster growth than other urban areas in Vietnam. In many urbanized areas, green belts are not planned and protected. As a consequence, the hot, stuffy air will allow the "island heat" phenomenon to occur, resulting in increasing rainfall and increasing the number of storms to the city. The rainy season of recent years in the city and the record of 20 hurricanes in the country in 2017 is the best evidence for the consequences of this phenomenon [6]. These rains are the result of the decline of the urban green, but also the direct impact of the accident on urban trees and urban floods.

In addition, the situation of air pollution in the city is evolving increasingly complex. Specifically, the results of measurements at 6 air monitoring stations located at the typical locations of air pollution in the city showed that 89% of air samples not meet standards. They are always at high risk for human health. The amount of dust that is generated by smoke and dust is the leading cause of pollution in the city. In addition, the air pollution caused by Plumbum (Pb) also increased rapidly. In addition, concentrations of NO_2 measured at monitoring stations exceeded the permitted standard and are showing an increased frequency [7].

Lack of GS also affects the health of people such as asphyxia due to respiratory failure, blood poisoning, even death. Respiratory disease has the highest rate of "sick people" (17.3%) in morbidity in 2015 in Vietnam, including respiratory disease, pregnancy and postpartum, circulatory, gastrointestinal, septic and parasitic diseases, and the second highest mortality rate (16.9%) after circulatory disease [8].

3.4. Solutions

The land cover status of the study shows that there is uneven distribution of land use types among districts, where GS is lacking, where it is too redundant. In order to solve and overcome this situation, the authorities should take measures to consolidate, expand and develop the system of urban GS, serving better spiritual life of residential.

In the 13 old inner city districts, houses and building works are dense, there is lacking vacant land, so growing trees in a concentrated manner will be difficult. However, it is possible to increase the planting of tall trees with canopy alternating between residential areas, along the roadside or along the road dividers. The upper part of the buildings should design green roofs, green walls. In residential areas, it is recommended to plant more trees in the balcony, the wall.

The new 6 counties are still in the urbanization phase, new plans need to balance built-up land and greenery, creating a green belt for the area of 13 old urban districts. Specifically, it is necessary to avoid the construction of concentrated houses such as in the area of 13 old urban districts. Land funds should be reserved for parks, lakes. Particularly in the east of the city, District 9 is lowland, with many rivers and canals. Conservation areas should be developed with many green trees and lakes to create an ecological environment for urban inhabitants.

4. Conclusions

Rapid urbanization in HCMC, leading to a reduction in green space and an increase in urban land, has led to unpredictable consequences for quality of life and environment. The research has used satellite data and remote sensing techniques to evaluate land cover in urban area. Statistical results of land cover and GSI calculations have shown that HCMC's GS distribution is uneven. Urban green space is concentrated in 6 new districts, which are not much urbanized. At the same time, the area of 13 old districts in the inner city achieved very low GSI. The failure to meet green standards affects the development of urban HCMC, causing damage to people and property. Therefore, from the results and the consequence, the study has suggested some solutions to overcome the current green shortage as well as to control the development of green urban areas in HCMC.

References

1. Tu, D.T.; Hai, T.Q.; Ha, N.T.T.; Ngan, N.T.M. Using multi-time LANDSAT images to research progress of urbanization in Da Nang city for protecting urban environment. *Environ. Mag.* **2015**, *8, 67-71*
2. Thanh, H.X. Establishment of land cover maps based on remote sensing analysis and processing. *Journal of Irrigation Engineering and Environment Science*. **2010**, *29, 27-33*
3. Tran Quang Loc, P.K.L. Researching and building urban environment quality index and applying to some urban areas in Vietnam. *Sci. Mag.* **2012**, *74B, 93-102*
4. National standard TCVN 9257: 2012. *Planning for green trees for public use in urban centers - Design standards*. **2012**.
5. Prime Minister. *Decision approving the adjustment of the master plan on construction of Ho Chi Minh City up to 2025*, No. 24 / QD-TTg. Hanoi. **2010**
6. Ministry of Natural Resources and Environment. *National Environment Status Report 2016*. Hanoi, **2017**, 196 pages
7. Department of Environmental Protection HCMC. *Ho Chi Minh City: 89% samples of air quality exceeded standards*. http://hepa.gov.vn/content/tintuc_chitiet.php?catid=252&subcatid=0&newsid=235&langid=0, [accessed on 01 July 2017].
8. Nhan Dan Newspaper. *Serious air pollution threatens human health*, Available: http://www.nhandan.com.vn/khoahoc/item/31862202-o-nhiem-khong-khi-nghiem-trong-de-doa-suc-khoe-con-nguoi.html, [accessed on 01 July 2017]