Comprehensive study on the amount of CO_2 absorbed by vegetation: A case study in Ho Chi Minh city, Vietnam

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Abstract. The city Ho Chi Minh (HCMC) is one of the largest cities in Vietnam with the most dramatically economic development rate. Along with the economic development, the urbanization process in this city is also taking place very fastly. Due to the rapid urbanization and development, the emission rate from the industry and transportation leads to the increase in the amount of carbon dioxide (CO_2) which has been worsening the climate change. Protecting forests and conducting afforestation so that CO_2 is transformed to nutrition through photosynthetic conversion is one of the most effective ways to mitigate the effects of climate change. As a result, the accumulation of CO2 emissions has become a global concern. Vegetation absorbs carbon dioxide, helps to conserve the environment, produces oxygen, reduces noise, and helps to stabilize subsurface water. This paper highlights the results of ENVI software which was used to interpret remote sensing images and Arcgis to evaluate the amount of carbon dioxide absorbed by vegetation in each administrative unit: district in HCMC and ward. According to the obtained results, the amount of CO_2 absorbed in urban districts "District 1", "District 3", "District 4", "District 5", "Phu Nhuan District" is immensely low due to the high population density in the center of city. The population is mainly concentrated in the center districts but land area for vegetation is low. Regarding the suburban area, with mangrove forests, Can Gio District has the highest amount of CO_2 absorbed of 35,894.075 tons/day and followed by Cu Chi District with 21,548.48 tons/day. It can be indicated that Can Gio and Cu Chi districts improtantly function like the greenhouse gas sinks for the whole HCMC. The success of this study could contribute to climate change mitigation and support in urban and land planning, as well as resettlement policies. Aside from that, CO_2 emission and absorption assessment and evaluation in large–scale cities like HCMC has become a crucial, urgent, and practical issue nowadays.

1 Introduction

The increase in the concentration of CO_2 in the atmosphere is the cause of the problem of climate change because the earth cannot absorb all the CO_2 and other greenhouse gases [1-

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5]. According to the World Meteorological Organization's (WMO) Greenhouse Gas Report, CO_2 emissions from 2015 to 2016 increased sharply from 400 ppm to 403.3 ppm. Climate change according to the worst scenario of the Ministry of Natural Resources and Environment (inundated area accounts for 23% of the natural land area), many industrial zones will be seriously affected. Most of the industrial zones are heavily flooded, the lowest is over 10% of the area, the highest is up to 67% of the area. Hiep Phuoc Industrial Park in Nha Be District is located next to Nha Be River, in the area strongly influenced by the East Sea tide, so the possibility of flooding is very high. Other significantly affected industrial zones such as. Phong Phu Industrial Park, Le Minh Xuan Industrial Park, Hi-Tech Park. The impact of climate change on the agricultural production model in Ho Chi Minh City is that most of the agricultural land area is flooded and saline intrusion leads to a reduction in agricultural production. Crops and livestock developed according to the urban agriculture model are affected, typically Binh Chanh District is planned to have the largest perennial ornamental plant area in the city with a scale of 550 hectares by 2025.

According to Japanese experts, 1 hectare of forest, dense plantation, or equivalent area absorbs 1000 kg of CO_2 per day and emits 730 kg of O_2. A hectare of grass, on the other hand, may absorb 360 kg of CO_2 and exhale 240 kg of O_2 every day [6-9]. The researcher [10] have applied the GIS model to predict the ability to reduce CO_2 through afforestation. The main goal of the study was to inventory CO_2 emissions in Ohio, thereby assessing the efficiency in CO_2 sequestration of plantations. The study suggests different mitigation levels from different forest planning policies. CO_2 emissions in 1996 were 214,038,081 tons. The amount of CO_2 absorbed from the existing and newly planted forests is about 89,227,483 tons. Price of applying GIS and remote sensing to create a hypothetical buffer zone with an area of 806,374 hectares capable of absorbing 9,106,650 tons of CO_2, equivalent to 4,246% of greenhouse gas.

Fangmeier et al. [11] have studied the application of high-resolution satellite imagery to estimate carbon emissions from deforestation in 2001. The work uses landsat ETM + image, combining field survey and linear regression method and unverified classification. Evaluate changes of plant mulch in the period 1992-2001. In addition, the result of research shows the conversion of primary forests is the main cause of carbon emissions. Acacia has the best carbon capture capacity, around 2.78 tons/ha per year. Meanwhile, bamboo forest can absorb up to 18 tons/ha and the secondary forest is 15 tons/ha. Recently, the integration of GPS and GIS technology with remote sensing has shown to be an efficient tool for monitoring changes in vegetation and the ability of a specific region to absorb greenhouse gases.

In this paper, we look at how much CO_2 is absorbed by vegetation in HCMC, Vietnam, and how this can help to mitigate the effects of climate change by supporting urban planning, land use planning, and resettlement strategies. Furthermore, one of the most important, pressing, and practical challenges today is the calculation and measurement of CO_2 emissions and removals in major cities such as Ho Chi Minh City.

2 Materials and Methods

2.1 Materials

The Department of Statistics and the Ho Chi Minh City statistical yearbook were used to create attribute data. It includes the information about population, area of districts, administrative division of HCMC in 2016 and studied location. The administrative border of HCMC and landsat 8 are the spatial data. Landsat picture data with a 30 m resolution was obtained from two major US websites, Earth Explorer and NASA, using photos taken in 2016.

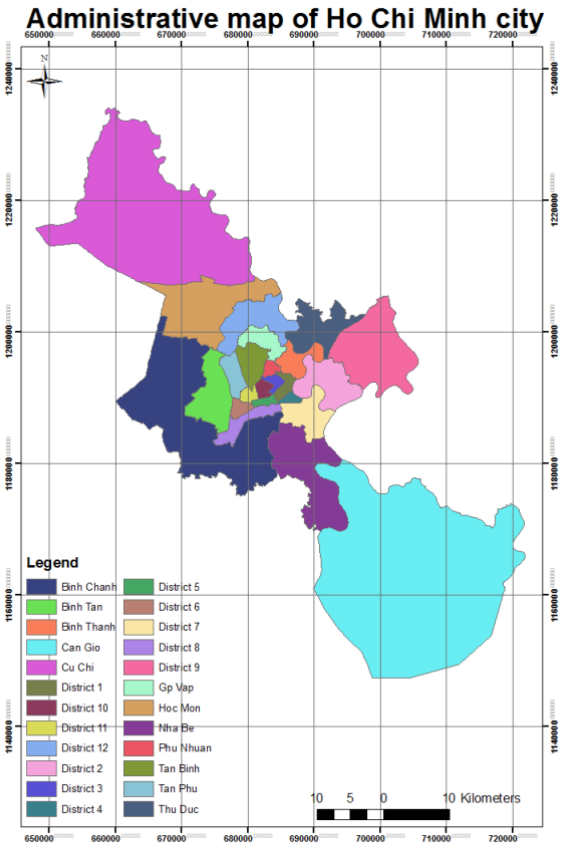

Fig.1. Administrative unit map of Ho Chi Minh city

Table 1. Data of landsat

Year	Path/row	Date	Quality	Cloud coverage
2016	LC08_L1TP_124053_20160221_20170329_01_T1	21 February 2016	9	0.47
	LC08_L1TP_125053_20160416_20170326_01_T1	16 April 2016	9	2.11
	LC08_L1TP_125052_20160228_20170329_01_T1	28 February 2016	9	20.7

2.2 Methods

Software used in the study is ArcGIS 10.1, ENVI 5.3 software along with supporting softwares such as Google Earth and Excel software. The steps included are data collection, data analysis and data processing, calculation of the potential of CO_2 absorbed from plants and commenting and evaluating the results. It can be summarized into 3 steps [12-14]:
Step 1: Collect baseline data for the calculation including attribute data on population, area of districts and communes, spatial data such as 2016 Landsat 8 image data and data administrative maps of Ho Chi Minh City at district and commune levels. The above data is collected from sources such as the University of Natural Resources and the Environment, NASA's URSI website in partnership with Geodesy and government regulators.

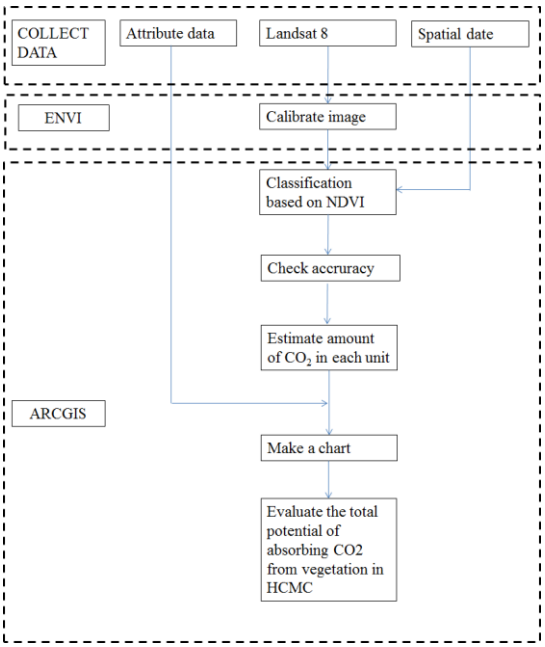

Fig.2. Methodology

Step 2: From the collected data, remote sensing image processing, NDVI value calculation, NDVI value classification and vegetation cover mapping were established. After the data processing process is completed, the satellite image interpretation combined with field survey will be performed and the results are presented in the form of a map of the total CO_2 absorbed potential by each district and district. HCMC wards and communes and tables.
Step 3: The calculated results are analyzed, compared and proposed solutions for environmental planners and managers.

2.1.1 Data Collection

- Landsat 8 in 2016 consists of 3 pieces collected from the website http: /earthexplorer.usgs.gov
- Data on natural and socio-economic conditions of Ho Chi Minh City from Ho Chi Minh City's website.
- Administrative unit map of Ho Chi Minh City at district, ward and commune levels from Ho Chi Minh City University of Natural Resources and Environment.
- HCMC population data in 2016 in ward, commune and district from the Statistical Yearbook of Ho Chi Minh City Statistical Office.

2.1.2 Image Calibration

The remote sensed imaged is combined and enhanced the quality, then cut by region. Landsat 8 is combined, enhance the quality then cut by region.
The acquired spectral reflectance observations in red/visible region (red) and near-infrared region (NIR) are used in the formula of Normalized Difference Vegetation Index (NDVI):

$$NDVI = \frac{NIR-eR}{NIR+R} \quad (1)$$

2.1.3 Classification

Table 2. NDVI classification

NDVI	Surface characteristic
< 0.1	Barren rock, water, concrete
0.1-0.2	Barren rock, shurbs
0.2 - 0.3	Shrub, Grassland, empty agriculture crop
0.3 – 0.6	Grassland, agriculture crop, sparse forest
>0.6	Tropical forest

(Source: NASA, 2013)

2.1.4 Application of GIS

Remote sensing data has a spatial resolution of 30m with the coordination of WGS 84. The adsorption of the pixel having NDVI value from 0.2 to 0.6 is 32.4 kg CO_2/day. Whereas the figure of the pixel having NDVI more than 0.6 is 90. The total CO_2 adsorption for each administrative unit is analyzed by Zone statistic tool as Table with Sum formula. After that, the data of total CO_2 adsorption is contained in a shapefile. The tool Joint was used to assign the aforementioned shapefile to the administrative data layer. Table of ArcGis 10.3 contains data on population, land size, and absorbed CO_2 amount, which is used to map the total absorption potential CO_2 in HCMC. Additional information such as grid systems, projection, annotation, scale ruler, and needle pointing direction are required to complete the map.

3 Results and Discussions

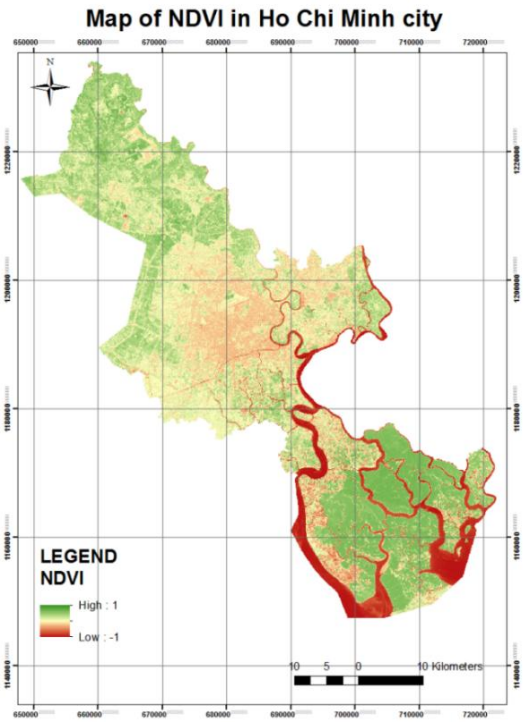

Fig. 3. Map of NDVI in Ho Chi Minh city

Fig. 3 shows the map of NDVI in Ho Chi Minh city. The green areas of the inner city and the suburban area of HCMC in 2016 are highly different. The NDVI value ranges from -0.48 to 0.78. Can Gio and Cu Chi districts are the areas having concentrated high NDVI index (NDVI > 0.6). In contrast, the downtown area has a low NDVI index (NDVI < 0.2) while the suburban areas have the NDVI index of about 0.2-0.6 [15].

Fig. 4 shows the information of Ho Chi Minh city with 3 NDVI value thresholds. Firstly, the locations having NDVI value lower than 0.2 are considered as a hydrological system or an empty land. Secondly, the areas having NDVI value from 0.2 to 0.6 are considered grassland and greenery. Thirdly, the areas having NDVI value higher than 0.6 are mainly mangrove forests. Their areas are 577,197 km^2, 71044,486 km^2, 460,707 km^2 and account for 27.7%, 50.15% and 22.15% of the total area respectively.

The study used the coordinates of survey locations found on Google Earth or recorded fields to determine the sort of object being surveyed to assess the accuracy of the aforesaid classification method. Then compare them to the value on the classified image to determine the classification method's accuracy. The result shows that combining NDVI method with threshold image classification gives quite high accuracy level, but there are still errors. The spectral disturbance of the image, the influence of the shooting angle and the blur of the terrai are inevitable during processing images. However, it is possible to use this method to analyze and interpretate image, especially the vegetation cover [15].

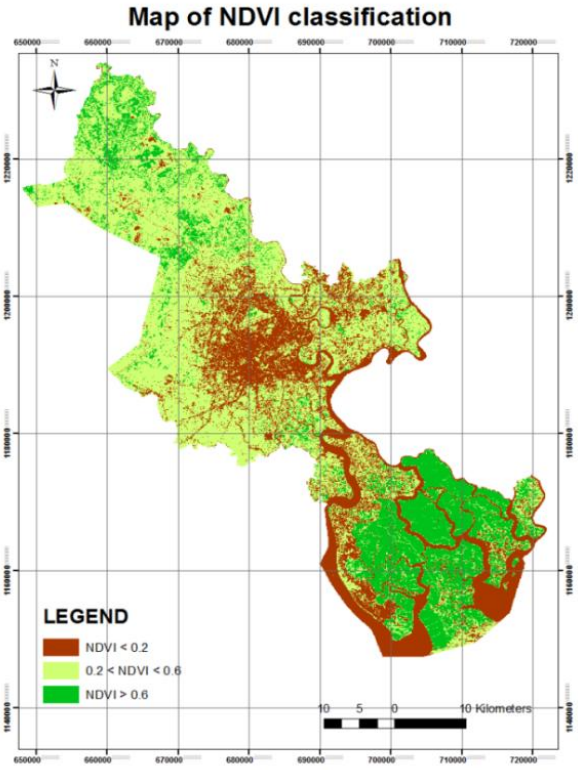

Fig.4. Map of NDVI classification

Photos Landsat 8 has an average resolution of 30m. Each pixel has NDVI values> 0.6, 0.2<NDVI<0.6, NDVI <0.2 with the corresponding daily CO_2 capturing capacities of 90 kg, 32.4 kg and 0 kg (Fig.5).

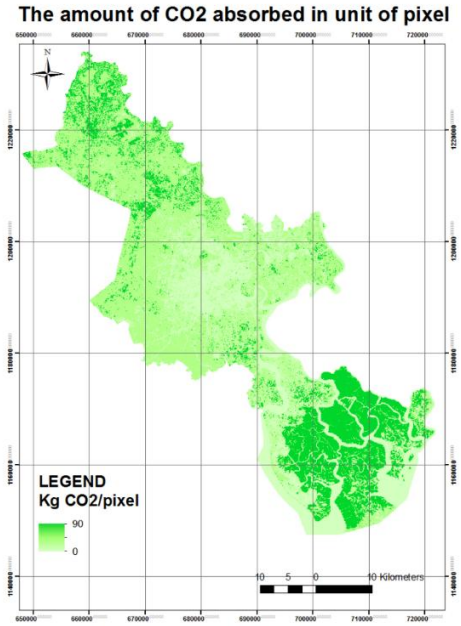

Fig.5. Map of carbon dioxide absorbed in unit of pixel

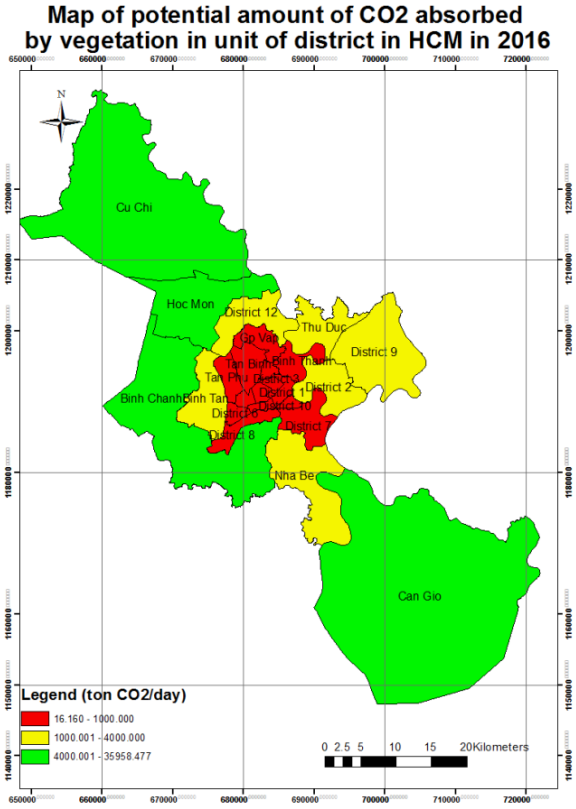

Fig.6. Map of potential carbon dioxide absorption by vegetation in each district unit

Fig. 6 presents a map of the total CO_2 potential uptake from green trees (vegetation) in HCMC in 24 districts of HCMC and Fig. 7 show a comparison chart of CO_2 adsorption potential between urban and suburban districts in HCMC.

The results show that the potential CO_2 absorption capacity of green trees (vegetation) in HCMC is about 84,732.77 tons of per day. In general, urban areas such as District 1, District 3, District 4, District 5, District 6, District 7, District 8, District 10, District 11 have a relatively low total potential for CO_2 absorption from plants due to the eclipse. Sparse objects, "scarce" land areas where the population is concentrated. Meanwhile, suburban districts such as Hoc Mon District, Binh Chanh District, Cu Chi District, Can Gio District have high CO_2 absorption reserves. In which, Can Gio district has the highest total potential amount of CO_2 absorbed from the vegetation cover in 24 districts, HCMC.

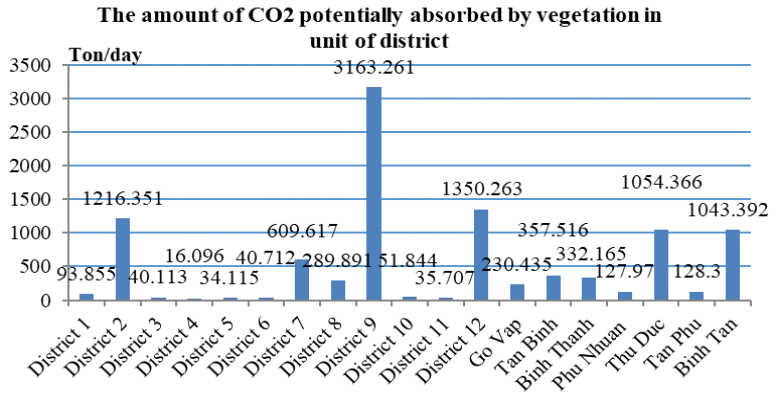

Fig.7. The chart of potential CO_2 absorption capacity of vegetation in district unit

In the downtown area such as District 1, District 3, District 4, District 5, District 10, Phu Nhuan and Binh Thanh, District 4 has the smallest vegetation coverage and the lowest CO_2 absorption capacity (16,096 tons CO_2 /day) due to some reasons such as: (i) a total area of only 4.18 km2 - the smallest area in HCMC; (ii) The population of District 4 in 2016 is 186,995 people.

Regarding urban districts, including District 2, District 6, District 7, District 8, District 9, District 11, District 12, Tan Binh, Thu Duc, Go Vap, Binh Tan and Tan Phu, the vegetation in District 9 has the highest CO_2 absorption capacity of approximately 3163,261 tons per day because of: (i) District 9 residents are still sparse compared to the old inner city districts; (ii) The population of District 9 in 2016 was 260,742 with a population density of 2,284 people/ km^2; (iii) District 9 is located in the east of the city, bordering District 2, Thu Duc and Dong Nai and Binh Duong provinces with the natural boundary of Dong Nai River and (iv) Location District 9 is bordered by provinces and far from the city center, so it has not really attracted the population. These results predict that District 9 will become a new ecological city with a natural canal system and a high proportion of greenery.

For suburban districts, CO_2 reserves are highest absorbed from mangroves in Can Gio district with absorption capacity of about 35,894,075 tons CO_2/day. The area has good air quality, sparsely populated, and a fresh environment with good conditions such as a total area of 704.45 km2 - the largest area in HCMC with population in 2016 of Can Gio District is 75,022 people - The least population Can Gio is a biosphere reserve area recognized by UNESCO. Moreover, its geographical location bordered with the South China Sea is thus favorable for mangrove development. Besides, Can Gio district is a new district merged into HCMC, so the population is still not concentrated.

4 Conclusions

Ho Chi Minh City's vegetation coverage and daily CO_2 absorption capability were explored in this study. HCMC's vegetation is thought to absorb around 84,732.77 tons every day. District 4 has the smallest vegetation cover and the lowest CO_2 absorption rate of 16,807 tons per day, compared to District 1, District 3, District 4, District 5, District 10, Phu Nhuan, and Binh Thanh. District 9 has the maximum amount of CO_2 absorbed by vegetation, with about 3,167.19 tons per day, among Districts 2, 6, 7, 8, 9, District 11, District 12, Tan Binh, Thu Duc, Go Vap, Binh Tan, and Tan Phu. With 35,514.22 tons of CO_2 absorbed per day, the mangroves of Can Gio District have the highest amount of CO_2 absorbed among suburban districts. As a result, the dense vegetation of the suburb districts, particularly Can Gio and Cu Chi District, is regarded as a greenhouse gas sink for Ho Chi Minh City.

Acknowledgments

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