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Review Article

Estimating the CO_2 Emission from Transportation: Case Study In Ho Chi Minh City, Vietnam

Van Thi Thanh Ho[1]*, Nguyen Nhat Anh Hao[2], Dien Vinh Le[3], Khang Pham Vinh[4], Huyen Duong Thi Thanh[1], Tam Ho Phung[1] and Truong Xuan Nguyen[5]

[1]Hochiminh City University of Natural Resources and Environment (HCMUMRE), Vietnam

[2]Hochiminh City University of Technology (HCMUT), Vietnam

[3]Lawrence S. Ting High School, 80 Nguyen Duc Canh, Tan Phong, Vietnam

[4]Vo Truong Toan High School, 482 Nguyen Thi Dang Street, Quarter 1, Hiep Thanh Ward, Minh City, Vietnam

[5]Southern Education Development Center, Office of Ministry of Education and Training, Vietnam

***Corresponding Author:** Van Thi Thanh Ho, Hochiminh City University of Natural Resources and Environment (HCMUMRE), Vietnam.

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Abstract

According to a Japan International Cooperation Agency (JICA) scientific report, it is reported that 45% of CO_2 emissions come from transportation source, therefore the calculation of CO_2 emissions from transportation is one of important and urgent issue for evaluation the CO_2 emissions. The results of the calculation and evaluation the CO_2 emissions that will be provided a scientific basis for policy makers to propose a feasible strategy to cut greenhouse gas emissions, particularly CO_2 from transport emissions. In this study, total CO_2 emissions from transport activities were calculated for 24 districts in Ho Chi Minh City, the biggest city in Vietnam. The result of study shows that the emissions ranging from CO_2 tons /year up to 110 CO_2 tons/year and focus on the downtown area in city. It is indicated that the total amount of CO_2 emissions in Ho Chi Minh City is quite high and need to have some policies to reduce the CO_2 emission such as the development a model of using public transport instead of personal vehicles that really need to be need to implement and implement. The results of research serve as a scientific data and provide calculated inventory data, methods to inventory greenhouse gases from CO_2 emissions from transport sources and support the goal of reducing total emissions that aims to build a low-carbon city.

Keywords: Climate Change; Population; CO_2 Emissions; GIS

Introduction

Air pollution affects the respiratory system causing many diseases such as chronic obstructive pulmonary disease, bronchitis, and lung cancer. With the current situation of air pollution in Ho Chi Minh City, people are exposed to many harmful gases every day, so the number of people getting sick is increasing with severe severity. Transport is one of the main activities that emit greenhouse gases (the cause of global warming). Each year emits 30 million tons of CO2, the third largest after the energy and agriculture sectors, accounting for 18.38% of the total annual greenhouse gas emissions into the atmosphere. To reduce these emissions, the transport sector has been oriented towards synchronous, sustainable, and environmentally friendly development, to reduce and effectively respond to climate change.

According to the statistics of the Institute of Transport Strategy and Development (Ministry of Transport), during the period 2011-2016, transportation activities in Vietnam consumed a large amount of energy, accounting for 30% of the total national energy demand, 60% of the total fuel consumption and increasing by 10% every year. In which, road transport consumes the largest energy, accounting for about 68% of the total fuel of the industry; 90% of fuel for transportation is gasoline and diesel (only 0.3% clean fuel). With the consumption of large quantities of fuel, transportation activities have emitted large amounts of greenhouse gases, increasing climate change. Currently, on average, each year transportation activities emit about 30 million tons of CO2. Of which, road traffic accounted for 86%, and railway, waterway, and airway accounted

for 14%. There have some previous studies that have been studied on the calculation models and some available software for the calculation of carbon dioxide (CO_2) emissions in logistics activities. General calculation formulas are presented mostly for transportation by truck, but by train as well. International Heinz Nixdorf Symposium and some previous research studied recommendations for a global standard for all modes of transport based on EN16258 for freight/logistics transportation. Based on ISO IWA 16, they are then compared and combined into a single overview. A case study of the introduction of CarbonCare (emission calculator) and its global transport customers were taken into account to incorporate practical guidelines for a blueprint. Davydenko., *et al*. 2014 have studied the changes of street use and on-road air quality before and after complete streets by different transportation modes and corresponding ultrafine particle (UFP) and fine particle (PM2.5) concentrations [1-4]. The study on Calculation of CO_2 Emissions from transportation in the transportation system is still limited until now [5,6].

Herein, we have studied the evaluation on the amount of CO_2 emission by transportation in Ho Chi Minh City, Vietnam. The total CO_2 emissions from transport activities were calculated for 24 districts in Ho Chi Minh City, the biggest city in Vietnam. the calculation and assessment of CO_2 emissions in big cities such as Ho Chi Minh City are considered as one of the most necessary, urgent, and practical issues today. Nonetheless, the results of this work will be given a full evaluation of reducing the impact of climate change and supporting urban planning, land use planning, and resettlement policies of people.

Material and Methodology

The research method to calculate CO_2 emissions from traffic includes the following steps:

- Collect and calculate the amount of CO_2 emissions caused by traffic activities.
- Application of GIS in the process of developing a tool to calculate CO_2 from traffic activities in HO CHI MINH CITY to form emission maps. With the available information, users can query related information; In addition, by looking at the map, we can get the status of emissions caused by the traffic process and then take appropriate measures to reduce emissions.
- The toolkit applies to other localities if the required data parameters are available.

The CO_2 emissions from vehicles are calculated according to the formula (IPPC) [7,8]

CO2 emissions = travel distance (km)* fuel consumption (liter/km)* CO2 emission rate of fuel (kg CO2/liter).

The research method to calculate CO_2 emissions from traffic activities in HO CHI MINH CITY is presented in figure 1.

In which the CO_2 emission coefficient of the fuels is calculated in table 1 and the fuel usage of some means of transport is calculated in table 2.

Figure 1: Study on CO_2 emission rule diagram from traffic activities in Ho Chi Minh City.

Fuel type	Density (kg/ltr)	Net Calorie Value (GJ/t)	Default CO_2 Emission Rate (tCO_2/TJ)	Fuel CO_2 emission rate (kg CO_2/liter)
Gas	0,7407	44,75	69,3	2,297
Diesel	0,8439	43,38	74,1	2,712

Table 1.1: CO_2 emission coefficients of fuels [7,8].

Transportation	Fuel type	Fuel consumption (liters/100km)	Fuel consumption (liters/1km)	Carrying weight
Motorcycles (4 strokes)	Gas	2,00	0,02	1 person
Scooter	Gas	3,50	0,035	1 person
Bus (31 seats, 49 stands)	Diesel	22,00	0,22	80 person
Car (4 seats)	Gas	8,00	0,08	1 person
Car (7 seats)	Gas	13,00	0,13	1 person

Table 1. 2: Fuel usage of some means of transports [7,8].

Methods of implementation

- **Tools and equipment:** SJCAM 4K action camera with 2MHD resolution and 170-degree original rotation is used for recording and storing data.
- **The conducting a survey**
  - Place the camera in the direction opposite to the direction of vehicle movement, according to the classification of traffic roads and according to Decision No. 32/2005/QD-BGTVT Promulgating regulations on road classification with 05 types of roads A, B, C, D, E.
  - Surveyed vehicles include motorbikes, cars (4-16 seats), buses, and trucks.
  - During the survey, there will be 2 timelines at peak and off time. Filming time in two-time frames: peak hours 7-8 hours and normal time frames from 12h-13g.
  - Recording time 10-15 minutes (in which the vehicle is assumed to go all the way through the survey road)
  - All vehicle volume data after recording will be analyzed, read, and count vehicles.
  - Record and store data files, calculate emissions based on fuel type, vehicle type, and road segment according to IPCC calculation manual.

Results and Discussion

Model results for digitizing roads

Perform the digitization of roads with full information such as street names, wards, districts, and road lengths, the classification of roads is made according to Decision No: 32/2005/QD-BGTVT with 5 types of roads A, B, C, D, and E. Digitized information on the system of roads is also encoded by road codes, ward codes, and district codes as the basis for building a traffic map of CO2 emissions from traffic activities in 24 districts of Ho Chi Minh City. Figure 2 is a digitized model and digitized roads in Ho Chi Minh City.

Figure 2: Digital model of the system of roads in 24 districts of Ho Chi Minh City.

Survey results and actual data collection on vehicle traffic on roads

Figure 3 and figure 4 are the actual image of the dash cam system recording vehicle traffic on the roads. After that, count the vehicles and classify them according to 04 types of vehicles in an average time of 10-15 minutes. From there, it is reduced to vehicle traffic per minute for peak hours and normal hours. The average vehicle traffic is calculated by taking the peak hour traffic plus the normal hour traffic. The results show that the average traffic of vehicles/min has been collected and measured for the roads. If you want to convert by an hour or day, you can multiply by the conversion time. This is a very important database for the next calculation of CO_2 emissions from traffic activities of vehicles then calculate the average emissions of vehicles on the roads of Ho Chi Minh City.

Figure 3: Photo obtained from camera recording in Tan Phu district at peak time (7am-8am).

Figure 4: Image obtained from camera at Cu Chi district road at normal hours (12:00-13:00).

Building a map of CO2 emissions from traffic on roads in Ho Chi Minh City

CO_2 emissions from vehicles are calculated from the following formula (IPCC): CO_2 emissions = travel distance (km)* fuel consumption (liter/km)* CO_2 emission rate of fuel (kg CO_2/liter), in which the fuel CO_2 emission rate (kg CO2/liter), fuel consumption (liter/km) are calculated according to the IPCC norm with the assumption that the vehicles will travel the entire distance. Calcula-

tion results of CO_2 emissions from traffic activities on roads in HO CHI MINH CITY are presented by the CO_2 emission map in the figure 5 and CO_2 emission comparison chart in 24 districts of Ho Chi Minh City shown in figure 6.

Figure 5: Map of CO_2 emissions from traffic activities of HO CHI MINH CITY districts.

From the emission mapping, it can be seen that CO_2 emissions from traffic activities are very high, reaching the highest to more than 3 million tons of CO_2/year and widely distributed in the range from 3000 tons of CO_2/year to 26,000 tons of CO_2/year. This is a rather large emission figure that has contributed a lot to the overall increase in CO_2 emissions for all sectors. In particular, Vietnam is a developing country, and the infrastructure for transportation is not high, People mainly move by personal vehicles and rarely use public transport, thereby greatly increasing CO_2 emissions in traffic activities. In addition, Ho Chi Minh City with rapid urbanization and industrialization, the population density has increased rapidly over the years and is the most populous city in Vietnam today. This result is consistent with previous studies in the report "Why are CO_2 emissions increasing in the Asian transport sector? Fundamental factors and policy options", by two authors Govinda R. Timilsina and Ashish Shrestha of the World Bank (WB), GHG emissions from traffic increase rapidly due to three main reasons: economic development, population growth and energy intensity in transport. In which, the main GHG emissions are 91.95% due to road traffic activities, 2.5% due to aviation activities and 4.8% belongs to water transport activities and the rest is railway traffic. At the same time, according to the report of the Japan International Cooperation Agency (JICA), greenhouse gas emissions in Ho Chi Minh City in 2013 are leading and many times higher than that of other cities in the C40 network - a group of 91 big cities that are heavily impacted by climate change [9].

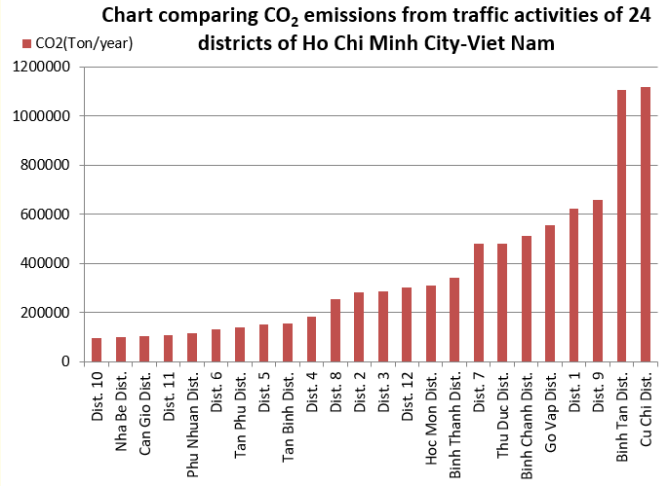

Figure 6: Chart comparing CO_2 emissions from traffic activities of 24 districts of Ho Chi Minh City.

The comparison chart of CO_2 emissions from traffic activities in 24 districts is shown in figure 6 From the chart, we can see that the distribution chart from District 10 to Binh Thanh District shows relatively low CO_2 emissions and increases gradually from District 7 to District 9 and the highest is in Binh Tan District and Cu Chi District. This result shows that the districts with CO_2 emissions from traffic activities depend on the location of the roads in the city centers where the number of companies is located, there are many apartment buildings and businesses, so the number of residents moving to workplaces is quite large. Binh Tan District for CO_2 emissions is because Binh Tan District has the highest population of 24 districts in Ho Chi Minh City. Particularly, although Cu Chi District is a suburban district, it has high CO_2 emissions in traffic because Cu Chi District currently has the highest number of communes with 21 communes in 24 districts of Ho Chi Minh City, in addition, Cu

Chi District has a rather long National Highway 1A and has a high density, especially very large trucks moving continuously.

This result is explained depending on the volume of vehicles moving in the roads of the districts. Geographical location, and the socio-economic situation of that area, if the central area where there are many services, the company, commercial buildings, the density of traffic moving in will be higher than wards and communes with roads that do not concentrate many services and companies. This can be considered as one of the first survey results on CO_2 emissions from traffic activities in large and densely populated cities in Vietnam and has great significance for the planning of transport infrastructure it not only solves the reduction of CO_2 emissions from traffic activities but also forms the basis for planning to match the city's development and urbanization.

Conclusions

This study calculated and assessed CO_2 Emissions from Traffic Activities in 24 districts of Ho Chi Minh City, Vietnam to make an assessment of CO_2 emissions from transportation activities, from that applying GIS technology in building a typical emission situation map in Ho Chi Minh City and proposing solutions to reduce CO_2 emissions from Traffic Activities.

The study calculated the total CO_2 emissions from traffic activities for 24 districts in Ho Chi Minh City. Calculation results have built a map of CO2 emissions from Traffic Activities for the whole Ho Chi Minh City. The two regions with negative emissions are colored from red to pale pink with emissions ranging from 14 tons CO_2/year to 110 tons CO_2/year and focusing on the areas of the Central District of Ho Chi Minh City, this leads to quite high total CO_2 emissions. This result is consistent with the socio-economic situation and the geographical features of the regions as well as the characteristics of a developing country such as Vietnam.

The remaining two regions have a positive total CO_2 emission and absorption which is a positive result but mainly focus on the suburban districts of Cu Chi, Can Gio, Hoc Mon District, Binh Chanh District, Nha Be District, and Binh Tan District. In which, Cu Chi and Binh Tan districts have the highest CO_2 volume, reaching 3 million tons of CO_2/year.

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