A Green Area Ratio for Sri Lankan Urban Areas

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ABSTRACT: With the rapidly expanding urban areas vegetation cover of urban areas tend to be reduced. Because of the rapid urbanization and industrialization amount of CO_2 emit to atmosphere is increasing. Global warming refers to the phenomena of Global average surface temperature is increasing. CO_2 considered be the Major cause for global warming. Green plants absorb atmospheric CO_2 and fix them as woody biomass which provides natural method of reducing atmospheric CO_2. This study has focused on a developing green area ratio for Sri Lankan Urban areas. Because of the differences of the CO_2 emissions and the tree species green area ratio developed in a foreign context cannot use for Sri Lankan urban areas. This study focus on developing a criterion for green area ratio for Sri Lankan Urban Areas.

1 INTRODUCTION

Global warming is considered one of the major problems human being has ever faced. Different organizations and Scholars have made several discussions on it. Causes for global warming and impacts of it have been estimated and explained by them. However it is obvious that there are some adverse impacts not only for human been but also for other living and non living components of the environment.

Global warming is caused by the emission of greenhouse gases. 72% of the totally emitted greenhouse gases are carbon dioxide (CO_2), 18% Methane and 9% Nitrous oxide (NO_X). Therefore Carbon dioxide emissions are the most important cause of global warming. The emissions of CO_2 have been dramatically increased within the last 50 years and are still increasing by 3% each year. (*http://timeforchange.org/CO2-the-cause-of-global-warming*).

Because of the predicted impacts of global warming world community has started to think about controlling emission of greenhouse gases. They are trying to set collective global target of reducing greenhouse gas emissions such as Kyoto Protocol. Locally also there are many programs to control the climate changes such as Vehicle emission testing program, Haritha Lanka program etcé

Trees in Urban areas provide a natural method to mitigate the increase of atmospheric carbon. Because trees store carbon in their structure and sequester additional carbon in the process of growth, they act as a sink for carbon dioxide (CO_2). While Urban forests are responsible for storing and sequestering large amounts of carbon they also provide other environmental benefits such as storm water runoff mitigation, energy saving through shading and air pollution reduction and enhance the aesthetic value of the urban areas.

According to land economics highest land values are in the urban areas because of the scarcity of the land and the competitiveness for available lands. Under this kind of situation green areas are less compatible in urban areas. Because of that there is a tendency to reduce amount of vegetation in urban areas. Although there are standards to provide open spaces, provision of adequate green has not concerned yet. But in some parts of the world there are ratio such as Green Plot Ratio, Green Area Ratio have been developed. These are not directly applicable to local situations as emission levels and absorption capacities of trees differ from context to another. Therefore this study intended to develop a criterion towards a green area ratio that is adoptable in Sri Lankan context. Green Area Ratio is derivative only by a long term testing process with many reiterations. Therefore this study is focus to develop a criterion for Green Area Ratio.

2 METHODOLOGY

In this study firstly the literatures about existing index and ratios have been reviewed. It was aimed to study the methodologies of the existing Green Area Ratios. After the literature review applicability of these ratios to Sri Lankan urban areas were tested. Since the emission levels and absorption capacities differ from context to context it concern about the differences of those factors from where the ratios have been originated. By considering the

differences found in previous step develop a criterion for Green Area Ratio in Sri Lankan context.

Primary data collection is the next step for the purpose of demonstration of this criterion for selected urban area. Two kinds of data have been collected; one in terms of Carbon dioxide emission of the particular urban area and the second is Carbon dioxide absorption capacity of the Sri Lankan Tree species. Then the demonstration of the Green Area ratio for the selected urban area was done

3 RESULTS AND DISCUSSION

3.1 *Study area*

For the purpose of this demonstration the Central Business District of Colombo city was selected as the study area. Carbon dioxide emission of the selected area has to be estimated with the collected data. For the convenience study area was reduced to Pettah GN division. Pettah GN division is predominantly a commercial area. Wholesale and retail businesses are the major activities in the area. Total land area of the GN division is 96.83 ha.

3.2 *Estimation of Carbon dioxide emissions*

Most of the estimation methods are based on the guidelines published by the Intergovernmental Panel on Climate Change (IPCC) for the preparation of Greenhouse gas inventory *(Inter-governmental Panel on Climate Change, "Greenhouse Gas Inventory Workbook", Volume II, (1996))*. Accuracy of the emission prediction may vary with the available data sources.

First estimate annual fuel consumption for each fuel type.

Then convert fuel consumption to standard energy units (t, l, M^3) because CO_2 emission factors are given in standards units.

After that by multiplying fuel consumption by emission factors can calculate the CO_2 emission.

Estimate CO_2 emission of a city is quite complicated exercises which require comprehensive data collection and observations. But for this exercise it was done rough estimation with the available secondary data. For that main tree sources were identified

1. Households
2. Commercial Activities
3. Transportation activities
4. Commuting population

3.2.1 Commercial Activities

The Predominant commercial activity in this area constitutes the wholesale and retail businesses. In terms of energy, main energy source is the electricity. Only a few places consume CO_2 emitting fuels. Although there are a few numbers of manufacturing industries since data is not available in terms of energy types, they have been ignored. Comparing with the other sources the CO_2 emitted from commercial activities has been ignored as the quantities were negligible.

3.2.2 Households

Annual CO_2 emission by Households

Table 4.5 ï Annual Household CO2 emission in study area

	(A) Lighting	(B) Cooking	(C) Total (A+B)	(D) CO_2 Emission Factor (Kg/liter) [a]	(E) CO_2 Emission Factor (Kg/ton) [b]	(F) CO_2 Emission (t CO2) (C x D, E)
Kerosene	180000 (ml)	1152000 (ml)	1332 (l)	2.519376	-	3.36
LPG	-	3744 (Kg)	3.744 (t)	-	2984.63	11.17
Fire wood	-	22995 (Kg)	22.995 (t)	-	1747.2	40.18

Source: a, b ï IPCC 2006 Guidelines for National Greenhouse Gas Inventories

3.2.3 Transportation activities

Emission factors by vehicle type for Sri Lanka

To calculate the total CO_2 emission by vehicles it has assumed that the same number of vehicles travel on every road in the area.

Table 4.8 ï Annual CO_2 emission from the vehicles within the study area

Vehicle Type	(A) No. of Vehicles	(B) Emission factor (CO_2 g/Km)*	(C) CO_2emission by Vehicle type (Kg) (A x B x 11.6)
Lorry Petrol		285	0
Lorry/Truck Diesel	817	800	7583.55
Bus Diesel	10932	800	101472.97
Medium Bus Diesel		788	0
3-Wheeler Petrol	6350	130	9578.07
Land vehicle Diesel	9	113	11.8
Motor cycle Petrol	2428	60	1690.29
Vans Petrol	478	285	1580.2
Van Diesel	717	400	3326.74
Cars Gas		175	0
Cars Petrol	2389	200	5544.57
Cars Diesel		275	0
Total vehicle emission		(t/CO_2)	47737.69

* Source - National Building Research organization

3.2.4 Commuting population

By respiration the living beings emit CO_2 in to the atmosphere. It is estimated that out of the

800000 daily commuters to Colombo, around 300000 comes to Pettah.

Table 4.9 ï Annual CO_2 emission by the Commuting population

No. Commuters C	(A) CO2 L/Year	(B) CO2 M3/Year (A/1000)	(C) CO2 t/Year (B x 1.854/1000)
300000	1379700000	1379700	2557.96

Source: C) Grama Niladhari - Pettah

- Expired air of Adult person consists with the 350ml air and 4% from it is CO_2, under normal circumstances respiratory rate of adult person is about 15 per minute.

(*Waugh A.; Grant A., 2006, Anatomy and physiology in health and illness*)

- Conversion factors of Carbon dioxide - 1 cubic meter = 35.32 cubic feet = 1.854 kilograms

Gas densities are at room temperature and pressure

(*U.S. Inventory of Greenhouse Gas Emissions and Sinks 1990-2004*)

3.2.5 Total CO_2 emission

Table 4.10 ï Total Annual CO_2 emission of the area

Sources of emission	CO_2 Emission (t CO_2)
Kerosene	3.38
LPG	11.17
Fire wood	41.85
Commuting population	2557.96
Vehicle emission	47737.69
Total emission	**50352.05**

According to the calculation highest CO_2 emitting source is the vehicle emission. It contributes about 95%. Comparing with the other sources the CO_2 emitted from households (Firewood, Kerosene, and LPG) is negligible.

3.3 *Carbon sequestration capacities of different tree species*

Information on the Carbon sequestration capacities of Sri Lankan tree species is very little. With the available data this analysis has been done. It required more studies on this field to full fill the data requirement. It must also be noted that with the age and the growth of the tree sequestration capacity is changing.

Table 4.11 ï Growth performances of tree species in first 20 years

Name of the Tree	Growth rate	Carbon Sequestration Rate (Kg per year)	Size of the tree (DBH) inches
Mahogany	Medium Growing	15 - 20	25 ï 30
Robarocia		15 - 20	
Kottamba		15 - 20	
Acacia	Fast Growing	10-Jun	15 -20
Teak	Slow growing	12 ï 15	25 - 30
Mara		15-Dec	

Source: Study of Growth performances of Sri Lankan Tree species, Forest department, Sri Lanka.
Note: assumed trees belong to same class have same sequestration rate

Because Growth curves of trees are not linear (figure 4.5) with the maturity of the trees they become neutral in terms of carbon sequestration. All the above figures have calculated before they become maturity.

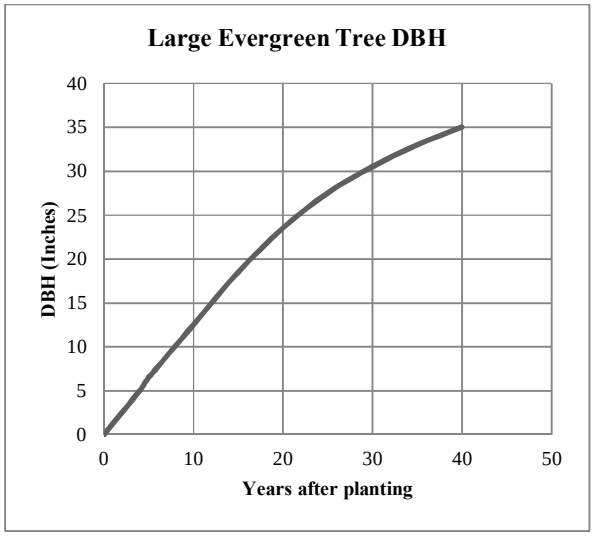

Figure 4.5 ï Growth curves of Large Evergreen trees
Source: McPherson, E. Gregory; Simpson, James R. [1999] *Carbon dioxide reduction through urban forestry*

3.4 *Estimating the required number of trees*

A method has been used to estimate the number of trees required to sequester emitted CO_2 based on the method developed by McPherson, E. Gregory; Simpson, James R., 1999, Carbon dioxide reduction through urban forestry.

Table 4.12 ï Number of trees required to absorb emitted CO_2

A. Name of the tree Species	B. Tree Age	C. Number of Trees	D. Area of trees (ha)	E. Annual Sequestration rate (Kg/Yr)	F. Carbon Sequestered (Kg) (C x F)
Mahogany	20	685995	343	20	13719905
Robarosia	20	685995	343	20	13719905
Kottamba	20	685995	343	20	13719905
Acacia	20	1371990	457	10	13719905
Teak	20	914660	392	15	13719905
Mara	20	914660	392	15	13719905
Total amount of Carbon Sequestered (t)					13719.09
Total amount of CO_2 Sequestered (t) x 3.67					50352.05

By planting one hectare of these trees it has estimated 30 ï 40 tons of Carbon can sequester within one year. Within one hectare approximately 1200 trees can be planted without any other uses.

3.5 *A Model for calculating required amount of trees*

$$Y = \frac{(N_m \times 20 + N_s \times 15 + N_f \times 10) \times 3.67 \times 100\%}{\text{Total CO2 emission of the area (Kg)}}$$

Where
Y = Percentage of sequestered CO2
Nm = Number of medium growing trees
Nm = Number of Slow growing trees
Nf = Number of fast growing trees

3.6 *Design the spatial configuration of tree cover*

It has identified three areas where can promote the vegetation in the study area.

1. Road sides
2. Open spaces
3. Building rooftops

3.6.1 Road sides

Total length of roads in the area is 11.6 Km. When considering both sides of the roads there are about 23 Km. But each and every road side cannot use for tree planting. Roads can use for tree planting identified and shown by figure below. By considering the median and the road sides of identified roads approximately 2.5 Km would be able to use for tree planting.

3.6.2 Open spaces

There are Lands in the area which can be used for planting trees. Especially railway yards behind the Bare Lake have a great potential to use for planting trees. Existing green areas and potential areas for planting trees have shown by the figure below. Altogether Total area of possible green cover is approximately 8 hectares.

3.6.3 Building rooftops

Within the study area approximately there are 35 ha of roof tops. If 1/3 of the total roofs will be able to convert in to roof top gardens, about 12 hectare can be planted. To encourage people to convert their roofs in to gardens special tax can charge for emitting CO_2. If they convert roofs in to garden then they will be released from the tax. As explain above if 1000 trees are planted per hectare about 12000 trees can be planted on roofs. Grass and bushes also can be planted on these roofs. When considering about the leaf area index, ratio of grass to the ground is roughly 1:1, for clump of bushes ratio is roughly 3:1 and for a well grown trees it is 6:1. *(B.L. Ong, 2003).* Instead of trees if we grow grass on above mention roofs then it will be equal to 2000 trees. If those are bushes it will equal to 6000 trees.

Table 4.13ï Total Number of trees can plant

Place of tree planting	Available space	Trees per unit area	Number of trees	Maximum Amount of CO2 can sequester
Road sides	2.5 Km	Distance between two trees 8 meter	312	6240
Open Spaces	8 ha	1000 trees per ha	8000	160000
Roof tops	12 ha	1000 trees per ha	12000	240000
Total trees can plant			20312	406240

By this analysis it clearly shows that the total amount of CO_2 emitted from the area cannot be offset by trees with in the same area.

3.7 *4.7 Percentage of CO_2 can offset*

$$Y = \frac{(N_m \times 20 + N_s \times 15 + N_f \times 10) \times 3.67 \times 100\%}{\text{Total CO2 emission of the area (Kg)}}$$

If only plant the medium growing trees

$$Y = \frac{(20312 \times 20 + 0 \times 15 + 0 \times) \times 3.67 \times 100\%}{50352050}$$

Y = 2.96%

If want to sequester 30% of emitted CO2 by planting Medium growing trees

$$30 = \frac{(Nm \times 20 + 0 \times 15 + 0 \times 10) \times 3.67 \times 100\%}{50352050}$$

Nm = 205800

4 CONCLUSION

The objective of this study is to introduce a criterion to develop a Green Area Ratio for Sri Lankan urban areas. There is a significant amount of carbon dioxide emitted in urban areas from various sources. Different urban activities like transportation, Residential, Industries, Commercial, Commuting population etc. are emitting CO_2 to the atmosphere. There are different absorbents of atmospheric carbon dioxide such as soil, sea (Phytoplankton) and vegetation. Among these sources trees are the best absorbent of atmospheric CO_2 in an urban area. Trees also provide other direct and indirect benefits as well. Hence, this study

intended to equate the amount of CO_2 emissions in an urban area and the sequestration capacities of tree species in its conceptual framework. Within that framework the study also has taken into consideration the competitive nature of the land uses in urban core areas, for which the provision of green areas is not at ease. Lands totally dedicated for trees are least competitive and alternative measures need to be sort.

As a planning tool Green Area Ratio can be used in planning process. In that way this study contributes to the knowledge of planning by introducing a criterion Green Area Ratio for Sri Lankan urban areas. In conventional planning vegetation are only used in terms of recreation, aesthetic value and to protect water catchment etc., but this study induce thoughts for planners about another benefit of trees. Upcoming trends like rooftop planting, urban forests, eco city concept have to be involved in the city planning.

According to the analysis total CO_2 emission of the area cannot be offset by the in situ vegetation. As mentioned in the previous chapters Vehicle fleet is the main CO_2 emission source of the area. Although annually numbers of vehicles on the roads are increasing lands available for tree planting will remain constant. Therefore, there should be a planning solution to manage the traffic flow into the core areas of cities. Encouraging efficient and comfortable public transportation modes is a need in all senses.

At the same time, when preparing city plans and city designs concepts of green buildings and eco cities which are target to reduce carbon emissions have to be put forward.

Also it needs the strong institutional support to encourage green practices and planting trees parallel with the ongoing developments. Local authorities, urban development authority and Central environmental authority have major roles to play in this regard.

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