Estimation of Carbon Footprint of Energy Management Centre, Trivandrum

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***Abstract*— Carbon dioxide is the chief greenhouse gas that results from human activities which causes global warming and climatic change. Carbon footprint has been used as an environmental indicator which helps to determine the quantity of emission from different emission sources, which in turn is useful for quantifying the impact of human activities on the environment and global climate. The objective of this study is to assess the Green House Gas (GHG) emission from various emission inventories namely buildings, green coverage, human respiration, electricity and transportation. The study area selected is Energy Management Centre, Trivandrum at Sreekariyam. The study area selected has a green building with a total built-up area of 4030.73sq.m. In addition to that, there are small buildings with a total built up area of 806sq.m in the study area. The built up area of building was found out using the software AutoCAD. The total green coverage of the study area is 11623.73sq.m and the same was calculated with the help of AutoCAD and georeferenced using Google Earth and Earth Point. Carbon footprint from different sources was estimated using "Consumption-based approach" by multiplying activity data with the corresponding emission factor. Emission from transportation sector was found out by conducting a survey. Emissions from various inventories were quantified using the emission factors given by Central Pollution Control Board, India (CPCB) and Department for Environment, Food, and Rural Affairs, UK (DEFRA). The potential area of GHG emissions was identified and the maximum and the minimum emission was found to be from transportation sector and human respiration which was obtained as 71196.03 kg CO_2e/year and 21.2 kg CO_2e/year respectively. The net carbon footprint from the selected inventories was quantified as – 4851. 25 kg CO_2e/year.**

Keywords*— Activity data, Carbon footprint, Consumption-based approach, Energy Management Centre, Emission factor.

I. INTRODUCTION

The Earth's climate is changing as a result of anthropogenic activity since the start of the industrial revolution. There is growing scientific evidence that burning fossil fuels contributes to rising temperatures and extreme weather events [1]; The public and decision-makers have started to recognize the need for action to mitigate global warming [2]. Governments, policymakers and businesses have been urged to seek ways to reduce greenhouse gas (GHG) emissions in response to growing interest and concern about climate change over the past two decades [3].

Concern about climate change started with the scientific recognition of the relationship between CO_2 emissions and global warming. The increasing worldwide interest in the causes and consequences of climate change, and in exploring ways to respond, resulted in the formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. The IPCC was the first worldwide effort to create awareness of global warming and to feed scientific insights on climate change to governments. The IPCC released its first assessment report in 1990 [4]. This report played an important role in the establishment of the United Nations Framework Convention on Climate Change (UNFCC), an international environmental treaty with the goal of stabilizing GHG concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system. Efforts under the UNFCCC led to the Kyoto Protocol [5], an international agreement to cut GHG emissions, with specific reduction targets by country, signed in December 1997 and entered into force in 2005. The overall goal was a collective reduction of GHG emissions by 5.2% in 2012 compared to the emission levels of 1990.

Carbon footprint estimation has been used as an environmental indicator to understand and quantify the main emission sources and it constitutes as an effective tool for energy and environment management .It helps us to determine the quantity of emission from different carbon emitting sectors, which in turn is useful for quantifying the impact of human activities on the environment and global climate. The planning commission of the Government of India advocates in the 12th Five Year Plan (2012-17) of the country for low carbon growth. The proposed actions will reduce India's emission intensity from 20% to 25% by 2020 with respect to the emissions in 2005. This includes policy interventions to reduce emission intensity through fuel efficiency standards, green building code and energy efficiency certificates. This necessitates decentralized mitigation strategies to minimize carbon emissions which require sector wise and region wise inventory of GHG emissions.

The carbon footprint estimation concept has been defined mainly by private organizations and businesses [6].The most extensive survey on the definition of the carbon footprint estimation was done by Wiedmann and Minx [6]. Their research shows that the available studies do not offer

uniformity in the definitions and methodology of the carbon footprint estimation. They suggest the definition of carbon footprint estimation is 'a measure of the exclusive total amount of CO_2 emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product'. Pandey et al. [7] describe the carbon footprint estimation as 'the quantity of GHGs expressed in terms of CO_2-equivalent, emitted into the atmosphere by an individual, organization, process, product, or event from within a specified boundary'.

A carbon footprint estimation is made of the sum of two parts; the primary footprint and the secondary footprint. The Primary footprint is a measure of our direct emissions of CO_2 from the burning of fossil fuels including domestic energy consumption and transportation. It has been reported that direct control of this emissions are possible. The Secondary footprint is the measure of the indirect CO_2 emissions from the whole lifecycle of products - those associated with their manufacture and eventual breakdown [8]. Footprints can be calculated for individuals, events, organizations or products [9].An organizational net carbon footprint measures the GHG emissions from all the activities across the organization, including energy used in buildings, industrial processes and company vehicles. [10]

Many papers in the scientific literature can be found dealing with estimation of net carbon footprint.

GAP et al. [11] estimated that all schools in the United Kingdom had a carbon footprint of 9.2 million tonnes of carbon dioxide in 2001, equating to 1.3% of total UK emissions. Only around 26% of this total carbon footprint can be attributed to onsite emissions from the heating of premises, whereas the other three quarters are from indirect emission sources, such as electricity (22%), school transport (14%), other transport (6%), chemicals (5%), furniture (5%), paper (4%), other manufactured products (14%), mining and quarrying (2%) and other products and services (3%).

Keoy Kay Hooi et al. [12] proposed framework of Green Campus Initiative (GCI) implementation in order to reduce the environmental impact at UCSI University. The primary data collected includes electricity, fuel, and water bills. These primary data were processed with the formulas had been developed earlier and resulted the total carbon foot-print produced by UCSI University in one year.
Sivaram P M et al. [13] assessed the carbon footprint of an educational institution and suggested suitable parameters for reducing it. Greenhouse gas emitting protocol is projected using three basic steps includes planning, calculation and estimation of CO_2 emitted. The estimation of CF is calculated by accounting direct as well as indirect emissions. The CO_2 absorbed by trees are also accounted. The 'hot spots' in the campus were identified. The main prioritization goes to transport and then followed by DG, cooking and then electricity.

Matthew Moerschbaecher et al. [14] estimated the annual carbon footprints primarily from energy usage at Louisiana State University. Total energy use is 2.43 million British Thermal Units resulting in per capita GHG emissions of 6.1 Metric tonnes CO_2, which was low, compared to many other universities because of lower utility costs. Several alternatives for reducing energy use and emissions were considered.

Georgia Bezyrzi et al. [15] developed an Environ-mental Management System to estimate the carbon footprint of one of the University halls of residence that will assist the University in assessing its environmental impact. The procedure adopted, and the sensitivity studies undertaken, helped to inform the extension of the carbon footprint study to the whole university campus.

Vishakha Sharma et al. [16] studied the execution of Green Campus Initiative (GCI) at the BITS Pilani, Dubai Cam-pus by assessing their carbon footprint outflow. This research also provided future recommendations that can be implemented to reduce energy consumptions and carbon footprint. The analysis of energy consumption and greenhouse gas (GHG) emissions has been segmented as Goods and Services emissions (paper, plastic, aluminum cans), Campus Energy emissions, Transport Emission and Wastewater emissions. The data provided the opportunity to lead in the area of energy conservation and reduction of carbon emissions.

The objective of the present study is to determine the carbon footprint of the study area and to make it carbon neutral.

II. METHODOLOGY

Determination of carbon footprint was carried out in two phases such as collection of data and quantification of carbon footprint.

A. Study area

The study area selected was Energy Management Centre, Trivandrum. The study area is located at8^0 54' 58" E Latitude and 76^0 9' 09" N longitude. Fig. 1 shows the study area and its boundary.

B. Collection of data

The relevant data about the study area was collected. The boundary for the project location was fixed based on reconnaissance survey. Preliminary assessment of the site was done.GHG inventory parameters were identified. Relevent emission inventories at each site were selected. Data was then assembled [13].All relevant unit conversion factors and emission factors for storage in the emissions inventory database were identified.

Figure 1. The study area

C. *Quantification of carbon footprint*

The consumption quantities for each source was converted to a common unit that is compatible with the emission factors available. The inventories contributing to high emissions were identified in the study area. Viable measures to reduce CO_2 emissions into the atmosphere were then suggested.

III. EMISSION INVENTORY SURVEY

Feasible emission inventories were selected to analyze the net carbon footprint of the study area. The selected inventories were electricity, buildings, transportation, human breathing, and green coverage. The primary details as well as parameter wise details were collected. The received data were assembled and the missing gaps were recognized.

A. *Electricity*

Heating of the buildings with electricity generates a certain amount of CO_2 due to the generation of electric power. On an average, electricity sources emit 1.297 lbs CO_2 per kWh i.e. 0.0005883 metric tons of CO_2 per kW [8] .The details of the consumption of electricity in different zones of the study area were collected. Energy efficient lights and fans are used in the green building.

B. *Buildings*

Buildings emit considerable amount of carbon dioxide into the atmosphere and add to the net carbon footprint. Continuous emissions are there from buildings. The manufacturing of building materials (cement, brick, gypsum wallboard, steel, etc.) accounts for about 12% of all emissions of carbon dioxide (CO_2). A square metre of brickwork produces 28 kg of carbon dioxide by the time it is delivered to site [8]. That equates to just 0.0001867 tones per square meter a year, over 150 years. Buildings cause 40% of the carbon emissions. The details of the total built up area of buildings and other structures in the study area were calculated.

C. *Green coverage*

Plants absorb carbon dioxide during photosynthesis, using sunlight as an energy source to convert CO_2 and water into sugars, cellulose and other carbohydrates and release oxygen. A tropical tree can absorb 9.5 kg CO_2eq/m^2 area/year [18]. Total green coverage area of the campus was identified.

D. *Human breathing*

Carbon dioxide emitted by a person per day is not negligible. It is equivalent to the emission of a car in a 5 km stretch. Humans emit 26 giga tons of carbon dioxide per year while CO_2 in the atmosphere is rising by only 15 giga tones per year. Just for breathing, humans emit per person each day 1140 grams of CO_2, assuming that they eat normally and follow a mean diet of 2800kcal.[8] The carbon dioxide emissions will be larger in the zone having highest population [8]

E. *Transportation*

Fossil fuels are used for transportation. The carbon dioxide emitted by different fuels is in different amounts. The engine of the vehicle burns fuel and creates a certain amount of CO_2, depending upon its fuel type, fuel consumption and the driving distances. One liter of petrol and diesel emits 2.3kg and 2.7 kg of carbon dioxide, respectively. Travelling by car for 1000 km can produce about 200-230 kg of carbon dioxide into the atmosphere. The transportation details of the study area was collected by conducting a survey among the occupants of the study area. Questions were asked about mode of transportation, fuel used and type of vehicle. The details give us the idea that the vehicles' using petrol as the fuel is more in the study area. The carbon dioxide emitted from petrol is less compared to that of diesel. [8]

IV. EMISSION FACTORS

Standard emission factors published by Central Pollution Control Board, India (CPCB) and Department for Environment, Food, and Rural Affairs, UK (DEFRA) were used in this study for calculating the GHG emissions and the same is given in Table 1.

V. CALCULATION

Total carbon dioxide emission is the sum of emissions due to each activity .Each activity data is multiplied with the corresponding emission factor to get the emission from that activity [17].

Activity data × emission factor = carbon emissions (1)

TABLE 1. EMISSION FACTORS

Item	Emission factor from CPCB	Emission factor from DEFRA's table
Electricity	0.82/kWh	0.19/kWh
Petrol	2.3/L	2.3/L
Diesel	2.734/L	2.79/L
Human respiration	0.4/person	0.4/person
Concrete work	0.2 / m^2/ year	0.2 / m^2/ year

VI. RESULTS AND DISCUSSIONS

The area of the study area selected was obtained using Google earth and Earth point. In the data collection, the emission from various sources and facilities in the college was estimated.

A. Emission from buildings

The details of the total built up area of buildings and other structures in the campus were calculated. Built up area for each building was calculated using AutoCAD software. Fig. 2 shows the area calculation of old administrative block using AutoCAD. Total built up area of all the buildings in the study area was found to be 4836.71square metres and the corresponding emissions were quantified as 968 kg/m^2/year.

B. Emission from Green coverage

Total green coverage of the college was found to be 11623.73 square metres. Total green coverage area was more than that of the built up area.. Emissions absorbed by trees was quantified as 110425.4 kg/m^2/year.

C. Emission from Electricity consumption

The details of the consumption of electricity was collected. Electricity consumption included fan, internet facilities, laptops etc. Consumption details of electricity on days with and without programmes were separately calculated to arrive at the total electricity consumption of the study area. Total electricity consumption from all the sectors in the study area was found to be 40719 KWh /year and the corresponding carbon emission is 33389 kg CO_2 e/year.

The variation in CO_2 emission due to consumption of electricity is shown in Fig. 3. Since the electricity consumption is low in September 2016 and October 2016, corresponding emissions obtained is similarly showing the same decreasing trend. Less number of programmes during these months resulted in low electricity consumption.

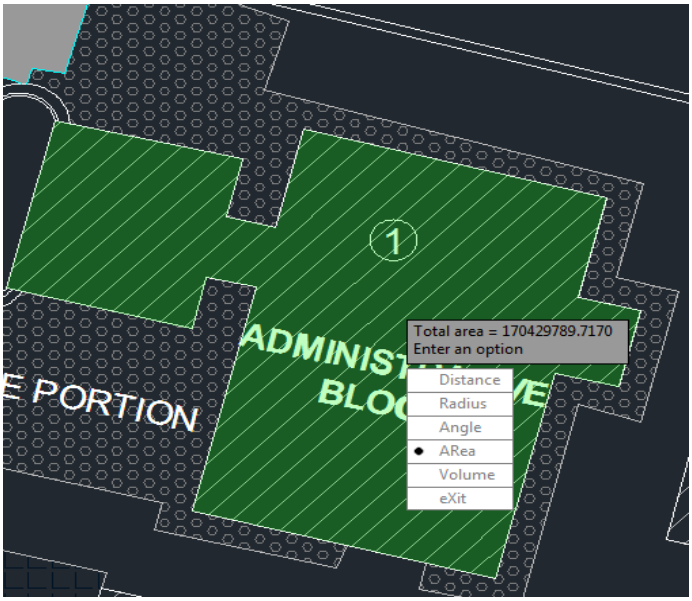

Figure 2. Area calculation of old administrative block using AUTOCAD

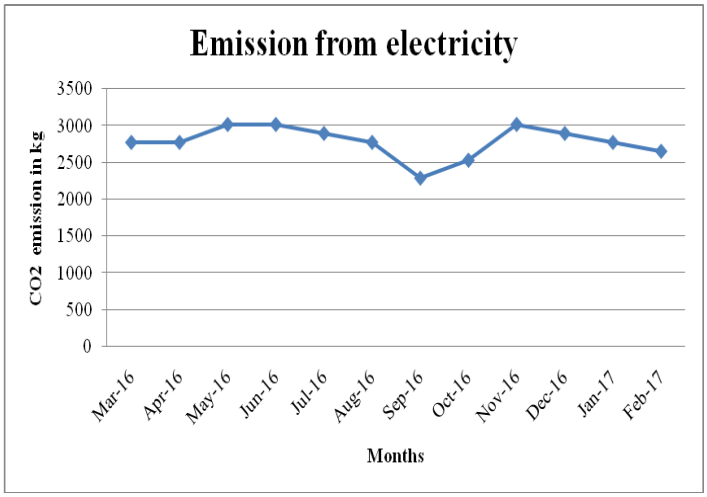

Figure 3. Variation in CO_2 emission due to consumption of electricity

D. Emission from transportation

The details of the transportation were surveyed. Almost all the staff members of Energy Management Centre participated in the survey. Majority uses two wheeler or four wheeler for transportation. Total emissions from transportation in the study area was found to be 71196.03 kg $CO_{2\ e}$ /year. Fig.4 shows the variation in CO_2 emissions due to transportation observed from March 2016 to February 2017.

E. Emission from human breathing

The total number of staffs in Energy Management Centre is fifty three and the total carbon emissions from human respiration amounts to 21.2 kg CO_2e/year.

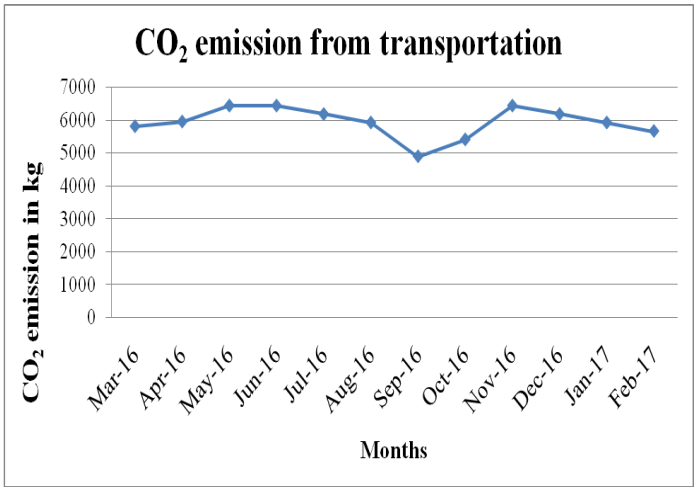

Figure 4. Variation in CO_2 emission due to transportation

VII. CONCLUSION

From this study it is clear that carbon emission reductions are possible, but these are highly dependent on the approach and parameters involved. The net carbon emission of the study area was found to be - 4851.25 kg CO_2 e/year. It has been observed that transportation sector contributes the maximum to GHG emission and thus the use of fuel is the thrust area that needs to be addressed along. It can be reduced by providing mass transportation facilities which can considerably reduce the fuel consumption. Analysis of the carbon footprint is basically a fair evaluation of the Carbon dioxide potency in the region under study. The scope of such a study is very much relevant in the current scenario of rising CO_2 levels in our very own ecosystem. The limitation of this study is that carbon emission factors such as water consumption, solid waste, solar panel and solar water heater were not considered.

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