Estimation of Carbon Footprint of Sacred Heart College, Kochi, Kerala, India

Athira Balakrishnan & Mathew M.J.
Dept. of Zoology, Sacred Heart College, Kochi – 682 013, Kerala, India
Email: *athirabkn@gmail.com*

ABSTRACT

The term "carbon footprint" is used to denote the amount of carbon dioxide produced by our daily activities and use of material goods. A common way to calculate a carbon footprint is in units of metric tons of carbon dioxide equivalent, which is a useful way to measure the relative effects of many different types of greenhouse gases. Emissions-emitting activities do not emit any one particular greenhouse gas but rather emit a variety of gases, with the most common being carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Feasible emission inventories selected to analyze the Carbon footprint include human factor, transportation, electricity, solid waste, production and consumption of food, LPG, natural gas etc. An Emission Inventory Survey was conducted at Sacred Heart College, Kochi, Kerala, India. The period of the study was appropriated from the month of August to February (academic year 2014-2015). Carbon offsetting or nullification of carbon footprints was also estimated by considering the following conservation method viz., bio-gas plant, non conventional sources of energy (wind turbine and solar panels) and car-pooling and using bicycles for transportation. The carbon footprint of the college was found to be 764.16 metric tons per year. From the data obtained and further calculations it is easily observable that the major part of CO_2 emitted is from Human Factor accounting for about 205.466 metric tons of CO_2 per year, i.e., about 26% of the total CO_2 levels. This is followed by CO_2 emitted by food items followed by LPG. Reducing the CO2 levels caused by Human Factor is not possible. At this point the importance of carbon offsetting arises. The levels that cannot be brought down can be neutralised by achieving any of the carbon offsets. Suggestions for decreasing the CO2 emission from electricity and LPG consumptions are to use non-conventional energy sources more. By establishing more solar panels and wind mills more offsetting can be done.

Keywords: Sustainability, carbon footprint, Sacred Heart College, Carbon offsetting

INTRODUCTION

The term "carbon footprint" is used to denote the amount of carbon dioxide produced by your daily activities and use of material goods. A carbon footprint consists of direct, or primary carbon production, and indirect, the secondary footprint. Primary footprint comes from the personal activities that result in carbon dioxide emissions – things like car burning fossil fuels, the energy used to heat and cool home, the electricity consumed at home or

work, etc. A carbon footprint has historically been defined as, the total set of greenhouse gas (GHG) emissions caused by an organization, event, product or person (Wright et al., 2011)

The term "carbon footprint" has grown in popularity over the past ten years in response to the increasing public awareness of environmental issues and climate change. This phrase is now widely used throughout the media, government and commercial world. The popularity of this concept is intrinsically linked to concern about increasing levels of CO_2 in the earth's atmosphere and the belief that increasing concentrations of CO_2 have and will continue to alter the earth's climate. The total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2).

A carbon offset is a reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for or to offset an emission made elsewhere. Carbon offsets are measured in metric tons of carbon dioxide-equivalent (CO_2e) (IPCC, 2001). One carbon offset represents the reduction of one metric ton of carbon dioxide or its equivalent in other greenhouse gases.

Carbon offsets are credits for reductions in greenhouse gas emissions made at another location, such as wind farms which create renewable energy and reduce the need for fossil-fuel powered energy. Carbon offsets are quantified and sold in metric tonnes of carbon dioxide equivalent (CO_2e). Buying one tonne of carbon offsets means there will be one less tonne of carbon dioxide in the atmosphere than there would otherwise have been. Carbon offsetting is often the fastest way to achieve the deepest reductions within businesses and it also often delivers added benefits at the project site, such as employment opportunities, community development programmes and training and education (islandoffsets.org, 2012).

Offsets are typically achieved through financial support of projects that reduce the emission of greenhouse gases in the short- or long-term. The most common project type is renewable energy, such as wind farms, biomass energy, or hydroelectric dams. Others include energy efficiency projects, the destruction of industrial pollutants or agricultural by-products, destruction of landfill methane, and forestry projects. Some of the most popular carbon offset projects from a corporate perspective are energy efficiency and wind turbine projects.

In this study, an attempt has been made to estimate the total carbon dioxide emission of Sacred Heart College, Kochi, Kerala, India and thereby find out the major emission factors of the college. Attempts were also made to estimate the carbon offsetting factors of the college.

MATERIALS AND METHODS

Emission Inventory Survey

An Emission Inventory Survey was conducted at Sacred Heart College, Kochi, Kerala, India. The period of the survey activities was appropriated from the month of August to

February (academic year 2014-2015). Feasible emission inventories were selected to analyze the Carbon footprint of the campus. The selected inventories were : Human Factor, Transportation, Electricity, Solid Waste, Production and Consumption of Food, LPG and Natural Gas

Data keepers were identified and the primary details were collected. Parameter wise details were collected. The received data were assembled and the missing gaps were recognized.

i. HUMAN FACTOR

Carbon dioxide emitted by a person per day is not negligible. It is equivalent to the emission of a car in a 5km stretch. Humans emit 26 gigatons 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. We went around each zone and collected the population details. The population details include the total number of teaching faculty, non-teaching staff and students. Table 1 shows the population details of each zone.

Table 1: Population Details

	Population (includes faculty, staff & students)	
Students	Day scholars	Hostellers
	2051	94
Faculty	115	
Non teaching staff	63	
Canteen staff	20	
College Women's Hostel staff	7	

ii. 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 litre of petrol and diesel emits 2.3kg and 2.7kg of carbon dioxide, respectively. Travelling by car for 1000km can produce about 200-230kg of carbon dioxide into the atmosphere. If a person travels by a bus for 1000km, it can add 1075kg of CO_2 to his/her Carbon footprint. Worldwide, the fossil fuels used for transportation contribute over 13%

of GHG emissions. Table 2 shows the transportation details for the college campus. There are 2 drivers in the institution. Also the students and staff depend on private vehicles too.

Table 2: Transportation Details

Sl. No	Type of vehicle	No. of vehicles	Fuel used
1	Bus	1	Diesel
2	Car	50	Diesel/Petrol
3	Scooter/ Bike	185	Petrol

The details give us the idea that the vehicles using petrol as the fuel is more in the college premises. The carbon dioxide emitted from petrol is less compared to that of diesel. The Carbon footprint by the emission inventory transportation will be quite high.

iii. ELECTRICITY

Electricity is one emission inventory which contributes much to the Carbon footprint of the institution. 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 1.297lbs CO_2 per kWh i.e. 0.0005883 metric tons of CO_2 per kWh. If the consumption amount of electricity is 1kWh, then about 10kg of CO_2 is released into the atmosphere. The emission factor given by eGRID 2010 version 1.1 for hydro electricity is 6.8956×10^{-4} metric tons CO_2/kWh. 50 grams of CO_2 is emitted from 1 unit of solar power.

Table 3: Consumption of Electricity

Sl no:	Buildings	Consumption (monthly) (kWh)
1	College Buildings	13470
2	College Canteen	2214
3	College Women's Hostel	1185
Total		16869

iv. SOLID WASTE

Generally, 1kg of solid waste is generated per capita per day. For high income countries, the solid waste generation is 1.1-5kg per capita per day. For middle income countries, it is 0.52-1kg and for low income countries the value is 0.45-0.89kg/capita/day. One kilogram of solid waste can emit about 0.125kg of carbon. The details of the solid waste generated in each zone are given below. The detail of the solid generation in the college campus is given in Table 4.

Table 4: Solid Waste Generated in the College Campus

Buildings	Solid waste generated per day(kg)
Canteen	15
Ladies hostel	10

The solid waste generated in the canteen and hostel is taken out of the campus and comes under other indirect emissions. It accounts about 25 kg per day. Solid Waste emits less amount of carbon dioxide compared to other emission inventories considered. The food waste from canteen is used to produce biogas.

v. FOOD PRODUCTION AND CONSUMPTION

Food is one of the consumption categories which cause the highest environmental impact on the climate. According to the study conducted by the European commission (2006), the food and drink category causes 20-30% of the various environmental impacts of total consumption. Worldwide, agriculture contributes to nearly 14% of total GHG emissions.

The Carbon footprint of an average diet is 0.75 tons CO_2-eq, without accounting for food transportation. The amount of GHGs produced by the production of food differs much from one food type to other. Meat products have a larger Carbon footprint than fruits, vegetables and grains. The Carbon footprint of an average meat eater is about 1.5 tons CO_2-eq larger than that of a vegetarian. Consumption details are given below in Table 5.

Table 5: Food Consumption Details

Zone	Area	Food details (per day)			
		Rice (kg)	Vegetables (kg)	Chicken (kg)	Milk (litres)
1	Canteen	90	45	25	45
2	Ladies hostel	10	8	5	8

The value of carbon dioxide emissions from food items are tabulated in Table 6.

Table 6: Carbon dioxide Emissions from each Food Item

Food Items	Carbon dioxide emitted per kg (kg)
Rice	0.92
Fresh vegetables	1.5
Chicken	3.5
Milk	0.95

vi. LPG AND NATURAL GAS

The consumption of one litre of LPG can release 1.5kg of carbon dioxide to the atmosphere. Also burning of wood (250kg) can add 33kg of carbon dioxide to the Carbon footprint. Table 7 gives the consumption details of LPG in canteen and hostels.

Table 7: Consumption Details of LPG and Natural Gas

Zone	Area	Consumption of LPG per month (kg)	Consumption of Natural Gas per month (kg)
1	Canteen	950	-
2	Ladies hostel	50	-
3	Laboratory	17	-

Carbon Footprint Estimation

Carbon footprint analysis can be done by suitably combining data collected with respective emission factor of the selected emission inventories. Table 8 represents emission factors of the selected inventories.

Table 8: Emission factors

Sl.No.	Emission inventory	CO_2 Emitted
1	Human factor	1140 grams per person per day
2	Petrol	2.3 kg per liter
3	Diesel	2.7kg per liter
4	Hydro electricity	0.68956kg per kWh
5	Solar based electricity	0.05kg per kWh
6	Solid waste	0.125kg per kg
7	Rice	0.92kg per kg
8	Fresh vegetables	1.5kg per kg
9	Chicken	3.5kg per kg
10	Milk	0.95kg per kg
11	LPG	1.5kg per L
12	Natural gas	0.775kg per L

RESULTS AND DISCUSSION

Carbon footprint of the campus was computed by suitably combining data collected with respective emission factor of the selected emission inventories. The results are summarized below.

i. HUMAN FACTOR

We considered day scholars to be in the college for 8 hours & hostellers' to be present for the full day. (16 hours in the hostel & 8 hours in class). Total working days over the

academic year are considered to be 200. Hostel is considered to be fully functional for 300 days a year. We have taken into consideration students attending labs on a regular basis. Table 9 indicates CO_2 emissions from human factor.

Table 9: CO_2 Emissions from Human Factor

ii.

Building	Population	CO_2 Emission per Year (kg)
Total	2350	205466

TRANSPORTATION

The emission was calculated taking into consideration that all other vehicles travel an average distance of 30 km per day. Fuel consumption and distance travelled are the major factors affecting the CO_2 emissions and the results are tabulated in table 10. CO_2emissions from other vehicles also are tabulated in table 10.

iii. ELECTRICITY

From central pool, we consider hydro-power to be the chief source of electricity. CO2 emission from electricity is considerably large and the concerned details are tabulated in table 11.

Table 10: CO_2 Emission from Vehicles

Vehicle	Total Count [C]	Distance Travelled in a day (Km) [C] x 30	Mileage (Km/l)	Petrol/Diesel used per day (l) [A]	CO_2 Emitted per day(Kg) [A] x E.F*	CO_2 Emitted per year (Kg)
Car	50	1500	15	100	230	46000
Scooter/Bike	185	5550	40	138.75	319.125	63825
Bus	1	30	4	7.5	20.25	4050
Total						113875

* E. F - Emission Factor for Petrol – 2.3 Kg of CO_2 per litre

Emission Factor for Diesel– 2.7 Kg of CO_2 per litre

Table 11: CO_2 Emission from electricity

Total Consumption per month (kWh) [A]	CO_2 Emitted per month (Kg) [A] x E.F*	CO_2 Emitted per year (Kg)
16869	11632.188	116321.8764

*E.F- Emission factor for hydro electricity-0.68956 kg of CO_2per kWh

iv. SOLID WASTE

Paper waste is generated from all around the college campus. Food waste is considered from canteen and hostel. Hostel is considered to fully functional for 300 days a year. College Canteen also functions for 300 days a year. The CO_2 emissions from solid waste are given in table 12.

Table 12: CO_2 Emission from Solid Waste

Waste generated per day (Kg) [A]	CO_2 emitted per day (Kg) [A] x 0.125	CO_2 emitted per year (Kg)
25	3.125	937.5

v. PRODUCTION AND CONSUMPTION OF FOOD

Hostel is considered to be fully functional for 300 days a year. College Canteen is also functional for 300 days a year. Assuming about 40% of the population brings their own food in the college, except in the case of hostels. The CO_2 emissions from various food items are tabulated in table 13.

Table 13: CO_2 Emission from Food Items

Food item	Amount (Kg) [A]	CO_2 emitted per day (Kg) [A] x E.F*	CO_2 emitted per year (Kg)
Rice	100	92	27600
Vegetables	53	79.5	23850
Chicken	30	105	31500

Milk	53	50.35	15105
Total			98055

E. F - Emission Factor for rice– 0.92 Kg of CO_2 per Kg

Emission Factor for vegetables– 1.5 Kg of CO_2 per Kg
Emission Factor for chicken– 3.5 Kg of CO_2 per Kg
Emission Factor for milk– 0.95 Kg of CO_2 per Kg

On an average, 0.212 kg of $CO_2$is emitted from one person's diet (one meal) per day.

Table 14: CO_2 Emission from Food

Campus	No. of day scholars	CO_2 emitted per year (Kg)
	2249	95357.6
Total		193412.6

vi. LPG

The LPG consumption in the canteen and the hostels contribute to the carbon footprint of the campus. Natural gas is not being used in this college. The emission details are as tabulated in table 15.

Table 15: CO_2 Emission from LPG

Consumption per month in Kg [A]	Consumption per month in litres [C] [A] x 1.04	Amount of CO_2 emitted per month (kg) [C] x 1.5	Amount of CO_2 emitted per year (Kg)
1017	1057.68	1586.52	158652

Carbon offsetting or nullification of carbon footprints is estimated by considering the following conservation methods:

i. Bio-gas plant
ii. Non Conventional Sources of energy (Wind turbine and Solar panels)
iii. Car-pooling and using Bicycles for transportation

The College canteen have one biogas plant which works on the solid wastes from the canteen itself and the biogas thus generated is used for boiling water. Hence approximately about 120 kg biogas is generated which is sufficient to boil about 100 litres of water for a day. About 300g of LPG can be replaced by 1 kg biogas.

Table 16. CO_2 replaced by Biogas plant

Consumption per month in Kg [A]	LPG saved in Kg [A] x 0.3 [C]	LPG saved per day in liters [D] [C] x 1.04	Replaced amount of CO_2 per year (Kg) [D] x 1.5 x 300
120	36	37.44	16848

There is one wind mill and solar panels instilled in the college for generation of electricity. This electricity generated is used as a backup for 9 hours and saves about 9-10 units per day. That will be about 2700 units saved per year.

Table 17. CO2 replaced by non-conventional energy sources

kWh saved in 1 day [A]	Replaced amount of CO_2 per day in kg [A] x E.F*	Replaced amount of CO_2 per year (Kg)
9	6.20604	1861.812

*E.F- Emission factor for hydro electricity-0.68956 kg of CO_2per kWh

There are students as well as faculty using bicycles for transportation. Also some of the teachers are using car-pooling system for reaching to college. For calculation in the case of cycle, it is compared with a two-wheeler having an average mileage of 40Km/L travelling an average distance of 30Km. The carbon emitted by one single two-wheeler, per day, reaching the college is 1.725 Kg. Regarding car-pooling, there are 5 persons involved in it. Hence the carbon emissions of 4 cars' are reduced. The carbon emitted by one single car, per day, reaching the college is 4.6 Kg.

Table 18. CO2 replaced by energy efficient transportation

No. of cycles [A]	CO_2 replaced by all cycles per day (Kg)	CO_2 replaced by car-pooling per day (Kg)	Total CO_2 replaced per day (Kg)	Total CO_2 replaced per year

	[B] [A] x 1.725	[C] 4 x 4.6	[B] + [C]	(Kg)
6	10.35	18.4	28.9	5780

The green cover of the college campus will act as an offsetting factor too. The numerous trees and plants in the botanical garden and around the Lakeview ground have great significance regarding carbon offsetting.

Table 19. Total offset

Carbon Offsets	Total (metric tonnes)
Biogas	16.848
Non-conventional energy sources	1.862
Energy efficient transportation	5.78
Total	24.49

Therefore the carbon offset of Sacred Heart College is 24.49 CO_2e.

The total carbon footprint of the college was determined on the whole. Values are tabulated in table 16.

Table 19: Total CO_2 Emission from Sacred Heart College, Kochi

Emission Inventory	Total (metric tonnes)
Human Factor	205.466
Transportation	113.875
Electricity	116.3219

Solid Waste	0.9375
Food Items	193.4126
LPG	158.652
total	788.665
Carbon Offset	24.49 CO_2e
Total CO_2 emission	764.16

The carbon footprint of Sacred Heart College was found to be 764.16 metric tons per year.

From the data obtained and further calculations it is easily observable that the major part of CO_2 emitted is from Human Factor. It accounts for about 205.466 metric tons of CO_2 per year, i.e., about 26% of the total CO_2 levels. Then comes CO_2 emitted by Food items followed by LPG. Reducing the CO2 levels caused by Human Factor is not possible. At this point the importance of carbon offsetting arises. The levels that we can't bring down can be neutralised by achieving any of the carbon offsets.

Suggestions for decreasing the CO2 emission from electricity and LPG consumptions are to use non-conventional energy sources more. By establishing more solar panels and wind mills more offsetting can be done. Also usage of biogas plant will reduce waste production and as a result decreases the dependency on LPG. Replacing LPG with Natural gas can also decrease the carbon footprint as the CO_2 emitted from the burning of natural gas (0.775Kg CO_2 per L) is much lower than that of LPG (1.5Kg CO_2 per L).

Regarding food, following more of a vegetarian diet can reduce the carbon emissions as vegetables have a smaller carbon footprint than non-vegetarian meals.

Yet another method to reduce CO2 levels is to use bicycles as the means of transport or switching on to private vehicles. This can produce tremendous results. Following the car-pooling method can also reduce CO2 emissions.

CONCLUSION

Sustainable Development stands for meeting the needs of present generations without jeopardizing the ability of futures generations to meet their own needs. It offers a vision of progress that integrates immediate and longer-term objectives, local and global action, and

regards social, economic and environmental issues as inseparable and interdependent components of human progress. Sustainable development ties together concern for the carrying capacity of natural systems with the social challenges faced by humanity. The concept of sustainable development helps us to understand ourselves and our world. Sustainable development requires meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life. Reducing is the most important rule to follow when trying to achieve substantiality and to improve green credentials. Reducing environmental waste means avoid using resources unnecessarily. Reducing the amount of environmental waste you generate is the single most important step you can take to limit your impact on the planet. The study clearly indicates the need to reduce CO2 levels through carbon offsetting, using non-conventional energy sources, following more of a vegetarian diet, as well as using bicycles as the means of transport and following the car-pooling method.

REFERENCES

http://www.islandoffsets.org/faq.html. Retrieved 2014-02-15

Intergovernmental Panel on Climate Change. 2001. Working Group I: The Scientific Basis. Retrieved 2014-02-15

Kiehl JT, Trenberthk E (1997), “Earth’s Annual Global Mean Energy Budget”, Bulletin Of The American Metrological Society, 78(2): 197-205.

Russell, Randy (2007), “The Greenhouse Effect and Greenhouse Gases”, University Corporation for atmospheric research windows to the universe and global climate change, part 2" 100th Cong., p. 44 (2007).

Wright L, Kemp S., Williams I. (2011). Carbon Foot Printing Towards A Universally Accepted Definition. Carbon Management 2 (1): 61-72.