ASSESSMENT OF GREENNESS THROUGH CARBON FOOTPRINT

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Abstract

With increasing global GHG emissions it is very important for global to reduce the harmful effect of GHG emissions for future generations. Since the last decade Carbon footprint has become one of the major concern for educational institutions to get their environmental impact and quantify sustainability effort. MNIT Jaipur campus is one of the technical institutes that decided to measure its carbon footprint. This research presents the maiden Carbon Footprint study of MNIT Jaipur Campus. This study was conducted using IPCC methodology with scope 1, scope 2 and scope 3. The scope 1 includes the direct transportation of campus and LPG consumptions. In scope 2, electricity was the only source of emission whereas scope 3 includes staff commuting, bore well water supply, wastewater treatment, papers, aluminum can and solid waste. The total carbon footprint of MNIT Jaipur Campus was calculated to be 1182.69 ton CO2 eq. This study concludes that 29% of the overall carbon footprint was found from purchased electricity. While emissions from LPG consumption (26%), solid waste (16%), water supply (12%) and aluminum can (10%). The activities wastewater (4%), staff commuting (1%) and direct transportation (1%) have low emission compare to other activities. GHG emission percentage from papers, staff commuting, and

direct transportation are negligible. This has a great contribution to achieving carbon neutrality of the campus. The per capita average emission found to be 0.273 ton CO2 eq. per person per year. Scope 3 emission has the highest contribution to the overall emission. From the literature, it was found that very few previous studies included scope 3 for calculating the carbon footprint, but this study shows that educational institutions have a significant impact on scope 3. Therefore every institution has needed to include the entire source associated with scope 3.

1. Introduction

Climate change is a critical issue which attracts the concentration of the world due to global warming. It is the challenge for all the countries either developing or developed to reduce greenhouse emissions. Since the last few decades, global warming is not only an environmental concern but also one of the largest challenges in the world. The rapid growth of population and energy consumption is the main cause of GHG emissions. Therefore lots of summits such as COP and IPCC are organized about carbon emissions in the international community which gives various protocols and regulations to decrease carbon emissions. CO_2 is the main contributor to global warming. According to Olivier et al., 2012 PBL Netherlands Environmental Assessment Agency Report 2016 CO_2 accounts for 72%, followed by CH_4 19%, N_2O 6% and F-gases (Fluorinated gases) 3%. Thus CO_2 emissions can cause a crisis in the future because it leads to increase the climate temperature and has spoiled the sustainability. Due to rising with the temperature, ice can melt, the level of sea increases and possibly flood can cause. In addition to summer, the temperature is continuing to rise, which reduces the soil moisture at some places and this can create a problem for agriculture, biodiversity and crop failure results in hunger and food supply.

As per IPCC, 2006 Anthropogenic GHG emissions are the main cause of global warming, a critical issue that different nations and global associations are endeavoring to tackle .According to Allen et al., 2014 During the period 2000 to 2010 anthropogenic emission has been increased by about 10 $GtCO_2$, from this maximum quantity shared by energy supply (approx. 47 %) followed by industry sector (30%), transportation sector (about 11%) and building (about 3%). GHG gases are Carbon dioxide (CO_2), Nitrous oxide (N_2O), Methane (CH_4), Per fluorocarbons (PFCs), Hydro fluorocarbons (HFCs), Sulphur hexafluoride (SF_6) and Nitrogen trifluoride (NF_3), etc. Out of these CO_2 focus has expanded from 279 p.m. to 397 ppm since 1800, essentially because of fossil fuel burning (EPA 2008, 3). According to International Energy Agency, 2017 India is now the 3rd largest energy consumer and Olivier et al., 2017 addressed that India is 3rd largest CO_2 emitter in

the world. Fig. 1 shows the global carbon emission for 2016. In 2016 the CO_2-e emission of India reached 2.53 $GtCO_2$ or 7% of the world total. The main reason for this is increasing GDP and increment in fossil fuel consumption. Still, its emissions are still lower than the developed countries. Under the Paris agreement, India pledged to reduce its emissions by 30-33% by 2030.
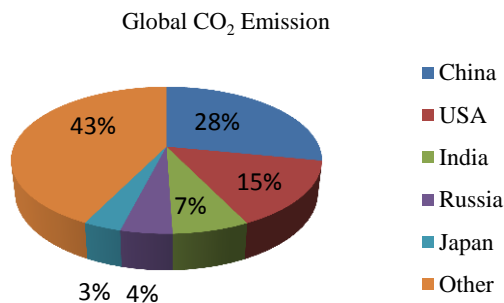

Figure 1: *Global CO$_2$ Emission*

To develop the environmental performance toward sustainable development every organization, businesses and government institutions have to focus on GHG emission. In the past decade, a lot of efforts were made by such organization to reduce GHG emission. Over time the number of mitigation policies has been developed for climate change. As per Allen et al., 2014 Instead of these policies, the GHG emissions have been continued to increase on average 1 $GtCO_2$ eq. or 2.2 % per year from 2000 to 2010 and during the period 2000 to 2010 the total GHG were maximum in past history. But still, few more efforts are needed to focus on it. According to Larsen et al., 2013 there has been one institution i.e. educational institution where they have been a specific focus on sustainable achievements. Various authors like Stephens and Grahm, 2010 and Wiedmann and Minx, 2008 have addressed that to focus on this there was a large number of initiatives; most of them have quite a broad scope: the role of universities in creating knowledge, integrating sustainability in education and research programs and the promotion of the environmental issues to the society. As per Gomez et al., 2016 around the globe, universities have been pioneers in advancing sustainability, including attempting to represent and decrease GHG emissions. Universities should be pioneers for sustainability and environmental developments. According to Li et al., 2015 universities can contribute a major role in promoting and assessing the GHG emission. So the universities along with the planning time horizon, organization are the ideal places to measure GHG emission.

In the framework of sustainable development and the alleviation of climate transformation, it is crucial to assess the carbon footprint of educational institute. Mendoza-Flores et al., 2019 assessed the environmental impact and calculate the carbon footprint of a public university campus in Mexico City using the GHG protocol (GHGP): Scope 1: direct GHG emissions; Scope 2: indirect

GHG emissions; and Scope 3: other indirect GHG emissions, on a calendar year basis. They found that the campus produced around 3000 tons of CO2 equivalent, with Scope 1, 2 and 3 accounting for 4%, 24% and 72%, respectively. Li et al., 2015 developed a novel methodology for estimating an average student's personal carbon footprint and deployed it at a university in Shanghai. They found that average annual carbon footprint was a relatively modest 3.84 tons of CO2 equivalent per student, with 65% attributable to daily life, 20% to transportation, and 15% to academic activities like studying. Men, graduate students, and students from metropolitan areas had higher footprints than women, undergraduates, and students from rural areas and small towns. Ridhosari and Rahman (2020) assessed the Carbon footprint at Universities Pertamina from the scope of electricity, transportation, and waste generation. They found that electricity is the greatest contributor of carbon emissions at the university, at 92.3%, followed by transportation at 6.66% and waste generation at 1.04%. Yanez et al., 2020 calculated the carbon footprint of Talca campus at the University of Talca in Chile through GHG protocol (GHGP) with three scopes—1) direct; 2) indirect; 3) other indirect emissions. They found that the Scope 3, which measures indirect emissions generated by activities like transportation of people, produced the highest contribution of 0.41 tCO2e per person to the UT's CF in 2016.

As per Larsen et al., 2013 GHG emission is indicated by the Carbon Footprint. It has proven to be an effective measure of direct and indirect GHG emissions in a wide range of studies, ranging from global, regional, and national to the sub-national level. According to Wright et al., 2011 carbon footprint is an indicator of the contribution made to climate change by a product, activity or population, and it can be treated as a decision-assisting tool. As per Pandey et al., 2011 the concept of carbon foot printing stems from "ecological foot printing or a measure of the biologically productive land and sea area required sustaining a given human activity. Wiedmann and Minx, 2008 have addressed the common definition for a carbon footprint is "a certain amount of gaseous emissions that are relevant to climate change and associated with human production or consumption activities". Many authors (Ho et al., 2016; Menikpura et al., 2016; Alwabr et al., 2016) have focused on the Environmental impact and emissions of different type of activities.

Malaviya National Institute of Technology situated in the pink city of India, Jaipur, reside in Northern India, a distance of 260 Km from Delhi. MNIT earlier known as the Malaviya Regional Engineering College was founded in 1963. MNIT spread over 125 hectares with lush of greenery. MNIT campus presents a spectacle of harmony in modern architecture and natural beauty. According to MNIT campus facilities, it has three functional areas: Hostels for students, Instructional buildings and Residential sector for staff. Research and development is the focal point to achieve its vision. On present campus have fourteen departments. In 2017, for the scope of this

study, there were 2989 under-graduate students and 862 postgraduate students. During this year MNIT employed 190 faculty, 17 administrative staff, 66 ministerial staff, 133 technical staff, and 68 supporting staff. For this study, MNIT has set a goal with a timeline, therefore a baseline standard for carbon footprint must be created to develop policies and investigate progress. The main goal of this study is to measure a Carbon Footprint of Malaviya National Institute of Technology, Jaipur using IPCC methodology with scope 1, scope 2 and scope 3. The carbon footprint of an educational institute is not a fully developed research area still, despite a growing movement to cut down GHG emissions from several organizations. To address the GHG emission of MNIT, this study evaluates the activities that emit GHG emission. From this, another goal of this research is to identify which activities are the greatest contributors to the carbon footprint and then provide some suggestions that offered to cut down GHG emission. This paper will be structured to give an overview of the reader to concern with greenhouse gas emissions. Section 1 provides the introduction, goal, and objectives. Section I will introduce the GHG methodology, scope of the study and also approach used to calculate the carbon footprint. The results of the study will be explained in section II. Finally, the conclusion is explained in section III.

2. Materials and Methods

2.1 Assessment Methodologies of Carbon Footprint

Because of the numerous sizes of investigation (worldwide, national, city/province, item), there is no single standard methodology for utilization based Carbon Footprint examination. According to Wiedmann, 2009 notwithstanding, three primary methodologies are presently a work in progress, including Environmental Expanded Input-Output (EEIO) investigation, Hybrid IO-LCA techniques, and Life Cycle Assessment (LCA). The decision of methodology depends upon functional unit and scale. Instead of this few standards have been developed and few are under development to give guidelines on Carbon Footprint evaluation at different scales and zones of use, including the 2006 IPCC rules, PAS2050, The Greenhouse Gas Protocol (WBCSD and WRI, 2004 and the International Local Government GHG Emissions Analysis Protocol (IEAP). Despite the diverse goals and target group behind these principles, they are not created in an isolated way. IPCC methodology provides a way for estimating inventories of anthropogenic emissions.

2.2 The Methodology Applied for This Study

All to calculate the carbon footprint for this project work, the case study follows the guidelines of IPCC 2006 methodology. IPCC guidelines follow a hierarchy of estimation methodologies and methods ranging from the use of emission factors. The most widely recognized calculation method is to obtain GHG emission by multiplying activity data with emission factors.

$$\text{GHG emission} = \text{activity data} \times \text{emission factor} \qquad (1)$$

Greenhouse gas emission divided into three categories: Scope-1, Scope-2, and Scope-3. Scope-1 includes every single direct source of GHG emissions from sources that are owned or operated by your organization, including (however not restricted to): generation of power, heat or steam; transportation or materials, items, waste. Scope-2 refers to indirect emissions from electricity, steam, cooling and heating consumption that are linked with the generation of imported sources of power and scope 3 refers to all other types of indirect emissions that may come from activities of the institution but occurred from sources operated by another organization.

Table 1 provides the relevant GHG emissions sources of the campus and reference to the emissions categories scope 1, scope 2 and scope 3 of GHG protocol.

Table 1: *Emission Category and Scope*

Scope	Emission Category
Scope 1	Cogeneration Electricity
	Stationary combustion
	Direct Transportation
	Refrigerants and chemicals
	Fertilizers
Scope 2	Purchased Electricity/Steam/Chilled Water
Scope 3	Faculty/Staff commuting
	Students commuting
	Air travel
	Goods and Services

2.3 Scope of Assessment

The World Resource Institute and World Business Council for Sustainable development Greenhouse Gas Protocol Corporate Standard is a commonly used standard for GHG Emission. As per WRI,2015 the GHG Protocol Corporate standard provides the guidelines for the Carbon Footprint by classifying the emission activities coming under three scopes, Scope 1, Scope 2 and Scope 3. According to Kyoto Protocol, 1997 Scope 1 emissions are direct greenhouse gas emissions that occur from various sources that are controlled by the organizations. Scope 2 considers the emissions from upstream emissions. For example, emission generates from purchased electricity. As per WRI, 2015 the Scope 3 emission is indirect emissions that occur from the sources controlled or owned by another entity. Table 2 provides information for various sources under three scopes.

Table 2: *Emission Scope and their Sources*

S.No.	Scope	Sources
1	Scope 1	Steam Generation
		Refrigerant % of Chemicals Usage
		Campus Vehicles
		Fertilization Applications
		Stationary combustion
2	Scope 2	Purchased Electricity
		Purchased Steam
		Purchased Chilled Water
3	Scope 3	Staff & Student Commuting
		Air Travel
		Solid Waste
		Paper Usage

Some recent carbon footprint studies have been widely accepted to apply various applications, few studies have focused on GHG emissions from higher education institutions and their management approach. Most of the studies focused on scope 1 and scope 2 emissions and few studies include scope 3. However, Robinson et al., 2015 has suggested that scope 3 accounts about 80% emissions of the carbon footprint of an organization. Thus the present study included scope 3 emissions to contribute to the carbon footprint of higher education institutions.

2.4 The Carbon Footprint Approach

Fig. 2 shows the basic approach to measure carbon footprint. The first step is to determine the system boundaries and sources that emit emissions. In this step the activities or consumption data are determined for example, electricity used (kWh), distance traveled (Km). The second step is to define the methodology of carbon footprint. Then, collect the activities data and drive the associated greenhouse emission factors. Apply calculation tool to estimate the emissions in ton CO_2 eq. for each activity and sum up each source's emission to determine overall emission.
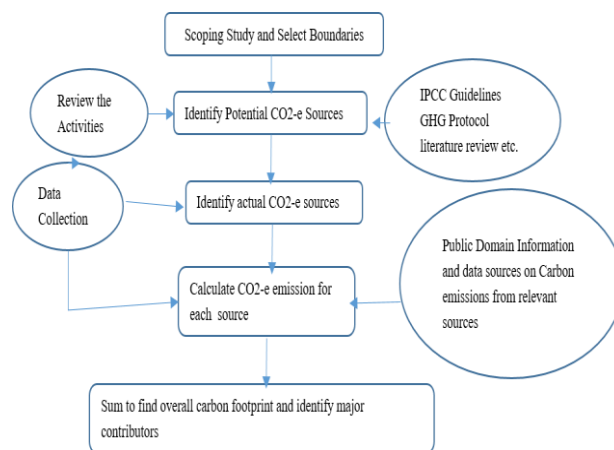

Figure 2: *Framework with Steps to Calculate Carbon Footprint*

2.5 Emission Factors

Selection of emission factors is the most challenging task for this study. Since these are the basis for the assessment and can influence the results. Thus, emission factors should be selected carefully or calculate only when sufficient data is available. For the selection of these emission factors in this study, we go through the various sources like IPCC emission factors, some literature, and country-specific report. We select the most reliable emission factors for each category and these factors, not affected much by geographical characteristics. The emission factor for electricity varies from country to country and also depends on the sources that are used to generate electric power. Table 3 provides the details about emission factors taken for this study.

Table 3: *Emission Factors used in this Study*

Source	Emission Factor	Units	References
Electricity Hydro	1.1389	Kg CO_2 /KWh	12
Water (Borewell supply)	0.67	Kg CO_2eq. /Kl	11
LPG	0.063236	t CO_2eq./ GJ	12
Vehicle Fleet			
Innova	0.2	Kg CO_2/Km	6
Bolero	0.195	Kg CO_2/Km	6
Bus	0.73551	Kg CO_2/Km	11
Ambulance	0.103	Kg CO_2/Km	6
Tractor	0.307	Kg CO_2/Km	6
ALTIS	0.149	Kg CO_2/Km	6
Staff commuting			
Car (Diesel)	0.12325	Kg CO_2/Km	6
Car (Petrol)	0.13275	Kg CO_2/Km	6
Bike (Petrol)	0.034	Kg CO_2/Km	6
Goods and Services			
Wastewater	0.217	kg / m^3	1
Aluminum Can	8	kg per Al. can	17
Paper	2.5	Kg CO_2/Kg	11
Solid Waste (Landfill)	0.87	kg CO_2 eq. / kg	1

2.6 Data Collection

Numbers of data are required for calculating the carbon footprint of the institute/university. In this section, an overview of data collection is provided. Different sources are identified from the literature review that emits GHG emissions under scope 1, scope 2 and scope 3. Table 4 provides the information of scope classifications as well as relevant emissions categories that are taken into consideration for calculating the carbon footprint of MNIT campus.

Table 4: *Emission Categories for MNIT Campus*

Activity	Scope
Direct Transportation	Scope 1
LPG	
Purchased Electricity	Scope 2
Staff Commuting	Scope 3
Water Supply	
Wastewater	
Papers	
Al can	
Solid Waste	

The data from these sources were collected from different departments such as estate section, stationary, hostel mess, etc. Table 5 provides information about data sources.

Table 5: *GHG Emissions Data for MNIT Campus*

S.No.	Source	Units	Quantity
1	Direct Transportation	km	72871.5
2	LPG	kg	96929.2
3	Purchased Electricity	kWh	301421
4	Staff Commuting	km	206400
5	Papers	kg	1866
6	Waste Water	m3	197649.64
7	Solid Waste	kg	220000
8	Aluminum can	No. of cans	14400
9	Water	liter	217800000

3. Result and Discussion

This section describes the emissions by scope 1, scope 2 and scope 3. Further, in this section emission are categories by each emission categories. The main goal of this study was to measure a Carbon Footprint of Malaviya National Institute of Technology. The study shows that total emissions recorded for the year 2017 1182.69 ton CO_2 eq. This is lower than the Norwegian

University of Technology and Science, which have calculated 92 kilotons of CO_2 equivalents. In table VI below the results of calculations are sown. GHG emissions are reported for each category in terms of total emissions in tons of CO_2 eq. and total emission in percentage. By far the largest contributors were purchased electricity (29%), which have 345.287 tons CO_2 equivalent. Transportation and staff commuting accounts very fewer percentages of emissions at 1% and 1 % respectively. This is very low than 16 % at Norwegian University of Technology and Science, 20% at University campus China because MNIT campus does not allow public vehicles and students vehicles into the campus. Scope 3 is quite significant than scope 2 and scope 1. Scope 3 is high mainly because of solid waste and aluminum cans. In scope 3 the emissions percentage of staff commuting and papers are negligible but still can be reduced. Purchased electricity accounts for the highest CO_2 emissions from all the sources followed by LPG consumption.

Table 6: *Carbon Footprint for MNIT Campus*

Activity	tons CO_2 - e	% of total Emissions
Scope 1		
Direct Transportation	16.4739	1%
LPG	303.845	26%
Scope 2		
Purchased Electricity	345.287	29%
Scope 3		
Staff Commuting	17.0145	1%
Water Supply	145.926	12%
Wastewater	42.889	4%
Papers	4.66	0%
Al can	115.2	10%
Solid Waste	191.4	16%
Total	1182.6954	100%

3.1 Footprint by Scopes

Another way to describe the carbon footprint in the form of scopes of emissions. All the scopes are very important for the study. Scope 1 directly connected to the emission sources while scope 2 and scope 3 do not include the sources that are directly connected to the inputs. Fig. 3 shows the emissions breakdown by scopes. The results show that scope 3 contributes the highest percentage of emission into the carbon footprint followed by scope 2 and scope 1.
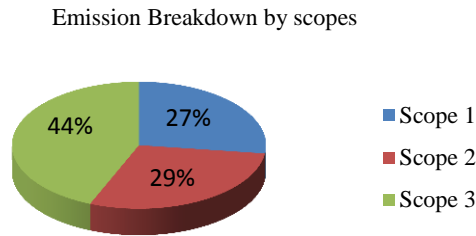
Emission Breakdown by scopes

Figure 3: *Emissions Breakdown by Scopes*

3.2 Footprint by Emission Categories

This is another way to categories the GHG emissions in terms of each impact categories. The fig. 4 shows that electricity is the highest emitting category because it is the largest consumption activity of the campus with a high emission factor. This category followed by LPG consumption that came up to be a large amount, since LPG is an important part of campus which is used for many purposes and results in a large number of emissions. Another major GHG emission for this study comes from the solid wastes, bore well water supply and aluminum cans. The electricity used for water supply was considered in the purchased electricity.
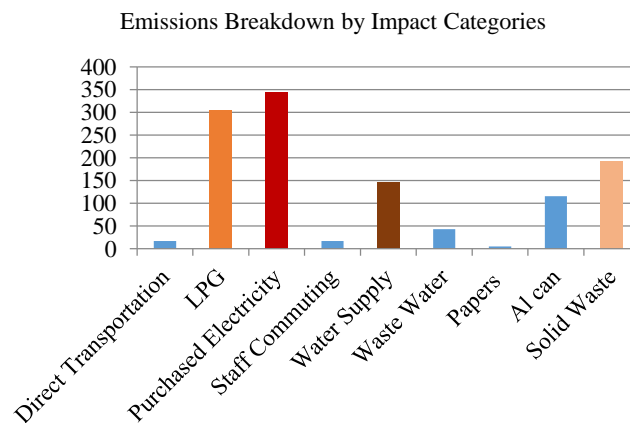
Emissions Breakdown by Impact Categories

Figure 4: *Emission Breakdown by Impact Categories*

To summaries purchased electricity is 29% of total emission and 26% of total emissions for LPG. Solid waste and water supply account 16% and 12% of the total emissions. Some uncertainty arises since this does not plant-specific emission data and there is also an uncertainty due to demand changes of water. Commuting accounts for only 1% of the total emissions because student commuting is not allowed on the campus. This is the major reduction in the commuting emission because emissions of student commuting are than employee commuting if they were allowed. However, wastewater emission still low but would have been higher if emissions of chemicals are included.

4. Conclusion and Recommendations

The main objective of the study was to measure the carbon footprint of MNIT campus. The result shows that the carbon footprint of MNIT campus was estimated 1182.69 ton CO_2 eq. with scope 1, scope 2 and scope 3. However, this amount is an underestimation because of unavailability of some data. Scope 1, scope 2 and scope 3 emissions of overall emission are 320.189, 345.287 and 517.089 ton CO_2 eq. respectively. Scope 1 had a total contribution of 27% of overall emission. In scope 2, electricity was the only source of emission and contributed 29% of total emissions. However, scope 3 contributed 44% of the total emissions. The activities with higher emissions were related to purchased electricity (29%), LPG consumptions (26%), solid waste (16%), water supply (12%) and aluminum can (10%). Since the activities wastewater (4%), staff commuting (1%) and direct transportation (1%) has very low emission. Therefore these categories have a great contribution to achieving carbon neutrality for the campus.

Creating a GHG emissions inventory is very important to make strategies to improve MNIT carbon footprint. To reduce the carbon footprint, the sources with higher emission should be prioritized. Examining scope 2, purchased electricity contributed 29% of overall emissions. This emission can be reduced by using solar PV panels. MNIT has large areas of rooftop that could be used for solar PV panels. Since solar panels are renewable energy sources and have no emissions related to its operations. Therefore, with the use of renewable source as an energy source, electricity, emissions can reduce by a large amount. In scope 3, solid waste contributes 14% of the overall emissions. One of the best methods to reduce this emission is to change the behavior of students. This could be done by encouraging them to waste less food, decrease the use of the plastic product, and sell food in recyclable containers. Another method to reduce waste emission is the recycling of wastes and decreasing in a landfill would be the better option. Another recommendation is MNIT need to make separate containers for dry waste and wet waste and also need to separate plastic and solid waste so that they can be recycled. Another activity in scope 3 is bore well water supply has a significant emission. This can be reduced by reducing water consumption. This can be done by encouraging students to use a shorter shower, less to waste. Another option to reduce bore well water supply is collecting rainwater. LPG consumption has 28% of total emission, this is a significant contribution but LPG consumption is necessary for canteens, hostels. Direct transportation and automotive commuting have low emission because MNIT campus not allowed public vehicles and students commuting by their own vehicles. This is very good work by this institute to achieve carbon neutrality. Aluminum cans (10%) have a significant emission in scope 3. This could be reduced by recycling of aluminum cans. For this MNIT campus needs to make a separate container to collect these cans.

Acknowledgment

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