A Critical Review on Carbon Footprint of Universities

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Abstract

The major reasons for global climate change are anthropogenic greenhouse gases (GHGs) emissions, a burning issue that international organizations and various countries are trying to solve.This change in climate impacts the ecosystem and society in various circumstances such as there is a risk of heat related illness and deaths. Manmade industries, institutions, factories, automobiles, deforestation, etc. are the major contributors to GHGs. Undereducational institutions,universities play a major role in "creating knowledge, integrating sustainability in education and research programs, and the promotion of environmental issues to the society". However the other side, universities are also contributing carbon and ecological footprint which creates a disturbance to the environment due to their activities in and out of campus. Universities are the places where the density of population, equipment, resource usage, and waste generation are more, which adds impact to state and country emissions. This white paper provides a critical review on carbon footprint (CF), methodologies like life cycle assessment (LCA), top-down, bottom-up approaches and various calculatorsused to estimate CF, comparison of CF of various universities throughout the world and identifying the major contributors whose impact is more in universities. In addition,CF reduction strategies,which assist as a compendium for individuals, universities, or organizations who are interested to know and measure their CF and provide a baseline to future.

Keywords: carbon footprint,University, LCA, Greenhousegas, ecological footprint.

1.Introduction:

Climate change denotesa significant change in variable weather or atmospheric parameter values i.e. temperature, rainfall, etc. patterns in specific places when associatedto past values. The major reasons for global climate change are anthropogenic greenhouse gases (GHGs) emissions, a burning issue that international organizations and various countries are trying to solve.Each GHGs has its capability to cause warming and their strengths mainly depend on the meantime for which that gas molecule exists in the atmosphere and radiative forcing it causes[1]. As per 2017 data,the biggest CO_2releasing nations are China (27.2%) followed by the USA (United States of America) (14.6%) and India (6.8%) .Around 72 % of global emissions are linked to household consumption from daily consumption and production decision of human behavior [2].The annual average concentration of most substantialGHG (i.e.CO_2) raised from 403(in 2016) to 405(in 2017) parts per million(ppm). The total concentration of all GHGs, counting cooling aerosols, attained a value of 449 ppm in CO_2 equivalents in 2016 an increase of 33 ppm more than that of 10 years ago (2006)[3].This change in climate impacts the ecosystem and society in various circumstances such as there is arisk of heat related illness and deaths. Due towarmer climate, there are chances of severe heat waves, floods, a rise in sea level, droughts, and also affects various species in the ecosystem.Manmade industries, institutions, factories, automobiles, burning fossil fuels, deforestation, etc. are the major contributors to GHGs.

On the category of institution, universities are being focused on sustainable developmental activities which are highlighted by a “specific conference (Environmental Management for Sustainable Universities) and several rankings”(e.g., the “Engineering Education for Sustainable Development) ” on the environmental functioning of universities [4]. Universities are places where the density of population, equipment, resource usage, and waste generation are more.Universities play a major role in“creating knowledge, integrating sustainability in education and research programs, and the promotion of environmental issues to the society”. And also recognized to take on “a leadership role in fighting climate change”.Technical education is one of the important sectors for GHG studies mainly for two reasons. Firstly, there is more technical education and each of these educational institutes contributes knowingly to GHG emissions. Secondly, in these institutes, more than a million students are enrolled. Due to this bulk number, it's better to create awareness among these students about GHGs emissions in the primary stages of education, expected to make them “climate champions in the future” [5]. Instead of the increasing number of universities for improving education for sustainable development, it is better to include “sustainability as an integral part of the institutional framework”[4].However, universities are contributing carbon and ecological footprint which creates a disturbance to the environment. Understanding the significance of mitigating climate change, so many organizations started to compute their own carbon footprints.

The concept of green campus is being highlighted nowadays, globally about 1400 institutions supported and signed Sustainability in Higher Education (SHE) declarations [6].UNEPhas recognized the important features of sustainable development are economic, social, and environmental pillars [7].According to DTEM, “the green campus concept offers an institution the opportunity to take the lead in redefining its environmental culture and developing new paradigms by creating sustainable solutions to environmental, social and economic need of mankind” [8]. A green campus holds higher education community that attempts to enhancethe campus energy efficiency and focused to improve quality of the environmentthrough providing education on sustainability and also producing healthy living and wealthy learning environments for everyone [9].The concept of Carbon footprint(CF) helps the university in monitoring and evaluating the actions having negative impact on climate change.In CF calculations, each activity that generates GHGs are considered.The estimation of the CF of the University has indeed been a long time taking the process and accurately total can’t be calculated, but an average value can be known.Knowing the CF of University will not only give a traceable value but also can be related to other educational institutions. This also provides a requisite baseline against which future mitigation efforts on the universitywill be assessed.

In present white paper provides a critical review on carbon footprint of universities and to identify the activities which show major impact and emission comparisons between universities.For this purpose, this paper is structured into various sections. Section 2 provides the information about basics of carbon footprint, whyit needs to measure it, methodologies used to measure. Section 3 tells about the methodologies used by various universities to calculate CF. Section 4 describes the results and discussions. Section 5 tells the conclusion and reduction plans or strategies.Universities considered in this study are Universitas Pertamina (UP) [10]. Autonomous Metropolitan University (UAM) [11], Bits PilaniUniversity (BPU) [5], Technical University of Madrid (TUM) [12], University of Cape Town(UCT) [13], De Montfort University (DMU) [14], Norwegian University of Technology and Science (NTNU) [4], National Autonomous University of Mexico (UNAM) [15] , The University of Alberta (UA) [16] , Edith Cowan University (ECU) [17].

2. Carbon Footprint (CF):

Wackernagel and Rees, [18] introduced the ecological footprint (ECF), through which the concept of carbon footprint is obtained and act as a subset to ECF.ECF is defined as the "biologically productive land and sea area required to sustain a given human population expressed as global hectares". Pursuant to this concept, CF is described as the land area needed to incorporate the total CO_2 generated by humans during its lifetime. From few decades, the concept of CF has been in use but identified differently as "life cycle impact category indicator global warming potential" [19].So, CF can be perceived as a hybrid approach or tool, originating its name from EF and conceptually being a "global warming potential indicator". Throughout the world, various definitions given to CF but mostly used definitions is "Carbon footprint is a measure of the greenhouse gas emissions that are directly and indirectly caused by an activity or are accrued over the life stages of a product or service", stated in carbon dioxide equivalents(CO_2-eq) [20].In other words, Carbonfootprintingis defined as a "measure by which a company orindividual can calculate how much carbon emissions they have produced during aproject or time period".While estimating CF of organization it is important to enumeratefull range of emission sources in order to specify overall impact of organization with a complete picture.To produce a "reliable footprint", need to follow an organized or systematized process and also incorporate a full range of possible emissions.The main reason to determine CF is to manage and reduce emissions over time, or to give a base line to future and report the value to third party.

Assessment of organization's CF can be an effective tool for ongoing energy and environmental management.Activities like fuel consumption, paper usage, electric usage, vehicular traffic,transportation, food production, and consumption, etc. are considered while calculating CF.CF calculations can be used for various sources liberating CO_2 emissions from individual activities, manufacturing of products, organization activities, cities, and countries.CO_2 equivalence (or CO2-eq) is used to represent carbon footprint, which is made up of several different greenhouse gases, in a single numeral. According to the “Intergovernmental Panel on Climate Change” (IPCC), there are a total of 18 GHGs but under the “United Nations Framework Convention on Climate Change (UNFCCC)” and its Kyoto Protocol, for carbon accounting only Methane (CH_4), Carbon dioxide(CO2), Hydrofluorocarbons (HFCs), Nitrous Oxide (N_2O), Perfluorocarbons (PFCs) and Sulphur-hexafluoride (SF6) are considered, with others being regulated away [21],[22].

Methods used for calculating carbon footprint:

Various approaches are available to calculate CF, all those include GHGs emissions emitted from the activities throughout its life cycle. From bringing the product manufacture right from extraction to final packing, delivery, usage, and to the final disposal these all are included in the life cycle, this analysis is also termed as “cradle to grave analyses”.Life cycle assessment (LCA) approach gives a perfect picture of inputs and outputs with regards to fuel consumption, production of air pollutants, usage and treatment of water, GHGs emitted, etc. and cost-benefit initiatives. LCA computes the emissions from each stage of the product's life cycle, technically termed as “Green House Gas (GHG) accounting”.[23]

For GHG accounting, guidelines and standards are available. Universal resources are:

1. International standard ISO 14064 (part 1 and part 2)used for designing GHG mitigation projects as well as for determining boundaries, analysis, and removal of GHG emissions [24].
2. Two GHG protocol standards World Resource Institute (WRI)/World Business Council on Sustainable Development (WBCSD)used for product LCA, corporate accounting, and reporting standard [25].
3. IPCC (2006) guidelines for National GHG inventories: Classified all the man-made activities into Five categories, 1. forestry, agriculture, and other land use, 2. energy, 3. industrial techniques and product usage, 4. Waste and 5. Others
4. For executing LCA and carbon foot-printing standards ISO 14025 and ISO 14067 are used respectively.
5. For determining the goods and services life cycle GHG emissions this standard Publicly Available Specifications-2050 (PAS 2050) of British Standard Institution (BSI) is used [26].

Countries like UK, USA developed their own guidelines for GHG accounting, for instance, Environmental ProtectionAgency (EPA) in USA, Carbon trust and Department of Food and Rural Affairs (DEFRA) in UK.

Life cycle assessment:

LCA is systematic set of procedures of computing and evaluating environmentally related inputs and outputs and also knowing associated environmental impacts of goods, material, or service throughout its life cycle. The life cycle comprisesof successive and interconnected phases of goods or products, service system from the extraction of raw material to the final disposal.One stage life cycle of material or product is connected to other secondary stages, similarly secondary stage events may future connected to others and so on. This impact is linked from first tolast stage, covering all this intermediate stage will expand the boundary which becomes complex to analyze. To overcome that "cradle and grave" need to be done suitably contingent onthe objective of the calculation and on the accessibility of data [27].

For estimation of GHGs two approaches that perform LCA are "Top Down" or "input-output analysis" and "Bottom-up" or "process analysis (PA)" [20]. Process analysis or bottom-up approach is introduced to know the environmental impacts of each productfrom "cradle to grave". The emission sources in this approach are disaggregated into various categoriesfor appropriate quantification. For small entities, this method is suitable and more accurate, whereas for large firms it becomes too difficult or complicates[28].Economic input-output (EIO) model offers an alternate top-down method to accept and perform operations for determining CF [29]. By combining with uniform environmental account data, CF can be established comprehensively and robustly by considering all higher order impacts. Inputs and outputs of this model are presented in matrix form. Advantage of this model is less time and manpower are required for processing. Model is limited to analyze the assessment of micro level implementation such as productsor processes [20].

By combining both EIO-LCA and PA-LCA, called "Hybrid-EIO-LCA" which is a state of art in LCA. Such an integrated hybrid method allows to preserve small emissions through PA-LCA, whereas higher scale emissions are taken by EIO-LCA. This will increase the completeness, strength, flexibility of estimates. Apart from these methods, CF is also calculated by using online calculators that are presented in Table 2.

In organizations various activities take place, each activity can't be categorized separately. Most oforganizations follow standard classification or categorization defined by GHG Protocol formed by the WRI and WBCSD. This approach gives a detailed assistance to corporate organizations on corporate emissions [30].

GHG protocol divided all the emission into three groups:

Scope1 includes all the direct emissions from a source owned or controlled by the organization (Major activities that come under this category are from the combustion of fuels from the gas used for heating, transportation within the campus. etc.).

Scope2 includes indirect emissions from the consumption of purchased electricity within the organization.

Scope3includes all other indirect emissions resulting from products and services, activities inside the organization but originated from the sources that are not owned or controlled by it.

Collectively three groups offer extensive accounting structure for abatement as well as management of direct and indirect emissions.Some of the entities where the carbon footprint is calculated and their total CF is presented in Table 1.

Table 1. Carbon Footprint of some Entities with their Annual Emissions.

S.no.	Organization /event/product/	Entity/activity considered	Carbon footprint (tons of CO_2-eq)	Reference
1	The CF of global tourism	Based on emissions from transport, shopping and food are major contributors	4.5 $*10^9$ per year in 2013	[31]
2	CF of two organic farms (small scale and large scale)	Based on equipment used (weeding tillage, tractors, mowing, vehicles). Net soil emissions consumables (electricity, diesel, gasoline)	7.144/ha for small scale 3.410/ha for large scale for 1 year	[32]
3	CF of waste from supermarket food	Analyzed data on products in the meat, dairy deli, cheese, fruit, vegetable department,	2500 for three years period	[33]
4	Chlor alkali plant	Scope 1: fuel usage in boiler and transportation of raw materials scope 2: Electricity usage,	4.358×10^3 per month	[34]
5	The CF of traditional woodfuels	For cooking and heating, charcoal and firewood are used.	1.0–1.2 $*10^9$ per year in 2009.	[35]
6	CF of the US Health Care Sector	Health Spending Category: Hospital, Physician/dental services, Other professional, Home health care, prescription drugs, Nondurable and durable equipment, Nursing home care, Administrative/insurance, Scientific research, structures/equipment	546 $*10^6$ per year in 2007	[36]
7	Average household in UK	Scope 1: CO_2 embodied in fuel consumptionfor personal vehicles and in houses scope 2and 3: CO_2 embodied in personal commuting, goods and services	Averagely 5.5×10^2	[37]
8	FIFA World Cup 2006	scope I: fuel	1.0×10^5	[38]

		usageassociated with onsite construction activities of stadiums,transport within the country, scope II: consumption of electricitywithin thestadiums,		
9	Hawaii Electric Industry	scope I: ground and air transportation scopes II: electric consumption	2.154 × 107 in year 2005	(USDoE, 2005)
10	plastics manufacturing	cradle-to-grave Raw material Manufacturing Secondary packaging Transport End-of-life	1 kg of recycled plastic produced 1.538 kg CO2eq i.e. $1.538 * 10^{-3}$	[39]

Table 2.**Online Calculators with a description of Parameters for Calculation of Carbon Footprint.**

S.no.	CF Calculator	Applica-ble Regions	Recommen-ded for	Input for individual or household1*,2*, 3*, 4*	Output units	Comments	references
1	EPA's (govt.)	US	Household	1a,1b 2a,2b 3	Lbs. of CO2 Per year	Quick, rough estimate of your CF by using U.S. average values and the final output value is compared with the average value. Offset options are also available to reduce CF value.	[40]
2	UN climate neutral (govt.)	nearly 70 countries	Household	1a,1b,1c 2a,2b,3, 4a,4b,4c	Tons of CO2 Per year	Required data is obtained from external and reliable sources (EDGAR, EPA, Climate Watch, ICAO, and other organizations).The final output	[40]

						value is compared with the country and world average emissions are shown for comparison. Offset options are also available to reduce CF value	
3	COTAP	U. S	Individual, small scale business	1a,2a,2b, 2c	Tons of CO2 Per year	Depending on Individual CF, they will collect donations to offset the CF value. Methodology considered is explained https://cotap.org/home/methodology/	Carbon offsets to alleviate poverty https://cotap.org/carbon-footprint-calculator/
4	Conservation universal carbon	Any region	Individual,household,event,trip	1c,1e,2b, 3,4a,	tons of CO2 per year	Final outputs are compared with US average values and also provide offset information like the number of trees plants to be plated to offset individual CF.	Conservation calculator https://www.conservation.org/carbon-footprint-calculator#/
5	Carbon neutral	Australia	Individual	1b,2a,2b,3,4a,4b, 4c	tons of CO2 per year	Requiredemissions factors and data are obtained from UK DEFRA, CSIRO, Australian bureau of standards	Australia Carbon neutral https://carbonneutral.com.au/carbon-calculator/
6	WWF carbon	UK and other	Individual or Household	1a,1b,1e 1c,2b,3,4a,4b,	tons of CO2 per year	Final outputs are compared with world and UK average values.	WWF FOR YOUR WORLD https://footprint.wwf.org.uk/#/questionnaire
7	Carbonify	Australia,UK,US and other	individual	1a,1b,2b,3,4a	Total Tons of CO2 annually	It is a simple and quick way of knowing individual CF and how many trees it would take to	Carbonify carbon dioxide emissions calculator http://www.

						offset those emissions.	carbonify.com/carbon-calculator.htm
8	Lehigh University	US and other	Household	1a,1b,1c,1d,1e,2a,2b,3,4a,4c	tons of CO2 per year	Final outputs are compared with world and US average values	Lehigh Universitywww.ei.lehigh.edu/learners/cc/carboncalc.html
9	ICICI Bank Go Green	India	Individual or Household	1a,1b,1c,2b	tons of CO2 e Per year	Final outputs are compared with world average value	ICICI BANK GO GREENhttps://www.icicibank.com/go-green/carbon-world-day/indexef62.html
10	Carbon Independent		Individual or Household	1a,1b,1c,2a,2b,3,4a,	tonnes CO2-e per year	The calculator is based around a family household unit. Final outputs are compared with the world,US,UK,China,India average value	Carbon independent CF calculator and climate change information https://www.carbonindependent.org/
11	Carbon Footprint Ltd.	Any region	Individual,small and large business and products	1a,1b,1c,2a,2b,2c,4a,4b,4c	tons of CO2e	Final outputs are compared with the world,European Union,India average value and also provides offset to the emissions	Carbon Footprint Ltd https://www.carbonfootprint.com/calculator.aspx
12	Green Progress	US and other	Individual or Household	1a,1b,1c,2b,3,4a	Pounds of CO2/year	No source,offsets details are given	Green Progress.com http://www.greenprogress.com/carbon footprint calculator.php

1*. HOUSE ENERGY
a. Heating energy source
b. Electricity usage

c. Number of people,house income,type of house, and area.

d. Equipment or products usage (AC,Laundry,TV, type of lights

2*. Transport

a. Vehicle (count,type,mileage)
b. Type of transport & distance traveled (air,rail,public,private)
c. Type of fuel source (gas,petrol,diesel)

3*. Waste generated and recycle(plastic,glass,newspaper,food,magazines,paper., etc.)

4*. Life style

a. Diet
b. Products purchase
c. Events and occasions
d. Shipping

Methodology:

This section tells about the methodologies used by various universities to calculate their CF

1.Universitas Pertamina (UP) [10] :

A private educational institute with an area of 68,569 m^2 situated in Jakarta, which is a learning center accounts forthe implementation of the green campus concept. Mainly they focused to compute the total carbon emission from the activities of electricity usage, transportation, and waste generation for the academic year 2017-2018. “Proportionate stratified random sampling” was applied to define the sample characteristic with a 10% significance level and the Slovin method is used to calculate the sample size. The information regarding transportation was collected by distributing a questionnaire survey to people in university (2621 members) from cleaning staff to higher officials of the university. Design of questionnaire is to categorize the type of transportation like public or private transportation used by university members. Used emission factors EFs (for diesel fuel is 2.2 KgCO_2/L-fuel whereas for gasoline/ petrol is 2.6 KgCO_2/L-fuel) and for average fuel consumption per day (0.13 L/km for passenger cars and 0.05 L/km for motorcycles) from Indonesian Ministry of National Development Planning(IMNDP) [40].Annual transportation total CO_2 emissions are computed by multiplying the total number of vehicles by the distance traveled within the university, amount of fuel used and the respective emission factor of fuels.

Required data regarding electricity used on campus was attained from the university’s Directorate of Facilities, Infrastructure, and Information Technology, in terms of kilowatt hour (kWh). The emission factor (EF) for electricity used is 0.741 kg CO_2/kWh taken from IMNDP [40]. Waste generated from every part of the university is collected and classified. All the domestic waste is transported to landfills by the third party, similarly, hazardous waste is also taken by a third party. For determining carbon emission from waste generation is obtained by adding waste transport and waste disposal carbon emission. For computing emissions from waste disposal a waste reduction model(WARM) is used which is introduced by USEPA. From waste management activities like “source reduction, composting, combustion, anaerobic digestion, recycling, and landfill”, WARM model can track and report greenhouse gas

(GHG) emissions [41]. Annual CO_2 emissions can be obtained from the WARM model by taking input as the amount of solid waste. The total amount of CF from the university is obtained by multiplying emission data with EF.

2. Autonomous Metropolitan University (UAM)[11]

The Cuajimalpa campus of the UAM is situated in the western region of Mexico City. The average population of the UAM-campus is 2751 for the year 2016.National emission factors [43] are applied for conversion, and for calculating CO_2 emissions, missing emissions factors are replaced with IPCC values. Activities that generate emissions are divided into 3 groups: scope 1(direct emissions), scope 2(indirect emissions), scope 3 (other emissions). Scope 1 includes fixed and mobile sources, fugitive emissions. Fixed sources like dining hall, laboratories, and showers, here for heating liquefied petroleum gas was used. Transportation, vehicle fleet, refrigeration comes under mobile sources. Required EF for combustion of LP Gas, gasoline was taken from [44]. Both private and public transportation services are provided and both the services are leased, for this reason, it is included in direct emission. The EF used for diesel urban buses [30]. Fugitive emissions from refrigerators, freezers, ultra-freezers, ice-makers were determined using USEPA proposed method [42]. Scope 2 includes Electrical energy**,**Government company Federal Electricity Commission (CFE) provides required electricity to university. Required Data is collected monthly from the administrative department. For computing emissions from electricity, EF was taken from the Mexican registry of emissions . Scope 3 includes other than scope 1 and scope 2 sources remaining sources comes under this. Data required is collected from various departments regarding water, paper consumption, food items, laboratories gases, Solvents. Municipal solid waste(MSW) is separated and sent to recycling whereas the nonrecyclable waste is sent to a municipal landfill. While generated Hazardous waste(HZW) from laboratory works is separated and future treated using thermal oxidation through an external organization. Used water in the campus is treated by using aerobic treatment plant, due to lack of 2016 data, so 2017 data of plant and COD. For Commuting purposes, both public and private transport vehicles are used. private transport emissions are assessed based on GHG protocol [30]. Work trips by faculty and students include lodging and transportation for conferences, scientific events, etc. The data was obtained from the expenditure policies prepared by the administrative services department. The emissions were computed by considering the distances, and air and land travel EFs [30], [42].

Total CF is calculated by multiplying the quantity of consumption by the emission factor.

The EF used for calculating emissions through water consumption is taken for paper consumption [40], Meat, MSW [45],laboratory gases [42],solvents (DataBaseEcoInvent 3.3 -SimaPro 8.3.0),wastewater treatment [44].

3. Bits pilani university (BPU)[5]

The average population of BPU is 5699 and an area of 328 acres. Required data is collected from various sources in university boundaries for theacademic year 2014-

2015. An offline survey was conducted among the students, teaching, and non-teaching staff to collect data regarding traveling, electronic usage, and food habits. GHG protocol of "ISO 14064" is applied for assessment of the total CO2 emissions. "Umberto NXT universal software and Ecoinvent v3.0 database software" used to compute the emissions based on LCA approach. In this study, all the sourceemissions are divide into 3 groups .scope -1(direct emissions-emissions from facilities within the institutional limits), scope -2(energy indirect emission-like imported electricity, heat or steam), scope-3(remaining indirect emissions-like communicating and business travel, transportation of materials, waste, chemicals used, refrigerants, workshop emissions, goods).Required data is collected from the Estate management unit (EMU), offline survey, and Centralized purchasing unit (CPU).Fuel used for fleet and services, imported electricity, waste, refrigerants (EMU), water consumption commuting and business travel (offline survey), goods, computer accessories, chemicals purchased, electrical and electronic purchases (CPU).Data regarding food emissions are obtained from [46]. When all this input source given to the software, which is inbuilt with emission factors for various sources will directly give the CO_2 emissions i.e. CF of University.

4. Technical University of Madrid (TUM) [12]

The School of Forestry Engineering at the TUM has an average population of 1385 (1150 students and 235 staff) in 9.7 ha (4.8 ha with forest and remaining with buildup land) for the year 2010.Followed GHG Protocol Corporate Standard [47] emission source classifications,scope 1 deals with direct emissions from the sources owned within the campus (natural gas, petrol, gasoline).Scope 2 defines purchased electricity, heat, or steam which are indirect emissions.Scope 3 accounts with all the remaining activities not owned or controlled by the institution (materials, service and contracts, construction works,water and soil consumption,municipal and hazardous waste, Agricultural and fishing resources, life cycle emissions of scope 1and scope 2, Forestry resources.)

For estimation, an advancement is made in methodology i.e. Environmentally-Extended Multi-Region-Input-Output (EE-MRIO) analysis which is a widely used approach [48]. EE-MRIO approach is built with the impact of product and service for the whole life cycle and the latest implementations made for calculating carbon footprint. Whereas a hybrid approach, Environmental-Input-Output Life-Cycle-Analysis (EIO-LCA) is used to derive main data from bottom-up into top-down through EE-MRIO analysis and this can be applied in corporate and product-based approaches [49]. The Compound Method based on Financial Accounts which is termed as MC3(its Spanishacronym "métodocompuesto de las cuentascontables") most acceptable method in Spain, CF is calculated by using version 2 of MC3 [50].Based on "the cradle-to-gate life cycle" MC3 is designed to compute CF at every phase of the LCA. The top-down approach in this is a real and current CF can be found using MC3 with low financial and time costs. This method initially estimates the corporate CF after that allocates it between dispatched service and products. For all direct emissions, MC3 follows the IPCC [1].For indirect emissions (Scope 2) are estimated in case of conventional energies, whereas for alternative energies [34].For Scope 3 emissions calculation are obtained from MC3 where 416 consumption categories developed. Related factors are taken from Waste related indirect emissions are examined in terms of biologically productive land and water required [6].

5. University of Cape Town(UCT)[13]:

UCT has a total population of 31129 (26254 students,5075 staff) in the area of 665 858m^2 for the calendar year 2014.Calculation of campus CF is included in the curriculum of the Information Systems department as a third-year course.In this, they usedGHG Protocol revised corporate accounting standard methodology for estimating CF.Two different methods used to consolidate GHG emissions i.e. "equity share and the control method". In this report, control approach is used, which is defined in either financial or operational terms and accounts for the entire 100 % of the GHG emissions. Allthe emissions are categorized into three scopes. Direct emissions from the combustion of liquid fuels like (vehicle fleet and LPG gas) within the campus comes under scope 1. Indirect emissions related to purchased electricity come under scope 2. Scopes 1 and 2 are from defined from (https://ghgprotocol.org/). Scope 3 includes emissions from the activities within the campus which comes under indirect emissions like food supply, commuting, business travel, paper products, air travel, and solid waste. EFs are taken from UK DEFRA[44] except for electricity which taken from local area Eskom of 0.94 tons CO_2e/MWh was used. The total contribution is obtained by multiplying EF with the amount of emission.

6.De Montfort University (DMU)[14]

For the academic year 2008-09 approximate population of DMU is 25580 members. DMU made a sustainability strategy that covers all directions of an organization related to sustainable development. Strategies like "Energy Policy, Green Travel, Waste management, carbon management". For calculating CF, "consumption-based carbon" approach is used, which can be determined by the LCA approach or EEIOenvironmentallyextended input-output analysis. Traditional GHG protocol emission classification is followed in this study (scope 1-direct emissions, scope 2 electricity, and scope 3 indirect emissions due to daily activities).All the emissions originated in the campus are analyzed into 3 categories: Building energy (emissions directly from campus buildings and equipment),Transportation or travel (emissions from directly or indirectly), Procurement (indirect emission from daily activities or goods and services).EF is obtained from the Guidelines to Defra/DECC's Greenhouse Gas Conversion Factors for Company Reporting [30].By following the basic approach of estimating CF is used here also i.e. collecting the data and multiplying with EF gives total CF.

7. Norwegian University of Technology and Science (NTNU) [4]:

NTNU has a population of 25500 members in the year 2009.For calculating CF,they used EEIO model. Various emissions from the campus are divided as per GHG protocol which covers all emissions (direct or indirect) into 3 scopes. Scope 1 includes direct process emissions, purchased indirect emissions under scope 2, and remaining indirect emissions due to daily activities under scope 3. EEIO model is similar to that used for "municipalities and countries" and has further been refined to assess the CF of central government entities such as universities. EEIO is based off a macroeconomic flow analysis of the transfer of money between sectors of an economy where the environmental impacts of each sector required to produce a good or services are added up to determine the complete supply chain impact. EEIO is "cradle-to-gate", it does not evaluate downstream impacts. Process data is based off a material flow analysis that adds up the environmental impacts of all the individual processes required to produce, use, dispose a good or service.

8. National Autonomous University of Mexico (UNAM)[15]:

"Universidad Nacional Autónoma de México" (UNAM), a cleaner research institute in Mexico has an average population of 1076 members for the year 2010. Bottom-up approach is used for calculating CF, which includes LCA. Followed standard GHG protocol for [1],[25] for classifying the emissions, direct emissions like vehicle fleet (under scope1), indirect emissions (purchased electricity under scope 2), and other indirect emissions due to daily activities (like commuting, paper air travel, solid waste and shipments under scope 3).The activity data attainment was done with a bottom-up approach. EF for electricity, air travel is obtained for solid waste IPCC waste model tool [1], for fuel consumption (gasoline in gal /year) were obtained from the Fuel Economy database [40], for paper used as proposed by Royal Melbourne Institute of Technology (RMIT) University Centre forDesign in 2007. This EF considers the complete life cycle of paper, including its final disposal in a sanitary landfill. By following the basic approach of estimating CF is used here also i.e. collecting the data and multiplying with EF gives total CF.

9.The University of Alberta (UA) [16]:

The average population of UA(Canada) is around 50000 members within 1.6 million m^2 of building space for the academic year 2012-2013. Source of emissions are categorized into three scopes. Under scope 1emissions from combustion due to heating plant and natural gas, vehicle fleet, refrigerant's and chemicals, agriculture emissions are considered. Purchased electricity was considered as scope 2. Under scope 3 emissions from the decomposition of solid waste,wastewater treatment, and scope 2 transport and distribution losses are considered.By using the Clean Air-Cool Planet Campus Carbon Calculator (CACPCCC) version 6.0, a customized application designed particularly for higher education institutions. CACPCCC is a free, transparent, comprehensive, and customizable solution to measure and analyze the institutional GHG emissions. CACPCCC is the most widely-used tool for measuring campus CF and modeling emissions abatement strategies(http://www.cleanair-coolplanet.org/.), by giving required input to the calculator,total annual CF is obtained.

10. Edith Cowan University (ECU) [17].

ECU is an Australian public university with an average population of 30,000 members for the year 2018, located in Perth, Western Australia.Classifictions of emissions are based on standard GHG Protocol into three scopes.Scope 1 includes direct emissions like burning of fossil fuels,heater or gas boilers for hot water,fleet vehicle emissions, and also includes fugitive emissions like leakages from the refrigerant,conditioners.Emissions from Imported electricity comes under scope 2.Under scope 3 emissions from the activities like air travel,water treatment,solid waste,transportation (indirect),consumables (papers &stationery).Data required is collected from respective departments and EF used for calculating CF are taken majorly for scope 1 and 2. Whereas for scope 3 emissions are indirect coming from various sources for this addition to the factors from an extra source of data is used to perform calculations [29],[30]. The total annual CF of the campus is obtained by multiplying emissions with EF.

Results and discussion:

Figure 1. shows the carbon footprint of the scope 1 activities of various universities.

Scope 1:

From the UP, the total CF due to scope 1activity i.e. transportation within the campus is 90.1 tons CO_2 eq/year. Most of the emissions are produced from students (i.e. 81 tons CO_2eq/year). Motorcycle users are contributing more than other vehicle users, it is about 79% of the members are using motor vehicles on the campus [10]. From UAM, among all sources of direct emissions, mobile sources emissions are more contributing to total CF about 83.06 tons CO_2eq (2.8%), while fixed sources are 24.16 tons CO_2eq and fugitive emissions are least with 3.39 tons CO2-eq. In mobile source emissions, most of the emissions are from gasoline vehicles, to reduce the emissions gasoline vehicles can be replaced with the ones with lower emission factor like electric or natural gas vehicles. In fixed sources, LP gas contributes more which can be replaced with the gas having less emission factor like natural gas [11]. It is shown that the emission factor for the combustion of natural gas is 12.5% lower than that for LP gas combustion [15]. In BPU, due to scope 1 sources (the petrol and diesel burned), 1.1 % of total emission i.e. 181.5 tons CO_2 eq is produced [5].From TUM, CF due to scope 1 activities is 169 tons CO_2eq which is 8% of total emissions from the campus. The main source of scope 1 is gasoil with 111 tons CO2eq of generation, there should take an opportunity to reduce emission from gasoil by replacing it with less emission factor source [12].From UCT, direct emissions(scope 1) contributed 755 tons CO2eq which is 0.88 % of total emission. Majorly from vehicle Fleet (130 vehicles) contributed about 465.4 tons CO2e and 289.4 tons CO_2eq from LPG(Rippon, 2015). In DMU, CF due to direct emissions (scope 1) is 3064.8 tons CO2eq which is 6% of total GHG emissions from the campus [14].From UNAM, CF due to scope 1 activities contribution is 81.2 tons CO_2eq which is 5% of the total CF value[15]. In UA, scope 1 activities contributed highest in this university with 52% of the total emissions i.e. CF of 169737 tons CO_2eq. Under scope1, cogeneration of steam contributed highest with 76381.65 tons CO_2eq and followed by cogeneration of electricity with 71289.54 t CO_2eq, then by on-campus stationery with 15276.33 tons CO_2 eq, agriculture with 5092.11 tons CO_2 eq, direct transport with 1697.37 tons CO_2 eq [16].From ECU, Scope 1 activities are the least contributors among all scopes in ECU with 7% to the total emissions of about 1,707.82 tons CO_2 eq. Among activities under scope 1, Natural Gas contributed majorly with 1440.76 tons CO_2 eq then followed by fugitive emissions 178.18 tons CO_2 eq and vehicle and equipment 88.88 tons CO_2 eq [17]. Scope 1 emissions shown in Figure 1 tells that UA is the highest contributor among all universities with 169737 tons CO_2 eq and least by UNAM with 81.2 tons CO_2 eq.

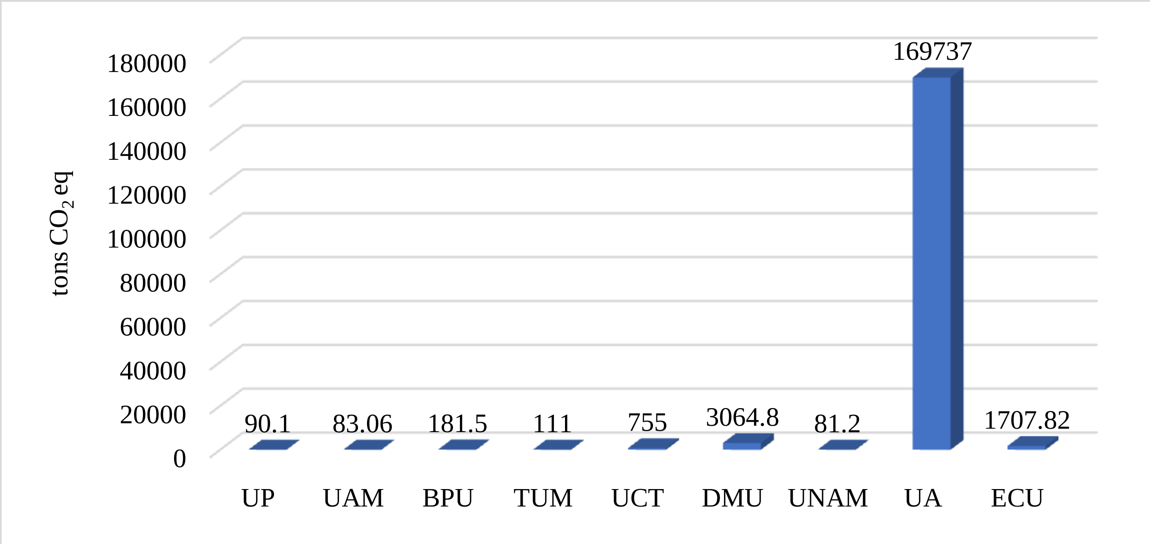

Figure1. Carbon footprint of scope 1 activities of various universities.

SCOPE 2:

Figure 2. shows the carbon footprint of the scope 2 activities of various universities.From UP,CF due to electricity is 1,247.8 tons CO_2 eq.As college is flexibly equipped well with computer laboratories, library, experimental labs, etc. which leads to high emissions[10]. In UAM, the second main emission source of the campus is electrical energy which is contributing 716 tons CO2 eq (24% of the total CF). In this about the distribution of activity is not shown, in order to reduce the emissions, it would be required to evaluate usage distribution [11]. From BPU, CF due to electricity is nearly 50% of the total emissions from the campus which is 8250 tons CO2 eq. It is a residential campus with a huge population and equipped with advanced infrastructure which leads to more consumption of electrical energy[5]. Moreover in India, most of the electricity is from coal-based production and it has large shares of nearly 60% in the overall production of India . In TUM, from scope2 i.e. electricity contributes 33% of total emissions (703 tons CO_2 eq), which is the second most contributor in the campus[12]. From UCT, due to more population, a huge amount of electricity is consumed and which contributed 76% of the total university CF i.e. 64 888 tons CO_2 eq. Scope 2 is a major contributor source to the campus[30]. In DMU scope2 contributed 15% of total GHG emissions i.e.7662 tons CO_2 eq which is the second most contributor in the campus[14]. From UNAM purchased electricity is the second major contributor in the campus with 653.4 tons CO2 eq which is 42 % of the total CF.UA is with a huge population contributed 129390 tons CO2 eq which is 40% of total emissions due to purchased electricity(scope2)[16].The major contributor of ECU is purchased electricity under scope 2 with 67% to the total emission about 16,840.28 tons CO_2 eq.Scope 2 emissions

shown in Figure 2 tells that UA is the highest contributor among all universities with 129390 tons CO_2 eq and least by UNAM with 653.4 tons CO_2 eq.

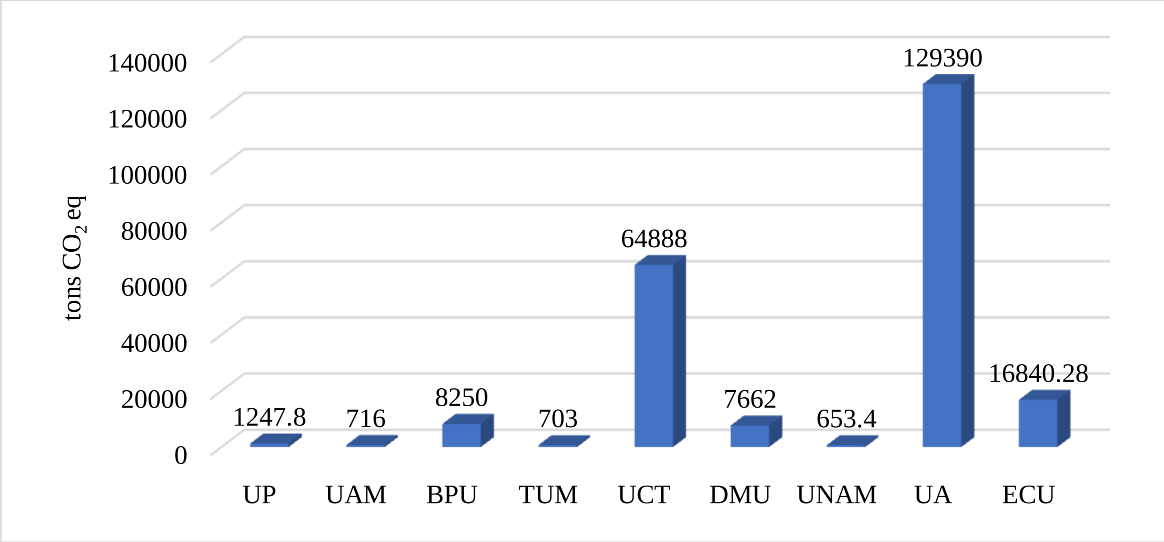

Fig 2. Carbon footprint of scope 2 activities of various universities.

SCOPE 3:

Figure 3. shows the carbon footprint of the scope3 activities of various universities.Emission of waste generation from UP isabout 0.05 kg/day of solid waste is generated by a person and a total of 0.02 tons CO_2 eq /year/person of solid waste is generated in the campus. Annual CF of solid waste disposal is 14 tons CO_2 eq /year which is from the simulation results of the WARM model. The distance traveled by truck for disposing of the waste into landfills is also considered and its emission also calculated i.e. 0.08 tons CO_2 eq for domestic waste transportation and hazardous waste transportation 5.6 × 10-4 tons CO_2 eq. Considering all the above emissions, the total CO2 emission of solid waste generation is 14.08 tons CO_2 eq[10].In UAM for the 2016-year, the total CF from scope 3 activities is 2128.32 tons CO_2 eq.Meat consumption contributed 108.67 tons CO_2 eq, a hypothetical situation, most of them like meat, to reduce the emission vegetables are substituted in place of meat and limiting meat once a week. Vegetables can reduce 20 % of meat consumption emissions per year. From the activities, under scope 3 paper consumption produced 16.52 tons CO_2 eq, usage of Water generated nearly 5.37 tons CO_2 eq, gases used in the laboratories 0.88 tons CO_2 eq, while treating municipal waste it is about 0.038 tons CO_2 eq, incase if the waste is not separated and sent it to landfill, it generated nearly 4.5 tons CO_2 eq. From the treatment of hazardous waste 0.05 tons CO_2 eq and wastewater treatment plant it is about 0.110 tons CO_2 eq is generated. Solvents used in laboratories produced 0.810 tons CO_2 eq. Cleaning products used in the campus produced 31.7 tons CO_2 eq, as cleaning is necessary to be safe and the emission count is low, introducing plans to reduce this is unnecessary. Work travel produced 424 tons CO_2 eq, as this journey may be for academic and scientific purposes, presence should be compulsory and emission can reduce by traveling less distance in flights and they can use video conference instead of direct meetings. The major impact of scope 3 is from Commuting which produces half of

the total emissions (51%) i.e. 1497.63 tons CO_2 eq.More than 40 % of travels are using private vehicles, using a public vehicle, electric vehicles and small distance by cycles is an opportunity to reduce emissions[11]. In BPU it is about48.9 % of total emissions are from sources of scope 3 i.e. 8068.5 tons CO_2 eq which is the second highest contribution. Among all, travel(commuting) related emissions are more (68% of scope 3), next followed by food (12 %) engineering workshop (10%) [5]. In TUM scope 3 contributesto 59.0% of total emissions i.e. 1275 tons CO_2 eq. Off all the activities, materials contributed more of 31% of total emissions i.e. 674 tons CO_2 eq, opportunity should take in reducing emissions by recycling the products, then followed by lifecycle emissions of scope 1 and scope 2 and Forest Resources (186.97 tons CO_2 eq),Water consumption (68.53tons CO_2 eq),Services and contracts (63.18 tons CO_2 eq), from construction works (54.16 tons CO_2 eq),Waste and discharges (<2 tons CO_2 eq) and Agricultural and fishing resources (1.47 tons CO_2 eq)[12].In UCT Scope 3 activities are the second major contributors with 23.1% to total university CF i.e. 19717 tons CO_2 eq. Under scope 3 major contributorsare commuting with 11.29% (9 634.20 tons CO_2 eq) followed by food supply with 7.6% (6484.64 tons CO_2 eq),air travel with 2021.23 tons CO_2 eq.Rest all activities contributed less than 2 % (recycled waste-19.63,paper products-487.41,water supply-120.56 ,non-recycled waste-155.52,business travel-348.57 tons CO_2 eq [13]. In DMU**, s**cope 3 contributed highest among all the scopes with 79% of the total emission i.e. 40353.2 tons CO_2 eq[14]. In UNAM, scope 3 emissions are the major contributions with 53 % of the total emission (842.4 tons CO_2 eq). Based on activities through transportation majorly contributes 45 %, through air travels 5% and shipment, paper solid waste 1% each[15]. In UA, CF due toscope 3 activities is 26224 tons CO_2 eq, under this scope 2 T&D losses contributing 14267 tons CO_2 eq, followed by solid waste with 5665.14 tons CO_2 eq and least by wastewater treatment 1050 tons CO_2 eq[16]. In ECU, scope 3 activities are second most contributors in campus with 26% to the total emissions about 6,432.86 tons CO_2 eq. Under scope 3 with major contributors are air travel with 3438.5 tons CO_2 eq, followed by electricity with 1443.45 tons CO_2 eq, events with 728.81 tons CO_2 eq,waste decomposition with 326.00 tons CO_2 eq, water use and disposal 323.17 tons CO_2 eq, natural Gas 111.82 tons CO_2 eq, consumables 51.83 tons CO_2 eq, vehicle, and equipment 4.65 tons CO_2 eq.Scope 3 emissions shown in Figure 3 tells that DMU is the highest contributor among all universities with 40353.2 tons CO_2 eq and least by UP with 14 tons CO_2 eq.

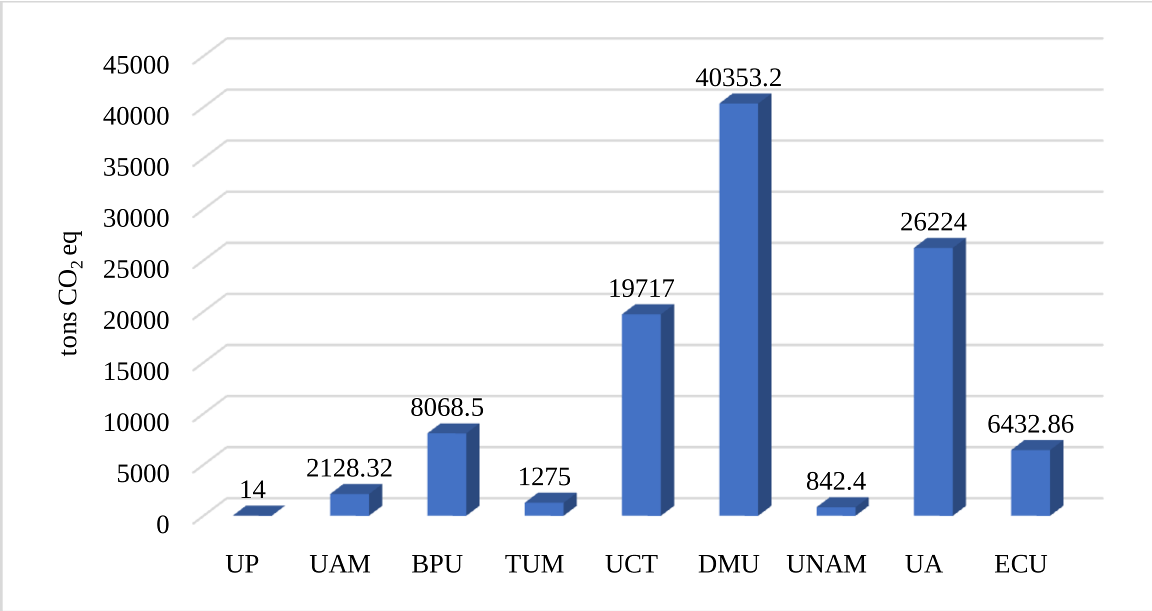

Fig 3. Carbon footprint of scope 3 activities of various universities.

Total Emission:

The total CF of universities is presented in Figure 4.The total carbon emission of UP for the academic period of 2017-2018 is 1,351.98 tons CO_2 eq. Emission through electricity contributed more about 92.3% of total carbon emission, remaining by transportation (6.66%) and waste generation (1.04%). The individual CF of UP is around 0.52 tons CO_2 eq/year[11].Total emissions of UAM due to various activities performed in the year 2016 is 2956 tons CO_2 eq. The average per capita CF is 1.07 tons CO_2 eq/year. Scope 1, Scope 2 and Scope 3 activities generated 4%, 24% and 72% of the total emissions (i.e. 110, 716 and 2130 tons CO_2 eq) respectively. Scope 3 activities are the main contributors to university CF. Among all activities, public transport (32%) stands first, next followed by electric energy (24%) and private transport (18%)[13].The annual total emission of BPU is 16500 t CO2 eq for the academic year 2014-15. The average per capita CF is 1.07 tons CO_2 eq /year.Scope 1, Scope 2 and Scope 3 activities generated 1.1%, 50% and 48.9% of the total emissions (i.e. 180.5, 8250 and 8086.5 tons CO_2 eq) respectively. Purchased electricity contributed more among all sources in the campus [5].Annual total CF of TUM for the year 2010 is 2147 tons CO_2 eq and per capita, CF is 1.55 tons CO_2 eq/year. Among all the sources, scope 3 sources contributed more of 59.0% of total emissions (1275 tons CO_2 eq), followed by scope2 with 33% of total emissions (703 tons CO_2 eq) and least by scope 1 with 8% of total emissions 169 t CO2eq) [12].Annual total CF OF UCT for the year 2013 is 85 360.02 tons CO_2 eq and the per capita CF is 2.74 tons CO_2 eq/year.Among the three scopes, scope 2 contributed more with 76% followed by scope 3 with 23.1% and least by scope 1 with < 1% to total University CF [13]. For the academic year 2008-2009 total GHG emissions(CF) from DMU are 51,080 tons CO_2 eq and the per capita CF is 2 t CO2eq/year.Among 3 categories which are classified in DMU, major contribution is from procurement activities with 38% of the total emissions i.e. 19273 tons CO_2 eq then followed by building energy with 34% of the total emissions i.e. 17118 tons CO_2 eq and last by travel category with 29% 14689 tons CO_2 eq. From the general classification of scope contribution, major contributions are from scope 3 with 79% followed by scope2 with 15% and least by scope 1 with 6% of total GHG emissions[13].The emissions from all the activities from the campus lead to produce a total CF of 92000tons CO_2 eq and the per capita CF is 3.61 tons CO_2 eq for the year 2009. Results are not showed in scopes classification but mentioned that scope 3 contributed majorly to total CF. From the structural composition of CF, emissions from energy, equipment, and buildings each contribute 19% of total CF, then followed by travel with 16% of total CF[4] .For the year 2010 total CF of UNAM is 1577 tons CO_2 eq. Major contributions are from scope 3 with 53 % of the total emission (842.4 tons CO_2 eq), followed by indirect emissions (scope 2) with 42% (653.4 tons CO_2 eq) and last by direct emissions scope 1 with 5% contribution (81.2 tons CO_2 eq). Based on activities through transportation majorly contributes 50 %, electricity contributes 42%, through air travels 5% and shipment, paper solid waste 1% each. Normalization of results shown that CF of per capita is 1.46 tons CO_2 eq/year[15].A total of 325351 tons CO_2 eq is emitted by UA, scope 1 contributed more with 52% of the total emissions i.e. 169737 tons CO_2 eq. Next followed by scope 2 with 40% (129390 tons CO_2 eq) and finally least by scope 3 with 8% (26224 tons CO_2 eq).Activities that contributed more are cogeneration of steam and electricity from scope 1, the purchase of electricity from scope 2, and transmission and distribution (T&D) losses from scope 3[16].Total gross GHG emissions from all activities in ECU are 24,981 tons CO_2 eq for the year 2018.Major contributions from scope 2 i.e. purchased electricity contributed 67%about 16,840.28 tons CO_2 eq, then followed by scope 3 with 26% about 6,432.86 tons CO_2 eq and least by scope 1 with nearly 7% about 1,707.82 tons CO_2 eq. %). The individual CF of ECU is around 0.83 tons CO_2 eq/year.GHG emissions from all the three scopes of various universities are presented in Figure 5.Percapitacarbon footprint from the all universities are given in Figure 6.

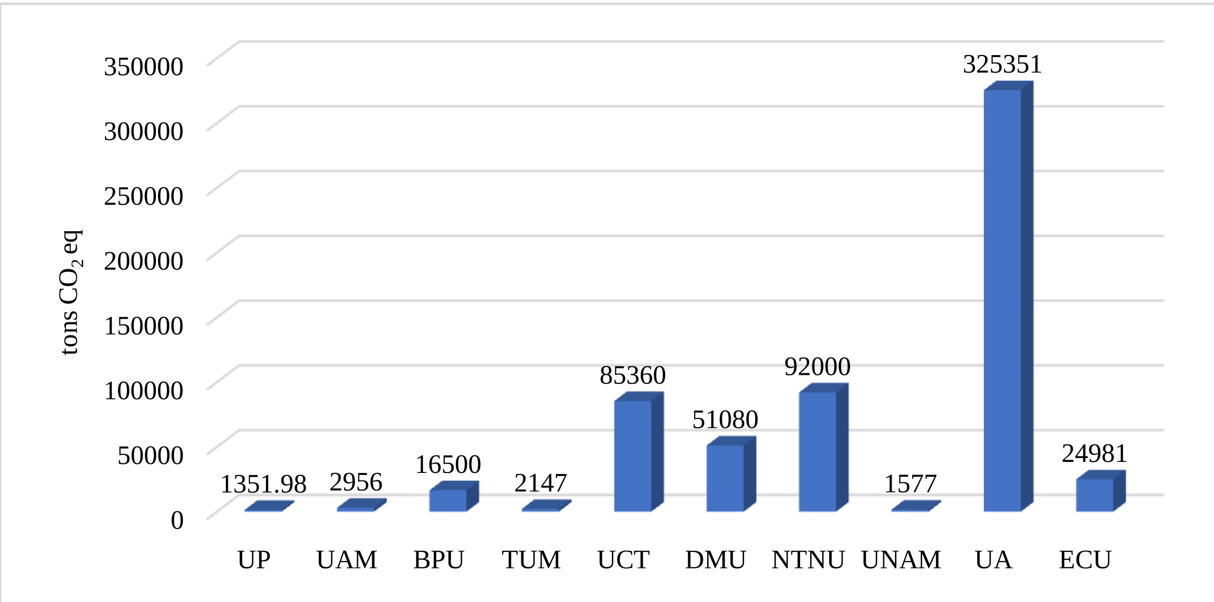

Fig 4. The total carbon footprint of Universities.

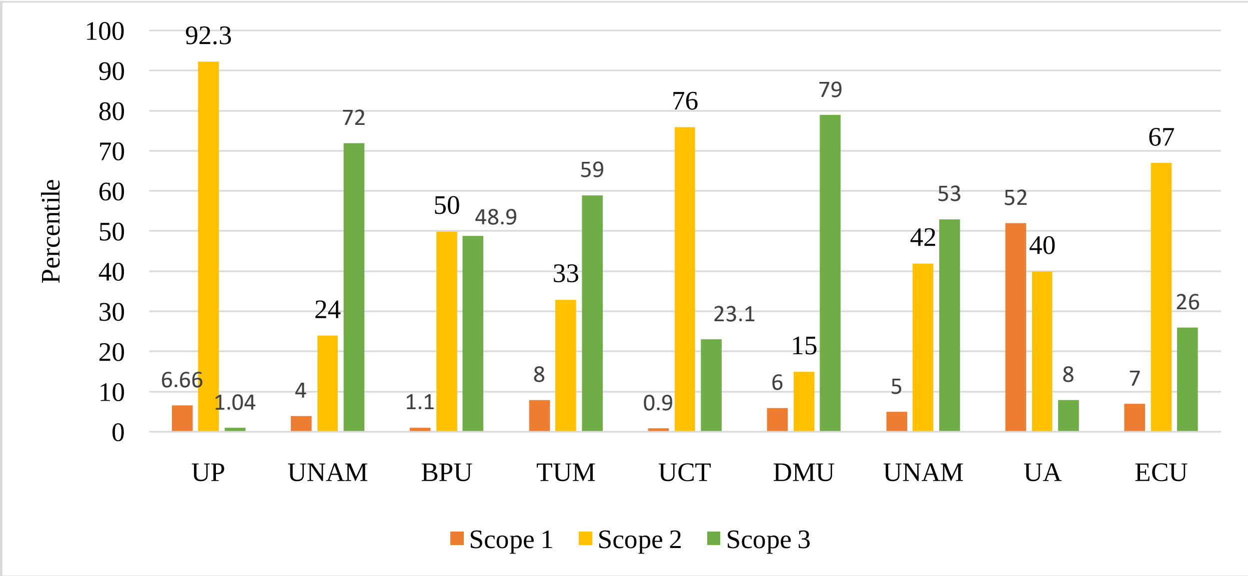

Figure5. GHG emissions from all the three scopes of various universities.

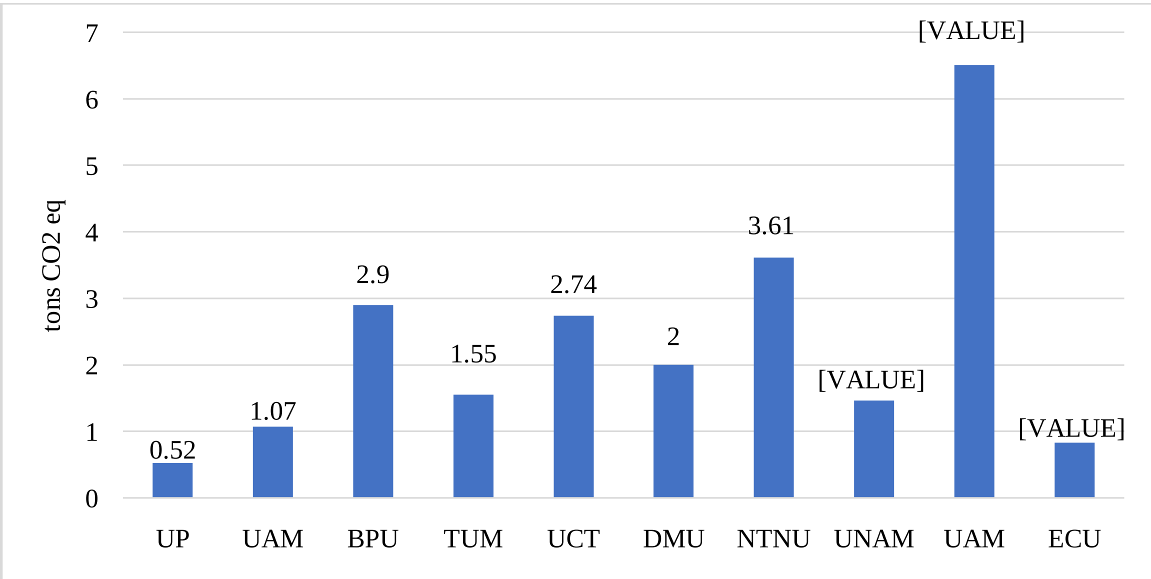

Fig 6. Percapita carbon footprint of all universities.

Comparison :

The emissions by the scope, total and per capita of universities were compared in Table 3.

Table 3 Comparison of emissions by the scope, total, and per capita of universities.

University/Institute	country	population	Year	Emissions (tons CO2 eq)				
						By scope (%)		
				Total	Per capita	S1	S2	S3
Universitas Pertamina (UP)	Indonesia	2621	2017-18	1,351.98	0.516	6.66	92.3	1.04

Autonomous Metropolitan University (UAM)	Mexico	2751	2016	2956	1.07	4	24	72
Bits PilaniUniversity (BPU)	India	5699	2014-15	16500	2.896	1.1	50	48.9
Technical University of Madrid (TUM)	Spain	1385	2010	2147	1.55	8	33	59
University of Cape Town(UCT)	South Africa	31129	2014	85360.02	2.74	0.9	76	23.1
De Montfort University (DMU)	UK	25580	2008-2009	51,080	2	6	15	79
Norwegian University of Technology and Science (NTNU).	Norway	25500	2009	92000	3.61	--	--	--
National Autonomous University of Mexico (UNAM)	Mexico	1076	2010	1577	1.46	5	42	53
The University of Alberta (UA)	Canada	50000	2012-2013	325351	6.51	52	40	8
Edith Cowan University (ECU)	Australia	30000	2018	24,981	0.833	7	67	26

S1 : SCOPE 1 , S2 : SCOPE 2, S3 :SCOPE 3

The summary of all studies reported in Table 3, used the same methodology of classifying scopes except NTNU. Among all universities UA is toped in emissions with 325351 t CO_2 eq, followed by NTNU, UCT, DMU, ECU, BPU with 92000, 85360.02, 51,080, 24,981 t CO_2 eq respectively, these university values are more due to high population. Remaining universities UAM, TUM, UNAM, UP emissions are less when compared to other universities, population is also one factor showing variation in emissions. Among all UP is least with 1,351.98 t CO_2 eq, highest emissions by UA with 325351 t CO_2 eq. Regarding per-capita again UA is with highest emissions of 6.51 t CO_2 eq and least by UP with 0.516 t CO_2.The major contribution in most of the institutions is associated with indirectemissions of purchased electricity (Scope 2) with more than 50% contributions in BPU, ECU, UCT, and more than 90 % in UP. Scope 3 activities also contributed majorly more than 50% contributions in UAM, TUM, DMU, UNAM. On the other hand scope, 1 contributed more than 50 % only in UA.

Variation in the emissions of universities maybe depends on many factors like population(technology), methodology (assumptions, emission factor), input data, lifestyle of individual and other factors.Population is directly proportional to CF of the university, more population means more consumption, activities which leads to more CF. Different universities used different methodologies with different assumptions and emission factors. In some calculators, they fixed some values like distance traveled in a year. Each methodology has its own assumptions that show variation in emissions. On the other hand, EF also has some influence on CF, depending on the region's emission factor changes.Different methodologies or calculators are built with different input data. In few studies they only consider direct emissions and few others consider both direct and indirect emission into considerations which shows a variation in emissions.In most cases, the total CF cannot be estimated accurately because of insufficient knowledge of and data about the complex interactions between contributing processes, including the influence of natural processes that store or release carbon dioxide

Reducing the Carbon Footprint

Carbon footprinting is an emerging hot topic which is appeared in news frequently with incipient concern towards climate change. As from the results of various universities shown that energy consumption is more, in order to reduce CF, the main way is to decrease the consumption of energy and minimize energy and individual waste. People must understand the effect that their carbon footprint has on the planet. With the spread of awareness, people need to know how they can reduce their carbon footprint.

Transportation:

For travel, the use of public transport or low-emission vehicles must be preferred. One of the major contributors to personal CF is “driving to work”, try to avoid using your own vehicle for short distances, instead use cycles or walking to reduce personal CF.If every individual uses their vehicle for transport that results in traffic congestion and poor air quality.Introduce the concept of odd/even number vehicle, once a week introduce “no pollution day act” no vehicles should go or pass within the campus to reduce carbon footprint.

House:

Insulation of houses, use of energy-efficient products, and reuse or recycle are other ways out.

When compared with energy consumption of incandescent bulbs, LED lamps and tubes consume less as well as have a benefit of lasting forever and containing no mercury. By using LED bulbs there is a possibility of reducing your CF of 6 tons per year .Adopt the concept of reuse, recycling for glass, metals, plastic, and paper, etc. Use reusable products like canvas shopping bags, avoid single usable products, and even better to grow vegetables in the garden to reduce transportation emissions.Use natural energy whenever possible for instance use sunlight instead of fans and hair driers for drying hair after the shower.Using solar panels not only saves your money and also reduces the CF of your household. At the time of generation of 1Kwh of electricity solar energy liberates less CO_2 emission(40 grams) when compared with coal(955 grams), natural gas (650 grams), nuclear energy (60 grams) [24],[25] .

Planting:

Individual CF can become 'carbon-neutral' by planting. A single tree absorbs CO_2 at a rate of 48 lb. For an average lifespan of trees is 40-50 years, nearly it can absorb one-ton CO_2 at its death [50].

Food:

Individual lifestyle also impacts on CF.A Study shows "Eating a vegan diet is likely to be best for the environment",that is consumption of ruminant meat (goat, beef, lamb, etc.) produces 20-100 times more emissions than those of plants. Whereaspork, milk, eggs,kinds of seafood, and poultry impacts 2 to 25 times more than plants per kilocalories of food produced[48].

Offsetting:

There is a possibility to neutralize the impacts of CF through "carbon offsetting". Many organizations like the Nature Conservancy, carbonify and several others offer carbon offset programs that invest donations toward "protecting land and planting trees", both proven ways to reduce GHG.

Universities need to provide dormitories for faculty and students within the campus or nearby areas to reduce transportation emissions.Cambridge University set its plans to reduce the CF,to control the electricity consumption they are planning to implement a scheme under which all the departments will be responsible for managing their own electricity budgets. Trying to introduce new designs and standards for constructing new buildings in an eco-friendly way. Regarding water consumption, they planning to introduce Automatic Meter Reading (AMR) for giving automatic warnings when consumption spikes and also for alerting if there are any leakages [47]. University of California (UC) developed strategies to reduce CF like developing "wholesale electricity options" which offer carbon-neutral electricity, development, and acquisition of biogasoption to offset CF. employing a mix of little programmatic developments to decrease the usage of fleet fuel through a "method of driving less while moving tohigher efficiency and zero-emission vehicles"[49].Each university needs to reduce its CF and make the campus as "Green campus". The main goals of the green campus concept include major engineering aspects like the treatment of water and wastewater, controlling air pollution, waste management, sustainable transportation, planning energy, and water efficiency.

Conclusion:

CarbonFootprint has emerged as a strong mode of GHG expression, which possesses the potential of being a "good entry point for increasing consumer awareness about environmental impacts". Results from the universities shown that scope2 i.e. purchased electricity is contributing more in most of the universities, scope 3 activities (commuting, etc.) also showed the next impact. Student's lifestyle is one of themajor factors in contribution towards electric consumption, as now a day's technology is providing amenities, students are addicted to the technology like using smartphones, laptops, gadgets for knowledge transfer.In addition to that, commuting activities are also contributing more from both student and faculty side.Universities discussed in this study are from different places of the world and used GHG protocol category of classifying the activities and their emission values are unlike which is previously mentioned it will depend on many factors. While calculating CF most of the universities assumed certain average values which will reduce the precision of total CF. In order to find the exact CF, each activity should be considered which happens in campus and out, related, or belongs to the institution.First, the university should decide what they exactly want to calculate. A decision has to be made on what emission categories should be included in the calculation. Everyone should show their interest in calculating CF and reporting it to a third party, which may be an individual or organization or industry. Knowing CF and neutralizing it is the primary step towards a good sustainable environment.Most of them may not know about carbon foot-printing, it is one's duty to know their contribution towards the environment.

This articleexplained CF i.e. what is CF, why need to calculate CF and how can we calculate CF. And alsocompared CF of universities and identified major activities impacts on universities CF. In addition to that, provided the reductions plans to reduce the emissions, which assist as a compendium for individuals, universities,or organizations who are interested to know and measure their CF and provide a baseline tothe future.

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