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Assessment of Carbon Neutrality and Sustainability of KCAET Campus in Kerala, India

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ABSTRACT

The study was conducted during 2021–22 with a view to analyze the carbon neutrality and sustainability of Kelappaji College of Agricultural Engineering and Technology (KCAET) campus. It was done for proposing and implementing sector-wise adaptation and mitigation strategies to develop KCAET campus of Malappuram district in Kerala as a "Carbon Neutral Campus". A carbon emission and sequestration analysis in the sectors of food consumption, transportation, energy, waste and AFOLU (Agriculture, Forest and Other Land Use) was done. The required data were obtained by conducting various surveys, and the corresponding emission factors were taken from available literatures. Carbon emission and sequestration of each sector was calculated as the product of the emission factor and activity data. The total carbon emission from the campus was found to be 522.086 CO_2 eq.t and the total sequestration from the campus was 177.2 CO_2 eq.t. Since the carbon emission is higher than carbon sequestration, it can be inferred that the campus is not carbon neutral. Strategies for achieving and maintaining carbon neutrality through reduction in emissions, improving stock of carbon and creating carbon credits/reserves need to be adopted. Since the major emission is from transportation and use of fuels, energy efficient methods to save energy and switching to renewable energy sources to bring down the emissions from energy consumption need to be implemented.

KEYWORDS: Carbon neutrality, carbon emission, carbon sequestration, energy consumption

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1. INTRODUCTION

The urgent and most concerned problem that various countries and international organizations are facing is the unpredictable climate change (Basic et al., 2015; Rising et al., 2022). International Panel on Climate Change (Anonymous, 2006) reported that the greenhouse gas emission due to human interventions is the major reason for the global climate change. Crippa et al. (2020) stated that more than half of global carbon dioxide (CO_2) emission is contributed by the three leading emitters *viz.* China, the United States, and India. In the Global South, China and India alone contribute almost 60% of the total CO_2 emissions in the group, whereas the top 10 emitters together contribute 78% (Fuhr, 2021). While housing only 11% of the world's population, the top 100 urban areas with the highest carbon footprint are responsible for 18% of the global total carbon emissions (Lee et al., 2021; Moran et al., 2018). Many researchers across the globe have studied the emissions originating from various areas and have proposed the potential prospects for reducing them (Satterthwaite, 2008; Kennedy et al., 2014; Hurth and McCarney, 2015).

The total amount of greenhouse gases that are generated by human actions is termed as carbon footprint and is used as a tool to assess sustainability from the perspective of greenhouse gas (GHG) emissions (Valls-Val and Bovea, 2021). It serves as a means to carbon neutrality. Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide in the soil (Nazir et al., 2024; Srinivasarao et al., 2015) and by terrestrial ecosystems (Liu et al., 2016; Tian et al., 2023). The net-zero carbon emissions indicate the adoption of mechanisms that pave way to equate the amount of carbon emitted into the atmosphere and the amount of greenhouse gases absorbed from the atmosphere. As per the Paris Agreement at Conference of Parties-21 (COP-21), India has committed to reduce the GHG emission intensity by 33–35% by 2030 from 2005 levels. There is a large gap between the sequestration ability of natural carbon sinks and the amount of emissions released globally (Kiehle et al., 2023). In this regard, it is very important to promote sustainability, and reduce GHG gas emissions (Maiti et al., 2023). Around 75% of the total energy consumption in India is from the households (Pachauri and Spreng, 2002). In order to bring down the overall emissions, it is essential to consider the demand and supply perspectives (Tian et al., 2016). Measures to reduce the emissions and attain carbon neutrality are implemented by various countries, institutions, organizations etc. (Kiehle et al., 2023).

Higher educational Institutions produce large amount of greenhouse gas (GHG) emissions due to students (Li et al., 2015; Shields, 2019) and staff (Wynes et al., 2019) behaviour and mobility, and also because of excessive on-campus consumption of energy (Hawkins et al., 2012) and water. Such institutions also generate substantial volumes of organic waste and associated GHG emissions (Mustafa et al., 2022; Ridhosar and Rahman, 2020). Rather, providing better livelihood opportunities and building socio-economic resilience through adaptation strategies are effective approaches for addressing the problem (Awuni, 2023; Roy et al., 2024).

The present study was carried out to assess the total carbon emissions generated from the student behaviour as well as from other sources in the KCAET campus, and to calculate the total carbon absorbed and stored by the vegetation and thereby study the scope of carbon neutrality within the campus. Three hierarchical tiers are given to categorize the methodology for assessment of carbon emission (Anonymous, 2006). Emission factors according to Tier 1 precision level were considered in the study for assessing various sectors.

2. MATERIALS AND METHODS

The study was conducted during 2021–22 at the Kelappaji College of Agricultural Engineering and Technology (KCAET) campus. The campus is located in Tavanur village on the southern banks of the holy river, Bharathapuzha. The campus comprises of approximately 40 ha and is located (10° 51' North latitude and 75° 58' East longitude) in Malappuram district of Kerala state in India.

The major courses offered at KCAET are BTech in Agricultural Engineering and BTech in Food Technology, MTech in Agricultural Engineering and Doctor of Philosophy programs. The entire students available in the campus were considered for the determination of carbon footprints. As KCAET is a residential campus, most of the students are inmates of the hostels, which made the study easier. The total number of inmates in ladies' hostel and men's hostel during the period of study were 196 and 117 respectively.

2.1. System boundary set-up for carbon footprint assessment

The carbon footprint of KCAET was assessed for the period of one year (2021–2022). The choice of the start and end dates for carbon footprint assessment was dictated by the data availability. The data of on-campus transportation, energy, food consumption, waste and AFOLU (Agriculture, Forestry and Other Land Use) were collected and recorded on yearly basis.

The major cause of temperature rise is the uncontrolled emissions of greenhouse gases. Carbon dioxide (CO_2) occupies major share in greenhouse gases (GHG's) and hence the assessment of emission levels makes use of CO_2

as an equivalent indicator. Quantities of Nitrous oxide (N_2O) and Methane (CH_4) are converted in terms of CO_2 by multiplying it with their corresponding Global Warming Potential (GWP). GWP is the heat absorbed by the GHG in atmosphere as a multiple of heat that would be absorbed by the same mass of CO_2. Table 1 gives the details of greenhouse gases and the time horizons of different gases.

Table 1: GHG and their corresponding GWP

Greenhouse gas	Chemical formula	Life time (years)	GWP for given time horizon
Carbon dioxide	CO_2	Up to 1000	1
Methane	CH_4	12	21
Nitrous oxide	N_2O	114	310

2.2. *Carbon neutrality of campus*

In order to determine the carbon neutrality of KCAET campus, the total carbon emission from different sectors such as food consumption as well as student and staff behavior were assessed. Student and staff behavior includes transportation, energy, waste, and AFOLU. The total carbon sequestration was calculated from the sources such as homestead trees, coconut trees, forest like dense vegetation, soil profile and organic carbon content of soil. The methodology used for calculating GHG emissions and its sequestration is based on a linear equation as:

Total emissions=∑Activity data* Emission factor ….(1)

Total sequestration=∑Sectoral data*Sequestration factor (2)

For calculating the carbon emission from food consumption, about 17 varieties of food items consumed in the hostel mess during a week was considered. The GWP of these selected food items were taken from the research paper by Pathak et al. (2010) and the amount of food consumed was taken from the mess record book. The carbon footprint for each activity was calculated as the product of the coefficient or emission factor in g CO_2 per kg (F_i) and the activity intensity or number of activity units (U_i) the students "used" (e.g.: kg of pulse used in hostel mess).

Total Emission, $GHG_i=\sum F_i \times U_i$ …. (3)

The student and staff behaviour including transportation, energy, waste and AFOLU (Agriculture, Forestry and Other Land Use) sectors were assessed for calculating the GHG emission profile of KCAET campus. Being a residential campus, most of the vehicles are owned by teaching and non-teaching staff. The college bus, two wheelers, auto rickshaw and motor car were used for the academic purposes. The total distance travelled by a vehicle is calculated on daily or weekly basis and extrapolated to a year. Emission factor corresponding to each vehicle type (Table 2) were obtained from Jayakumar et al. (2018).

Table 2: Emission factors for vehicles

Vehicle type	Emission factor (CO_2)	N_2O (g km^{-1})
Two-wheeler	0.0324	0.19
Motor car	0.149	0.2
Auto rickshaw	0.1322	1.28
College bus	0.328	1.2

In the energy sector, the emission from the consumption of electricity and the fuel which was required for domestic purpose was included. The main fuel used in the campus is Liquefied Petroleum Gas (LPG). The data regarding electricity consumption from academic buildings, ladies' hostel, men's hostel, staff quarters etc., and LPG consumption details from ladies' hostel, men's hostel and staff quarters were collected. The data collected were on monthly basis, and then converted to annual basis. The corresponding emission factors were taken from Jayakumar et al., 2018. Table 3 shows the emission factor values for electricity and LPG.

Table 3: Emission factor of electricity and LPG

Source	EF (Tonnes/MWh)
Electricity	0.81
LPG	2.9

In this study, the biodegradable waste from ladies' hostel, men's hostel and staff quarters were also considered for determination of the total carbon emission. Two biogas plants and one aerobic composting system is available for the disposal of the biodegradable waste. In certain cases, the waste is dumped in a place and soil is filled over it in each month. Absence of proper system for waste management causes higher GHG emissions from it. The emission factor for biodegradable waste is taken from Jayakumar et al. (2018) and the value was 0.541 tonnes of CO_2 eq./ tonne of waste.

Emissions from AFOLU sector were quantified based on IPCC 2006 guidelines for National GHG inventory. It considers livestock and rice cultivation (irrigated paddy cultivation). The state specific emission factors of cattle for enteric fermentation and for manure management were taken as 38.83 and 2.7 in kg $head^{-1}$ $year^{-1}$ respectively, and the emission factor for irrigated paddy cultivation was taken as 11 (Jayakumar et al., 2018). The data regarding number of cattle were collected from KCAET farm office and the area of irrigated paddy cultivation was found out using Google Earth Pro and Arc GIS software. The total carbon emission was calculated by adding individual emissions from each category detailed above.

Biomass in the trees, plants and all the living system consists of carbon. Plants and trees prepare their food by the process of photosynthesis in which they take up carbon dioxide from the atmosphere. They are the only source of natural removal process of carbon from atmosphere, which in turn is termed as carbon sequestration. To find the total carbon sequestration in KCAET campus, the individual carbon sequestration from forest, homestead trees, coconut plantation and from soil was calculated. There are no global guidelines for accounting carbon sequestration, since parties to United Nations Framework Convention on Climate Change (UNFCCC) are not obliged to report their sequestration levels.

The details regarding the area of homestead trees in KCAET were obtained from Google Earth Map. The emission factor for the homestead area was taken as 0.9 t/500 sq. m (Jayakumar et al., 2018). The total area of the homestead was multiplied by the emission factor to get the carbon sequestrated in this regard. Carbon sequestrated from coconut plantations plays a key role in the total carbon sequestrated from the campus. The area of coconut plantation was calculated from Google earth map (Figure 1) and the emission factors were obtained from Jayakumar et al. (2018) as 4.6 t ha^{-1} year^{-1}. The data of soil series, profile, organic carbon content etc. were accessed from the Department of Soil Survey and Soil Conservation, Kerala. The soil of KCAET falls under Thuyyam-Mannur-Perumbuzha series. The total exposed soil area was calculated using Google earth map. The average soil organic content in percentage was converted to kg ha^{-1} by multiplying it with a factor 93.4. It was obtained as 0.96% at a depth of 17 cm from the ground surface.

Figure 1: Estimating the area under paddy cultivation

The process of carbon sequestration will occur at the above ground biomass, litter and below ground biomass. Forest being the densest area, plays a vital role in reducing Green House Gases, and their conservation is important on the Carbon Neutral trajectory of development. The data regarding the area of KCAET under forest like dense vegetation were obtained from Google earth map and it was multiplied with corresponding emission factors. The emission factors for soil and biomass separately were taken from Jayakumar et al. (2018) as 0.3 and 46.9 in t ha^{-1} year^{-1} respectively. The total carbon sequestrated was obtained by adding the individual sequestration from trees in the homestead, coconut plantation, forest like dense vegetation and soil profile and soil organic content.

The carbon neutrality of the KCAET campus was checked by analysing the total carbon emission and sequestration. Some recommendations were made to bring down the carbon emission and to increase the sequestration so as to attain the objective of carbon neutral campus.

2. RESULTS AND DISCUSSION

3.1. Carbon emission from the campus

The GHG emissions from food consumption varies according to the food products which were consumed by the inmates of Ladies hostel, Men's hostel and staff quarters in the campus (Table 4).

In KCAET campus, mostly the vehicles are used by teachers and non-teaching staffs. The college bus, two wheelers, motor car and auto rickshaw were considered for calculating the carbon emissions. The number of most accustomed vehicles in the campus was collected. The average annual covered distance in km was calculated. By multiplying with the emission factors and suitable conversion factors, the total emission of carbon from transportation was obtained. Table 5 shows the carbon emissions from vehicles in the campus.

Energy sector accounts for the emissions from electricity consumption and emissions from the other types of fuel used for meeting domestic energy needs in the campus. The LPG used for cooking in the hostels and the electricity consumed in the campus were taken in this category. Table 6 shows the carbon emission from different energy sources.

The biodegradable waste from ladies' hostel, men's hostel and staff quarters were also considered for the calculation of carbon emission. Table 7 shows the details of carbon emissions from biodegradable wastes. Greenhouse gases are emitted from the wastes due to its improper disposal and management. Therefore, it was concluded that, by adopting efficient waste management measures in the campus, the GHG emissions can be reduced significantly.

As per Intergovernmental Panel on Climate Change (IPCC), Agriculture, Forestry and Other Land Use (AFOLU) contributes to carbon emission. The livestock and irrigated paddy fields were the two contributors available in the study area in this category. Livestock sector in general, supplements the agriculture sector. Ever

Table 4: GWP of food items

Sl. No.	Food item	Amount (kg)				GWP (g CO_2 eq. kg^{-1} fresh wt)	GWP (tonne CO_2 eq.)
		Ladies hostel	Men's hostel	Staff quarters	Total		
1.	Rice (ordinary)	5472	1488	6297	13257	711.9	9.44
2.	Poultry meat	2064	2448	1830	6342	801.1	5.08
3.	Bread	115.2	76.8	924	1116	257.2	0.287
4.	Potato	1104	624	390	2118	132.0	0.28
5.	Fish	1478.4	1320	1620	4418	756.5	3.34
6.	Banana	384	120	1305	1809	97.6	0.177
7.	Paratha	1383.8	1158.7	90	2632.5	261.7	0.689
8.	Cauliflower	240	264	174	678	138.4	0.094
9.	Sambar	1056	864	8105.4	10025	199.3	2.00
10.	Egg	208.0	192	480	880	668.0	0.60
11.	Rice (Basmati)	480	1632	195	2307	858.9	1.98
12.	Pulse	216	336	255	807	207.9	0.168
13.	Brinjal	192	144	222	558	141.0	0.079
14.	Milk	2016	3360	8328	13704	766.8	10.50
15.	Omlet	633.6	234.24	825	1692.84	608.7	1.030
16.	Idli	1176	839.04	1179.3	3194.34	682.5	2.01
17.	Dosa	3993.6	4992	4752	13737.6	729.3	10.02
Total							47.774

Table 5: Carbon emission from vehicles

Vehicle type	Total no's	AACD (in km)	Emission factor		N_2O in tonnes of CO_2 eq.	CO_2 in tonnes of eq.	In tonne CO_2
			CO_2 (kg km^{-1})	N_2O (g km^{-1})			
Two-wheeler	7	10220	0.0324	0.19	4.21	2.32	6.53
Motor car	5	10920	0.149	0.2	3.38	8.135	95.28
Auto rickshaw	1	2190	0.1322	1.28	0.84	0.291	3.09
College bus	1	6934.12	0.328	1.2	2.49	2.274	10.595
Total							215.765

Table 6: Carbon emission from energy sources

Source	EF (t/MWh)	Consumption (MWh)	CO2 eq. Emission (mt yr^{-1})
Electricity	0.81	43.59	35.31
LPG	2.90	62	179.8
Total			215.11

Table 7: Carbon emission from waste

	In tonnes	EF for open dumping tonnes of CO_2 eq. / t of waste	Total emissions in CO_2 eq. tonnes
Biodegradable waste generated	21.64	0.541	11.707

since climate change started impacting the productivity of thermo-sensitive plantation crops like coffee, livestock has been a steady source of income for the local people. Livestock is one of the major or marginal sources of income for the farmers. The cattle available in KCAET accounts for the livestock carbon emission from the campus. A portion of the campus is irrigated under paddy cultivation, which contributes a percentage of carbon emission. The carbon emitted from livestock and irrigated paddy field are tabulated in Tables 8 and 9 respectively. The total carbon

Table 8: Carbon emission from livestock

Livestock	Total no	EF (for enteric fermentation) (kg head^{-1} year^{-1})	EF (for manure management state specific) kg head^{-1} year^{-1}	Total CH_4 emissions in kg	CO_2 eq. tonnes
Cattle	18	38.83	2.7	747.54	15.698

Table 9: Carbon emission from irrigated paddy

	In ha	In sq.m	EF (mean CH_4 flux, g m^{-2})	CH_4 emission in g	CH_4 Emission in tonnes	CO_2 eq.t
Area under irrigated paddy	6.9	69392.23	11	763314.53	0.763	16.03

emitted from the AFOLU was calculated by adding up the carbon emitted from livestock and that from irrigated paddy fields (Table 10).

Table 10: Carbon emission from AFOLU

AFOLU	In CO_2 eq. tonnes
Livestock	15.698
Paddy	16.03
Total	31.73

The total carbon emission from the KCAET campus was calculated by adding up all the individual emissions discussed so far. Table 11 shows the total carbon emitted from all the categories.

Table 11: Total carbon emission

Sector	Emission in CO_2 eq. tonnes
Food consumption	47.774
Transportation	215.765
Energy	215.11
Waste	11.707
AFOLU	31.73
Total	522.086

2.2. *Carbon sequestration from the campus*

The carbon sequestration from the campus was found mainly due to the vegetation and trees present in its premises. The homestead trees accounts for 1.28% of the entire campus area. The sequestration due to homestead trees was calculated and tabulated in Table 12.

Table 12: Carbon sequestration from homestead trees

	Total area (m^2)	Emission factor (t 500 m^{-2})	In CO_2 eq. t
Homestead Trees	51037.06	0.9	91.87

About 5 hectares of the campus area is covered by coconut plantation. Carbon sequestration occurs at the above ground biomass, litter and below ground biomass from the plantation, playing a vital role in reducing Green House Gases emissions. Table 13 shows the carbon sequestrated by coconut plantation in the campus.

Table 13: Carbon sequestration from coconut plantation

	Total area (ha)	Emission factor (t ha^{-1} year^{-1})	In CO_2 eq. tonnes
Coconut plantation	5	4.6	23

The data of soil series, profile and organic carbon content obtained from the Department of Soil Survey and Conservation (DSSC), Government of Kerala was used for the calculation of carbon sequestrated from the soil. The soil in the campus was of "Thuyyam-Mannur Perumbuzha "series. The average organic carbon content was calculated as 89.66 kg ha^{-1} and the carbon sequestrated by the area was found to be 3.24 tonnes CO_2 eq. The details are tabulated in Table 14.

Table 14: Carbon sequestration from soil profile

	Total area (ha)	Avg. organic carbon content (%)	Avg. organic carbon content (kg ha^{-1})	Carbon stock (t)
Thuyyam-Mannur-Perumbuzha series	36.12	0.96	89.66	3.24

The area under forest like dense vegetation in the campus was determined from the google earth map as 1.26 ha. The carbon sequestrated by forest like dense vegetation for the area is given in Table 15. About 3.15% of total campus area is occupied by forest like dense vegetation area

Table 15: Carbon sequestration from forest like dense vegetation

	Total area (ha)	Sequestration factor in t ha^{-1} $year^{-1}$		Carbon sequestration
		Soil	Biomass	
Forest like dense vegetation	1.26	0.3	46.9	59.09

The total carbon sequestrated due to the available vegetation in the campus was calculated by adding up all the carbon sinks in the campus. The carbon sequestrated by various sectors are tabulated in Table 16.

Table 16: Total carbon sequestration

Sl. No.	Sector	Sequestration in CO_2 eq. t
1.	Trees in the homestead	91.87
2.	Coconut plantation	23
3.	Soil profile and organic carbon content of soil	3.24
4.	Forest like dense vegetation	59.09
Total		177.2

The assessment showed that the total carbon sequestrated in KCAET campus is about 177.2 tonnes of CO_2 eq. Homestead trees, forest like dense vegetation and coconut farm forms largest carbon sinks in the KCAET Campus. They contribute to almost 85% of the total carbon emission and serves as carbon reservoirs.

Based on the baseline assessment of total emissions and sequestration for the year 2021–2022, it was found that the total carbon emission from the campus was 522.086 CO_2 eq. tonnes. The total carbon sequestration was 177.2 CO_2 eq. tonnes.

The difference between total emissions and sequestration was calculated as 344.886 tonnes of CO_2 eq. As a final observation, it can be stated that KCAET Campus is not a carbon neutral campus as the emissions slightly overtook the sequestration (Figure 2). This surplus of GHG emission over the carbon stock has to be brought down to zero in order to achieve net zero emission or carbon neutral status for the campus. For achieving net zero emissions, it is very important to understand how the emission rates are going to be in the future. A target has to be set to reduce the projected carbon excess to zero

The carbon emission from food consumption contributed by various sectors in the campus (Figure 3) depicts that the emission due to food consumption is higher from staff quarters.

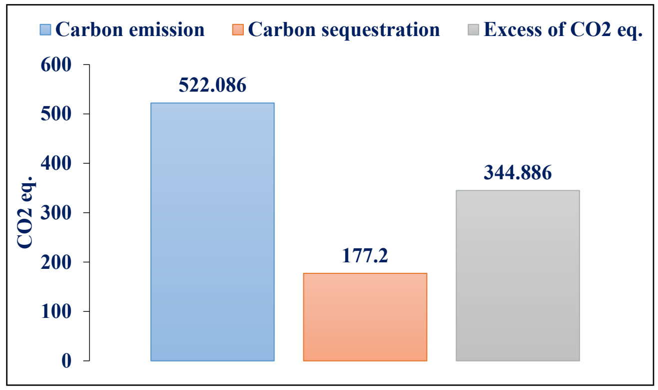

Figure 2: Carbon flow in KCAET campus

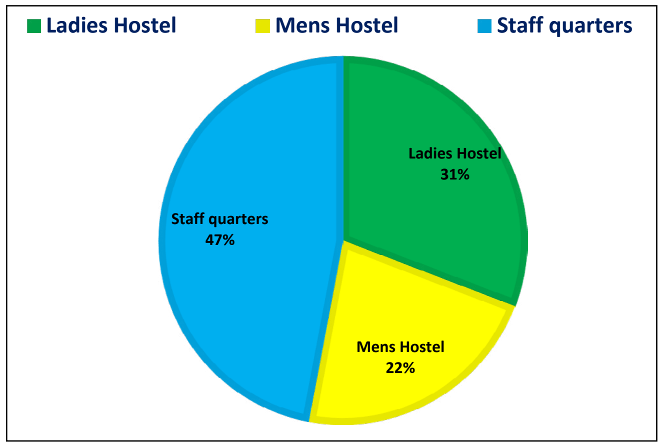

Figure 3: Carbon emission from food consumption in the campus

The results of the GHG emission analysis showed variations in GHG emission from food within food products offering possibilities to reduce the GHG emission from food consumption. An example could be a shift from animal food products to plant-based food products. Within plant-based foods, products based on rice (rice, dosa and idli) would emit more GHG compared to wheat-based products (chapatti and bread).

In transportation sector, the largest contributor was motor car which contributed 39% of the total emissions. The college bus and two wheelers accounted for significantly fewer emissions, about 35% and 22% of the total, respectively. Auto rickshaw occupied the least value of 4% of the total. Figure 4 depicts the carbon emission from various transportation aids in the campus. The transportation sector contributed about 42% of the total carbon emission.

The energy sector accounted for the emissions from electricity consumption and emissions from the other types of fuel used for meeting domestic energy needs. This sector contributed about 41% of total GHG emission from

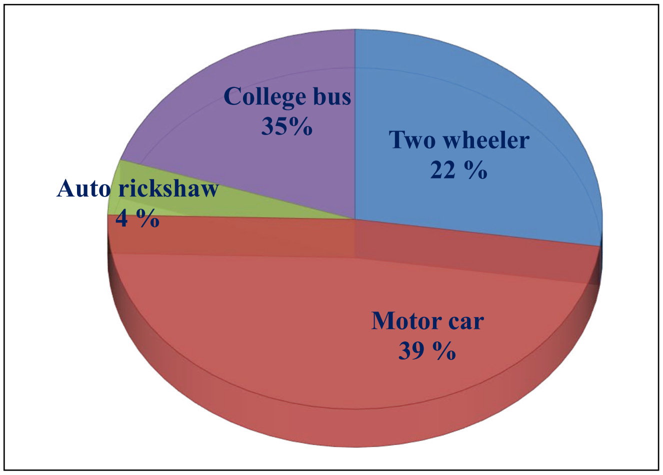

Figure 4: Carbon emission due to transportation

KCAET campus. Electricity consumption at household level contributes 20% and LPG consumption contributes 80% of total emission from energy segment. Figure 5 depicts the carbon emission from energy sector.

'Zero Waste and Zero Emissions' is one of the important pillars of 'Carbon Neutral Campus' project, even though

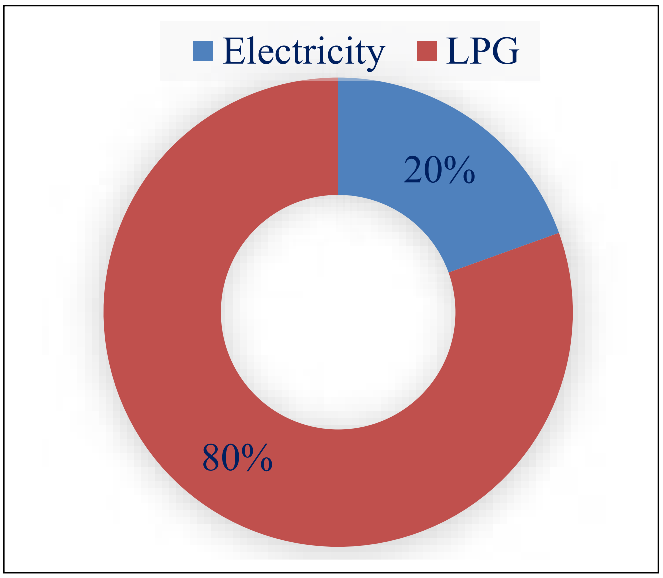

Figure 5: Carbon emission from energy sector

contribution from bio degradable wastes to the total emissions was the least with 3.5% of total emissions from the campus. The study considered emissions from livestock and rice cultivation (irrigated paddy cultivation) out of the three major contributing activities and it contributes about 9.6% of total emissions of carbon in the campus. Livestock is one of the major or marginal sources of income for the farmers. Livestock and irrigated paddy cultivation in the campus, contributes to 15.7% and 1.69% respectively, of total emissions from the AFOLU sector.

Figure 6 depicts the total carbon emissions from various sectors discussed above. The results reveal that, transportation and energy sector is the highest contributors to the total carbon emission from KCAET campus, followed by food consumption, AFOLU and waste. The emissions from wastes contributed the least to the total emissions.

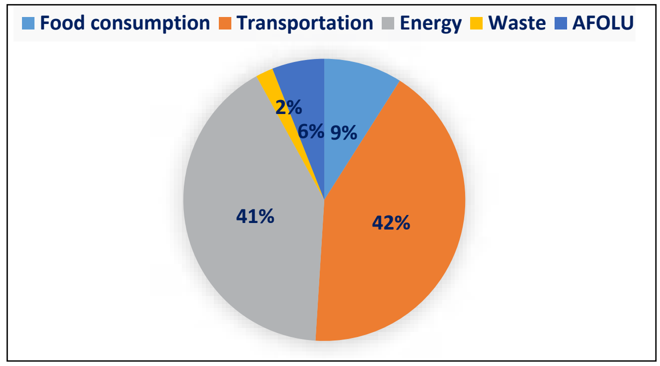

Figure 6: Total carbon emission from various sectors

The carbon sequestration in the campus was mainly contributed by homestead trees (52%), followed by forest like dense vegetation (33%) and coconut farm (13%). Figure 7 depicts the percentage of carbon sequestrated by various sectors in KCAET campus.

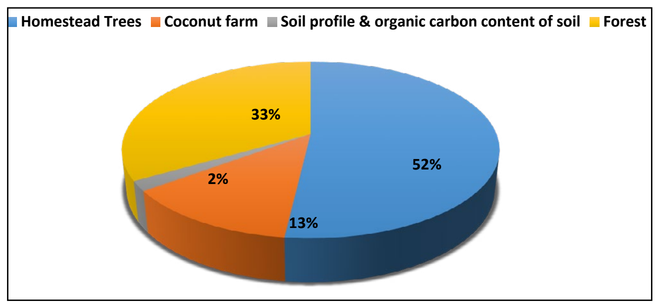

Figure 7: Total carbon sequestration

The carbon neutrality refers to an equilibrium state in which carbon emissions and carbon sequestrations are equal, which in turn refers to a zero-emission condition. The state of carbon neutrality can be achieved by reducing the emissions, improving stock of carbon and creating carbon credits / reserves. Assuming a fully grown tree would sequestrate about 25 kg of Carbon per year, to meet the gap of 344.886 t of the excess emission from the campus may require about 14000 trees to be planted. Creating additional reserves of carbon through developing solar power plants, practicing agro-ecology, conservation and improvement of forests etc. are also suggested to attain carbon neutrality.

The solar power panel established on the roof top of academic building was also considered while calculating the total emission from electricity. This adds a scope that by enlarging the solar power system to the entire roof top buildings of KCAET, entire grid can be supported by solar power itself and reduce the total carbon emissions.

Energy efficiency measures includes usage of LED bulbs, solar mobile phone chargers, solar lighting, production of solar energy, thermos boxes, and biogas plants. By adopting various energy efficient equipment's/ methods to save energy and switching to renewable energy sources and best practices will help to bring down the emissions from energy consumption.

Transportation sector accounts for 42% of GHG emission in the campus. The emission from transportation cane be reduced by the use of electric autorickshaws instead of diesel autos which produce less emission, pollution and noise. Avoid the use of two wheelers and four wheelers, instead travel by bicycles for short distance. Energy sector accounts for 41% of GHG emissions in the campus. By adopting various energy efficient equipment's/ methods to save energy and switching to renewable energy sources and best practices will help to bring down the emissions from energy consumption.

The composting of organic waste and agricultural waste is the back bone of the process of enriching the soil carbon levels. Composting need to be promoted at household and community levels. Waste contributes 11.707 tonnes of carbon per year in the campus. It accounts for about 2% of total GHG emission in the campus. 100% reduction in the emission from waste is possible by adopting appropriate waste management technologies and processes. Source level aerobic composting, material recovery and recycling and green protocol can be practiced to achieve 'Zero Waste' notion.

4. CONCLUSION

Consumption of energy in the form of electricity and LPG contributes 42% and 41% of the total GHG emission respectively. Certain control measures need to be adopted to neutralize an excess emission of 344.886 CO_2 eq. t. Accordingly, recommendations are suggested to make KCAET a carbon neutral campus. Within the limitations of time and technical constraints, a sincere effort was taken to carry out an inclusive and comprehensive emission inventory and sequestration study of the campus. Sincere efforts are needed to ensure proper adaptive and mitigation measures so as to reduce the emissions, and to attain sustainable development.

5. SCOPE FOR FUTURE RESEARCH

Carbon sequestration estimation was limited to soil carbon, above and below ground biomass of homestead trees and carbon stored in forests and plantations. Other sequestration methods also need to be considered. Due to lack of project span, major part of data used was that for a period of one year duration. More data is needed for arriving at precise conclusions. Emission inventory in the transportation sector is a complicated process and it was scoped down to emissions from internal traffic from the major vehicles inside the campus.

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