SHORT ARTICLE

Tracing footprints for a greener tomorrow; A cross-sectional study to assess the carbon footprint of the urban households of Vijayapura city

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ABSTRACT

Background: The concept of carbon footprint is rooted in measuring the volume of greenhouse gases, predominantly carbon dioxide (CO2), resulting from human activities. India has witnessed a significant surge in greenhouse gas emissions due to rapid economic growth and population expansion, making it the world's third-largest CO2 emitter. This upsurge intensifies the natural greenhouse effect, leading to global temperature rise, ocean acidification, and heightened risks to human health. **Objectives**: To assess the Carbon Footprint generated by urban households of Vijayapura. **Material and methods**: This study employs a cross-sectional approach targeting urban households residing within the operational area of the urban health center in BLDE(DU), Vijayapura City. The sample, comprising 150 households, was selected via systematic random sampling. Data was collected through household visits and interviews with the family heads using a semi-structured questionnaire. and analyzed utilizing SPSS Software Version 26. **Results**: The analysis of carbon emissions highlights that primary emissions surpass secondary emissions. Notably, households categorized under the upper socioeconomic class exhibit a statistically significant carbon emission rate of approximately 39.47 tonnes per month. **Conclusion**: This study's assessment of the carbon footprint emanating from urban households illuminates the pivotal connection between day-to-day choices and the broader ecological context.

KEYWORDS

Carbon Footprint, Urban household, Greenhouse gases, Sustainable Development Goals (SDGs), Ocean Acidification

INTRODUCTION

Over the past two decades, growing concerns have emerged regarding the impact of human activities on natural ecosystem and human well-being. Among these concerns, carbon emissions stand out as a significant contributor(1). The concept of a "Carbon

Footprint," denoting the greenhouse gases (GHG) produced by human activities, particularly in terms of carbon dioxide (CO2), has gained heightened importance in recent years(2). The amplified greenhouse effect due to excessive carbon emissions has led to global temperature rise, Ocean acidification, and health risks(3).

The Carbon Footprint serves as a global measure of sustainability and a potential indicator of worldwide warming trends (4). Despite considerable environmental degradation, there remains limited widespread awareness regarding carbon emissions(5).

India's GHG emissions have experienced substantial growth in recent years. In 2021 , India contributed 2,710 million metric tons of greenhouse gas emissions, establishing itself as the world's 3rd-largest emitter of CO2(6). Urban households have undergone notable consumption shifts in tandem with rapid urbanization and economic progress(7,8,9).

The primary footprint encompasses immediate CO2e emissions stemming from fossil fuel usage, encompassing driving and flying. On the other hand, secondary footprint encompasses inadvertent CO2e emissions spanning from production to disposal (10,11).

The focus of SDG Target 14.3 is to "minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels (12,13) " which is what our study is focused on.

To assess consumption patterns and associated carbon emissions per unit of consumption among various socioeconomic groups within urban households in Vijayapura.

Objectives:

1. To Evaluate the diversity of consumption patterns within urban households in Vijayapura.
2. To Analyze variations in carbon emissions across different socioeconomic groups.

MATERIAL & METHODS

Study Type: Cross-sectional research design

Study Population: Urban households

Study Area: Urban field practice area of Shri BM Patil Medical College in Vijayapura City.

Study Duration: June to August 2023

Sample Size calculation: A systematic random sampling technique was used to obtain a sample size of 150 households, ensuring proportional representation from each socioeconomic class, after line listing of the households

Inclusion Criteria: Residing in the urban field practice area with a minimum period of one year

Exclusion Criteria: Those who are not willing to participate in the study are excluded

Ethical Consideration: Institutional Ethical Clearance was obtained

Consent: Informed consent was obtained from the study participants

This study follows a cross-sectional research design conducted within urban households situated in the field practice area of Shri BM Patil Medical College in Vijayapura City. After obtaining Institutional Ethical Clearance this study was conducted by house-to-house survey systematic random sampling technique based on socioeconomic classification to get equal representation across various socioeconomic classes, to obtain a sample size of 150 households. The study period was between June to August 2023, involving personal visits to households, during which the heads of the families were interviewed utilizing a Semi-structured Questionnaire.

The questionnaire was structured into three distinct sections. The first section focused on gathering sociodemographic particulars of the households, while the second section delved into sources of primary emissions, encompassing aspects like electricity consumption, usage of LPG, and transportation patterns. The third section was dedicated to investigating secondary sources of emissions, such as expenditures related to food, pharmaceuticals, clothing, education, and more

The data obtained from the households was meticulously recorded in an Excel spreadsheet. Subsequently, carbon footprints were calculated using a validated online tool accessible at https://www.carbonfootprint.com/calculator.aspx, which has been designed for use in various countries, catering to different settings and requirements.

Statistical analysis: To analyze the collected data, SPSS software version 26 was employed. The data presentation entailed the use of measures like Mean, Standard Deviation, and Percentages, alongside the presentation of data through Tables and Charts. To compare variables, a One-way ANOVA with a Post Hoc Test was implemented. Additionally, the correlation between socioeconomic status and carbon emissions per person per year was investigated using the chi-square test.

RESULTS

Table 1 outlines the distribution of study participants across different socioeconomic classes according to Modified BG Prasad classification. These classes were categorized into three groups: Upper Class (combining classes 1 and 2), Middle Class (class 3), and Lower Class (combining classes 4 and 5). Among the participants, 26% held degrees, while 9% were found to be illiterate. Additionally, 37% had completed their primary schooling, and 34% were enrolled in PUC (Pre-University Course).

Figure 1 graphically represents the carbon emissions originating from distinct household categories, from total carbon emissions, primary and secondary were calculated by using the online accessible tool. In the Upper Class (Class I), households emitted an average of around 39.47 tonnes of carbon monthly, with 34.51 tonnes attributed to primary emissions and an additional 4.96 tonnes to secondary emissions. For the Middle Class (Class II), emissions totaled 20.92 tonnes per month, with 17.82 tonnes as primary emissions and 3.1 tonnes as secondary emissions. Meanwhile, the Lower Class exhibited emissions of 11.09 tonnes per month, of which 10.25 tonnes were primary emissions and 0.84 tonnes were secondary emissions.

To statistically analyze these differences, a one-way ANOVA was conducted and significant variations among the three socioeconomic classes regarding carbon emissions were identified (Table 2). The average annual CO2 equivalent output per person in India stands at 0.56 tons. Utilizing this average value, calculations were made for all study participants across the three socioeconomic classes, as depicted in Table 3, revealing significant distinctions in carbon emissions per person per year between the classes.

Furthermore, Table 4 indicates significant associations between education levels and carbon footprint emissions per person per year, as determined by a chi-square test. Post hoc tests, showcased in Table 5, demonstrated statistically significant differences in monthly carbon emissions between the Lower Class and Middle Class, Lower Class, and Upper Class, as well as Middle Class and Upper Class. Similarly, Table 6 highlights substantial differences in primary carbon emissions per month between these socioeconomic classes.

Lastly, Table 7 underscores significant variations in secondary carbon emissions per month among the Lower Class, Middle Class, and Upper Class, reinforcing the interconnectedness between socioeconomic status and carbon emissions.

Table 1: Socioeconomic status of the study participants.

Socioeconomic Status (Modified BG Prasad Classification)	No. of. households	Percentage
Class I	50	33.30%
Class II	50	33.30%
Class III	50	33.30%
Total	150	100.00%

Figure 1. Distribution of Carbon emission

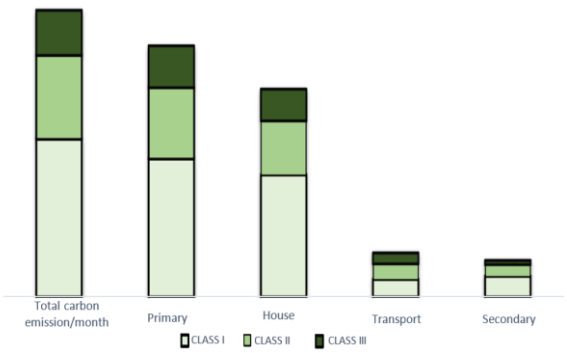

Table 2: Distribution of carbon emission and its association with socioeconomic classes

	Lower class		Middle class		Upper class		One way NOVA	P Value
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. deviation		
Carbon emitted es/Month	.2218	.08201	.4184	.14167	.7894	.39514	68.121	.000*
Primary	.2050	.08145	.3564	.13927	.6902	.38096	54.009	.000*
Secondary	.0168	.00587	.0620	.04257	.0992	.09147	25.008	.000*
House	.1546	.07282	.2754	.12544	.6058	.34920	57.234	.000*
Transport	.0504	.06068	.0810	.06045	.0844	.07354	4.127	.018*

** - Statistically significant.*

Table 3: Socioeconomic classes and their association with Carbon footprint emitted/year/person

Socioeconomic status	<= 0.560 Carbon emitted Tonnes/Year/person	0.561+ Carbon emitted in tonnes/Year/person	Total	Chi-Square Tests	P value
Class I	0	50	50		
	0.00%	100.00%	100.00%		
Class II	3	47	50		
	6.00%	94.00%	100.00%		
Class III	34	16	50	76.274	.001*
	68.00%	32.00%	100.00%		
Total	37	113	150		
	24.70%	75.30%	100.00%		

** - Statistically significant.*

Table 4: Educational status of the study participants and its association with Carbon footprint emitted /year/person.

Educational Status of Study Participants	Carbon footprint emitted/year/person			Chi-Square Tests	P Value
	<=.560	>0.561	Total		
Illiterate	7	7	14		
	50.0%	50.0%	100.0%		
Primary Education	17	29	46		
	37.0%	63.0%	100.0%		
PUC	11	40	51		
	21.6%	78.4%	100.0%		
Degree Holder	2	37	39	16.850	0.001*
	5.1%	94.9%	100.0%		
Total	37	113	150		
	24.7%	75.3%	100.0%		

** - Statistically significant.*

Table 5. Post hoc tests – Total Carbon emissions/Month and Socioeconomic classes.

Carbon emitted in Tonnes/Month		
Lower class	Middle class	0.001*
	Upper class	0.001*
Middle class	Upper class	0.001*

** - Statistically significant.*

Table 6. Post hoc tests - Primary carbon emissions/Month and Socioeconomic classes.

Primary Carbon emitted in Tonnes/Month		
Lower class	Middle class	0.006*
	Upper class	0.001*
Middle class	Upper class	0.001*

** - Statistically significant.*

Table 7: Post hoc tests - Secondary carbon emissions/Month and Socioeconomic classes.

Secondary Carbon emitted in Tonnes/Month		
	Middle class	0.001*
Lower class	Upper class	0.001*
Middle class	Upper class	0.005*

** - Statistically significant.*

DISCUSSION

The examination of carbon footprints within urban households provides a captivating insight into environmental behaviors and inequalities that exist among different socioeconomic segments. Particularly in the Indian context, where the mean annual CO2 equivalent output per individual is 0.56 tons, disparities become evident, with affluent individuals contributing approximately 1.32 tons and their less affluent counterparts emitting around 0.19 tons.

Upon a deeper exploration of this study's findings, a striking dichotomy comes to light. The upper class, often associated with higher income brackets, exhibits an elevated average carbon emission of 2.11 tons per person annually, surpassing the national average for the upper class at 1.32 tons. This contrast underscores variances in consumption habits, lifestyle preferences, and resource utilization prevalent within this societal segment.

Conversely, the lower class, representing economically disadvantaged individuals, registers an average emission of 0.4 tons per person per year, significantly higher than the national lower-class average of 0.19 tons. This apparent increase might be attributed to several factors, including living conditions, energy sources, and limited access to sustainable alternatives(14).

This study underscores that household emissions are profoundly influenced by income levels, particularly within the upper class. This observation highlights the influential role that socioeconomic status plays in shaping carbon footprints. This finding resonates with the outcomes of a similar study conducted in India by Grunewald et al(15), where a comparable pattern was discerned.

In a parallel urban study by Bhoyar et al(16)., higher carbon footprints were linked to electricity consumption, travel patterns, and cell phone usage. This phenomenon can be attributed to the urban lifestyle's substantial reliance on electricity, the increased need for travel, and the demand for mobile connectivity. In contrast to our study's recorded 2.11 tons of CO2e per person annually, Bhoyar et al(16) research revealed considerably higher urban carbon footprints, averaging 2.5 tons of CO2e per person yearly. Similar, to their findings, our study identifies electricity consumption and travel as primary drivers of urban carbon footprints, alongside LPG usage.

CONCLUSION

This study assessed urban household carbon footprints, revealing a direct link between socioeconomic status and emissions. Higher classes exhibited greater footprints, which underscored the need for targeted interventions to achieve SDG Target 14.3, which aims to minimize the carbon footprint and promote sustainable consumption and production of goods and services.

PUBLIC HEALTH IMPORTANCE

Reducing carbon emissions necessitates tailored strategies for various socioeconomic groups. High-income families can substantially reduce emissions by prioritizing renewable energy adoption and energy-efficient technology. Middle-income families would benefit from support programs promoting energy efficiency and sustainable modes of transportation. Lower-income households require assistance in accessing affordable and cleaner energy sources. By bridging emissions disparities, society can move towards a greener future, uniting well-being with ecological health through informed action.

LIMITATION OF THE STUDY

The study's sample size is small and it has a representation of only urban areas. Hence may not be generalizable.

RELEVANCE OF THE STUDY

The study on urban household carbon footprints in Vijayapura enhances understanding of how socioeconomic factors influence emissions, underscoring the importance of tailored interventions for sustainable living.

AUTHORS CONTRIBUTION

All authors have contributed equally.

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