Bourdieu's sociological lens: unveiling the dynamics of household carbon footprint in the Kalyani sub-division of Nadia district, West Bengal, India

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Abstract

This study employs anthropological and sociological frameworks, particularly Pierre Bourdieu's habitus and structural constraint concepts, to dissect the intricate nexus between energy consumption, carbon footprint, and sociocultural dynamics. The research unfolded in the Kalyani Sub-division of West Bengal, India, encompassing both urban and rural landscapes. Data collection entailed comprehensive interviews with 610 households during the period spanning December 2021–May 2022. Statistical analysis was rigorously executed through SPSS, while carbon footprint computations drew upon the well-regarded Intergovernmental Panel on Climate Change emission accounting methodology. Analysing global carbon dioxide emissions spanning 1850–2011, the study underscores the alarming surge in emissions driven by industrialization and non-renewable energy consumption. The ensuing disparities in emissions across nations and regions are attributed to socioeconomic factors, urbanization, and individual lifestyle choices. It becomes evident that socioeconomic status, education, and gender roles exert significant influence over energy consumption behaviour, with higher educational attainment correlating with heightened environmental awareness. Simultaneously, income inequality acts as a structural constraint, limiting sustainable behaviour adoption. Education emerges as a potent tool in mitigating structural limitations, challenging traditional gender norms, and addressing income disparities are deemed essential for universal access to sustainable practices. This research urges the formulation of context-specific interventions and policies to tackle the multifaceted drivers of carbon emissions, providing policymakers and practitioners with valuable insights into promoting environmental sustainability. Future research should delve into diverse sociocultural contexts and rigorously assess intervention efficacy, enriching our understanding of the complex interplay between habits, structural constraints, and carbon emissions, and guiding us towards a more sustainable and equitable future.

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1 Introduction

Energy consumption is a derivate of practices that develop in the interaction between people and things, in a sociocultural space, over time (Oladokun & Odesola, 2015; Shekari et al., 2021). It inconspicuously bridges nature and culture. From the viewpoint of energy consumption, the ability to utilize energy for human development acts as a gauge for the level of civilization of any period, population, or community (Adger et al., 2013; Lutzenhiser, 1992). In terms of Leslie White—*"culture evolves as the amount of the energy harnessed per capita per year is increased, or as the efficiency of the instrumental means of putting the energy to work is increased"* (White, 1959). With biological evolution, cultural evolution also in terms of energy transition from Palaeolithic to Neolithic and currently with the industrialization process, the amount and choice of harnessing energy have been changed (Joyce, 1988; Lutzenhiser, 1992; Shamsul, 2019). With industrialization, the addition of other resources like oil and coal has provided abundant power to fuel technological progress and economic growth (Behera et al., 2015; Huang et al., 2018; Martínez & Cámara, 2021; Ramakrishnan & Creutzig, 2021). Such kind of energy-intensive consumption is continuing to increase and brings with it a dilemma to reduce carbon emissions. On the other hand, climate change bridges nature and culture. Hence, energy-consuming practices and society need to be sustainably compatible, otherwise, limiting global warming to close to 1.5 degrees Celsius or even 2 degrees Celsius over pre-industrial times will be beyond reach (IPCC, 2018). With rapid industrialization and urbanization, the rising energy-centric anthropogenic activities are inevitable and abruptly pollute the environment leading to global warming and climate change (Cai & Vandyck, 2020; Froemelt & Wiedmann, 2020; Isenhour & Feng, 2016; Ivanova et al., 2016). Recently, climate policymakers considered household consumption as a serious threat to the environment as it contributed to 72% of global greenhouse gas (GHG) emissions (Baiocchi et al., 2022; Baynes et al., 2011; Huang et al., 2018; Martínez & Cámara, 2021). An in-depth insight into household energy consumption demonstrated that people are more inclined to the energy services (light, heat, comfort, convenience, cleanliness) that are being provided via varied sources and subsequently such demand for energy services is strongly influenced by cultural practices and social norms, performance and positioning and thus affecting the environment (Baynes et al., 2011; Connolly et al., 2022; Druckman et al., 2012; Mainar-Causapé et al., 2020; Zhao et al., 2019).

Household carbon footprint (HCF) has been increasing substantially in the twenty-first century. A study in Brazil revealed a strong correlation between Consumer Durable Index (CDI) and energy consumption. On the one hand, from the year 2000 to 2013, the increase in CDI reflects the country's socioeconomic improvements, but, on the other hand, it may conflict with Brazil's effort towards increasing energy security, assuring affordability and reducing the country's carbon footprint (Sanches-Pereira et al., 2016). In the case of wealthier Americans, the per capita footprints have ~25% higher per capita footprints than those of lower-income residents due to larger homes (Goldstein et al., 2020). Therefore, mitigation of carbon emissions has become an urgent measure to tackle climate change. Focusing on China, one of the fastest-growing economies with a massive population has reported 2.46t CO_2e per capita in rural parts, which is around one-third of China's average footprint, indicating the large potential for future growth (Zhao et al., 2014). In the process of urbanization and rural revitalization, there is a high possibility that the HCF continue to increase, maintaining high levels of inequality. In the case of the carbon footprint (CF) of rural China, provinces; average education; and non-farm income are among the important

factors influencing inequality. Hence, 36–45% of global emissions can be attributed to the top 10% emitters, whereas the bottom 50% emitters contribute 13–15% of global emissions (Deng et al., 2021; Sun & Wang, 2021; Tian et al., 2016). Another major finding from the study in a developed country like Finland by Salo et al. (2021) indicates that household expenditure is mostly influenced by the increase in the number of adults in a household which affects the household carbon footprint (Irfany et al., 2015). A study by Ramakrishnan and Creutzig (2021) considers energy as a pre-condition for a decent standard of living. Additionally, household decisions on energy consumption act as a driver to maintain or improve status, resulting in social zero-sum games, with environmentally harmful outcomes. Nielsen et al., (2021) have stated that consumption in high socioeconomic status (SES) results in significantly greater GHG emissions than that of those with lower SES. The top 1% of earners worldwide emit twice as much CO_2 through consumption as the bottom 50% of earners (15% against 7%, respectively). However, many ultrahigh-net-worth people with assets exceeding US$50 million have remarkably enormous carbon footprints as a result of their expenditure, including owning several homes and flying in private jets. On the other hand, the pursuit of status or reputation in the US residential sector reduces energy use by 20% or increases the desire to engage in low-carbon consumption behaviour by 0.81, whereas the loss of status encourages sustainable behaviour. It has been demonstrated that adults from the Czech Republic (OR = 2.5) are more influenced by social status signals than metropolitan Chinese people (OR = 0.23) (Mach et al., 2018; Martens et al., 2021). Hence, it can be suggested that the status is found to have positive impacts on both high- and low-carbon consumption decisions and actions. Being the largest and final consumption source, household consumption is complicated, diverse, and highly behaviour-driven, which implies that the household sector could be the source of a considerable reduction in GHGs. So, to encourage the reduction of household emissions, apart from status, the local lifestyle and geographic differences can also explain the emission variations in terms of household demand. Chen et al., (2019) estimate that for Beijing residents, when direct and indirect energy consumption and CO_2 emissions are taken into account, the total household energy consumption proportion compared to the city increases from 22.7 to 59.2%, and the total household CO_2 emissions proportion increases from 32.2 to 68.8% in the research period. In 2011, urban indirect household energy consumption accounted for 73.5% of the total household energy consumption, while rural indirect household energy consumption accounted for only 48.6% of total household energy consumption. The expenditures of rural and urban residents varied among various industrial sectors, and the energy intensity varied within each sector. In the case of developing countries, large inequalities are observed between urban and rural areas. The average per capita CF of urban inhabitants in developing countries is 1.49t CO_2, 45% higher than the average value of 0.82t CO_2 in rural areas (Connolly et al., 2022; Garba & Bellingham, 2021; Muller & Yan, 2018). Electricity consumption and transport are the largest contributors to the total CF in all expenditure groups. High-income rural households have an average per capita CF of 12.38t CO_2, which is 25% higher than the equivalent urban high-income group (Connolly et al., 2022). Latin American and Caribbean nations, with an average per capita CF of 2.1t CO_2 in rural areas and 2.3t CO_2 in urban areas, have one of the smallest differences between urban and rural (Zhong et al., 2020). In comparison, China has greater inequality between urban and rural areas, where the high-income group have an average per capita CF of 10.7t CO_2 in urban areas compared to 8.1t CO_2 in rural areas (Huang et al., 2018; Jia et al., 2022; Wang & Chen, 2020). Despite geographical areas, cultural practices, and gender roles in decision-making and consumerism are also important to understanding the dynamicity of HCF (Adger et al., 2013; Boutaud et al., 2016; Lutzenhiser, 1992; Shekari et al., 2021). In

the case of cooking fuels, it is widely recognized that households frequently stack different fuels according to considerations like fuel prices, the food being cooked or seasonal influences on fuel availability or cooking practices (Akintan et al., 2018). Socioeconomic factors including income, family size, gender, age, occupation, and education are recognized as particularly important influences on energy choices although the role of user priorities and supportive government policies is also acknowledged (Choudhuri & Desai, 2020; Ivanova & Buechs, 2022; Long et al., 2022; Räty & Carlsson-Kanyama, 2010; Richler, 2017; Theine et al., 2022; Toro et al., 2019).

In the case of developing countries like India, the estimation of carbon footprint (Lee et al., 2021; Williamson et al., 2018) is very elaborate and data extensive research, based on secondary data from NSSO and IMS where very few studies work rigorously on primary data. Within this study, Lee et al., (2021) calculated and compared the household carbon footprints (HCFs) in 623 districts in India, based on micro-consumption data from 203,313 households and explained their variation by economic, cultural, and demographic factors. The results show that the eradication of extreme poverty does not conflict with ambitious climate change mitigation in India. Also, household income directly affects the purchasing power and overall expenditure of a household and concludes that a shift from medium-to-high expenditure households is accountable for an increase in India's overall carbon footprint from 674.7 to 744.6 Mt CO_2 (Lee et al., 2021). Electricity (0.19t CO_2/capita), food (0.12t CO_2/capita), and consumable goods (0.07tCO_2/capita) and is established that socioeconomic differences and religious background have influenced the carbon footprint of Indian households. Further, it is noted that Sikhs and Buddhists have a higher household carbon footprint where Sikhs spend more on electricity and transport followed by Christians who spend more on transportation (Lee et al., 2021). Previous studies based on household expenditures reported that private transport, electricity use, and service demand in India account for a smaller proportion of individuals' carbon footprints, whereas food accounts for a slightly higher share as compared to developing countries (Alagh, 2006; Aleksandrowicz et al., 2019; Connolly et al., 2022; Kala Seetharam Sridhar, 2007; Wang et al., 2020). It is evident from existing literature that there is a limited comprehensive assessment of household GHG emissions calculated based on primary consumption data. Hence, realizing the urgency to mitigate climate change and global warming, it was felt essential to identify effective emission reduction strategies by measuring the latest carbon footprint and comprehensively underpinning the emission patterns and apportionment of emissions across socioeconomic classes as well as variations across varied socio-cultural, ecological, and climatic zones of India. So, the present study aimed to compute the overall household carbon footprint and the contribution of different household activities to emissions. Apart from this, the study critically assesses and analyses the impact of age, education, and gender of decision-makers on energy consumption and tries to understand the energy consumption in a sociocultural context.

2 Theoretical framework and concepts

The present study demonstrates the relevance of studying energy consumption in the present era through an anthropological lens. Leslie White argued over sixty years ago that anthropology holds a significant position in studying the unique relationship between energy, technology, and culture. But, with time, anthropology is not limited to it but starts growing its concern over climate change significantly to understand the link between

energy consumption, cultural development, and environmental deterioration (Evolution & Society, 1877). Measuring environmental deterioration through one parameter-carbon footprint is never solely a quantifiable and measurable fact. Rather, it is always also a social and cultural phenomenon that cannot be understood through technical models and terms alone (Crate, 2011; Parks & Roberts, 2010; Powell, 2013; Swaidan, 2012). This study, hence, applies Bourdieu's theory which can offer some new insights into the issue of energy consumption and associated carbon footprint.

2.1 Habitus, and the energy consumption and associated carbon footprint

In the quest for a sustainable future, understanding energy consumption has become paramount. Energy consumption, from the electricity we use to power our homes to the fuel we burn for transportation, has significant implications for environmental sustainability. While technological and economic factors undoubtedly influence energy consumption, there is another, often overlooked, aspect at play: Pierre Bourdieu's concept of habitus (Husu, 2022). Pierre Bourdieu's sociological concept of habitus provides a unique lens through which to understand how individuals and communities engage with and make decisions about energy consumption. To appreciate the role of habitus in energy consumption, it is essential to grasp the concept itself. Habitus represents the internalized, often unconscious, framework through which individuals perceive and navigate the world around them. Shaped by early socialization experiences, habitus guides individuals' preferences, tastes, and behaviours (Côté, 1996; Husu, 2022; Kastner & Stern, 2015; Lutzenhiser, 1992; Shamsul, 2019; Swaidan, 2012). These dispositions are deeply ingrained and largely taken for granted, impacting various aspects of life, including energy practices.

2.2 Structural constraints in energy consumption

Energy consumption is a critical issue in contemporary society, with profound implications for environmental sustainability and socioeconomic well-being. While individual choices undoubtedly influence energy consumption patterns, it is equally crucial to consider the role of structural constraints in shaping how people use and access energy resources. Pierre Bourdieu's sociological theory, particularly his concept of structural constraints, provides a valuable framework for understanding how broader social, economic, and environmental factors influence energy consumption (Edgerton & Roberts, 2014; Herbert & Collin-Lachaud, 2017; Husu, 2022; Piroddi, 2021). This paper explores the intricate relationship between Bourdieu's structural constraints and energy consumption, highlighting how factors such as education, socioeconomic status, and geographic location can significantly impact energy practices and carbon footprint.

3 Methodology

3.1 Study area

This cross-sectional study was undertaken in the rural and urban areas of the Kalyani Sub-division falls under district Nadia in West Bengal state in eastern India. Under the Kalyani Sub-division, Kalyani Township was selected for this study. The town was established in such a way that the sustainability and harmony between nature and man can be maintained. Kalyani had a history of establishment and development. The foundation stone of this township was

laid in 1949 after realizing the population influx and massive disruption faced by Kolkata due to the partition in 1947 and the immigration of a large number of refugees from the newly formed Nation known as Pakistan (Islam & Tarafder, 2012).

3.2 Selection process

The selection of municipalities and community development blocks was done by the stratified sampling method. The two municipalities—(1) Kalyani (2) Gayeshpur and one community development block—(1) Haringhata were selected. Villages and wards were selected based on Probability proportional to size (PPS) after arranging them in ascending order based on the total number of households as per the census 2011. Later on, the households were selected randomly in both urban and rural areas. A total of 650 households were chosen for this study. Out of 650 households, only 610 households (urban = 311 & rural = 299) with complete information were selected for further study.

Extensive fieldwork was conducted between December 2021 and May 2022. Before fieldwork, the tools were validated and standardized. Besides this, permission was obtained from the government authorities. Since the respondents were Bengali speaking, under the guidance and supervision of experts, the interview schedule was designed in both Roman English and Bengali script, which helped the researcher to elaborate the purpose of the study properly to the respondents. For data validation and analysis, the English language was taken into account. Before the interview, prior consent in written and verbal was obtained from all the respondents, and data collection was completed following the ethical guidelines of the HELSINKI Declaration. A respondent was interviewed for around 45–50 min. Because of the prolonged duration of the interview, the study participants were interviewed mostly during their leisure time preventing the occurrence of any risk during the study.

3.3 Data analysis process and carbon footprint calculation-

Data analysis for this present study was conducted step-by-step in 2 different phases-

1. The first phase was carried out to perform data validation in MS Excel by extracting data from 610 interview schedules.
2. In the second phase, all the validated data were imported to SPSS (Statistical Package for the Social Science) software for statistical analysis and to compute the magnitude of carbon footprint emitted from various energy sources.

After reviewing country-specific and universal carbon footprint calculation models and calculators, the Intergovernmental Panel on Climate Change (IPCC) emission accounting method was used (IPCC, 2018).

4 Results and discussion

4.1 Historical overview of CO_2 emission

The global pace of emission of carbon dioxide is evident in Fig. 1. This has been recorded since the advent of the industrial phase. This was the period when countries tremendously

used fossil fuels and other non-renewable sources to raise the standard of living. On the other hand, the enormous use of non-renewable energy negatively affects the environment and human well-being as well. In the beginning phase of industrialization, 198 $MtCO_2$ emission was recorded in 1850. Later on after 40 years, in 1890 globally 1304 $MtCO_2$ carbon dioxide emission was recorded. Likewise, in the post-industrial phase, i.e. in the year 2011 a drastic change was noticed in the emission level, i.e. 32,274 Mt CO_2 at the global level (Bin & Dowlatabadi, 2005; IPCC, 2018; Salo et al., 2021; Wier et al., 2001).

The emission of CO_2 of selected countries during 1850 is presented in Fig. 2. The UK occupied the topmost position for emitting carbon dioxide. This was recorded as 124 $MtCO_2e$ followed by the USA (40.9 $MtCO_2e$), Germany (15.3 $MtCO_2e$), etc. On the other hand, Russia (0.064 $MtCO_2e$), China (0.011 $MtCO_2e$), India (0.263 $MtCO_2e$) & Japan (0.00522 $MtCO_2e$) were the least emitters. After a century quite a different scenario was observed during the 1960s where the USA was the top emitter with an emission of 3.66 Gt carbon dioxide per year followed by Russia (940 $MtCO_2e$); Germany (840 $MtCO_2e$), China (829 $MtCO_2e$) & UK (624 $MtCO_2e$). In 2018, China became the top emitter and emitted 10.80 $GtCO_2e$ carbon emission followed by the USA (5.51 $GtCO_2e$). In the 1850s and 1960s, India was one of the least emitters, but in 2018, it also came into the picture for emitting the most (2.44 $GtCO_2e$) followed by Russia (1.80 $GtCO_2e$), Japan (1.14 $GtCO_2e$), and the UK (381 $MtCO_2e$), Fig. 3. Historically, in the beginning phase of 1850, the United Kingdom (UK) was considered to be one of the top emitters. While China, India & Japan are significantly the least emitted countries. In the year 2018, a different scenario has been observed due to the mega emitting sectors like industries, buildings, production, construction, etc. These days carbon-intensive lifestyle also acts as a contributing source of emission. The influence of modernity and Westernization motivates people to purchase carbon-intensive goods and services. Hence, measuring the emission level of households and individuals in terms of carbon footprint has been proposed these days by eminent researchers and scientists (Baiocchi et al., 2022; Koide et al., 2021; Veal, 1993).

Research these days has recorded an exorbitant increase in household carbon footprint though the magnitude of carbon footprint differed between developed and developing countries. Figure 4 clearly illustrates a difference in annual household carbon footprint at the global level. Flanders (Belgium) in 2019 emitted 33.1 tCO_2e followed by Germany (30
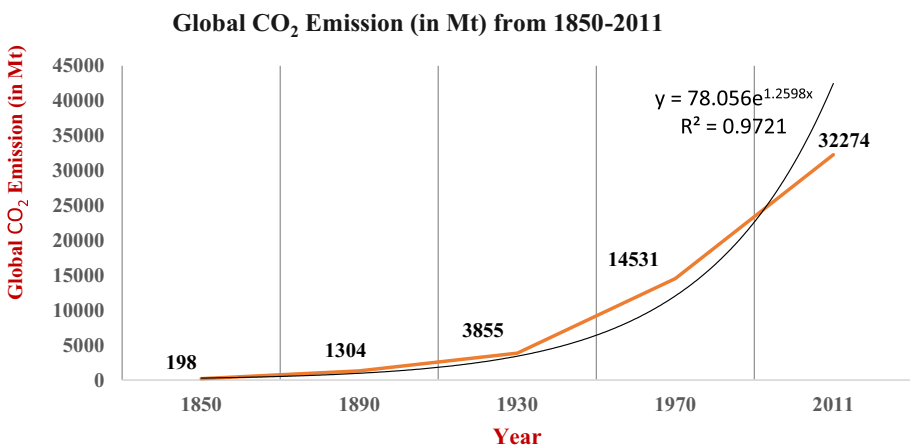

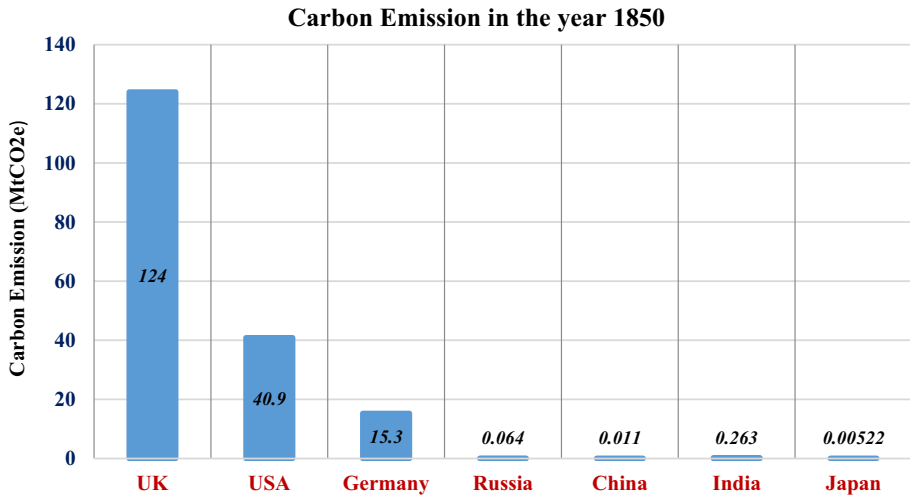**Fig. 1** Global carbon dioxide emission (MtCO2) from 1850 to 2011
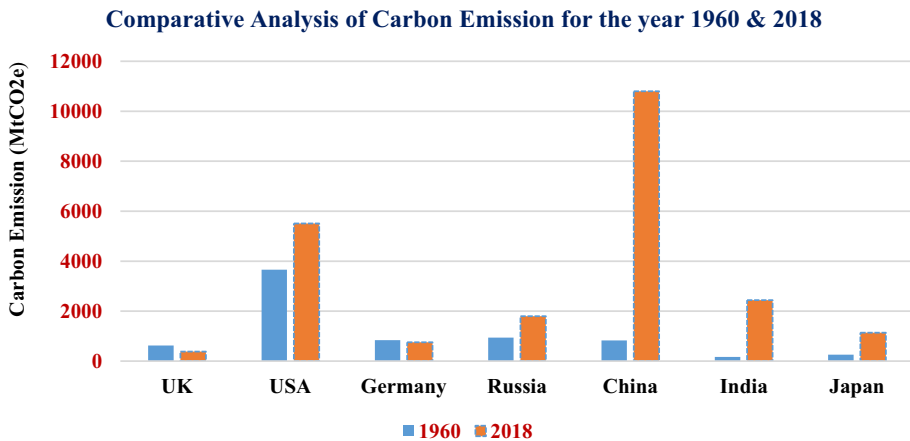
Carbon Emission in the year 1850

Fig. 2 Carbon emission in the year 1850

Comparative Analysis of Carbon Emission for the year 1960 & 2018

Fig. 3 Comparative analysis of carbon emission for the years 1960 and 2018

tCO_2e), the US (22.3 tCO_2e), & UK (20.18 tCO_2e). In 2015, 5.96 tCO_2e was recorded in the Yangtze River Delta, China. Besides this, in 2021, Malaysia was responsible for emitting 11.76 tCO_2e, while India annually emitted 6.5 tCO_2e per household. Behind all the emissions from consumption, the sociodemographic characteristics (household size, age, education, female employment status & income) positively affect environmental sensitivity. Income has played a significant role and marked differences in carbon footprint which have been observed as one moves from the poorest to richest quintile (Druckman et al., 2012; Kus et al., 2017; Miehe et al., 2016; Minx et al., 2013; Wier et al., 2001). It affects the environmental household practices which are mostly not influenced by other demographic characteristics (Bülbül et al., 2020). Daily commuting, garbage disposal, electricity & long-distance travel generally make up more than half of the total carbon footprint of households in urban and peri-urban areas (Christis et al., 2019; Salo et al., 2021). The

A Comparison of Annual Household Carbon Footprint (tCO2e) at Global Level and Present Study
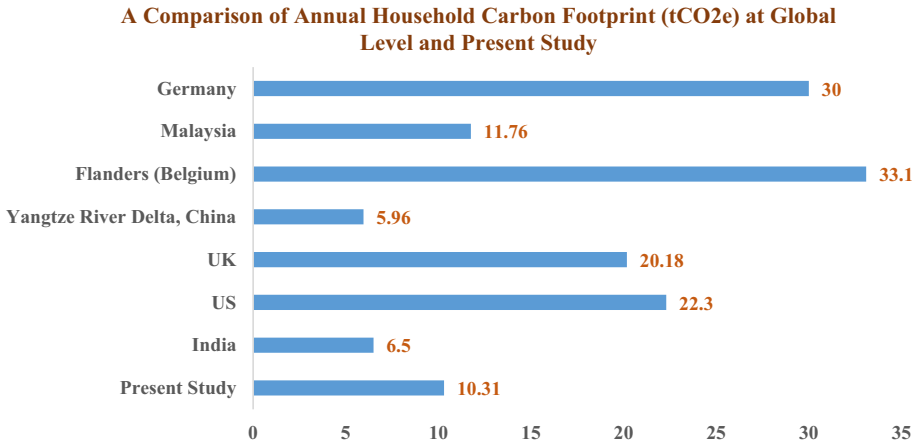

Fig. 4 A comparison of annual carbon footprint at the global level and present study

effects of urbanization and urban sprawl on household lifestyles actively contribute to rising emissions (Zen et al., 2022). In the case of the present study, the Kalyani region of West Bengal is accountable for emitting 10.31 tCO_2e, see Fig. 4. In the case of urban areas, food; electricity; and cooking fuel accounted for 82.69%, 13.35%, and 3.96%, respectively. While, in rural areas, food has the highest emission level (86.67%) followed by cooking fuel (8.33%) and electricity (5%) see Figs. 5 and 6. In a study by Miehe et al., (2016) in Germany, household size and income are the drivers of household carbon footprint. The highest income households emitted 4.25 times more CO_2e from indirect consumption of energy including housing (34%), food (18%), and goods (15%), while transport emitted 34% energy as compared to the lowest income group.

Growing population with rising economic development produces greater CO_2 emissions, due to production and consumption activities (Liu et al., 2020). Other major elements such as poverty, illiteracy (Toro et al., 2019); high fertility rate, rapid decline in mortality, and immigration are indirectly responsible for the high carbon footprint (Sikdar

Fig. 5 Emission % from different household activities in urban areas
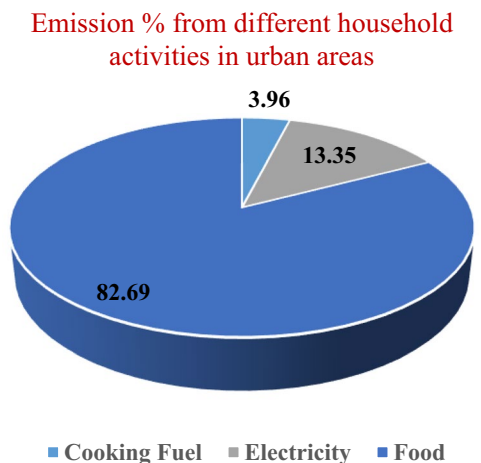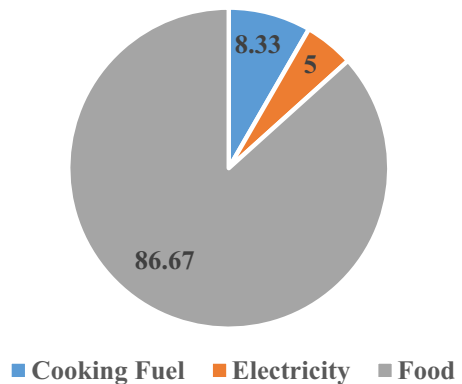

Emission % from different household activities in urban areas

Emission % from different household activities in rural areas

8.33

5

86.67

■ Cooking Fuel   ■ Electricity   ■ Food

& Mukhopadhyay, 2017). Even a shift from an extended to a nuclear family affects the household's carbon footprint (O'Neill et al., 2010; Wier et al., 2001). Cultural practices and gender roles are also important in the increase of carbon footprint. Human behaviour and its effects on the consumption pattern and intensity of energy utilization with its related emissions have been found in many works (IPCC, 2018). Behavioural changes and human choices both are interdependent and are affected not only by economic factors but also by other driving forces including technology, political, cultural, psychological, and environmental factors that equally contribute directly or indirectly affect the HCFs (Jack & Ivanova, 2021; Joyce, 1988; Kulkarni et al., 2013; Miehe et al., 2016; Pang et al., 2020; Tobarra et al., 2018).

In the case of the present study, Fig. 7 displays the probability of emission of different household practices (food, electricity & cooking fuel) among low, middle & high socio-economic status (SES). These curves provide a means of assessing visually whether the probability of emission was different for these sub-groups. The log-rank test was used to examine formally whether the difference was statistically significant, it showed a *p*-value less than 0.05 among all the cases (food, electricity & cooking fuels) in different SES. Hence, it can be said that altogether the probability of emissions was differently observed among the SES. The high SES households have a high probability of emission indicating that with the improvement in SES, the annual carbon footprint in the case of food and electricity consumption, increases because of overconsumption of non-veg food and electronic goods. On the other hand, medium SES households have the highest probability of emission in the case of cooking fuels. However, when it comes to energy consumption, there is essentially a "human factor". Ultimately, people decide how they consume. Among domestic activities, key energy investment decisions (e.g. heating system or car choice) have a particularly significant impact on overall energy consumption. However, in most real-world decision-making situations, purely rational decision-making is impractical due to situational constraints (e.g. limited time, and limited cognitive capacity) (Graeber, 2011; Horta et al., 2014; Lutzenhiser, 1992). Simon argues that most decisions are made in a bounded rational sense, with decision-makers focusing on those aspects they consider most relevant (Jaffe, n.d.; Oladokun & Odesola, 2015; Shekari et al., 2021). The decision is made when a subjectively satisfactory alternative is found. Hence, in this study, a Kaplan–Meier
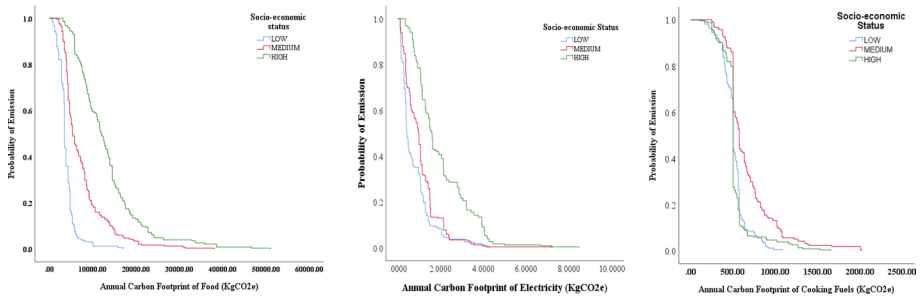
Fig. 7 K–M curve showing the probability of emission of food, electricity, and cooking fuels in urban and rural areas based on socioeconomic status

survival analysis (K–M Curve) was conducted to investigate the differences in the probability of emissions if exists for the decision-maker has a different educational background. The analysis revealed important insights into the probability of emission based on the educational background of the decision maker. In the matter of annual carbon footprint (food, electricity & cooking fuels), a log-rank test was applied showing significant differences in the probability of emission among the different education levels in this study. In terms of cooking fuels, in rural areas, the cumulative proportion of emission at time 1 is 0.977. This means that at the end of time 1, approximately 97.7% of 'Illiterates' living in rural areas emitted 221.10 $KgCO_2e$. On the other hand, at the end of time 6, 96.4% of individuals with 'Primary Education' in urban areas emitted 251.34 $KgCO_2e$, while at the end of the same time, 95.7% in rural areas emitted 272.40 $KgCO_2e$. The 97.8% of individuals with 'Secondary Education' in rural areas emitted 251.34 $KgCO_2e$, while in urban areas at the end of time 5, 97.2% emitted 261.96 $KgCO_2e$. 98.8% of decision makers with 'Senior Secondary' education in urban areas at the end of time 1 emitted 113.66 $KgCO_2e$ as compared to rural areas where decision makers with 'Senior Secondary' education 96.5% contributed 251.34 with 'Senior Secondary' education at the end of time 3. The decision-makers who were 'Graduates' or holding higher degrees in urban areas at the end of time 1 emitted 197.56 $KgCO_2e$. Hence, it can be stated that with the attainment of higher educational qualifications, the decision-maker became more aware of energy-intensive consumption, which directly contributes to reducing emissions. Similarly, the K–M Curve showed a significant difference in the probability of emission in the case of electricity and food consumption between different educational backgrounds of decision-makers as the log-rank test showed a *p*-value less than 0.05. Interestingly, in the case of electricity consumption, the households with 'self-aware' persons which are categorized as 'AWARED' responsible for emitting a much lesser carbon footprint (1.021 $KgCO_2e$) as compared to the decision-maker possess a higher educational degree, see Fig. 8.

Furthermore, the three scatter plot diagrams simply explain the correlation between the dependent variables (DV)—annual carbon footprint of household consumption (food, electricity & cooking fuels) and independent variable (IV)—age of decision maker in both urban and rural areas. In this analysis, in the case of annual CF $_{(food)}$ (DV) of the urban area, the regression equation, $y = -7.22 \times 10^3 + 3.82 \times 10^2 \times x$, reveals key insights into the relationship between DV (*y*) and IV (*x*). The intercept (-7.22×10^3) suggests the expected starting point of y (annual $CF_{(food)}$) when *x* (age of decision-maker) equals zero. Notably, the coefficient of *x* (3.82×10^2) indicates that for each unit increase in the age of the
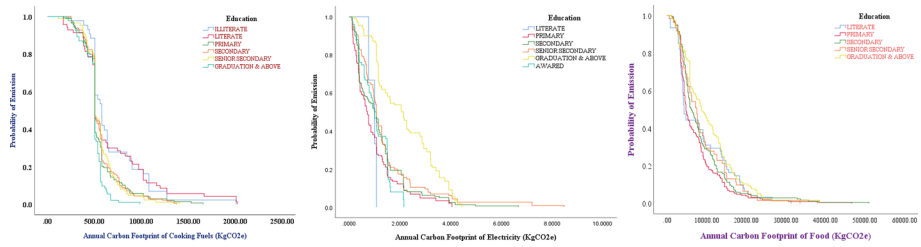
Fig. 8 K–M curve showing the probability of emission of cooking fuels, electricity, and food in urban and rural areas based on education status of decision maker

decision maker, an increase of 3.82×10^2 units in annual $CF_{(food)}$ was noted, with the positive sign signifying a positive correlation. Moreover, the R-squared value of 0.250 signifies that approximately 25% of the variance in annual $CF_{(food)}$ with a statistically significant relationship was observed within this model. Similarly, a 26.6% variance in annual $CF_{(food)}$ with a statistically significant and positive relationship as $p < 0.05$ was observed with the age of decision-makers in rural areas. The consumption of non-vegetarian food and rice was observed which gradually contributed to rising emissions. Mostly the decision-makers belonged to the middle-aged group engaged in cooking and hence the food practices were mostly controlled by them, see Fig. 9a.

Moreover, a weak and negative correlation was observed between annual $CF_{(electricity)}$ and the age of the decision-maker. Only a 13.7% variance was noted in annual $CF_{(electricity)}$ as apart from the age of the decision-maker, the purchasing behaviour and proper utilization of electronic goods simultaneously affect the carbon footprint. In this study, it was observed that people tend to buy less carbon-intensive electronic goods to save both money and electricity, see Fig. 9b.

Besides this, a significant and negative correlation was observed between annual $CF_{(cooking\ fuels)}$ and the age of decision-makers in urban areas. 24.7% variance in carbon footprint clearly illustrated that other factors also contributed to the change in emission level. With the increase in age, cooking techniques and wiser usage of cooking fuels simultaneously affect the carbon footprint. On the other hand, a weak but significant and positive correlation was established between $CF_{(cookin\ fuels)}$ and the age of decision-makers in rural areas as $p < 0.05$. A 17.7% variance in carbon footprint due to age put stress on the other factors as well. In this present study, the availability of resources like wood drastically
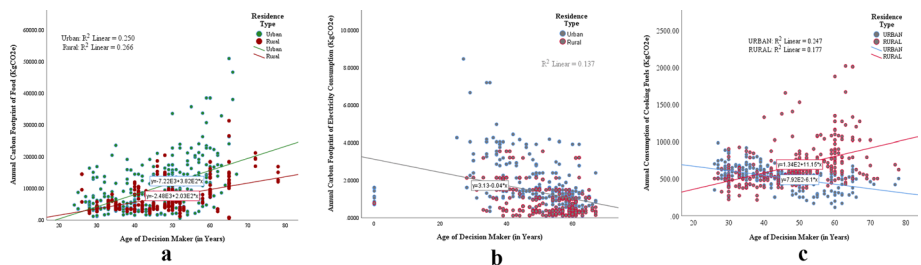

Fig. 9 **a**, **b** and **c** illustrates the scatterplot showing the correlationship between annual CF (food, electricity & cooking fuels) and age of decision-maker

affects the carbon footprint as the rural dwellers are still dependent on wood and forests for cooking fuels, see Fig. 9c.

It was evident from Fig. 10a that the annual carbon footprint of food was higher when the 'males' decided on the menu as compared to 'females' in both the urban and rural areas as males prefer to purchase and eat 'non-veg food' over vegetarian food. Besides this, in the case of annual CF of electricity, due to the high awareness among the household members resulted in less annual CF (1.06 KgCO$_2$e) as compared to the female decision-maker (2.1987 KgCO$_2$e) and male (1.6067 KgCO$_2$e) in urban areas. On the other hand, in rural areas, 'female' decision-makers look after the usage of electronic goods which contribute to less emission (0.8030 KgCO$_2$e) as compared to males (0.9296 KgCO$_2$e) and 'self-aware persons' (1.0031 KgCO$_2$e), see Fig. 10b. Furthermore, Fig. 10c depicted that the annual CF was higher in rural (835.03 KgCO$_2$e) as compared to urban (454.62 KgCO$_2$e) when 'males' look after the consumption of cooking fuels. Similarly, the same was observed in the case of females ($CF_{(rural)} = 621.11$ KgCO$_2$e; $CF_{(urban)} = 552.05$ KgCO$_2$e).

From the above outcomes, it can be affirmed that households are made up of interconnected parts that play a range of duties all of which are crucial in ensuring that the basic social requirements of the members are met. The long-term functions that society allocates to different members of a household are differentiated based on gender. Domestic work and energy-related activities are strongly dominated by females, although gender decisions are less prevalent (Bindu et al., 2021). The way decisions are made in households is affected by the fact that males are often in charge of making them. Due to socially and culturally ingrained gender norms, the majority of countries face barriers to energy-related activities (Bindu et al., 2021). In addition, this study's analysis sheds important light on the intricate interactions between household carbon emissions, behavioural patterns, and broader socioeconomic structures. This study investigated the fundamental mechanisms causing carbon emissions, particularly within the context of household carbon footprints, drawing on Pierre Bourdieu's theories of Habitus and Structural Constraints. One of the cornerstones of Bourdieu's theory is based on the concept of habitus, which refers to the embodied dispositions and practises learned via socialisation and life experiences. In the context of carbon emissions, we find that Habitus has a considerable impact on household habits and consumption patterns. Our investigation shows that household habitus has a significant impact on carbon-intensive or environmentally conscious behaviour (Edgerton & Roberts, 2014; Herbert & Collin-Lachaud, 2017). Specific social groups' consumption habits are a reflection of the cultural norms, values, and lifestyle decisions that adhere to those groups. For instance, households with higher education levels from urban regions exhibited a stronger awareness of energy-intensive practices, resulting in lower carbon emissions (Elasu et al., 2023; Nielsen et al., 2021; Ramakrishnan & Creutzig, 2021). This shows that
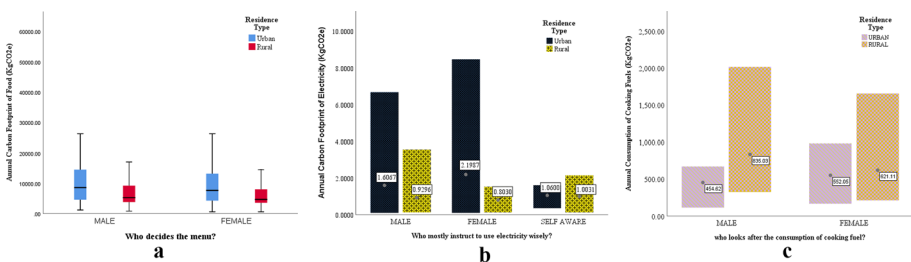

Fig. 10 **a**, **b**, and **c** illustrates the mean annual CF (food, electricity & cooking fuels) and age of decision-maker

increasing people's knowledge and awareness could change their habits and encourage them to adopt greener practices (Bindu et al., 2021; Elasu et al., 2023; Gayoso Heredia et al., 2022; Richler, 2017).

In addition, Bourdieu's theory places a strong emphasis on structural restrictions as external social and economic influences that influence people's behaviour positively or negatively. These restrictions are a result of systems in more general society, such as wealth inequality, resource scarcity, and educational attainment levels (Edgerton & Roberts, 2014; Husu, 2022). The socioeconomic position was revealed to be a significant structural constraint on carbon emissions in our study. Higher SES households had the potential to spend on environmentally friendly products and energy-saving equipment, hence lowering their carbon footprints (Ateba et al., 2018; Chen et al., 2019; Kastner & Stern, 2015; Oladokun & Odesola, 2015; Shekari et al., 2021). However, households with lower SES struggled financially, which limited their ability to develop durable behaviours. The unequal distribution of resources based on income is compatible with Bourdieu's assertion that structural limitations like income can uphold social hierarchies (Edgerton & Roberts, 2014; Herbert & Collin-Lachaud, 2017; Husu, 2022; Piroddi, 2021). Furthermore, education has also developed into a substantial structural constraint. Higher educated decision-makers demonstrated more environmentally conscientious conduct and decreased carbon emissions. In addition to increasing awareness, education gives consumers the authority to make decisions to bring solutions to lessen their carbon footprint. This study underlines the significance of education in mitigating the consequences of structural limitations, hence supporting Bourdieu's assertion that education may be a transforming force (Husu, 2022).

5 Conclusions, implications, and future directions

In conclusion, this study highlights the relevance of Bourdieu's theories in unravelling the complexity of household carbon footprints. The interaction between habits and structural constraints highlights the need for comprehensive and context-specific approaches to addressing carbon emissions. By acknowledging the power of education, the influence of gender norms, and the impact of income disparities, we can work towards a more sustainable and equitable future. As we face increasing environmental challenges, understanding the cultural and social dynamics that underpin carbon emissions is essential. By integrating theoretical frameworks like Bourdieu's, we can pave the way for informed, effective, and socially just strategies to combat climate change and promote a more sustainable world for present and future generations.

Therefore, the theoretical and empirical insights gained from this study have profound implications for both policymakers and practitioners in the field of environmental sustainability. By recognizing the interaction between habitus and structural constraints, appropriate interventions and policies can be developed to address multiple aspects of the causes of carbon emissions. Education appears to be a powerful tool for changing habits and minimizing the impact of structural constraints. Efforts to increase environmental education and awareness should be prioritized, especially among vulnerable and less educated populations. Additionally, promoting gender equality and challenging traditional gender roles can lead to more equitable and sustainable consumption patterns. Equally important is addressing structural constraints related to income.

Policies aimed at reducing income inequality, increasing access to renewable energy sources, and providing financial incentives for environmentally friendly activities can help

narrow the socioeconomic gap about carbon emissions. Such initiatives should prioritize marginalized communities to ensure that the benefits of sustainability are accessible to all. While this study provides valuable information, several avenues exist for future exploration. Studying the intersection between habits and structural constraints, taking into account factors such as age, ethnicity, and geographic location, could help better understand carbon emissions in other populations together. Longitudinal studies tracking changes in habits and carbon emissions over time would provide insight into the dynamic nature of these relationships. Additionally, more research is needed to explore the effectiveness of specific interventions and policies in changing habits and reducing carbon emissions. Comparative studies in different regions and countries can provide a broader perspective on the cultural and structural determinants of sustainable behaviour.

Data availability Data we will be made available as per the reasonable request.

Declarations

Conflict of interest Authors have no conflict of interest.

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