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Household Carbon Emissions in India: Correlation with Income and Household Size

Sumita Nair*, Sukhpreet Kaur Bhatia and Madhu Chandrakar
Bhilai Institute of Technology, Durg, Chhattisgarh, India
✉ drsumitanair@yahoo.in

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Abstract: This paper reports the carbon emission of households of Bhilai, Durg, Rajnandgaon region of Chhattisgarh, India and their correlation with the income and household size. The total direct carbon emission is studied against the three household CO_2 emission activities viz. energy, transport (petrol), and LPG (liquefied petroleum gas) for different income groups. The ANOVA and linear regression model study of the area reveals that the highest contributor for total primary CO_2 emission is household energy uses; on the contrary the emission from LPG uses has the highest impact for every unit difference in uses. Notwithstanding the income is positively correlated with energy uses while an LPG emission remains almost constant for all income groups. The study of impact of household size on total primary CO_2 emission put forward the adults have more impact with a coefficient value of 24.2 units as compared to 17.1 for children. The income is positively correlated with total primary emission but household's characteristics influence emissions differently for low, middle and high income groups. Hence household's size and CO_2 emission from different activities have greater impact on total emission than income. For emission reduction policies those areas should be targeted.

Key words: Households, CO_2 emission, income, household size, emission reduction.

Introduction

One of the most challenging issues of 21st century is global warming which is changing the earth's climate system due to emissions of greenhouse gases from different anthropogenic activities. In coming decades, the human induced greenhouse gases release into the atmosphere might cause serious, potentially irreversible changes to the global climate (IPCC, 2014). This is already being experienced in several parts of the world (IPCC, 2007b). More than half of the world's population is living in cities and urbanization is transforming the global environment at unparalleled rates and scales (Seto et al., 2011; Grimm et al., 2008). Cities are estimated to account for about 78% of total global greenhouse gas (GHG) emissions, but are also the loci for innovative solutions to reduce emissions (Pataki et al., 2006; Bai, 2007; Kennedy et al., 2010; Lin et al., 2010; Dhakal, 2010; Kaye et al., 2006). Carbon management in cities is increasingly focusing on individual households, and communities due to population growth and improved living standards of urban residents (Jones et al., 2011; HM Government, 2006; Dietz et al., 2009; Druckman et al., 2009; Wang et al., 2009; Feng et al., 2010). Household lifestyle has been recognized as a major driver of energy use and related GHG emissions besides technology efficiency (Lenzen et al., 2011; Bai et al., 2012; Weisz et al., 2010; Schipper et al., 1989; Weiy et al., 2007; Jones et al., 2011). Since cities are getting more attention in reducing carbon emission, this study of primary carbon footprint of BDR (Bhilai, Durg and Rajnandgaon) region of Chhattisgarh, India could result

*Corresponding Author

in finding the innovative solutions to reduce the CO_2 emission from households and help government in framing tailor-made policies for reducing greenhouse gas emissions of the cities.

A carbon footprint can broadly be defined as a measure of the greenhouse gas (GHG) emissions that are directly and indirectly caused by an activity or are accumulated over the life stages of a product or service, expressed in carbon dioxide equivalents (Wiedmann et al., 2007). A carbon footprint is a measure of an individual's contribution to global warming in terms of the amount of greenhouse gases produced by an individual and is measured in units of carbon dioxide equivalent (Lynas et al., 2007).

The carbon footprint or the total carbon emission of households is calculated for the time period of a year and is a sum of primary or direct and secondary or indirect carbon footprint.

Primary carbon footprint is a measure of direct emissions of CO_2 from burning of fossil fuels, energy consumption and transportation while Secondary is a measure of indirect emission, which is calculated on the basis of CO_2 emission associated with whole lifecycle of products and services including their manufacturing and eventual breakdown (Tukker et al., 2006). The direct emissions from households depends mainly on number of persons in a family, income levels, the type and extent of uses of energy source of an individual or a family. Hence there is increasing awareness of an individual's behaviour or lifestyle as a source of global carbon emissions (Bin et al., 2005).

The Intergovernmental Panel on Climate Change (IPCC) has indicated that the risk of severe climate change impacts will increase markedly with a temperature increase of 2 °C above preindustrial levels (EPA, 2006). The current rate of global temperature increase is between 0.2 and 0.3 °C/decade (EPA, 2006). Growing public awareness about climate change and global warming has resulted in an increasing interest in 'carbon foot printing'. The global community now recognizes the need to reduce greenhouse gas emissions to mitigate climate change.

This study of household's primary carbon footprint profiles in correlation with different household characteristics like income and household size will help us to develop tailor-made planning and policy measures to reduce the greenhouse gas emission of cities because the total carbon emissions are associated with all goods and services purchased by households (Carbon Trust, 2006; Daly, 1996; Daly and Cobb, 1989; HM Government, 2005; UN, 2002; UNCED, 1992).

The World Bank experts reveal that in the year 1995 to 2010, India has become one of the fastest progressing countries in the world, in addressing its environmental issues and to improve the environmental quality India has to face many challenges to compete with other developed nations. Pollution remains a major challenge and opportunity for India.

India is the world's fourth largest carbon dioxide polluter and accounts for 7% of total carbon emissions in 2011. Sectorwise annual GHG emission shows that electricity generation (21.3%), industrial processes (16.8%) and transportation fuel (14%) are the major sectors contributing primarily to Green House Gases (GHG). The main drivers of these emissions have been: (1) the growing expenditures per capita, (2) population and (3) increasing energy intensity in the food and agricultural sectors. Household energy requirements have increased significantly, both in total and per capita terms over this time period. In this paper household energy consumption and their carbon dioxide emission pattern is studied. If the carbon emission pattern of households of domestic sector is known the appropriate steps can be taken to reduce the emission values from these areas because every sector of an economy has a potential for energy saving and energy saving potential of different sector of Central East India is given in Table 1.

Table 1: The annual energy saving potential in Central East India (NPC, 2009)

Sector	*Saving potential (BTU)*
Agricultural	0.423
Municipalities	0.0323
Commercial	0.0044
Domestic	0.376
Industries	0.616

It is clear from the table that every sector in the Central East India has a potential for energy saving in which domestic sector has the energy saving potential of 0.376 BTU. Hence a study on assessment of CO_2 emission from different activities of domestic sectors will help in targeting key areas for total emission reduction.

The objective of this research work is to identify and analyse the impact of the different direct sources of carbon emission on primary carbon footprint. After analysing the different household activities which directly release carbon, (1) fossil fuel combustion, (2) transportation and (3) electricity consumption were considered for the study. Further, in this paper, we focus on impact of household income and household size on total carbon emission which can help to achieve the possible reduction potential because once the size of a carbon footprint is known, a strategy can be devised to reduce it.

Materials and Methods

Study Area

Chhattisgarh is the 10th largest state in India with an area of 135,194 km^2. With a population of 28 million, Chhattisgarh is the 17th most populated state in the country. Chhattisgarh is a resource-rich state and is a source of electricity and steel for the country. For the study of total CO_2 emission from different household activities, the two densely populated districts Durg and Rajnandgaon of Chhattisgarh, India were selected. Bhilai is a city in the district of Durg which is famous for its steel and chemical industries notably the Bhilai Steel Plant. As of 2011 census Durg-Bhilai urban agglomeration had a population of 1,064,077 and Rajnandgaon of 163,122. The area selected for the study is Bhilai, Durg and Rajnandgaon and is shown in Figure 1a, b.

Figure 1a: Sampling site Chhattisgarh, India.

Data Collection

For the study the three densely populated areas B-D-R (Bhilai, Durg and Rajnandgaon) of Chhattisgarh, India were selected. The sampling method was Stratified Random, specially tailored and was based on primary questionnaire. The selection criteria of questionnaire were based on the household income and size of the household of the entire three BDR regions. As a result, the residential community was differentiated based on income and household size for the study of carbon emissions. Hence a systematic random sampling method was used to select the households to be surveyed. Approximately 350 households in each region were included in the sample. The list of the resident households in each residential community, provided by local residents' committees, was used as a framework of the population to be sampled. To encourage the people towards data collection a public awareness activity is organised first in which an informative pamphlet is distributed among the people to understand the importance of measuring carbon footprint and the need to know their carbon footprint. Self-administered questionnaire is designed to collect data from people. The questions for the interview were selected carefully to obtain desired detailed information. Clear instruction in the form of option available for each question is given on how to fill questionnaire. The questionnaire was given to the people and the completed forms were collected from the people there only. A structured

Figure 1b: Study area Bhilai, Durg and Rajnandgaon (BDR).

questionnaire survey was conducted through face-to-face interviews in each area in all the three seasons (rainy, winter and summer) in between August 2014 and March 2017.

Survey Data

The sample size of the study was 1100 households which provide a good representation of the target population. The data collected were analysed to calculate the household's total carbon emission. Nonetheless, because the sample questionnaire was unlikely to collect exact information on household income due to its sensitivity and confidentiality, the questionnaire employed discrete choices of household income brackets. For this study the samples were classified into three income categories—higher, lower and middle income group. The lower income group (LIG) was in the income range of Rs. 25,000 to Rs. 100,000, middle (MIG) was 100,000 to Rs. 500,000 and Higher (HIG) in the range 5,00,000 to 15,00,000 per year. For household's total direct carbon emission, the emission from different sources like electricity, LPG and petrol were calculated.

Estimating Carbon Emission

Carbon footprint models or calculators are widely available on the Internet. Existing models calculate the individual or household primary carbon footprint by converting the amount of electricity, oil, gas or coal used per year into equivalent CO_2 emissions. They also convert the number of kilometres driven in a car, kilometres on various types of public transport to CO_2 equivalent emissions. Models or calculators are provided by a range of organizations including government agencies, non-governmental organizations (NGOs) and private companies. The model used for carbon emission calculation in this study is as follows:

We focus on three major household sources of carbon dioxide emissions: transportation, residential electricity consumption and domestic fuel. The following equation provides an accounting framework for organizing our empirical work:

$$\text{Total Emissions} = \gamma_1 \times \text{Transportation} + \gamma_2 \times \text{Electricity} + \gamma_3 \times \text{Domestic Fuel} \quad (1)$$

The main goal of this study was to estimate equation (1) for higher, middle and lower income group households. In this equation, transportation represents energy use from a vector of activities including litres of annual gasoline consumed for households that own a car. We recognize that households consume other products (such as what they eat) that have carbon consequences but those are not included in this calculation. To estimate carbon dioxide emission by different activities each activity is multiplied by its corresponding DEFRA conversion factor (Table 2).

The DEFRA Conversion Factors (Defra, 2011)

These conversion factors are produced by the UK Government to help companies calculate greenhouse gas emissions from a range of activities, including energy use and transport activities. These conversion factors convert activity data (e.g. litres of fuel used, tonnes of waste sent to landfill) into kg of CO_2 equivalent (CO_2e) (Table 2).

Table 2: DEFRA conversion factor 2011

Activity	*Unit*	*kg CO_2 e per unit*
Electricity	kWh	0.5246
LPG	L	1.4918
Petrol	L	2.3117
Diesel	L	2.6676

Result and Discussion

Magnitude of Household Carbon Emissions

The average carbon emission in the studied three regions was accounted to be 3.12 tonnes CO_2 per year per household. The studied three emission sources account for 2.03, 0.202 and 0.913 tonnes of CO_2 emission per year per household from energy, LPG and petrol uses respectively. Electricity is the largest single contributor (at 65%) of the total carbon emissions from all types of household energy consumption. This result is consistent with other studies (Boussauwk, 2009; Duffy, 2013).

Effect of Household Size on Carbon Emission

Carbon reduction policies can target households or individuals. For potential distributional implications the household size and composition are important. For example, studies on Personal Carbon Allowances or similar policies have to make assumptions about the allocation per person in each household (DEFRA, 2008; Gough et al., 2011; Starkey, 2012). Previous literature has shown that household size is an important factor for household emissions and that there are economies of scale once individuals share household resources (DEFRA, 2008; Druckman and Jackson, 2008; Gough et al., 2011). However, the extent of economies of scale has not yet been compared in detail for different areas of emissions.

Baiocchi et al. (2010) found that households with children have higher impact on direct total carbon emission than households without children. DEFRA (Dept. of Environment, Food and Rural Affairs, Govt. of U.K., 2008), reported a positive correlation of direct total CO_2 emission with number of children in households, but correlation was not significant for more than two children.

Data from present study suggest that households with children have lower CO_2 emission than without, holding other factors constant. Similar results are also reported by Gough et al. (2011) they found that households with children have lower per capita emissions because children are likely to consume less than adults.

Interestingly this study reveals that for two adult household the total emission increases by approximately 37% with addition of one child in household. Further, households with two, three children don't contribute in increasing CO_2 emission rather the total emission decreases with increasing household size; lower standard of living with increasing household size could be the reason. The same trend is followed by other household activities like petrol and LPG (Figure 2). The total emission with increasing number of adults in the households shows increasing pattern and reach maxima with four adult households (Figure 3).

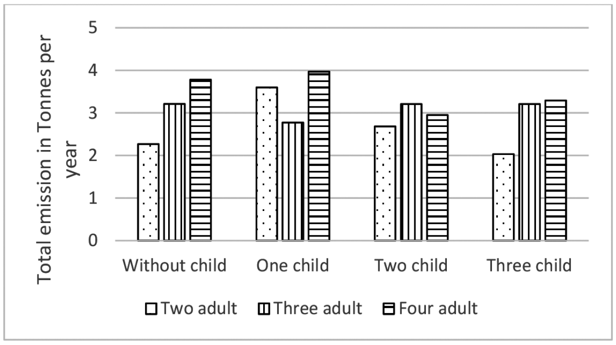

Figure 2: Effect of household size on total CO_2 emission.

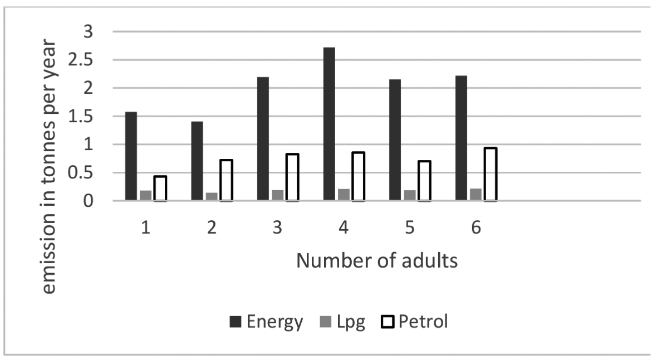

Figure 3: Number of adults in household and CO_2 emission from different activities.

Effect of Income on Carbon Emission

The present study of effect of income on CO_2 emission reveals the income is positively correlated with total emission since emissions increases with increase in income level (Figure 4).

Other studies that investigated income conclude that emissions rise with income (Baiocchi et al., 2010; Brand and Boardman, 2008; DEFRA, 2008; Druckman and Jackson, 2008; Fahmy et al., 2011; Gough et al., 2011; Weber and Matthews, 2008) which is quite obvious because more income one has the more likely he/she is to spend.

Druckman and Jackson (2008) and Dresner and Ekins (2006) found a positive correlation between income and home energy emissions. DEFRA (2008) and Fahmy et al. (2011) find an increase of home energy and transport emissions combined with rising income. Brand et al. (2008, 2010) report a high correlation between income and transport emissions. However, when controlling for other variables, Brand and Preston (2010) only find a significant relationship between income and flight emissions, but not for emissions from car travel. Baiocchi et al. (2010) confirm significant positive relationship between income and total household CO_2 emissions and Gough et al. (2011) for total and individual areas of greenhouse gas emissions.

But expenditure translates quite differently into CO_2 emission. Buchs and Schnepf (2013) studied that one pound of expenditure on living translates differently for indirect or direct CO_2 emissions. Hence not only how much a person earns but how he spends also decide the total CO_2 emission by households. Present study reveals direct emissions from petrol and electricity are positively correlated with income groups while total emission remains unaffected by LPG emission (Figure 4). Hence with rising income the expenditure increases on travelling and electricity uses while LPG consumption remains almost constant. To control or reduce total CO_2 emission from households the policies should be framed to control the travelling emission and

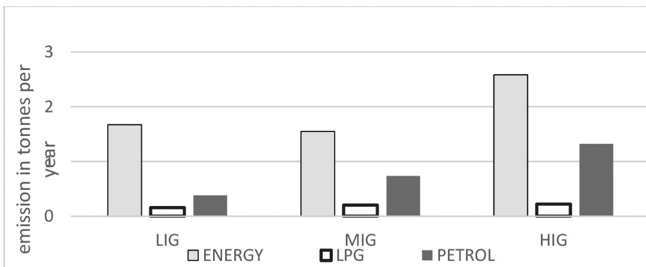

Figure 4: Effect of income on different carbon emission activities.

electricity emission from household with increasing income.

Seasonal Variation in Carbon Emission

The seasonal variation in carbon emissions is also studied and the statistical analysis of the data obtained is shown for energy, petrol and LPG consumption in Table 3. In the U.S., Glaeser and Kahn (2010) found tight link between electricity consumption and hot summers, presumably because of extensive use of air conditioning.

It is evident from the table that energy consumption is higher in summer season which is obvious and LPG and petrol are showing a minor peak in winter season followed by summer and then rainy season.

Table 3: Statistical analysis of the seasonal data (average monthly basis)

	Mean	*Median*	*Mode*	*Skew*	*Standard deviation*
Energy Consumption					
Rainy	139.8	122.4	159.5	0.07	60.1
Winter	157.6	174.9	182.0	-1.3	43.2
Summer	209.1	174.9	227.3	1.4	119.5
LPG					
Rainy	14.3	14.9	10.4	-0.01	5.1
Winter	20.3	20.9	20.9	0.9	8.3
Summer	16.8	10.4	10.4	1.49	11.9
Petrol					
Rainy	52.3	48.2	32.1	1.45	29.9
Winter	96.2	96.3	64.2	0.22	43.3
Summer	80.8	80.3	80.3	-0.003	32.9

ANOVA Test and Regression Analysis

Effect of Household Characteristics on Total Carbon Emission

To study the relationship between carbon emission from households and household's characteristics like income and size, a correlation analysis and ANOVA test were applied. The correlation analysis was applied in order to explore as extensively as possible the relationship between household carbon emission and household characteristics. ANOVA test was used to examine whether average household CO_2 emission vary by household specific characteristics that can be characterized into multiple groups like income and size of the households. OLS regression was employed to analyse the significance and weights that multiple factors may contribute to household carbon emissions. The different household characteristics were studied for the total emission. The dependent variable total emission is tested for the other three independent variables: petrol, energy and LPG. The variables were tested for the Linear Regression model and results suggest the data fit the linear regression model (higher R and R^2 values).

On comparing the R and R^2 values for all the three household characteristics it is clear from the data that the energy has the highest impact with a value of 0.920 on the total emission characteristics and second is the petrol consumption with R value of 0.606 while LPG ranked third with an R value of 0.304. Table 4 presents the linear regression model values for the test data.

Table 4: Linear regression model for predictor variable petrol, energy and LPG on response variable total emission

Predictor variables	*R*	*R Square*	*Adjusted R Square*	*Std. error of the estimate*
Petrol	.606	.367	.364	99.278
Energy	.920	.847	.847	49.402
LPG	.304	.092	.089	120.455

A typical output produced from a simple linear regression of Total emission on Petrol (That is petrol emission is being used to predict total emission). Predictor variable – Petrol and Dependent – Total emission. The predicted total emission for mean petrol emission of 76.1 kg CO_2 e per month is

$$146.28 + 1.54\ (76.1) = 263.47$$

The regression coefficient for the predictor is the difference in response per unit difference in the predictor. For longitudinal data the regression coefficient is the change in response per unit change in the predictor. Here total emission differs 1.54 units for every unit difference in petrol emission and 5.151 units and 1.14 units with LPG and energy respectively. The distinction between cross sectional and longitudinal data is still important. These total emission data are cross sectional; so difference in petrol emission and total emission refer to difference between the households (Table 5).

The column labeled source has three rows: regression, residual and total. The column labeled sum of squares describes the variability in the response variable Petrol. The total amount of variability in the response variable Petrol is the Total Sum of Square. The error that is the amount of variation in the data that cannot be accounted for by this simple method – is the total sum of squares. When the regression model is used for prediction, the error is the variability about the regression line and

Table 5: Regression coefficient for total emission of the area

	Unstandardized coefficients		*Standardized coefficients, Beta*	*T*	*Sig.*
	B	*Std. error*			
Energy	1.144	0.031	0.920	36.419	0.000
LPG	5.151	1.045	0.304	4.930	0.000
Petrol	1.540	0.132	0.606	11.702	0.000

this is the amount of uncertainty that remains. The regression sum of square is the difference between the total sum of square and the residual sum of square. Since the total sum of square is the total amount of variability in the response variable Petrol, and the residual sum of squares that still cannot be accounted for after the regression model is fitted, the regression sum of square is the amount of variability in the response that is accounted for by the regression model. Each sum of square has a corresponding degree of freedom (DF) associated with it. The one-way ANOVA for CO_2 emission from energy, petrol and LPG of BDR region is shown in Table 6.

In ANOVA mean squares are used to determine whether factors are significant. The predictor variable's mean square is obtained by dividing the predictor variable's sum of squares by the degree of freedom.

Effect of Income on Total Carbon Emission

The descriptive statistics of the data for the entire income group suggest that the emission from all the three household characteristics increases as the income of the household increases. The data predict the fit of linear regression model. The R^2 value of all the three household characteristics for lower, middle and higher income group suggest that the same trend is followed and the energy has the highest impact on the total emission and the energy and LPG has higher impact on total emission as compared to other two income group while petrol has higher impact on middle income group (Table 7).

The significant value in the table tells us whether the two conditions that are being compared are significantly different or not. Value greater than 0.05 suggests that there is no statistical differences between two conditions means and if the value is lower than 0.05 that suggest that the two condition means are not likely due to chance. From Table 13 it is clear that for lower income group the Petrol factor and for higher income group the LPG factor has significant value greater than 0.05 while other values are less than 0.05 indicates that the difference between the two condition means are not likely due to chance (Table 8).

The total emission differs largely with every unit difference in LPG emission for all the income groups (Table 8) with a value of 4.3 for lower income group, 2.1 for middle income group and 3.2 for higher income group, while impact of energy emission stands second and the petrol emission third.

Effect of Household Size on Total Carbon Emission

The effect of household size is studied in two perspectives. One was the households with increasing number of adults and the second was the households with increasing number of children with two or four adult households. The results of the regression analysis are shown in Table 9.

It is clear from Table 9 that adults have more impact on total emission than children (higher R and R^2 value). And if we study the effect of increasing children on different household size it gives clear picture that the effect of children is more on four-adult households in total emission as compared to two-adult households.

Table 6: One-way ANOVA for energy, petrol and LPG emission of BDR region

		Sum of squares	*df*	*Mean square*	*F*	*Sig.*
	Between groups	2426710.416	155	15656.196	29.466	.000
Energy	Within groups	45163.833	85	531.339		
	Total	2471874.249	240			
	Between groups	11597.096	155	74.820	3.750	.000
LPG	Within groups	1696.107	85	19.954		
	Total	13293.203	240			
	Between groups	522711.871	153	3416.417	6.235	.000
Petrol	Within groups	46027.024	84	547.941		
	Total	568738.895	237			

Table 10 represents the effect of table of coefficient for different household size on the total emission of the area. With every addition of child in household the total emission increases by 24.5 units and 17.1-unit increase in addition of each adult in households. So the adults play more important role in emitting carbon dioxide as compared to children in the households.

Conclusion

In this paper first the total carbon dioxide emission of the selected region of central east India BDR region is calculated for all the three income groups and then the association between household characteristics like income and size of the households and carbon dioxide

Table 7: Linear regression model for predictor variable energy, petrol and LPG on response variable total emission for three income groups

	Predictor variables	*R*	*R square*	*Adjusted R square*	*Std. error of the estimate*
LIG	Energy	0.967	0.934	0.932	26.9
	Petrol	0.142	0.020	-0.009	103.36
	LPG	0.402	0.162	0.137	101.16
MIG	Energy	0.912	0.832	0.830	32.74
	Petrol	0.524	0.275	0.268	64.79
	LPG	0.206	0.043	0.034	78.12
HIG	Energy	0.822	0.676	0.672	52.88
	Petrol	0.467	0.218	0.209	82.18
	LPG	0.164	0.027	0.016	91.66

Table 8: Table of coefficient for effect of income on all emission area for three income groups

	B	*Unstandardized coefficients*		*Standardized coefficients*	*T*	*Sig.*
		Std. Error	*Beta*	*Beta*		
LIG	Energy	0.931	0.042	0.967	22.29	00
	LPG	4.379	1.710	0.402	2.562	0.015
	Petrol	0.616	0.737	0.142	0.836	0.409
MIG	Energy	1.097	0.047	0.912	23.427	00
	LPG	2.1	0.945	0.206	2.22	0.028
	Petrol	1.346	0.211	0.524	6.39	00
HIG	Energy	0.930	0.069	0.822	13.399	00
	LPG	3.2	2.078	0.164	1.541	0.127
	Petrol	0.817	0.167	0.467	4.892	00

Table 9: Linear regression model for effect of household size on response variable total emission

	R	R^2	*Adjusted R square*	*Std. error of the estimate*
Effect of increasing children with 2 adults	0.440	0.194	-0.612	70.627
Effect of children with 4 adults	0.687	0.472	0.208	34.304
Effect of increasing adult	0.755	0.570	0.498	39.369

Table10: Table of coefficient for effect of household size on total emission of the area

	Unstandardized coefficients		*Standardized coefficients*	*T*	*Sig.*
	B	*Std. Error*	*Beta*		
Increasing children	24.5	49.94	0.440	0.491	0.710
Increasing adult	17.119	6.075	0.755	2.818	0.030

emission across three emission areas—energy, transport (petrol), and LPG—were compared which added value to this paper. The total carbon emission of this area is 3.12 tonnes CO_2 per household per year. The overall energy (electricity) emission is 2.03, while LPG is 0.203 and Petrol is 0.913 tonnes of CO_2 per household per year. This study is highly relevant from a public awareness perspective because household characteristics are differently related to emission. Data suggest that the highest emission is from energy use while petrol (transportation) stands second and then LPG.

For total emission the income is an important determinant of CO_2 emission. The low income group has more energy emission than transportation while the LPG remains almost same for all the three income groups. Hence any change in transportation policy like petrol fuel pricing will least affect low income group. The home energy emission will affect the all income groups at its maximum. Second the household size is very differently related to home energy and transport emission. Children add less to the total emission, rather increase in household size decreases the total emission; lower standard of living with increasing household size could be the reason for low income group while the case is not true for high income group. Home energy emission for without child households increases only by about half to double for three adults' households compared to two adults' households, indicating higher economies of scales in this area. Surprisingly children add less to a households CO_2 emission than expected for all areas studied.

The linear regression model studies for total emission for the three income groups suggest that the energy has the highest contribution on total emission. The total emission including all the emission groups differ 1.54 units, 5.15 units and 1.14 units for every unit difference in petrol, LPG and energy emission respectively. The total emission differs largely with every unit difference in LPG emission with a value of 4.3 for lower income group, 2.1 for middle income group and 3.2 for higher income group. From the standard error of estimate, it is clear that the energy emission from the households have the highest contribution on total emission while LPG has the highest impact with each unit increase. For the different size of household, the adults have more impact with a coefficient value of 24.2 as compared to 17.1 of increasing children on the total emission of the area. Hence households with specific characteristics will affect the total emission irrespective of high or low income group. For emission reduction those areas should be targeted. Household with elderly will have lower emission values due to lower travel and energy emission. If we examine whether household characteristics influence emissions differently for low, middle and high income groups, the results show that the different points of emission are not very much affected by higher than to middle or lower income group emissions. This shows that more detailed analysis at different ends of the emission distribution can uncover different patterns of CO_2 emissions and capacities for emission reduction.

Finally, household size and the presence of children have more impact on poorer household than for richer for total, and transport emissions. Hence household characteristics other than income play important role in total emission. Since cities are getting more attention in reducing carbon emission, this study from central east India (BDR region) could result in the innovative solutions to reduce the emission from household uses and will help in framing tailor-made policies for reducing greenhouse gas emissions of the cities and their implications. Further these results show the need of more detailed analysis at different ends of the emission distribution in future which can uncover different patterns of CO_2 emissions and capacities for emission reduction.

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Calendar of Events

6th International Conference on Coastal and Ocean Engineering (ICCOE 2019)
25th to 28th April 2019
Bangkok, Thailand
Website: http://www.iccoe.org/
Contact person: Ms. Sophia Du
Organized by: CBEES

ICEE 2019 - 4th International Conference on Energy and Environment: Bringing together Engineering and Economics
16th and 17th May 2019
Guimaraes, Portugal
Website: http://icee.dps.uminho.pt
Contact person: Paula Ferreira
Organized by: Universidade do Minho

The Asian Conference on Sustainability, Energy and the Environment 2019 (ACSEE2019)
20th to 22nd May 2019
Tokyo, Japan
Website: https://acsee.iafor.org/
Contact person: Inkar Alshimbayeva
Organized by: The International Academic Forum (IAFOR)

International Symposium on Energy, Water and Environment (SEWE 2019)
25th and 26th May 2019
Regina, Canada
Website: http://isewe.org/
Contact person: Ms. Jewel Hou
Organized by: University of Regina

10th International Conference on Environmental Science and Technology (ICEST 2019)
7th to 9th June 2019
Xiamen, China
Website: http://www.icest.org/
Contact person: Ms. Sophia Du
Organized by: Xiamen Ocean Vocational College

WaterLand-2019
26th to 28th June 2019
Kaunas, Lithuania
Website: http://conferencewaterland.weebly.com/
Contact person: Otilija