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Relating Emissions of Carbon to Characteristics of Consumption in India

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ABSTRACT

In order to determine how the average Indian's emissions may be reduced, one needs to understand the consumption basket and the implications of various categories of household consumption (such as cereals or durables) on emissions. With this in mind, this paper looks at consumption choices in India and calculates per capita carbon dioxide emissions of the different categories of consumption during 1987-1988 to 2007-2008. It is seen that both the increase in per person consumption and a change in the product basket have led to an increase in emissions per person. Further, the urban or higher class Indian emits more, not only because he consumes more of everything (compared, respectively, to the rural or lower class Indian), but also because of differences in the composition of consumption. Four products/product groups – fuel for cooking, fuel for lighting, durables and housing – are further explored to identify several problem products.

KEYWORDS

Carbon emissions, Consumption, Expenditure, Product groups, Consumer groups, India.

INTRODUCTION

The fact that India is the third highest emitter of Carbon dioxide (CO_2) (after China and the USA) is less important relative to its future potential, given that it emits only 6.24% (2015) compared to 28.21 and 15.99% by the two other countries, and given that its rank is 127th in terms of per capita emissions (1.7 metric tonnes per year) [1]. This is supported by the fact that over 1990-2012, India's per cent change in emissions was 236% (second only to China for which it was 262%) [2]. During this period the per cent change in the European countries has been negative or very low. In 2016 the change in emissions per capita has been 5.1% for India, whereas for China it was actually negative (–0.7%) [3].

In order to comprehend how India's future emissions may be limited or reduced, one needs to look at the past. What has caused India's emissions to rise? For most high

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emissions countries including India, a positive and very high correlation between Gross Domestic Product (GDP) and CO_2 emissions (the Pearson correlation coefficients are 0.99 for both China and India, 0.95 for the US and 0.94 for Japan for the period 1987-2008) points towards the obvious culprit, total production (the one exception to this is the EU, for which the correlation coefficient is negative at –0.39. This may be due to aggressive climate policies). Of the two components of GDP, population and per person production, the former has certainly been responsible, but the continued decline in population growth rates since the 1980s increasingly shifts the responsibility to the rise in per person emissions, which in turn has been caused by the rise in per person income and expenditure [4].

This paper focuses on per person emissions (in this paper the term 'emissions' refers to emissions of CO_2, which constitutes 80% of greenhouse gases) and its immediate cause, per person expenditure. It determines total emissions per person per year and its change over time. It also breaks up these emissions by product and well as consumer groups in order to identify the culprits.

Scientists have constantly endeavored to measure the relative carbon footprints of specific consumer goods such as household power technologies [5] or various food categories [6]. Social scientists, too, are shifting from discussions on sectoral emissions [as in publications by the Intergovernmental Panel on Climate Change (IPCC)] to exploring the role of the consumer in climate change.

A body of research that is almost wholly based on input-output analysis uses various data sources to look for the reasons behind changes in consumption over time in the context of global warming. The start may be attributed to the debate between Commoner [7] and Ehrlich and Holdren [8] on what impacts environmental degradation the most. While the latter considered overpopulation to be the overriding factor, the former had a more balanced approach and thought that technological and social development had the capacity to contain environmental damage. This debate resulted in the IPAT equation:

$$\text{Impact} = \text{Population} \times \text{Affluence} \times \text{Technology} \tag{1}$$

What becomes implicit, in this sort of formulation, is that if the growth in population and affluence cannot be contained, climate change mitigation policy has to centre on technological solutions [9]. Income class and the consumption basket come up as critical determinants of an individual's carbon footprint in much of this work [10]. Hertwich and Peters [9] calculate the shares of certain product groups (food, shelter and mobility turn out to be the most important consumption categories in the current context, followed by services and manufactured goods) in per capita Greenhouse Gas (GHG) footprint – for 73 countries. For India, this share is 41% for food, 14% for shelter and 12% for mobility, whereas for the US these shares are 8%, 25% and 21% respectively. Food and services take up a greater share in developing countries, while mobility and manufactured goods rise rapidly with income and dominate in rich countries. A paper by Kok *et al*. [11] has reviewed several of these publications, including the work on Australia initiated by Lenzen [12] and taken up by others too, which points out the greater role of indirect versus direct emissions and once again concludes that increasing incomes increases emissions.

Data based research increasingly makes the point that technology cannot, by itself, keep climate change in check, and that the role of affluence (vis-à-vis population growth) is on the rise. Hence, there is a need to reduce or control per capita consumption [13]. In their study of China and India, Hubacek *et al*. [4] observe an enormous rise in emissions by the average individual. According to them, India requires an (improbable) gain in energy efficiency to the tune of 98% to satisfy 'current' carbon agreements. Feng, Hubacek and Guan [14] use the IPAT model to analyze what contributed to the growth of

CO_2 emissions in 5 regions of China over the last 50 years. They find regional as well as rural-urban differences in consumption trajectories. They, too, determine that technological improvements have not been able to fully compensate for the increase of emissions due to population growth and increasing wealth. Alfredsson [15] has conducted an interesting study of Swedish households that concludes that adopting green patterns of consumption while retaining the same level of total consumption does not solve the problem of climate change – it is at best a temporary palliative. Part of the reason is the rebound effect – the money or energy saved is used to increase the consumption of other products. Further, increasing levels of per capita incomes (and hence expenditure) not only cancels out the emissions reduction but also causes a net increase in emissions.

Policy-oriented discourses accompany research that is skeptical about technology. Some of them investigate the political economy of consumerist growth in developing countries led by the middle classes, who are influenced by the state as well as entrepreneurs to consume more (see articles in Lange and Meier [16]). Others, in a similar vein, question the assumption that more products enhance happiness – thereby finding a solution to climate change through the reduction of material consumption [17]. Rajan [18] presents a comprehensive coverage of transport policy for climate change mitigation – much of it, however, applies to climate policy in general. In his view, technology and pricing have to be supplemented by social as well as infrastructural change. Kola-Lawal *et al*. [19] explore implementation factors (such as drivers, benefits and barriers) affecting pro-environmental behaviour in developed versus developing countries. Shakya [20] provides a comprehensive demand-oriented package for Kathmandu, Nepal. For India, similar studies have been done by Padukone [21], Sanwal [22] and Roy [23].

Research substantiated by data on household consumption in India and its implications for climate change is somewhat limited. Rather, there is some literature on consumption and its determinants that can be useful, though it does not touch upon carbon impacts. Gangopadhyay and Wadhwa have done this for general consumption patterns [24] and Pachauri [25] looks at energy consumption. Lakshmana [26] tries to identify demographic factors that may have affected India's environment (including its climate) – these include changes in population, age structure, household size and the urban population. The conclusions are not based on a concrete analysis of data that conclusively proves the correlations. The most substantial research on the connection between consumption and climate change in India remains the 1997 paper by Murthy *et al*. [27], where they use input-output tables to connect consumption behavior amongst certain classes of Indian consumers and the resultant carbon emissions. They thereby estimate average emissions per capita in 1990 and project what it will become in 2020. By exploring scenarios of technology improvement, they, too, indicate a bias towards technological solutions. A subsequent paper by Parikh *et al*. [28] is an update of the earlier work.

This research carries the enquiry forward, looking in some detail at the individual consumer's expenditure and emissions thereof. Several aspects of this research have not been investigated well in previous work – one, it looks at changes over a twenty year span, two, it investigates the less researched issue of the rural-urban divide as well as the well-researched one of income class differences, both being extremely relevant in the context of consumption behavior in developing nations with a large rural population, and three, it looks at smaller product sets (for example, several components of food rather than food as a whole) including individual products (such as specific durable goods) as well as product types (such as mud vs. brick houses) in order to identify the culpable products.

RESEARCH GOALS

Per person emissions may go up because of a rise in the quantity of consumption by the average person (which is in turn caused by a rise in real income per person), but it may also go up because of changes in the consumption basket. In previous research, changes in the quantity and composition of the average Indian's consumption of goods and services over time (Table 1) and differences (in both quantity and composition of consumption) between rural and urban India, as well as between expenditure classes [29] – have been identified. The chief objective of this paper is to determine per person emissions and its change over time and also to apportion this amongst product and consumer groups.

Emissions data for individual products (produced in India) as well as household consumption data (of product groups or individual products) from the National Sample Survey (NSS), mainly on Monthly Per Capita Expenditure (MPCE) but also in other forms – is used for this research, and the time span is 1987-1988 to 2007-2008 (20 years).

Table 1. Real MPCE on individual consumption categories, rural and urban, 1987-1988 and 2007-2008 (in 1987-1988 rupees)

Product group	Rural		Percent change, rural	Urban		Percent change, urban
	1987-1988	2007-2008		1987-1988	2007-2008	
Cereals	41.33	31.89	–23	36.97	32.49	–12
Vegetables	8.23	12.47	51	13.12	16.00	22
Fruits and nuts	2.57	3.48	35	6.27	7.71	23
Milk and milk products	13.63	15.47	13	23.84	26.52	11
Eggs, fish and meat	5.11	6.76	32	8.85	9.81	11
Fuel for cooking and lighting	11.77	19.29	64	16.72	31.27	87
Clothing	10.52	12.59	19	15.00	19.93	33
Footwear	1.55	1.87		2.69	3.64	
Misc. goods and services#	22.78	48.84	114	58.64	145.94	148
Durables	5.64	7.12	26	10.60	15.48	46
Total	123.13	159.78	30	192.7	308.79	60

Includes conveyance, education, medical care, rent and miscellaneous consumer goods
Source: NSS, 2010, pp A22-A23

EMISSIONS PER PERSON BY PRODUCT GROUP, CHANGES OVER TIME

To estimate emissions due to the individual's consumption by product group, Indian data on emissions intensity for individual products compiled by Grunewald *et al*. [30] is used. This data is for the year 2005 (and includes goods that were imported). It is in terms of emissions in kilo-tons per 100,000 rupees, which is converted to grams per rupee. The authors have estimated CO_2 emission intensities a using single region input-output model based on Global Trade Analysis Project, www.gtap.agecon.purdue.edu (GTAP). Both direct and indirect emissions from goods produced and consumed in India as well as imports were accounted for [30], pp 4-7. In the study, carbon emissions from coal, crude oil, natural gas, petroleum products including kerosene, electricity (coal-based) and fuelwood have been considered. Given that the share of renewable and nuclear energy in the production of electricity was negligible in 2005, it may be said that the fuel sources implied high levels of CO_2 emissions per unit energy produced.

As the data is in 2005 prices, retail price indices are used to obtain corresponding values for 1987-1988, 1993-1994 and 2007-2008. Emissions intensity for product 'groups' is then determined by using weights to add up the individual emissions intensities where the weight used with emissions by product *i* is given, for the relevant year (1987/1988 or 1993/1994 or 2007/2008), by:

$$W_{\mathrm{i}} = \text{MPCE on product } i \text{ / MPCE on all products in the group} \tag{2}$$

Table 2 gives the emissions per rupee (2007-2008) of each product group, listed in terms of rank (highest to lowest), in rural and urban India. It needs to be observed that data on emissions per kg of the product is not being presented here. Emissions intensity (that is, emissions per rupee) is the product of emissions per kg and kg per rupee (the latter being the inverse of price).

Table 2. Emissions intensity (gm/rupee) by product groups, 2007-2008

Rural			Urban		
Product group	Emissions intensity [gm/rs]	Rank	Product group	Emissions intensity [gm/rs]	Rank
Fuel for cooking and lighting	133.47	1	Fuel for cooking and lighting	279.02	1
Misc. goods, entertainment	44.67	2	Misc. goods, entertainment	41.00	2
Clothing and footwear	38.87	3	Cereals and cereal substitutes	37.55	3
Cereals and cereal substitutes	37.44	4	Clothing and footwear	37.48	4
Medical care	37.19	5	Beverages, refreshments, processed foods, etc.	35.26	5
Beverages, refreshments, processed foods, etc.	32.49	6	Medical care	34.52	6
Durables	30.85	7	Durables	34.17	7
Conveyance	30.54	8	Conveyance	27.35	8
Betel leaf, tobacco and intoxicants	22.85	9	Pan, tobacco and intoxicants	23.23	9
Sugar, salt and spices	17.76	10	Sugar, salt and spices	17.67	10
Education	15.10	11	Consumer services excluding conveyance	15.96	11
Consumer services excluding conveyance	14.92	12	Edible oil	14.00	12
Edible oil	14.41	13	Pulses and their products	11.69	13
Taxes and cesses	12.91	14	Education	11.41	14
Pulses and their products	11.78	15	Eggs, fish and meat	8.99	15
Eggs, fish and meat	7.99	16	Milk and milk products	6.14	16
Milk and milk products	6.14	17	Fruits	3.41	17
Fruits	3.49	18	Taxes and cesses	3.36	18
Vegetables	3.16	19	Vegetables	3.15	19
Rent	2.90	20	Rent	2.90	20

Source: derived by authors using data from Grunewald *et al*., 2012, NSS, 2010

So cheaper products would show higher emissions intensity, even if emissions per kg were the same. This may be why emissions intensity for cereals is very high, and higher than for other food items including animal based foods.

The emissions intensities turn out to be different in rural and urban areas because the consumption baskets are different – for example, in the case of fuel for cooking and lighting, for which the difference is very high, the basket of goods is also very different –

in particular, in cities each rupee buys much more electricity as well as Liquified Petroleum Gas (LPG), while in villages each rupee buys more fuelwood and kerosene, and far less electricity. The enormous emissions intensity of electricity (about 0.5 kg per rupee) causes the rural-urban difference in emissions intensity for this category.

Using the emissions intensity data for 1987-1988 and MPCE data for 1987-1988 and 2007-2008 (both in 1987-1988 prices) (Table 1), total emissions due to an individual's monthly consumption of various product groups in 1987-1988 and 2007-2008 in both rural and urban India (Figures 1 and 2) is derived. Over 20 years, there has been a huge increase (around two times) in the category 'miscellaneous goods and services', which includes conveyance, medical care and educational services. The increase is also substantial for fuel used in cooking and lighting. On the other hand, there has been a significant drop in emissions from cereals. For all other product groups including non-cereals and durables, the rise in emissions is not as significant. The difference between urban and rural India is that the former had much higher levels of emissions to begin with, and the changes are also higher for fuel used in cooking and lighting, as well as for miscellaneous goods and services. On the other hand, the drop in emissions from cereals is proportionately less than in rural India.

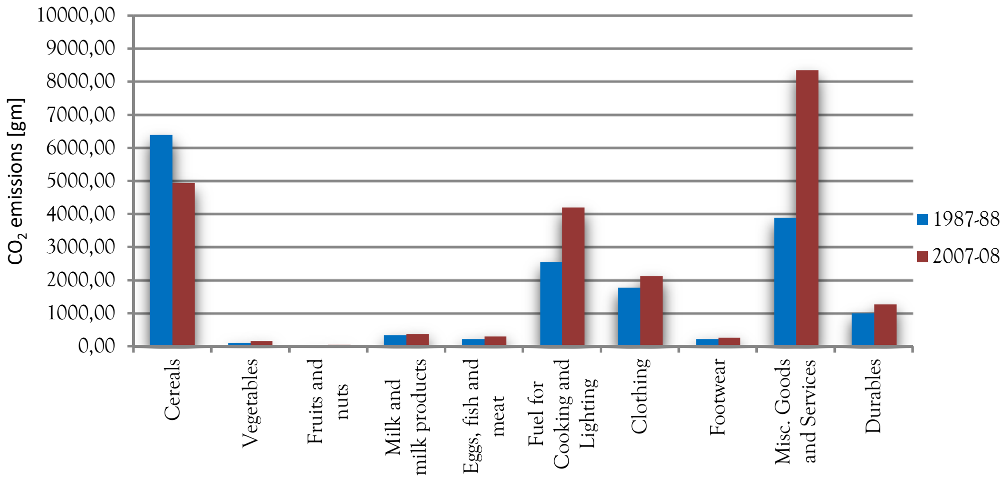

Figure 1. Monthly per capita emissions by product group, rural, 1987-1988 and 2007-2008 (source: derived by authors)

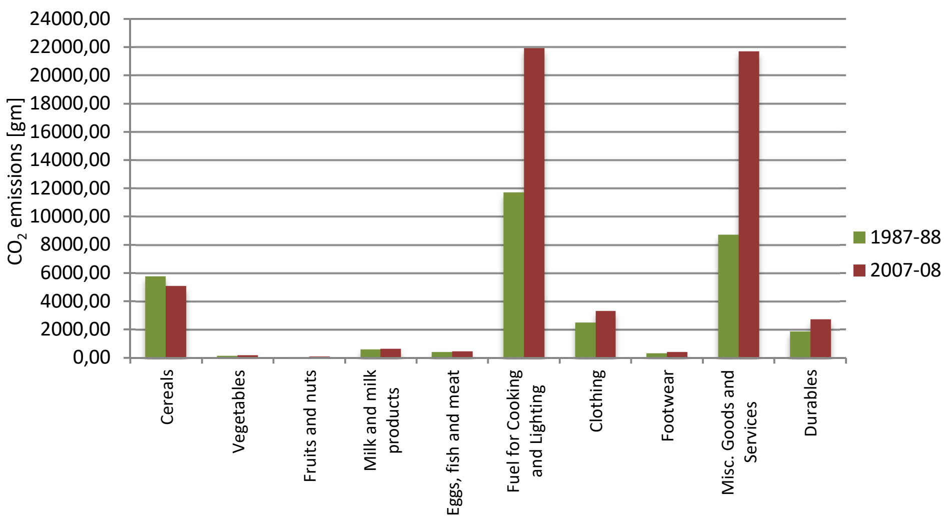

Figure 2. Monthly per capita emissions by product group, urban, 1987-1988 and 2007-2008 (source: derived by authors)

The three major policy measures related to food are the Public Distribution System initiated in the 1960s, which made cereals available at a low price, the Green Revolution of the 1970s, which increased the output of cereals per unit land and the White Revolution (also called Operation Flood) which began in 1970 – a sea-change to a co-operative system of milk production and distribution that eliminated middlemen, enhanced rural incomes and made milk more easily available. The impact of all three policies occurred before the time period of this study, but they may have determined the initial consumption levels of cereals and milk in 1987-1988. While the first two policies reduced cereal deficiency in both rural and urban India [31], it is Operation Flood that may have contributed to the greater consumption of milk in urban areas. The prohibitive price as well as the lack of distribution outlets prevented rural India from increasing milk consumption to the same extent [32].

If one looks at the food and non-food divide for monthly per person emissions (Figure 3), emissions per person from food goes down very slightly, particularly in urban areas, whilst that from non-foods goes up significantly – hence of course average emissions go up, and it is the non-foods that drive the change.

Hence, to sum up, total average emissions by an Indian have gone up – and this is to be expected, given the rise in real expenditure. But the change in the product 'basket' has also had a negative effect, in spite of the fall in emissions of cereals, because of the dominance of emissions from non-foods. Also, as there has been a fall in the percentage of rural population (from 75.2 in 1987 to 69.8 in 2008), the impact of the greater magnitudes as well as changes in urban India on the total effect is even more.

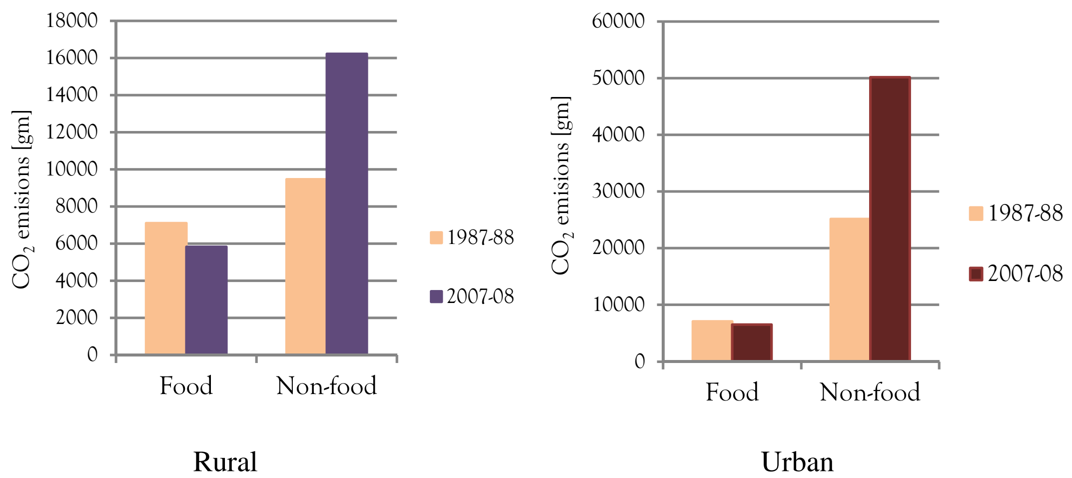

Figure 3. Monthly per capita emissions, food versus non-foods, 1987-1988 and 2007-2008 (source: derived by authors)

EMISSIONS PER PERSON BY PRODUCT GROUP, RURAL-URBAN AND CLASS DIFFERENCES

Table 3 provides, for 2007-2008, the difference in MPCE by product group in rural and urban areas. Using this in conjunction with Table 2, one can derive the rural-urban differential in monthly per capita emissions on various product groups. This is shown in Figure 4. Whilst there are significant differences in several categories, the one that stands out is for cooking and lighting fuel. Figure 5 demonstrates the differences in terms of food and non-foods as well as cereals and non-cereals in urban and rural areas. The emissions due to the consumption of non-foods or non-cereals is significantly higher in urban compared to rural India – the difference is much lower for food or cereals. In other words, non-foods and non-cereals drive the rural-urban difference. As rural India constituted around 70 per cent of the total population in 2007-2008, its lower levels of per capita emissions from all product groups and in particular, fuel for cooking and lighting, pulls down the country level emissions per capita.

Table 3. Absolute and percentage break-up of MPCE by product group, rural and urban, 2007-2008

Product group	MPCE (2007-2008 rupees)		Percentage of total MPCE	
	Rural	Urban	Rural	Urban
Cereals & cereal substitutes	125	131	16.1	8.9
Pulses & their products*	25	33	3.2	2.2
Milk & milk products	60	107	7.8	7.3
Edible oil	33	46	4.3	3.2
Eggs, fish & meat	26	39	3.4	2.7
Vegetables	49	64	6.3	4.4
Fruits	14	31	1.8	2.1
Sugar, salt and spices	30	37	3.9	2.5
Beverages, refreshments & processed food#	43	94	5.6	6.4
Food	404	582	52.4	39.6
Betel leaf, tobacco & intoxicants	19	20	2.5	1.3
Fuel for cooking and lighting	75	126	9.7	8.5
Clothing & footwear$	56	95	7.3	6.4
Education	28	105	3.7	7.1
Medical care	49	76	6.3	5.2
Conveyance	30	94	3.9	6.4
Consumer services excl. conveyance	35	115	4.5	7.8
Misc. goods, entertainment	44	97	5.6	6.6
Rent	3	86	0.4	5.9
Taxes and cesses	2	13	0.2	0.9
Durable goods	28	62	3.6	4.2
Non-foods	368	889	47.7	60.4
All	772	1,472	100	100

* Includes gram
# Includes purchased cooked meals
$ Excludes tailoring charges
Source: NSS, 2010, p 19

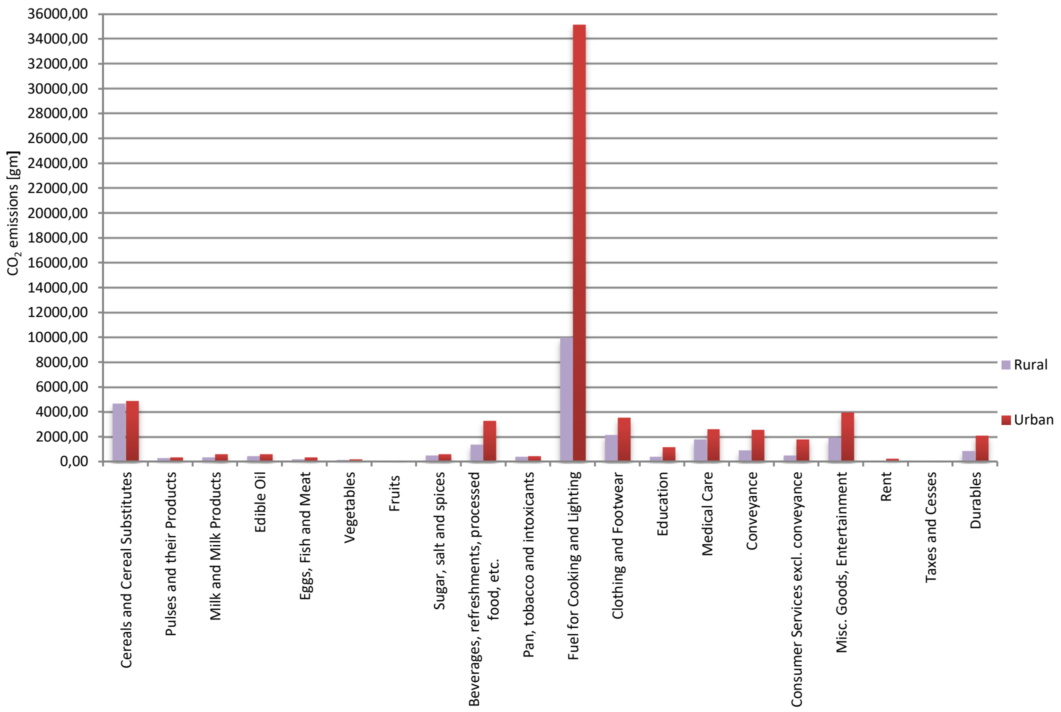

Figure 4. Monthly per capita emissions by product group, rural versus urban, 2007-2008 (note: pan is the Indian word for Betel leaf, source: derived by authors)

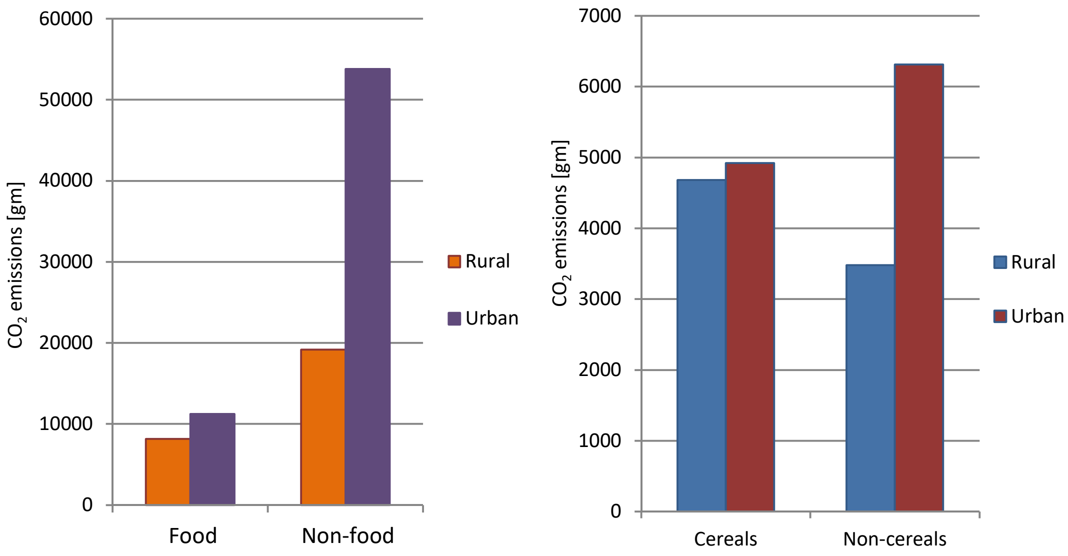

Figure 5. Monthly per capita emissions, food/non-foods and cereals/non-cereals, rural vs. urban, 2007-2008
(source: derived by authors)

Data on MPCE on product groups in each decile class [33] is used in combination with emissions intensity data (Table 2) to derive emissions per person in each decile class and for each product group in both rural and urban India in 2007-2008 (Tables 4 and 5). Some of the product groups in the NSS may sometimes have to be aggregated to obtain the groups that have been presented in this paper: for example, 'fruits fresh' and 'fruits dry' are added to obtain data for 'fruits'. First, for all classes, the 'magnitude' of emissions is highest for fuel for cooking or lighting, and (to a much lesser extent) for cereals and cereal substitutes. But the categories medical care, 'miscellaneous goods and entertainment', 'clothing and footwear' and durables also cause reasonably high levels of emissions for the 'highest' (10th) decile class in urban as well as rural India, and the same holds for 'beverages, refreshments, processed foods etc.', 'consumer services excluding conveyance', education and conveyance in 'only' urban India. Interestingly, emissions from conveyance are the lowest amongst the high emission groups in urban India (it is, as may be expected, not very significant in rural India). Second, whatever the product group, emissions 'always' go up with class, because consumption always goes up with class. The increase of emissions with higher class is particularly high for 'milk and milk products', fruits, education, medical care, conveyance and 'consumer services excluding conveyance' in both rural and urban areas and additionally for 'beverages, refreshments, processed foods, etc.' and 'miscellaneous goods and entertainment' in urban areas. Further, there is a very distinct jump from the 9th to the 10th decile classes in both urban and rural India – especially for education, medical care, conveyance, durables and 'beverages, refreshments, processed foods, etc.'. Third, the emissions ratio between non-foods and food increases steadily with higher class but there is again a sudden leap (by 52% in both urban and rural areas) between the 9th and 10th decile classes in both rural and urban India. The emissions ratio between non-cereals and cereals also rises with class, with the rise being particularly high between the 1st and 2nd as well as the 9th and 10th decile classes in both rural and urban India.

It may therefore be concluded that the higher classes are more responsible in terms of per person emissions, both because of the quantity as well as the composition of the consumption basket, with the responsibility being distinctly higher for the uppermost decile class.

Table 4. Monthly per capita emissions by product group and decile class, rural (gm), 2007-2008

Product group	Decile class									
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Cereals and cereal substitutes	3,566	4,084	4,327	4,450	4,652	4,734	4,781	5,000	5,284	5,758
Pulses and their products	153	194	223	239	264	279	302	323	354	461
Milk and milk products	59	122	165	214	266	316	415	493	650	995
Edible oil	267	332	383	409	449	490	531	558	619	758
Eggs, fish and meat	73	105	126	152	169	192	215	264	322	484
Vegetables	94	111	126	133	143	154	164	176	197	234
Fruits	10	16	20	26	30	37	46	57	77	154
Sugar, salt and spices	286	357	407	449	489	531	579	638	713	909
Beverages, refreshments, processed foods, etc.	484	744	863	1,018	1,086	1,210	1,411	1,681	1,875	3,562
Food	4,189	5,297	5,995	6,566	7,158	7,748	8,541	9,486	10,886	14,999
Betel leaf, tobacco and intoxicants	201	260	308	343	409	413	440	520	609	826
Fuel for cooking and lighting	5,520	6,664	7,476	8,250	8,972	9,767	10,603	11,681	13,517	17,718
Clothing and footwear	1,135	1,389	1,568	1,718	1,865	2,052	2,269	2,588	3,037	4,261
Education	73	111	144	172	214	252	338	406	562	2,005
Medical care	341	497	663	797	998	1,209	1,427	1,893	2,751	7,524
Misc. goods, entertainment	812	1,048	1,213	1,408	1,525	1,814	2,049	2,351	2,857	4,353
Conveyance	140	223	277	356	425	552	748	1,001	1,514	3,852
Consumer services excl. conveyance	134	192	226	268	323	394	481	608	851	1,728
Rent	0	1	1	2	2	3	4	5	12	58
Taxes and cesses	4	6	8	10	13	20	22	29	40	79
Durables	227	286	325	364	411	499	575	754	1,041	4,070
Non-foods	6,910	8,910	10,413	11,874	13,460	15,451	17,795	21,285	27,493	57,777
Total	11,100	14,206	16,408	18,439	20,619	23,199	26,336	30,771	38,380	72,776

Note: the values have been rounded off to the nearest whole number
Source: derived by authors

Table 5. Monthly per capita emissions by product group and decile class, urban (gm), 2007-2008

Product group	Decile class									
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Cereals and cereal substitutes	3,735	4,107	4,401	4,586	4,687	5,070	5,198	5,403	5,786	6,177
Pulses and their products	167	203	228	240	262	288	314	326	371	406
Milk and milk products	94	151	213	261	297	353	412	474	587	794
Edible oil	307	373	437	473	510	558	612	653	727	777
Eggs, fish and meat	94	153	173	207	224	239	261	297	324	452
Vegetables	112	140	154	176	188	205	224	241	268	319
Fruits	21	33	48	56	68	81	104	130	179	325
Sugar, salt and spices	392	499	567	597	636	680	706	733	804	902
Beverages, refreshments, processed foods, etc.	896	1,257	1,562	1,907	2,128	2,411	2,759	3,948	4,977	10,456
Food	5,278	6,708	7,836	8,786	9,510	10,581	11,649	13,237	15,457	21,619
Betel leaf, tobacco and intoxicants	227	315	373	366	429	482	478	505	552	845
Fuel for cooking and lighting	16,468	20,717	24,451	28,206	30,254	33,162	36,928	42,654	47,018	70,885
Clothing and footwear	1,408	1,819	2,050	2,468	2,795	3,229	3,644	4,389	5,212	8,571
Education	186	295	446	580	754	1,064	1,418	2,131	2,995	6,863
Medical care	541	988	1,152	1,346	1,545	1,940	2,717	2,911	4,752	8,996
Misc. goods, entertainment	1,147	1,707	2,056	2,703	3,127	3,551	4,181	4,974	6,141	10,085
Conveyance	192	339	478	620	800	1,075	1,408	1,903	2,721	6,537
Consumer services excl. conveyance	215	439	634	923	1,308	1,654	2,428	3,115	4,557	10,549
Rent	17	38	72	84	137	154	213	283	445	1,061
Taxes and cesses	22	38	52	79	83	118	140	172	223	581
Durables	219	318	499	585	807	1,110	1,348	2,129	3,186	11,065
Non-foods	12,023	17,711	22,593	27,698	33,657	40,700	50,784	64,279	87,259	185,635
Total	17,301	24,419	30,429	36,484	43,167	51,281	62,432	77,517	102,715	207,254

Note: the values have been rounded off to the nearest whole number
Source: derived by authors

DISTRIBUTION OF HOUSEHOLDS ACCORDING TO TYPES OF PRODUCT USED

Data on the distribution of households according to the various kinds of fuel or housing and various durables provides insight that may be fruitfully used in policy formulation. As this data is not in terms of MPCE, emissions calculations are not being made. However, the emissions implications will become obvious wherever comparisons are necessary. For durables, the non-availability of data reduces the time period to 1993-1994 to 2009-2010.

Fuel for cooking

It has been seen that emissions from the use of cooking and lighting fuel constitute the highest proportion of total emissions for all consumer groups. These emissions have increased enormously over time and one may assign a much greater responsibility to urban and upper class India. Policy measures, however, require that specific 'types' of fuel used by households and their relative carbon emissions are understood. For this, data on the distribution of households according to the nature of fuel employed may be observed.

Firewood and chips has been the dominant cooking fuel in India, and it remains so, but the importance of LPG has grown steadily, especially after 1999. The use of LPG went up by 13% between 1999-2000 and 2004-2005, whilst the use of kerosene and firewood declined by 12% and 1% respectively [34, 35]. Although the role of firewood remains significant, LPG is now the dominant cooking fuel in urban India.

Two policies that could have had an impact on emissions from the use of firewood in rural India were the National Program on Improved 'Chullahs' (cook-stoves) and Joint Forest Management (JFM) initiated in 1983 and 1990 respectively. The first program provided fuel efficient cook-stoves at highly subsidized (50 per cent) prices. The objective was fuel efficiency – but it was, for a variety of reasons (such as the free availability of firewood), not successful [36]. The second program (JFM) could have controlled the use of firewood and also increased forest cover, thereby reducing carbon emissions. The former did not occur because there were no cheap substitutes for firewood, and the latter occurred marginally – between 1990 and 2000 the average annual reforestation rate was 0.57 per cent, this reduced to 0.04 per cent between 2000 and 2005. The total change in forest cover between 1990 and 2005 was only around 6 per cent, and in 2005 the forest cover stood at around 23 per cent of total land area [37]. On the other hand, the LPG program, which was initiated in the 1950s but gathered momentum in the 1960s, was very successful. However, even though LPG was subsidized, only urban households in the middle and higher income groups could afford it, and access to the gas cylinders was poor in the rural areas [38]. This bias has led to the rural-urban difference seen in Figure 6.

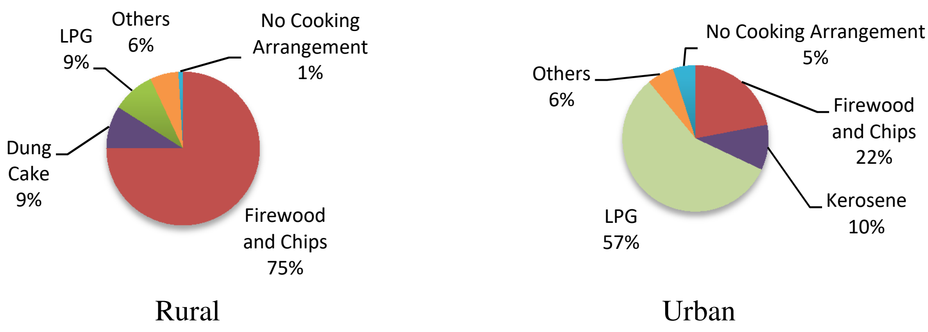

Figure 6. Distribution of households according to the fuel used for cooking, 2004-2005 (source: NSS, 2007, pp 8-9)

Data on emissions by various fuels is available from sources such as biomassenergycentre.org.uk or volker-quaschning.de. The latter says that emissions in kg of CO_2 per kilo-watt-hour is 0.39 for wood, 0.34 for hard coal, 0.26 for kerosene and 0.23 for LPG. It also says that emissions for electricity depends on the fuel used and the efficiency of the power plant – if it burns coal and the efficiency is 34%, 1 kg. CO_2 is emitted per kilo-watt-hour of electricity use.

As emissions from LPG are less than that from firewood and chips or even kerosene, it may be inferred that over time the shift to LPG has kept emissions low. Also, the urban (Figure 6) and higher classes (Figures 7 and 8) are less responsible for per capita emissions due to the greater use of LPG as a cooking fuel.

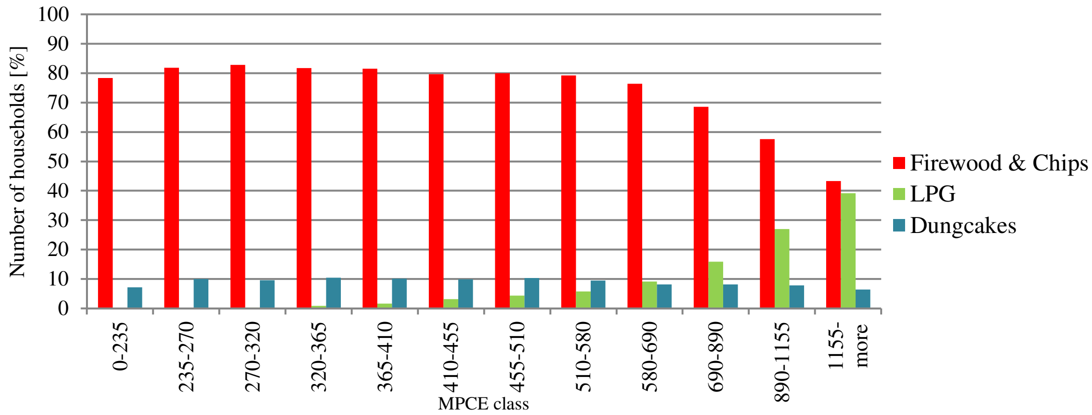

Figure 7. Distribution of rural households according to the primary source of energy used for cooking by MPCE class, 2004-2005
(source: drawn using data from NSS, 2007, p 10)

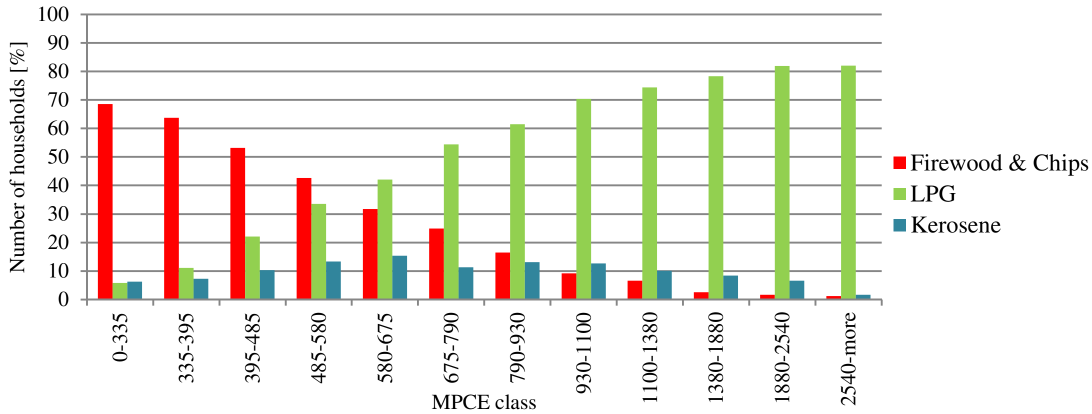

Figure 8. Distribution of urban households according to theprimary source of energy used for cooking by MPCE class, 2004-2005
(source: drawn using data from NSS, 2007, p 10)

Fuel for lighting

Between 1987-1988 and 1993-1994, there has been an increase in the proportion of households using electricity for lighting by 13 percentage points (24 to 37%) in rural areas and 9 percentage points (72 to 83%) in urban areas. In 1993-1994, kerosene remained the main source of energy for lighting in rural India. But a decline had occurred in the percentage of households using kerosene (74 to 62% in rural and 27 to 16% in urban areas) since 1987-1988 [34]. By 2004-2005, kerosene no longer remained the main source of lighting in rural areas and became insignificant in urban areas. There has been an increase in the proportion of households using electricity as the major source of lighting by 7 percentage points (from 48 to 55%) in rural areas and by 3 percentage points (from 89 to 92%) in urban areas between 1999-2000 and 2004-2005. At the same time, there was a drop in the percentage of households using kerosene as the primary source of energy for lighting from 51 to 44% in rural India, and from 10 to 7% in urban India, since 1999-2000 [35].

Hence electricity has become the dominant source of lighting in both rural and urban India, replacing kerosene, but kerosene remains significant for the former. The increasing choice of electricity for lighting, given that in India electricity is produced with low-grade coal and hence emits more per kilo-watt-hour compared to kerosene (or for that matter, any other energy source) has increased per capita emissions over time. Also, the urban (Figure 9) and higher classes (Figures 10 and 11) are more responsible for emissions relative to the others, due to their greater use of electricity for lighting.

The objective of policy makers has always been to encourage electricity use – at first in urban areas, and then in rural areas. There were several rural electrification programs in 1988-1989, 2002 and 2004-2005 [39].

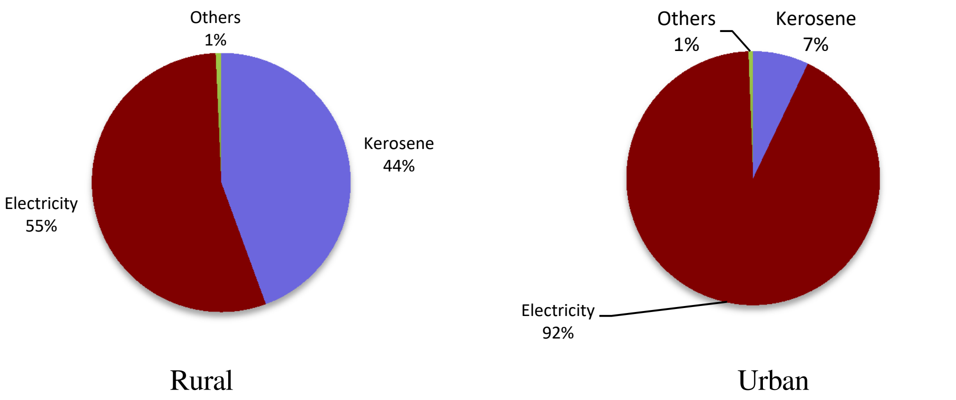

Figure 9. Distribution of households according to the fuel used for lighting, 2004-2005 (source: NSS, 2007, p 13)

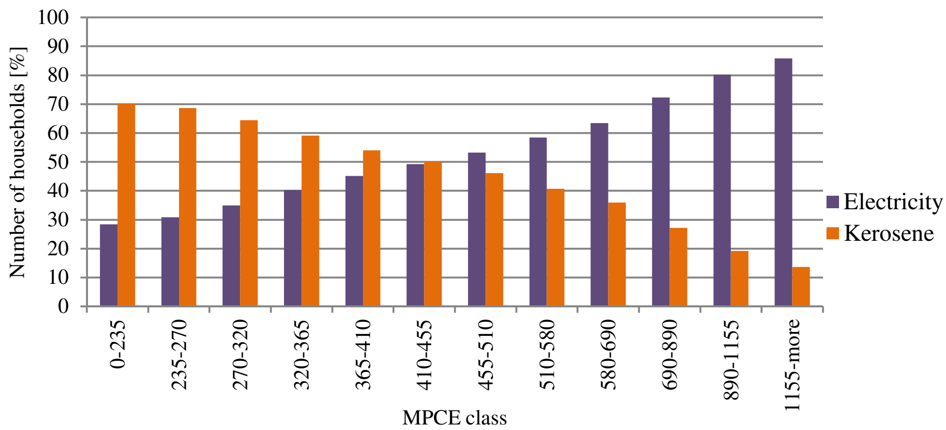

Figure 10. Distribution of rural households by primary source of energy used (electricity and kerosene) for lighting by MPCE class, 2004-2005 (source: drawn using data from NSS, 2007, p 15)

Although the rate of increase in electricity use has been very high, around 20 per cent of the population, mostly in rural areas, is yet to access it [40]. There are differential subsidies on electricity based on the type and quantity of use – households and especially the poorer ones are heavily subsidized [41]. On the other hand, the subsidy on kerosene was ineffective in promoting equitable access to the fuel due to large leakages [42].

Hence government policies and their effectiveness clearly affected the shift to electricity for lighting. The absence of efficiency standards in production, transmission, distribution and use, as well as the use of low quality coal, implied (as Figures 1 and 2 indicate) enormous increases in carbon emissions due to this shift to electricity. It is only near the end of the time span of this study that the National Electricity Policy (2005) and the National Action Plan on Climate Change (2008) spelt out the need to use non-fossils and introduced a tariff structure that favoured them, but even in 2010, renewables constituted only 9 per cent of the total [43].

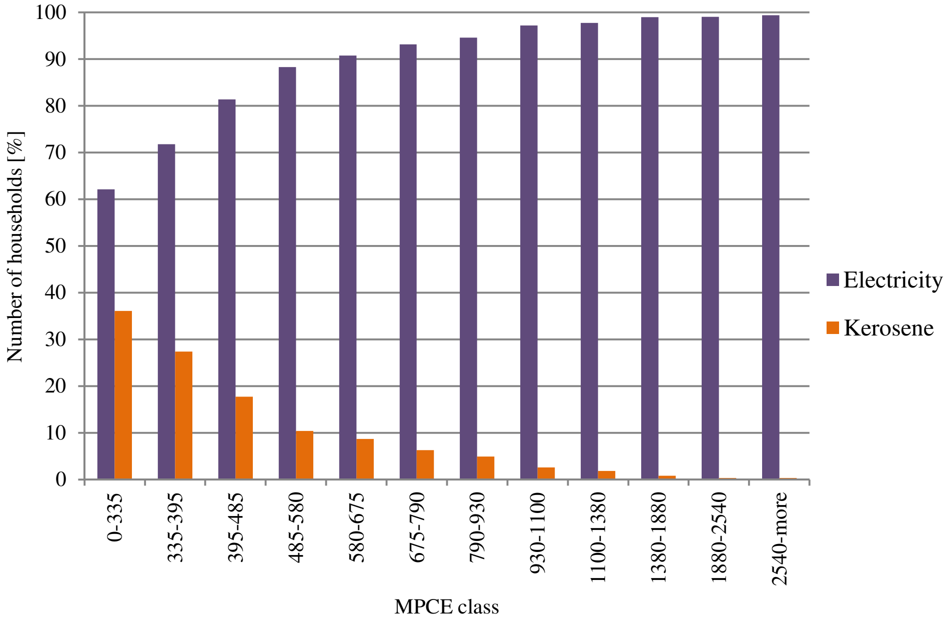

Figure 11. Distribution of urban households by primary source of energy used (electricity and kerosene) for lighting by MPCE class, 2004-2005

As seen earlier (Table 1), the use of energy by each individual for the purpose of cooking and lighting has increased over time, this, combined with the preponderance of electricity (for lighting) is negating the positive impacts of a shift to LPG (as evident from Figures 1 and 2), and upper class and urban India play a prominent role in this process.

Durables

The category 'durables' includes many kinds of goods, some that require energy for their use, and some that do not. The emissions impact of each of these products may be expected to be very different. Once again, therefore, policy decisions would require an understanding of the relative pollution implications of various durables.

As may be expected, since 1993-1994 there has been a rise in the use of durables over time (Tables 6, 7) and urban India as well as the richer classes (Tables 6, 7 and [44]) consume more durables compared to their rural and poorer counterparts, with a steep jump in per capita consumption between the 9th and 10th expenditure decile classes [33]. For durables, therefore, the postulate that the urban and higher classes cause more emissions per capita holds. The 'percentage' increase is greater for motorcycles and scooters, TVs, refrigerators and washing machines in rural areas and much greater for motor cars and jeeps in urban areas. For air conditioners and air coolers, too, the percent increase is substantial – and similar – in urban and rural areas (Table 7).

There are only a few (non-electronic, non-motorized) exceptions, most notably bicycles, whose use (in 2009-2010) decreases (in terms of percentages of possessor households) after a particular decile class (for bicycles it is the 7th decile class in rural areas and the 3rd decile class in urban areas) [44], although there has been an overall (though not significant) increase in the use of bicycles (Tables 6, 7). It is interesting, moreover, to note that other than bedsteads (and fans in urban areas), the average number of individual durable goods possessed is less than 1 in 1999-2000.

Table 6. Percentage of households possessing various durable goods, rural and urban

Item	Rural [%]			Urban [%]		
	1993-1994	1999-2000	2009-2010	1993-1994	1999-2000	2009-2010
Bedstead	68.7	79.1	89.4	74.3	81.8	89.8
Radio	26.8	30.4	26.5	41.8	35.1	23.3
TV	-	18.7	41.7	-	59.5	75.8
Tape recorder/CD player	5.2	9.1	-	21.6	27.8	-
Electric fan	15.9	26.3	55.2	56.6	68.5	90.6
Air cooler/AC	0.5	1.7	5.0	6.4	10.9	21.4
Bicycle	32.7	40.5	54.9	37.1	39.0	41.1
Motor cycle/scooter	2.1	4.5	13.9	11.6	18.4	33.0
Motor car/jeep	0.2	0.4	1.4	1.2	2.7	6.5
Refrigerator	0.9	2.7	7.1	12.3	22.9	39.0
Washing machine	0.2	0.6	1.8	4.1	8.9	19.9
Sewing machine	5.6	7.4	10.9	18.4	20.3	21.7

Source: derived from NSS, 1997b, pp 14-15, NSS, 2001, pp A-468, A-501, NSS, 2012, p 34

Table 7. Average number of durables possessed per household and percent change, 1993-1994 to 1999-2000, rural and urban

Item	Rural			Urban		
	1993-1994	1999-2000	Percent change	1993-1994	1999-2000	Percent change
Bedstead	2.1	2.5	19	1.8	2.1	17
Radio	0.3	0.3	0	0.4	0.4	0
TV/VCR/VCP	0.1	0.2*	100	0.4	0.6*	50
Tape recorder/CD player	0.1#	0.1	0	0.2#	0.3	50
Electric fan	0.3	0.4	33	1.1	1.4	27
Air cooler/AC	0.01	0.02	100	0.1	0.2	100
Bicycle	0.4	0.5	25	0.4	0.5	25
Motor cycle/scooter	0.02	0.05	150	0.1	0.2	100
Motor car/jeep	0.002	0.004	100	0.01	0.1	900
Refrigerator	0.01	0.03	200	0.1	0.2	100
Washing machine	0.003	0.01	233	0.04	0.1	150
Sewing machine	0.1	0.1	0	0.2	0.2	0

Note: this data is, when possible, corrected to one decimal place
* Excludes VCR/VCP
# Excludes CD player
Source: NSS, 2001, pp A468-A501, NSS, 1997b, pp A1-A2, A51-A52

Following liberalization and reformation in 1991-1992, banks and financial institutions were allowed to provide loans (without stringent conditions) for the purchase of motorized vehicles. Also, liberalized financial markets created the possibility of paying for durables in easy monthly instalments [45]. However, prices as well as greater access to electricity allowed only urban Indians to take advantage of these changes. This is reflected in the changes and their difference over the study period. Amongst durables, the products of greatest concern are motorized vehicles, whose emissions implications from production as well as use are the highest [46]. Emission norms were first instituted in 1991, and then catalytic converters and unleaded petrol were made mandatory. India is following EU emissions norms since 1999, albeit with a time lag. However, the inspection and maintenance program is imperfect and corrupt. Also, like the EU, there are no limits on CO_2 emissions from motorized vehicles [47]. While there are investments on public transport and it continues to be preferred by the majority due to much lower costs, a tax on fuel has been the only instrument used to discourage commuters from using low occupancy private transport [48].

Dwelling units

The NSS does not include dwelling units in the data on MPCE (although 'maintenance' is included), perhaps because expenditures on purchasing houses are lump sum and infrequent. As housing has been identified to be a product with a high carbon footprint [49], it would have been useful if one could have compared emissions due to the monthly 'consumption' of housing vis-a-vis other products. In the absence of this possibility, types of housing (on which data exists) and the manner in which this is changing in India are observed. The nature of dwelling units, that is whether they are 'pucca' (made with brick, cement, steel, etc.) or 'katcha' (made with natural materials) is important from the perspective of emissions. Although no exact calculations of carbon emissions for the two types of dwelling unit are available, the list of materials for each type [50] allows one to infer that the construction of 'pucca' houses, for the same floor area, causes much more carbon emissions, as it is much more energy intensive compared to the construction of 'katcha' houses. Also, statements regarding the difference between the two in terms of carbon emissions can be found in websites such as www.yourhome.gov.au /technical/fs56.html [Your Home Technical Manual 5.6, Mud Brick (Adobe)].

By the end of the first decade of the 21st century, 'pucca' houses dominate the scenario (Figure 12), replacing 'katcha' and 'semi-katcha' houses. The rate of change is far greater in rural India, whilst the possibility of change in urban India (which had a high percentage of 'pucca' houses to begin with) was itself limited. It may then be deduced that this pronounced shift in the direction of 'pucca' houses has vastly increased carbon emissions. Moreover, the urban (Figure 12) and higher classes [33] are more responsible, the latter also because they occupy larger covered areas. It should, however, be noted that the percentage of 'pucca' dwellings in rural areas (50% in 2007-2008) is not at all small, and the average covered area is marginally greater in rural compared to urban areas [33].

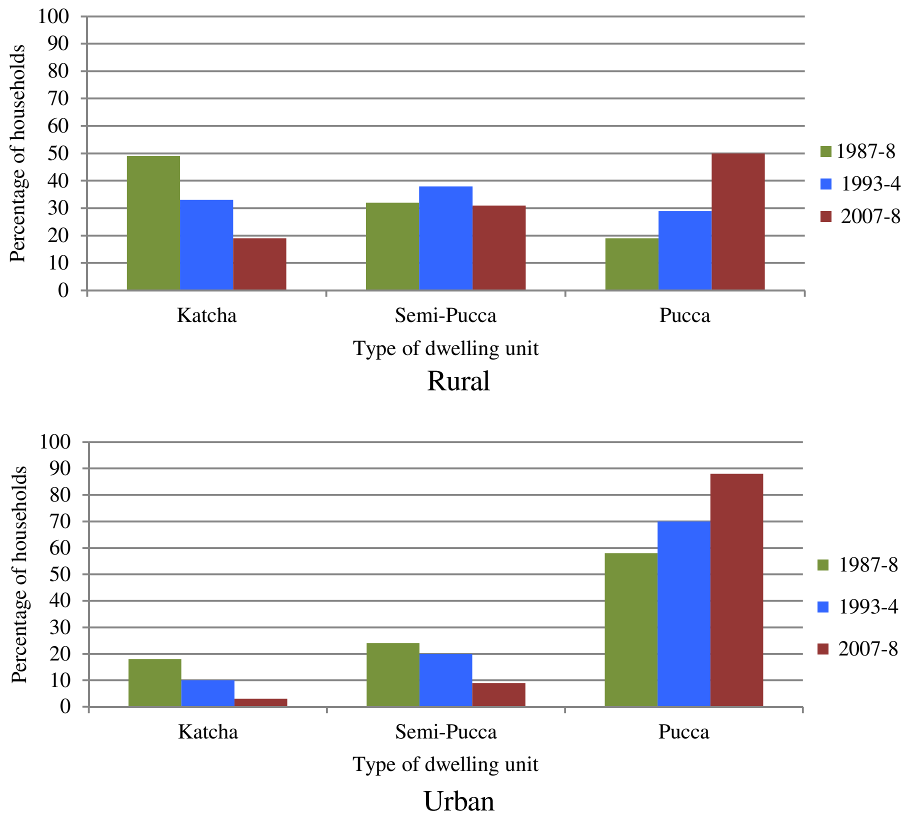

Figure 12. Distribution of households according to the type of dwelling unit, 1987-8, 1993-4, 2007-8 (source: NSS, 2010, pp 32-33)

The liberalization of 1991-1992 also allowed banks and financial institutions to provide easy loans to both purchasers and builders of 'pucca' houses. Also, schemes to provide affordable housing to the urban poor have existed since the 1950s, but they have had minimal impact. It is the liberalized loans that contributed to the enormous increase in the construction of 'pucca' houses in both rural and urban areas [51].

CONCLUSIONS

Over 1987-1988 to 2007-2008, both the total as well as the composition of consumption has changed such that there are more emissions per person. The more significant changes are a fall in emissions due to cereals and a rise in emissions due to fuel for cooking and lighting, as well as a set of services including conveyance, medical care and education. Second, at the per capita level, urban India is far more responsible (for carbon emissions) in terms of quantity as well as the product mix. The difference is due to the greater predominance of non-foods in urban India and is particularly significant in the case of fuel for cooking and lighting. As rural India compares favourably relative to urban India in terms of per capita emissions, its dominance in total population (70 per cent in 2007-2008) has a positive impact on per capita emissions of the average Indian. Third, as one ascends the expenditure class ladder, the carbon footprint at the per capita level goes up, both due to the quantity and the composition of consumption – the latter being increasingly weighed in favour of non-foods. There is a significant jump in emissions between the second highest and highest decile classes in both urban and rural India – hence the highest decile class may be clearly earmarked for policies to abate carbon emissions.

A few interesting features need to be highlighted. One, the consumption of cereals has declined over time, and this decline is more for the urban and higher classes – as emissions intensity (grams per rupee) of cereals is high, this should have had a positive effect over time and reduced the responsibilities of urban and higher class India – however, because of the greater impact of non-foods relative to food, this impact is not visible. Two, the only product that allows the urban and affluent to score a point over the rural and less affluent is LPG used in cooking, which emits far less per unit energy use compared to fuelwood or kerosene. However, this advantage, too, is eclipsed by the greater use of electricity for lighting in urban areas as well as by those who are better off.

In general, most policies taken up before 2008 had objectives other than emissions reduction (such as energy efficiency), although some of them might have inadvertently had a beneficial effect on emissions. It is only in recent years that climate abatement is in itself a policy objective [52]. A 'carbon tax' has been introduced for coal, and CNG/LPG have become mandatory for some forms of public transport in big cities. Electricity subsidies have been generally reduced, but increased for renewable sources. Also, as has been seen, policies favoured urban India – such as Operation Flood, the promotion of LPG for cooking, providing access to electricity and housing schemes. In fact, policies such as easy loans encouraged consumption (and emissions thereof) in urban India. The urban bias is being corrected to some extent – for example, LPGs are being made more available in rural areas, and general subsidies have been replaced by subsidies for low income groups. There are programs of rural electrification using renewables – in particular, solar energy. On the whole, however, existing policies are far from sufficient for India to keep its recent promise to cut the emissions intensity of GDP (from 2005 levels) by 33-35 per cent by 2030 [53].

What are the implications of the results in terms of policy? Currently consumption expenditure is heavily weighed in favour of cereals. Amongst food items, the emissions intensity of cereals, in grams per rupee, is the highest. Hence in the present scenario a certain amount of shift towards non-cereals (as is occurring), especially in rural India, would improve the average diet and would actually reduce (as is seen in Figures 1 and 2) total emissions. However, one category that requires attention is 'beverages, refreshments and processed foods', whose emissions (and MPCE) are very high for the highest decile class. Amongst non-foods, the major category of concern is fuel for cooking and lighting (more specifically electricity for lighting and fuelwood for cooking), but services like conveyance, medical care and education and conveyance also require attention. Further, nearly all products are of concern when one looks at the uppermost decile class – especially in urban areas but also in rural. The consumption of durables, though not substantial as yet, is increasing rapidly. Amongst durables the category to watch out for is motor vehicles (both cars and bikes), but the use of several electronic goods like refrigerators, televisions, air conditioners and washing machines are also increasing rapidly (though their current values are low) in rural areas. Newer products, in particular mobile phones and computers are not included in the reports of 2007-2008 and earlier. They make an appearance in Report No. 541 of 2009-2010, where it is seen that their use (in terms of the number of possessor households) increases considerably with expenditure class. Finally, there has occurred a sea change in the nature of housing, with a predominance of 'pucca' houses whose construction causes greater emissions.

Most of the changes – such as the conversion to 'pucca' houses, electrification and the purchase of electronic goods – are perhaps inevitable – as they improve the quality of living. For these, policy can only concentrate on reducing emissions caused by their use. In a few cases, such as for conveyance, one can think of substitutes or try to control demand.

The trends identified in this paper will intensify in the immediate future, not only because real per capita expenditure is going up, but also because rural India is emulating its urban counterpart – it is shifting to electricity and 'pucca' houses, and purchasing motor vehicles – in fact, the per cent increase in some of these products is much greater – this forebodes a dangerous future that would be similar to the current situation in China – where rural household energy consumption is higher than urban, one of the reasons being the replacement of bicycles with motorbikes [54]. Further, the rapid urbanization of the Indian population (at around 2.7% per year) increases the impact of the energy guzzling urban consumer.

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