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A Review on Household's Carbon Dioxide Emission of Municipalities

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Abstract:

The major issue of today's era is to combat global warming and conserve environment. The emissions of different greenhouse gases from sources are major cause of concern. Municipalities are considered as one of the main sources of carbon emission of the countries and also the key area of emission reduction potential. India is the second largest in population, fourth largest in energy consumption and third largest in greenhouse producer and burns ten folds fuel wood as compare to United State. By adopting carbon emission reduction practices, carbon credits can be earned which can be traded in international market. This study of carbon dioxide emission of municipalities suggests that the emission reduction policies of municipalities can earn carbon credits for countries. In these emission reduction practices Household's emissions can play important role because it accounts for about 78 % of the total emission. To reduce carbon emission of countries, carbon emission reduction strategies can be adopted and in these considerations the household activities are the major cause of concern. Electricity, gas use, transportation, food etc. are the major carbon emission contributors and nevertheless these can be served as the major carbon emission reduction activities. Present study suggests that the reduction in household emissions can result in achieving the carbon emission reduction target of country. Few data from studies on emission reduction policies facilitates the future scope and need of household carbon emission of municipalities study.

Keywords: Environmental carbon trading, Electricity, Food, Gas use, Household carbon emission, Municipalities, Transportation.

1.0 Introduction:

Household carbon emissions from cities are one of the chief causes of greenhouse gas emissions because more than half of the population is living in cities and global environment is transforming at high rate due to urbanisation. Cities are not only 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 DE et al., 2006; Bai XM 2007; Kennedy C et al., 2010; Lin et al., 2010), Dhakal 2010; Kaye et al., 2006). Studies from different researchers reveals the life style and living standard of cities are get affected by urbanization and life style of city's households plays important role in deciding the energy use and the total greenhouse gas emission of municipality (Lenzen et al.,2011; Bai XM et al.,2012; Weisz H et al., 2010; Schipper et al., 1989; Weiy et al., 2007; Jones CM et al., 2011).These municipality sectors are therefore can be targeted to implement the carbon emission reduction strategies. Carbon management in cities is increasingly focusing on individuals, households, and communities due to population growth and improved living standards of urban residents Jones CM et al., 2011; HM Government 2006; Dietz T et al., 2009; Druckman et al., 2009; Wang et al., 2009; Feng et al., 2010).To reduce the total carbon dioxide emission of municipalities all household activities should be analysed in detailed and structured way and the key factors for carbon emission reduction should be identified. On the basis of the municipality's structure and different household consumption pattern a proper tailor made planning should be implemented to achieve the carbon emission target of countries. It is now widely accepted that increasing atmospheric concentrations of greenhouse gases (GHGs) are responsible for increasing global temperatures that has resulted in the phenomenon known as climate change (IPCC climate change 2007). Increasing population, energy use and higher standard of living are some of the main activities responsible for these carbon dioxide emissions.

Considering the different carbon emission activities the main contributor is electricity generation while other activities like transportation, industrial activities and households activities are also responsible for these emissions. A tremendous increase in total greenhouse gas emission of municipalities is observed which also get affected by economy of the country. The greenhouse gas emission of US is almost double than the China supports the fact. Higher economy of the country raises the per capita income which could lead to higher carbon emission.In 2011 India was the fourth largest carbon dioxide emitter and its contribution towards total emission was around 7%. The Intergovernmental Panel on Climate Change (IPCC) have 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). According to a World Bank Survey since 1995 Indian environmental conditions are getting much more attention due to frequent and rapid reporting of environmental issues and their remediation. To combat the environmental status of developed nation India has to fight many environmental challenges nevertheless this can be an opportunity for Indian environmental quality status. India has enormous pollution challenges of air, water and soil pollution and to embark on different environmental challenges individual and corporate are mounting to deal with the problems of emission and its effects. To start with the greenhouse gas emission reduction policies the strategies of measuring carbon foot printing of municipality could serve as a first step.

2.0 Carbon Foot Printing:

A carbon footprint is the total carbon emission from an individual or municipality by their different activities. 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 can also be considered as 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). To challenge the problem of global warming and climate change with the interest of reducing greenhouse gas emission the carbon footprint of an individual or organisation should be evaluated. In deciding the carbon foot print of any municipality many factor play important role like population, income per capita and use of different sources of energy and these emission can be reduced by using energy efficient equipment, alternative and renewable energy resources and proper solutions to waste generation problems. Evaluation of carbon foot print can help to identify the climatic impact of these emissions and play a major role in constructing the policies for green housegas emission reporting and their reduction. Nevertheless the accounting of carbon foot print of an organisation not only promotes the positive image of the organisation but also helps in challenging the problems of climate change.

3.0 Types of Carbon Foot Print:

There are different types of carbon footprint, e.g. for organisations, individuals, products, services, and events. Different types of carbon footprint have different methods and boundaries. The various approaches and types of greenhouse gas assessment are

a) Product Carbon Footprint is related to the total greenhouse gas emission related to the distinct products or services. For the assessment of product carbon foot print two approaches can be consider either the total carbon emission related to the manufacturing of that product or the emissions related to the marketing, distribution and consumption of that product.
b) Corporate Carbon Footprint is the calculation of the total greenhouse gas emission related to the different activities of an organization.
c) Individual Carbon foot print includes the activities associated with the emission of carbon dioxide from different household activities like energy use, transportation and LPG, food use etc.

Figure 1 shows the flow chart of different factors which decide total carbon foot print of any country. Carbon foot print of any country depends upon its carbon foot print of individual, corporate and product further Individual's carbon foot print depends upon several factors including transportation, Industry, residential, agriculture etc. The residential carbon foot print i.e. carbon foot print of a municipality depends on electricity, petrol/diesel for transport, food clothes and LPG gas consumption by the Individual.

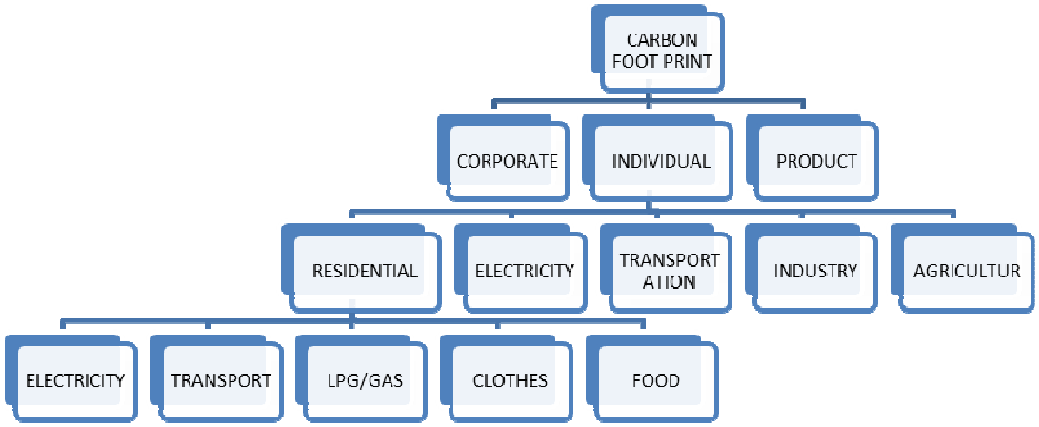

Fig. 1: Flow chart of factors which decide Carbon foot print of any country

According to the Intergovernmental Panel on Climate Change (IPCC), there are a total of 18 greenhouse gases with different global warming potentials, but under the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto protocol, only the following gases are considered for the purposes of carbon accounting (IPCC 1990; UNFCCC 1997): Carbon dioxide, Methane, Nitrous oxide, Hydrofluorocarbons, Per fluorocarbons.

4.0 Household's Carbon Emission Activities:

This paper reviews the different household activities which can be accounted to calculate the individual carbon footprint. A carbon footprint of an individual 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, 2007).It is made up of the sum of two parts, the direct or primary footprint is a measure of our direct emissions of CO2e from the burning of fossil fuels including domestic energy consumption and transportation (e.g. car and plane); and the indirect or secondary footprint is a measure of the indirect CO2e emissions from the whole lifecycle of products and services we use including those associated with their manufacture and eventual breakdown (Tukker and Jansen, 2006).There is increasing awareness of an individual's behavior or lifestyle as a source of global carbon emissions (Bin and Dowlatabadi, 2005). The different household activities which can affect the greenhouse gas emission can be identified and linked together by calculating the carbon foot print of an individual and households. There is increasing awareness of an individual's behaviour or lifestyle as a source of global carbon emissions (Bin et al., 2005). The evaluation of individuals carbon foot print can play a very important role in controlling the carbon emissions from municipality which are the major contributor. In future a concept of individual carbon tax and trading will be needed for greenhouse gas emission management. Carbon emission models may possibly be used in the future as a tool to calculate carbon taxes, allocation of carbon units and the basis for personal carbon trading (O'Donoghue, 1997). Hence to develop the environmental policies and improving environmental status of country the key area of concern will be municipalities because the household consumption stands first in global level with an emission percent of 72 while the government consumption is 10 % and 18% is from investments.

In recent years, several studies have been published on the distribution of household emissions and the role of socio-economic factors for the UK and for other countries. The distributional analysis of the consumption of energy in different household's activities is carried out by many researchers e.g. Burney, 1995; Cohen et al., 2005; Herendeen and Tanaka, 1976; Herendeen et al., 1981; Larivière and Lafrance, 1999; Lenzen et al., 2006; O'Neill and Chen, 2002; Pachauri, 2004; Reinders et al., 2003; Vringer and Blok, 1995),but the association between the emission statistics and the household characteristics is still a area of study. Druckman and Jackson analyze home energy (2008) and total emissions (2009) at the small area level but not the association statistics. The contribution of different

municipal activities towards total carbon footprint is shown in Figure 2.

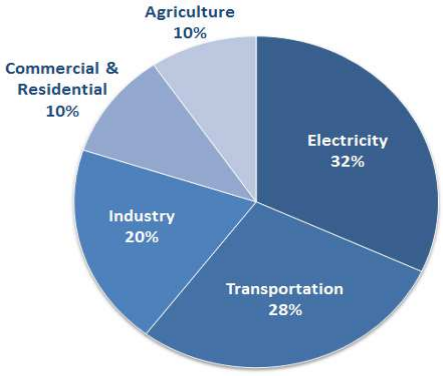

Fig. 2: Breakdown of a typical municipalities carbon foot print

5.0 Major Carbon Emitter Household Activities:

To study the carbon foot print of households first the identification of different carbon emitter activities are necessary which can play important role in emission coefficient of greenhouse gases. The major activities which accounts for the carbon emission calculation are:

Domestic gas: The main use of domestic gas in household is for cooking and home heating. The size of the household, climatic regimes decides the extent of greenhouse gas emission due to the use of domestic gas.

Electricity: This is another one of the significant attributes of household carbon emission becausemany household appliances run on electricity and hence accounts for carbon emission. In UK the average home uses about 4,000 units of electricity a year. Using this figure, we can calculate that domestic electricity use of an average household which accounts for about a tonne of CO2 per person per year. This is why the government is encouraging the development of renewable power sources such as solar and wind.

Car: There is one car for every two people in the UK, and each one travels an average of about 9,000 miles a year. This emission statistics are different for smaller or newer cars as compared to older ones**.**

Food: The food production system accounts as one of the major contributor of greenhouse gas emitter. This is mainly because of the emissions coming from the livestock farming and heavy use of fertilizers which emit nitrous oxide through breakdown, one of the greenhouse gases, hundred times more powerful than carbon di oxide. A big difference to greenhouse gas emission in food production system can be brought about by adopting veganism.

Clothing: The production of different types of fabric like wool, cotton has a very high degree of carbon emission coefficients. The carbon foot print of natural fibres is generally 20 times higher than its weight. In comparison to these, manmade fibers emit lesser greenhouse gases.

Paper: The carbon foot print of virgin paper is incredibly higher as compared to the recycled newsprints. Facilitating the use of recycled paper can reduce the greenhouse gas emission to larger extent**.**

Above activities are considered as major contributors towards calculating carbon foot print of an individual or municipality. Breakdown of typical person's carbon footprint is shown in Fig. 3

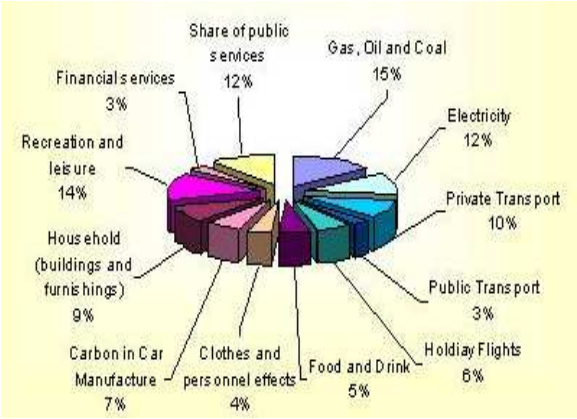

Fig. 3: Breakdown of typical person's carbon foot print

6.0 Studies on Carbon Footprint of Municipalities of Some Countries:

Many researchers studied the carbon foot print of individuals, industries and products of national and municipal levels. Due to growing climate concern the accounting of carbon foot print is becoming very popular for researchers. A cross country study of carbon foot print by Hertwich and Peters, 2009 concluded the extent of carbon foot print increases with increase in the GDP of the country based on the Global trade analysis data. The consumption pattern of any country is highly influenced by the per capita income. In view of the reduction in carbon emission by the countries developed nations are shifting their industries to less developed countries as a result of which the carbon foot print of producing industry increases as compared to the consuming country. According to Druckman and Jackson, 2009 in UK about 40 % of the consumption carbon foot print comes from outside of the country and this contribution is continuously increasing. Hence in deciding the carbon foot prints of any country the household's income level and the international trade practices of that country play important role. The carbon emission studies carried out in many municipalities suggest that the household characteristics play very important role in deciding the carbon emission quotient of any municipality. Carbon footprint data of some countries are shown in figure 4.

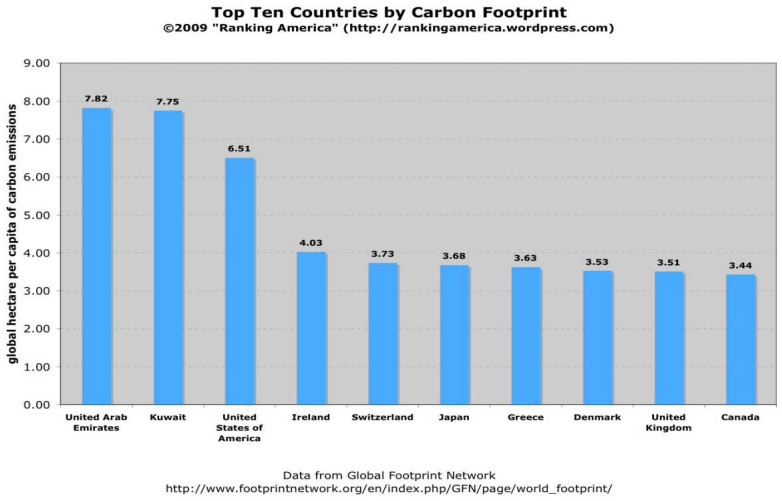

Fig. 4: Carbon footprint of different countries.

The study of carbon foot print of a Norwegian city by Larsen and Hertwich, 2009 and Weber and Matthews, 2007 revealed the major portion of carbon footprint of municipality comes from indirect emission while household emission accounts for only 30%.Hence a shift in the research study trend from production to consumption perspective is indicated. To combat climate change the accounting of household carbon footprint could help to develop local climate strategies. According to a carbon foot analysis study of UK by Haq and Owen, 2009 the average carbon foot print per capita is 12.58 tonnes per year in which household and transportation contribution is of around 60 % while in 2001 it was reported 20.7 tonnes by Stockholm environmental Institute at the University of York. The different energy uses in household are given in table 1.

Table 1: Average energy use in the home

Source	Electricity use
Space heating	61%
Water heating	23%
Lighting and appliances	13%
Cooking	3%

(http://www.canwesavetheworld.com/uk/index.html)

7.0 Studies on Carbon Footprint for Household Carbon Emission of Indian Municipalities:

As far as the carbon foot print studies of Indian municipalities are concerned, India is currently second most populous country in the world and third biggest greenhouse gas emitter contributing

about 5.3%of the total global emissions. As India is one of the fast growing economies in the world the transportation and per capita income is increasing and this eventually increases the India's contribution in global greenhouse emission. Higher level of energy consumption is a measure of concern because it not only deteriorates the air quality of municipalities but also contribute to the degradation of the environment. In an average household the size and the different energy uses are important to consider because these will serve as the locai for the reduction of greenhouse gas emission from municipalities. The energy use in terms of different appliances in the house is shown in Table 2.

Table 2: Electricity use in different appliances in the house

Source	Electricity use (excluding electric heating)
Lighting	19%
Consumer electrics	19%
Cold appliances	18%
Wet appliances	15%
Cooking	15%
ICT (computers etc)	9%
Other	5%

(http://www.canwesavetheworld.com/uk/index.html)

In total, consumer electronics use the same amount of energy as lighting. The electronic jungle of wide-screen TVs, digi boxes and DVDS found in many households is also taking its toll on the environment, even when these appliances are seemingly switched off. A digital TV set-top box on standby uses enough energy to emit 0.06 tonnes of CO2 in a year. Emissions from households and commercial establishments occur due to energy consumption for cooking, lighting, heating and household appliances. Studies are carried out using input-output analysis and aggregated household expenditure survey data to calculate the CO2emissions from energy consumption for different groups of households for the year 1989–1990 (INCCA, 2010; BSI, 2008; Garg et al., 2004, 2006; Murthy et al., 1997; Pachauri et al., 2004).A study on carbon emission of India in 2007 suggests that the residential sectors emits carbon many folds than commercial sectors and also the target area for achieving the reduction potential of carbon emission by using the existing and new energy efficiency techniques (Gupta et al., 2006; Reddy at al., 2009). The carbon dioxide equivalent emission by different cities during 2009 –2010 was studied by Ramachandra et al.2015.The percentage emission by different sectors in some municipalities of India is given in table 3 which indicates Transportation and Domestic sectors are the major contributor in total emission of the municipalities.

Table 3: Greenhouse Gas Foot Print of some Indian Municipalities (% emission). (Ramachandra et al., 2015)

Municipality	**Domestic**	**Industry**	**Agriculture & livestock**	**Waste and waste water**	**Transportation**	**Electricity consumption**
Mumbai	37.2	7.89	0.12	8.46	17.41	23.44
Hyderabad	11	11.38	0.46	6.7	56.86	7.54
Chennai	39.01	20.25	0.05	3.72	19.5	15.77
Bangalore	21.59	12.31	1.31	5.73	43.48	15.46
Ahmedabad	27.88	22.41	1.52	7.17	24.92	11.8
Delhi	30.26	7.89	2.49	5.78	32.08	19.28

Table 4: CO_2equi.Emission/Capita of some Indian Municipalities (Ramachandra et al., 2015)

Municipality	**CO2 equi. Emission/ Capita (Tonne)**
Delhi	2.40
Mumbai	1.84
Kolkata	3.29
Chennai	4.79
Bangalore	2.23
Hyderabad	2.29
Ahmedabad	1.80

The per capita carbon dioxide equivalent emission of the different municipalities and the results are shown in table 4 (Ramchandra et al., 2015). It reveals the per capita emission is highest in Chennai followed by Kolkata and then Delhi with emission value of 4.79, 3.29, 2.40 Tonnes of carbon dioxide equivalent emissions respectively. A study from Central East Indian locations also reports the emission value of 4.7 Tonnes carbon dioxide equivalent emission per year (Nair, 2013). Household emission data from central India are limited indicating future scope of the study in this area.

8.0 Conclusion:

Being the highest contributor towards greenhouse emission the municipalities are getting more attention and in reducing carbon emission. The review of literature from different countries reveals that the major contributor is household emission. Hence all household characteristics should be considered to achieve emission reduction from this sector. The study of household carbon emission of municipalities could result in finding 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. The target of carbon emission reduction though municipalities can be easily achieved.

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