

Developing Framework for Assessment of Carbon Characteristics of Neighbourhoods in Indian Context

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ABSTRACT: With rapid urbanization and industrialization across the globe, climate change and other associated problems are increasing, which gives concern to everyone to find ways to control the reasons which caused climate change eg. Greenhouse gas emissions also many ways identified to find the alternative and sustainable way to make or push our cities and neighbourhood towards low carbon development eg. Green cities, solar cities, Eco cities, Smart cities and low carbon cities. The aim of this work is to study the various concepts related to low carbon cities and to identify suitable indicators and parameters at the neighbourhood level in order to develop a framework for assessing the neighbourhoods in terms of its carbon character. This study will help to identify the areas in which there is need to put more focus to promote low carbon development. This will also help to compare the carbon characteristics of different type of neighbourhoods on the basis of its consumption pattern.

KEYWORDS: LOW CARBON DEVELOPMENT, LOW CARBON NEIGHBOURHOODS, LOW CARBON FRAMEWORK, CARBON FOOTPRINT

I. INTRODUCTION

Climate change- is a very simple term- it implies a change in climate. 'Global Warming' is yet another term that is frequently used. These two terms together lead us to think that climate change is occurring on a global scale, and, as a result, the climate is warming up, little by little(Firodia, 2017).

Climate change takes place due to the increased concentration of greenhouse gases in the atmosphere and has emerged as a serious global environmental threat and poses a challenge to mankind. According to the third assessment report (TAR) of the intergovernmental panel for climate change (IPCC), the increase in the concentration of GHG in the atmosphere during the last 100 years has caused the mean temperature to rise by 0.4-0.8 Degree C globally(Watson, 2001).

The Report, "Hot Cities: battle-ground for climate change" from the centre of the united nation for human settlements (UN-Habitat) has stated that cities are "Responsible for 75 percent of global energy consumption and 80 percent of greenhouse gas emissions"(Anon., 2011); while Clinton foundation suggests that cities contribute "approximately 75 percent of all heat-trapping greenhouse gas emissions to our atmosphere, while only comprising 2 percent of land mass" The city's Carbon footprint is directly proportional to the high rate of urbanization in its present form. Urban density, form and spatial organization can have a wide variety of implications for a city's greenhouse gas emissions. The high concentrations of people and economic activities in urban areas can lead to 'economies' of scale, proximity, and agglomeration that can have a positive impact on energy use and associated emissions(Seth, 2017). Research by the World Bank of 120 cities around the world indicates urban populations over the past two decades have been growing at more than 1.7% per annum, with the urban footprint of cities growing at more than 3.3% annually. The world strives to reduce (GHG) emissions, through low carbon footprints to reduce vulnerability to the impact of climate change(Angel, et al., September 2005).

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

Thus it is inevitable that cities need to be studied and understood in this context. As mentioned earlier cities contribute to almost 75% of the total emissions. All the metropolitan cities in their process of urbanization and development have been energy guzzling cities. So cities which are experiencing rapid urbanization and development should be paid due attention towards low carbon development

A target can be achieved only by proper planning at various levels. In case of the environment, Intergovernmental Panel on Climate change (IPCC) has set targets at the global level. These are enshrined in Kyoto protocol and 'Agenda 21' published at first earth summit. This is 'Macro approach. To achieve the 'Macro' target we have to plan at 'Micro' levels. Such plans have to be in line with macro plans but need to be based on local needs. India too has as prepared its macro plan called 'National action plan on Climate change (NAPCC). **Cities should give up 'Carbon intensive' development and adopt 'Low Carbon' development.**

My study if it will do on city level will be the macro plan but I have selected the micro approach for doing study at neighbourhood level.

We have considered neighbourhoods as our area of interest in terms of low carbon development because city level studies are common and much focus is not given on developing neighbourhood level plans. Carbon emission is majorly related to the consumption pattern of people. So, low carbon neighbourhood approach will bring a behavioural change among people which will help achieving carbon efficient cities because neighbourhoods are considered as basic unit of a city. Assessing the carbon characteristics of neighbourhoods will help in developing low carbon neighbourhoods by applying certain strategic interventions.

II. LOW-CARBON NEIGHBOURHOOD

A neighbourhood that practices sustainable clean technology, low carbon practices and emits relatively low carbon or greenhouse gas emissions to avoid the negative impacts of climate change called as Low carbon neighbourhood.

"Why create a low carbon neighbourhood?"

- To improve health
- To empower your community
- To improve quality of life
- To benefit the local economy
- To improve resilience
- To address climate change
- To reduce energy bills" (Ellis, 2018)

III. SCOPE

The study is limited to domestic/household sector of neighbourhood.

IV. LOW- CARBON NEIGHBOURHOOD INDICATORS

The focus of the study to understand the indicators through which the carbon characteristics of neighbourhood in Indian context. Energy, environment and transport has been selected as broad indicators for measuring carbon characteristics of neighbourhood. Each main indicator is having sub-indicators. Expert consultation, various studies and literature review guided the selected indicator. Main indicators are categorized in three distinct group as- i) Energy; ii) environment; and iii) Transport; further, detailed in twenty indicators. Each indicator is studied and explained down.

1) **Energy Indicators:** Energy use contributes most of the carbon dioxide emissions which means for low carbon development it's important to study the energy at neighbourhood level. In my study I have selected six indicator in energy sector at household level.

- **Electricity consumption:**

Electricity use is the largest contributor to global warming. More than 60% of all global greenhouse gas emission is due to electricity use in one form or another (world resource institute, 2005). Therefore electricity consumption

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 3, March 2018

should be less or it should be from the renewable source of energy. Average Electricity consumption per household can be compared in neighbourhoods.

- **CO2 emission:**
CO2 emission itself is most important indicator while developing the low carbon neighbourhood. Average Carbon dioxide emission per household can be compared to neighbourhoods.
 - **Cooking fuel source:**
Greenhouse Emission from cooking fuel is significant (Singh, Pachauri, & Zerriff, October 2017). For cooking fuel, two indicators have been selected. Percentage households using cooking fuel as LPG per neighbourhood is the first indicator second is percentage household using firewood and kerosene per neighbourhood. Over two-thirds of Indians use solid fuels to meet daily cooking energy needs (Singh, Pachauri, & Zerriff, October 2017), while LPG fuel is cleaner compared to firewood and kerosene.
 - **Household appliances having 4-5 star ratings:**
Higher ratings in household equipment's lead to savings in energy as well as money in long run (Parikh & Parikh, 2016). Percentage of household appliances having 4-5 energy star ratings will save energy more also will emit less carbon dioxide emission.
 - **Households having renewable energy equipment/source:**
Percentage of households having renewable energy source or equipment's at household level in each neighbourhood is taken another indicator. More the renewable energy generation at a household level lesser will be carbon emission and cleaner will be the environment (Schanes, et al., 2016).
- 2) **Environment Indicators:** Environmental conditions should be healthy for better life. It is very important in terms of low carbon development. Low carbon development is not possible without considering the environmental indicators. Six indicators are selected to study environmental aspects for neighbourhood as population density, green space, built-up area and air quality levels.
- **Population density:**
Higher population density enables fewer expenses on transportation also enables services and amenities that together reduce a community's GHG emissions. So Population density should not be very less because commercial nodes become a challenge also transit system become more motorized transport.
Higher population density means lower energy used in travel and reduces the resource use and emissions from transportation. (Senbel, et al., 2010)
 - **Green cover per total area and open space per capita:**
Green cover per total area of neighbourhood and open space per capita will tell about the green space availability and status of the same. Green cover per total area will be in percentage. While open space per capita will tell about the availability of open space per person. More the green space will be available better will be the environmental health. Green space having many environmental benefits as well as human health benefits. (Heinze, April 25, 2011). Green area and open space also helps to reduce the carbon footprint by carbon sequestration process. (Waran, May, 2001)
 - **Built-up area:**
A developed area i.e. any land on which buildings and/or non-building structures are present. For low carbon neighbourhood the built-up area should be less.
 - **AQI level and PM 10 concentration:**
AQI level and PM 10 concentration is two indicator which selected for checking air quality of neighbourhood. The AQI is an index for reporting daily air quality. It tells you how clean or unhealthy your air is, and what associated health effects might be a concern. The AQI focuses on health affects you may experience within a few hours or days after breathing unhealthy air (Mamta, 2009), While PM10 is particulate matter 10 micrometres or less in diameter which creates problems in breathing also lungs diseases.
Both indicator directly tells about the present status of air in particular neighbourhood. Low carbon neighbourhood or healthy neighbourhood should having AQI levels as minimum as can. Also PM10 concentration should be in limits prescribe by pollution control board.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 3, March 2018

3) **Transport Indicators:** Contribution in carbon footprint is high due to transportation (Schipper, et al., 2011). Transportation indicators also considered for developing the low carbon neighbourhood. Indicators taken for study is Vehicles ownership, income spending on travelling, mode of travel and accessibility to various amenities and services.

- **Vehicle Ownership (2W, 4W Converted into PCU)**

Vehicle ownership in each household varying with two-wheeler and four-wheeler. For comparing the number of two and four wheeler need to convert into Passenger carriage unit. The vehicle ownership in terms of PCU can be calculated by following equation by IRC.

$$\text{Passenger Carriage unit (PCU)} = 0.5 \times \left(\frac{\text{Avg } 2W \times 4.8}{\text{Avg } HH} \right) + 1 \times \left(\frac{\text{Avg } 4W \times 4.8}{\text{Avg } HH} \right)$$

Conversion factor for 2W and 4W is 0.5 and 1. (Anon., 1990), The value of Avg 2W and Avg 4W is ownership in each neighbourhood.

- **Income spend on travelling:**

Travel expenses of households are calculated wrt. To total household income. Percentage of travel expenses should be as minimum as can so that people can depend on the NMTs mode more than motorized transport.

- **Mode of travel (Public and NMTs):**

Travel mode in any neighbourhood use to by two-wheeler and Four-wheeler, by walking and Cycle, IPT, and by Bus. Dependency on public transport and NMTs should be more for low carbon environment. Mode share percentage in public transport and NMTs directly proportional to the healthy neighbourhood.

- **Accessibility indicators:**

There are five indicators under accessibility domain- i) access to public transport ii) access to Health facility iii) access to Recreational facility iv) access to educational facility v) Access to market, Accessibility refers to the ease with which a site or service may be reached or obtained; it can thus be said to measure the relative opportunity for interaction or contact with a given phenomenon such as a park (Gregory, 1986). Accessibility is measured in terms of distance in meters to various services (Public transport, Health facility, Recreational facility, Education facility, and market). More accessible the various services in the neighbourhood more healthy and liveable is the community. Lesser the distance for various services less will be a dependency on Motorized transport mode so does the environmental impact also lesser the carbon emission will emit from motorized transport.

Measuring the quantitative indicators helps to understand the current environmental condition and low carbon character and helps to develop the neighbourhood towards lower carbon emission target leads to Low-carbon neighbourhood.

V. APPLICATION OF WEIGHTAGES TO THE INDICATORS

Delphi method was used to prioritise the Indicators and defining their Weightage. A total of 12 experts, from both private and academic sectors with expertise in urban/environment/social planning, project management, neighbourhood development and policymaking, were involved in the Delphi study.

With 'expert opinion survey' weight is given to indicators and sub indicators. Generated weight for three main indicators out of 1 is .3927 for energy, .291 for environment and .3163 for transport. Further weights for sub indicators is given on the basis of importance shown in the table 1.

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Vol. 7, Issue 3, March 2018

Table 1: Indicator Weights based on Expert Opinion Survey

Indicator	Sub-Indicators	Unit	W
ENERGY (.3927)	Electricity consumption	Kwh/HH	0.0972
	% of households LPG fuel consumption for cooking purpose	Percent	0.0401
	% of households Kerosene and firewood consumption	Percent	0.0185
	% Of household applianceshaving 4-5 star ratings	Percent	0.0345
	CO2 emission/HH	Kg/HH/Month	0.0855
	% Of households having renewable energy equipment/source	Percent	0.0702
ENVIRONMENT (.291)	Population density	Persons/hectare	0.0301
	Green cover per total area	Percent	0.0854
	AQI level	Unit	0.075
	PM 10 concentration	µg/m ³	0.0632
	Built-up area	Sq. meter/capita	0.0143
	Open Space per capita	Percent	0.0385
TRANSPORT (.3163)	Vehicle Ownership(2W,4W Converted into PCU)	PCU	0.0674
	Income spend on travelling	Percent	0.0578
	Travel Mode to work(Public)	Percent	0.0375
	Access to Public transport	Meters	0.0471
	Access to Health facilities	Meters	0.0424
	Access to Recreational facilities	Meters	0.0473
	Access to educational facilities	Meters	0.0146
	Access to Market	Meters	0.0334

VI. CONCLUSION

The Proposed framework considered plans for low carbon cities and sustainable cities which finally reach to three main broad indicators for measuring the neighbourhood. Approach taken here is Micro to macro in which changes has been first done at neighbourhood level (Micro) to city level (Macro). The low carbon index generated from this framework can act as a tool for the policy maker and stakeholders for effective low carbon, energy efficient urban planning also raising awareness concerning the need to develop the low carbon neighbourhood in an urban area. It helps prioritising the indicators which need to be addressed first. This framework will be a prototype for the Indian neighbourhood as well as Asian neighbourhood to access the low carbon character at the neighbourhood level. This identification and study of indicators for measuring low carbon neighbourhood help to compare the different types of neighbourhoods in terms of carbon character.

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ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

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Visit: www.ijirset.com

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