Understanding the Micro and Macro structures of a more sustainable city as conceptualised by Hilderbrand Frey

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***Abstract*— Sustainability of a city is usually expressed in terms of efficiency of energy usage, public transport systems, waste disposal systems and quality of life of inhabitants of the city. The city structure as a point of reference for the sustainability of a city has not been explored much. Hilderbrand Frey in his book "Designing the city: Towards a more sustainable urban form (1999)" has taken up certain models of city structure and analyzed these models with respect to predefined indicators of sustainability. This paper attempts to follow that particular study and derive how the models of city structure can contribute to the sustainability of a city. The indicators of sustainability of a city were summed up as: Degree of containment of development, access to services and facilities, environmental conditions, potential for social mix and local autonomy, degree of adaptability, sense of place and centrality. The overall dimensions of four selected city models catering to two different population sizes were derived. Findings of the study points out that regardless of the population size some of the models show similar characteristics in quantitative aspects and changes across models are more evident in qualitative aspects**.

Keywords—Sustainable cities; City Structure; Micro structure; Macro Structure; City core

I. INTRODUCTION

The United Nations statistics on cities indicate that the world's cities occupy just 2 per cent of the Earth's land, but account for 60-80 per cent of energy consumption and 75 per cent of carbon emissions. Cities are marked by concentration of population, built structures and activities. It is this concentration that becomes the decisive factor in sustainable development by reducing the land consumption. Sustainable city is defined as the city that meets the needs of the present without sacrificing the ability of future generations to meet their own needs. This resonates with the sustainable development as defined by Bruntland Commission in 1973. Cities all over the globe are pursuing the goal of sustainability by redefining the way how cities are structured and how cities work. It is in this context that Micro and Macro structures of cities as conceptualized by Hilderbrand Frey in his book "Designing the city: Towards a more sustainable urban form (1999)" needs an examination of how the structure of city can lead to sustainability.

The paper is structured in two distinct parts. The first part is descriptive and tries to describe the models taken up for evaluation by Hilderbrand Frey. The second part is a discussion on the models and the findings, with focus on the relevance of the city structure to the cities in India. The study does not look into how the grading and evaluation of city models were performed but rather the city structure and aspects in the models that contributes to sustainability.

II. CITY STRUCTURE

A city structure as the name suggests tells how the city is structured or is arranged in terms of built and un-built components and the linkages in between. A structure plan provides the guide for the growth of the city. It determines the land use, the amount of built and un-built spaces of a city and how they are linked to each other. Structure models are practical necessities since cities are complex entities and one cannot manage complex real problems, under the pressure of time, without employing some prototypes. (Lynch, 1984).

III. MICRO STRUCTURES OF A CITY

According to Hilderbrand Frey, microstructures constitute the parts of the city that comes together to make up the whole city. The term used are "cells" or "neighborhood" but without any reference to the neighborhood as defined by Clarence Perry, 1920. The micro structures of a city are entities that add up to make up the city whole. These are spatial units that host small scale functions of services and amenities within a catchment

area of housing. The inter-relationship between people, transport and amenities forms the basis of micro-structure of the city (Ciuffini, 1995). The important determinants on the micro structure are accessibility, proximity and functional mix. Sustainability criteria demand, the use of public transport system to reduce congestion and pollution. Hence, accessibility and proximity to public transport would determine the size of the neighborhood. The size of a cell is determined by 10 minute walking distance from a house door to the nearest transport stop or services and amenities. The size is worked as an area that comes within 600m radius of a transport stop. Thus the area of a cell or neighborhood works out roughly as being contained within a square kilometer and with a density of 60 persons per hectare it can host a population size of 6000.

The services and facilities in a neighborhood cater to the fulfillment of day – to-day needs and requirements. Provisions beyond this are catered by a higher order spatial unit. These larger units can be connected to the neighborhood through public transport system. A number of larger units are in turn connected to each other by a higher order public transport system (LRT). These higher order centers/ districts may be linked to a town centre through a rapid transport system. Hence, a hierarchical system of spatial units and linkages connects to form the city.

There are arguments that it is not necessary for the users to be dependent on the one and the same local amenities and facilities available. There can always be preferences and choices which could be governed by accessibility. Also, a hierarchical structuring may result in a rigid form of the city which is not conducive for an open society (Alexander, 1998).

Within the choices and preferences available to the people of a neighborhood, it is the less mobile category such as the elderly and disabled that benefit from this micro structure the most. Easy access to public transport system enables these groups to avail of higher order functions such as specialty hospitals that are located farther away. Variety is created by providing mix of housing types and densities and thus again provides freedom of choices to individuals.

A group of 4 or 5 neighborhood can form a district, and would serve a population of 25000 – 35000. The core area would have a radius of 150m and would cater to most requirements of the connected neighborhoods. The structure of the city evolves as an agglomeration of linked districts, which are an agglomeration of linked neighborhoods'. Parallel to this and supporting this structure should be the hierarchical systems of public transport systems.

A diagrammatic form of equally spaced neighborhood units linked to a town centre would fail to represent the ground conditions of a city since neighborhood units evolve out of topographical and historical conditions. But this model of micro structuring helps in reading the structure of the city and gives possible directions of city growth.

IV. MACRO – STRUCTURED CITY MODELS

Macro-structures are concerned with a city's overall form and development pattern. In this case, the density of population, area of the city, minimum and maximum distances forms the criteria for the study. The macro structure models are derived within a framework of understanding that city form is never finite, rather it undergoes change and hence adaptability of the model to changing situation and circumstances are vital. The models that have been taken up for the study are the ones that were proposed by Kevin Lynch in "Good city form," 1984.

A. Macro Structure 1 (The Core City)

It is the model of a compact city, with very high density, and all functions packed into one continuous body, (Fig.1). According to Kevin Lynch (1984), the extension of the core city is relatively small. One example of such core city is Paris that has high density from core to the edge. Green spaces within such cities are seen in small pockets, housing would be multi- storey apartments and travel distances would be short. Lynch is of the opinion that such a city would be highly image able and the degree of flexibility would be low. The density of population would typically be 35000 persons per square kilometers. The maximum absolute population of core cities would be limited between 25000 and 250000 beyond which the problem of congestion would become evident. This threshold population was the same that Lynch suggested for satellite city model too.

B. Macro Structure 2 (The Star City)

This model was also proposed by Lynch. It has a single core of high density and mixed uses (Fig.2). Transportation routes (fingers) radiates out from this core. Secondary centers or other sub-centers of high to medium density are located along the public transport routes. The sub centers would develop at transport stops. High intensity functions are located near the sub centers and low intensity development away from the sub centre. There would be wedges of green in between. City of Copenhagen is an example. The star city can be linked to other cities to form a metropolitan multi- nucleated structure. The travel time to the core city would be around half an hour. The sub-centers too can be linked to each other through concentric transport routes but the development would only be around the intersecting nodes.

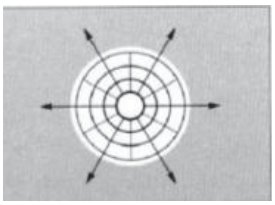

Fig.1 The core city

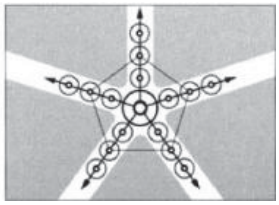

Fig.2 The Star city

Adapted from Hilderbrand Frey,"Designing the city: Towards a more sustainable urban form," 1999.

C. Macro Structure 3 (Satellite City)

In this model, a central city is surrounded at same distance by a set of satellite communities of limited size, (Fig.3). Ebenezer Howard was a major proponent of this model. According to Lynch these cities can host a population between 25000 and 250000. The growth of satellite should be limited to a particular size and when that growth is achieved another satellite should start. The satellites of Paris are an example. Size of the central city and the distance between the new town and central city are crucial for a satellite to work as an independent entity. In the case of Paris city this distance, instead of being green buffer was totally developed as part of the city, making the satellite concept ineffective. Facilities provided by the centre city should be only marginally of higher order than the satellites otherwise the people will depend on the core city for major functions and that could lead to congestion.

D. Macro Structure 4 (Galaxy of settlements)

Lynch presented this model at a metropolitan scale of interconnected old centers and sub centers. The core would be of high density and low rise structures (Fig.4). These would develop around traffic nodes. Low density developments would come at the edges. Lynch proposed dispersed sheet model and JH Minnery (1992) proposed spread city model, both having similar characteristics. If the radii of the node is 600metres and achieve medium to high density development, then it would resemble the transit oriented development (TOD) model put forth by Calthorpe(1993) and traditional neighborhood development(TND) model proposed by Duany and Plater Zyberk(1991). These models are not favored by the author due to the opinion that these models were conceived as alternative to urban sprawl.

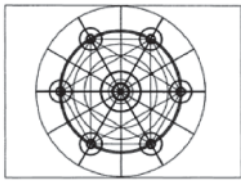

Fig.3 The satellite city

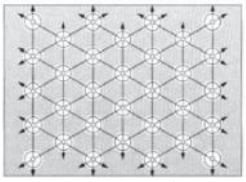

Fig.4 The Galaxy of settlements

Adapted from Hilderbrand Frey,"Designing the city: Towards a more sustainable urban form," 1999.

E. Macro Structure 5 (Linear city)

Soria Y Mata was known for putting forward this model for the city of Madrid in 1892. The city grows along a continuous transport line,(Fig.5). Dense nodes of development occur around transport stops. Less intensive uses are located in parallel bands of space outside the compact strips of development. The model has no central core. The easy accessibility to green areas and the possibility for ranges of density are the attractors of this model. The basic idea is to increase the quality of life by making all the facilities available within walking distance from housing areas. The linear city is manifested as the strip of Las Vegas. Its failure is due to huge investments required for an efficient public transport system. Thus it becomes economically viable only in the form of cross-city links (Minnery, 1992). That would make this model to be called a linear development rather than linear city.

F. Macro Structure 6 (Polycentric net or regional city)

Lynch's polycentric net takes a triangular grid pattern that can grow in any direction (Fig.6). This model is characterized by range of densities, with higher density around the junctions of transport networks. It can also be seen as a combination of larger and smaller core and linear cities. It also shows the characteristics, structure and form of a regional city (JR Minnery, 1992).

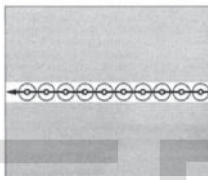

Fig.5 The Linear city

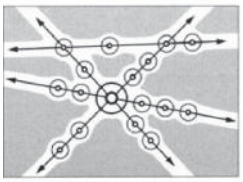

Fig.6 The Polycentric Net

Adapted from Hilderbrand Frey,"Designing the city: Towards a more sustainable urban form," 1999.

V. COMPARISON OF THE MODELS

Out of the six models explored, four of them namely, the core city, Star city, Satellite and linear city were compared with respect to dimensions and area. The polycentric net and Galaxy of settlements were not included in this due to its being regional in character and low density development respectively. The built up and the open area were taken in the percentage of 60% and 40%. The net population density was taken at 6000 persons per square Kilometer the case being similar to Glasgow and other cities. Area and dimensions were worked out for a population of 250000 and 500000 so as to exclude the population of a metropolitan scale. Population dispersal in star and Satellite were taken in the order of 23% for the core and 77% in the fingers or satellites.

The findings indicate that total area of the city across the selected models were similar for both of the population size. The Star city model showed an exponential increase in green areas when population size is taken at higher value of 500000 there by indicating that it is viable for shorter finger.

When the city models share similar overall area, population density and open land, then the indicators of sustainability shifts towards aspects of accessibility and mobility that is resulted due to compactness or fragmentation of urban land. Of these the core city model is unable to provide easy access to open areas. The services and facilities of a core city could be concentrated leading to congestion. The other three models are seen to achieve a comparable degree of decentralised concentration of facilities and services. This indicates that Star, Satellite and linear cities has the potential to provide similar functional, social and environmental qualities regardless of overall population size.

The indicators of sustainability that were taken up for performance evaluation of the city models were: Degree of containment of development, access to services and facilities, environmental conditions, potential for social mix and local autonomy, degree of adaptability, sense of place and centrality. With a scoring system of good, bad and neither it is found that the core city scored worst and the Satellite and the Polycentric net city scored the best. The linear city and the galaxy of settlements scored less than the middle value indicating its low level of performance with respect to the sustainability indicators. The star city scored above the middle value suggesting that it has more potentials than issues with the indicators of sustainability.

V. DISCUSSION

Clarence Perry defined neighbourhood unit in 1920 on the basis of half mile distance or 10 minute walk to the nearest elementary school. The pace and stride of a child was the basis for arriving at the dimension of a neighbourhood. Hilderberg based the neighbourhood as the area catered by services, facilities and transport stop within the reach of 10 minute walk. An idea that tries to include majority of activities (stay, work & leisure) can result in inclusiveness and an inclusive city is a sustainable city in terms of social aspects. The micro-structure was derived from the premises of accessibility and proximity and was expressed in terms of density of population. This ensures equity and inclusion which can make a city better place to live. The micro structure also has the ability to integrate and make up the larger city. Gestalt theory (1920) of Berlin school tells that the whole is not the sum of the parts there are things that are not tangible but present within and contribute to the whole(Graham Shane,2005). It is here that a city can also be expressed in terms of the places that it hosts. Several places can come together to form the city and the non-places in between also become a part of it. The linkages between the places and between the places and non- places can occur at spatial, social and economic levels. Hence this two pronged approach consisting of quantitative aspect of proximity and accessibility and the qualitative aspect of place can improve the sustainability of the neighbourhood cell.

The macro structures looks at the city as a single entity. It was seen that the core city model works for smaller population of 250000. When the population increases, all the negative aspects begin to outweigh the positives and thus make it less sustainable model. The study also is based on the premise that reducing the Carbon emissions would result in sustainability. Hence the factors of access and mobility by which the six macro models were chosen for the study attempts to attain sustainability by addressing the environmental concerns. It is this aspect that comes under scrutiny while searching for the viability of these models in its applicability to Indian cities. The large percentage of people below the poverty line in the cities of India indicates that economic considerations should outweigh the environmental and social considerations for attaining sustainability. Looking at the city structure of traditional cities of India suggest that most of the traditional Indian cities are star shaped. The current approach of putting up ring roads and flyovers to decongest these star cities acts on the basis of shifting the congestion from one place to other.

The new city plans of India are based on sector approach. Chandigarh(1966), Gandhinagar(1970)(Fig.7) and Naya Raipur(2000) are the few examples. The sectors are based on grid iron model and it has the ability to ensure equal accessibility to services and functions (Hilderbrand Frey,1999). It was first adopted by Le Corbusier for the city of Chandigarh(1966) and was seen to be followed by the cities that were planned much later. An approach of decentralised and intense service and facilities nodes can make the sector/ grid iron model more sustainable. Though the pervasive power of the established is evident in such approaches, it is necessary to pursue other city forms on sustainable basis. Hilderbrand Frey had towards the end of the study tried to demonstrate how the poly centric city/net city form, though initially rejected for being dispersed, can be intensively densified. The net city model differs in geometry from the sector model. The brief examination of densification of net city by Hilderbrand Frey suggests possibilities of its applicability at a metropolitan scale, such as Mumbai and Chennai. Hence for the case of Indian cities further examination regarding the comparative performance in terms of sustainability of star city model, Sector/ Grid iron city model and net city model is required.

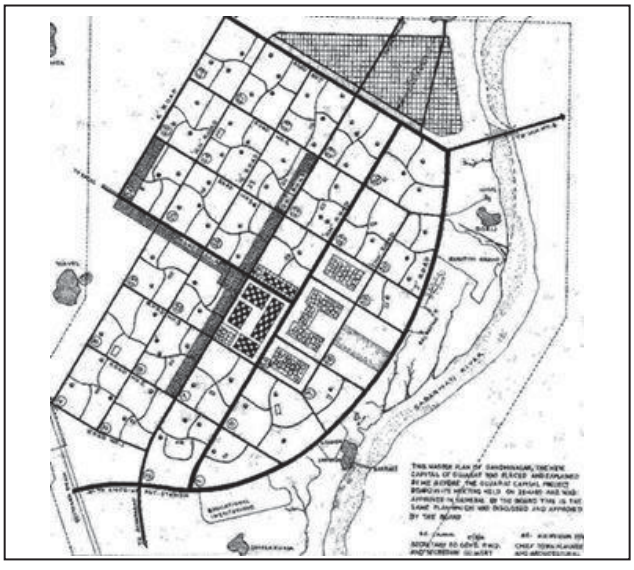

Fig.7 Sector Plan of Gandhinagar
Adapted from Publication by Gujarat Urban Development Authority, 1970

VI. CONCLUSION

The focus of the study was to establish the connection between the city structure and sustainability. The proposals of city models by Hilderbrand Frey are based on the premises of reducing emissions and improving mobility and access. The city models based on accessibility and mobility has the potential to create inclusive cities. The Satellite model and the Poly centric city models were found to perform better than the rest of the city models. Both these models showed high degree of containment, better access to green open spaces, and potential for self sufficiency.

The indicators of sustainability were based on environment and social concerns. The study points out that city structures are unable to address the issues related to economics such as poverty. The study findings are related to quantitative aspects of a city but the essence of a city lies in its qualitative aspects. Aspects such as sense of place and centrality were part of the indicators of sustainability, but these aspects cannot form part of a city model, actually they are part of a real city. The city structure has the ability to provide a framework for the structuring and directing the possible growth of a city but as Kevin Lynch puts it, the real city emerges as a product of group behaviour of individuals on the city structure.

Acknowledgment

The department of Architecture, College of Engineering Trivandrum

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