

URBAN FORM IN SUSTAINABLE NEIGHBOURHOODS

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Abstract

Urban form is the generalized physical indicator or the manifestation of a built-up area. It demonstrates physical patterns, layouts and structures of neighbourhood designs, which defines the physical character of neighborhoods and communities within the City. Overall, the city or neighbourhood forms are constituted and configured of a set of 'elements' of its urban form, which could be identified as streets, street blocks, plots and buildings. In each of these configurations, elements are combined in a specific way, originating a different identifiable character, unique to each and every neighbourhood or city.

Neighborhoods always possess a strong physical reality inside cities with distinctive physical, social and economic characteristics. They are the main 'unit' of city which play a key role in formation of cities. Elements and composition of such formation or the urban form of a neighbourhood are identified as key factors that are claimed to influence sustainability and human behaviour. As an important concept in Planning and Architecture, sustainability is central in consideration of development of cities, and neighbourhoods. Cities cannot be considered sustainable if their component neighbourhoods, do not meet sustainability criteria.

This paper intends to examine the relationship between urban form and neighbourhood sustainability to identify urban form of a sustainable neighbourhood. It investigates the elements and composition of urban form that attempted to promote sustainable neighbourhoods, reaching compatible sustainability concepts.

Key words: Urban Form, Sustainable Neighbourhoods, Relationship, Compatibility

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Introduction

'Urban forms' or the city forms simply describe a city's physical characteristics. At the broad city or regional scale, urban form has been defined as the spatial configuration of fixed elements (Dempsey, 2010). Urban form may encourage and establish the fact of neighbourhood sustainability, amicably with the social, environmental and economic factors, (Leeds, 2003) and may have the potential to create areas safe, friendly, convenient, crime preventive and long lasting.

A 'sustainable neighbourhood' is a place where people prefer to live today, and in the future, that is socially, environmentally and economically healthy; a place that is safe, well planned and built to last long. Debates about sustainability mainly focus on environmental concern, incorporating economic and social dimensions.

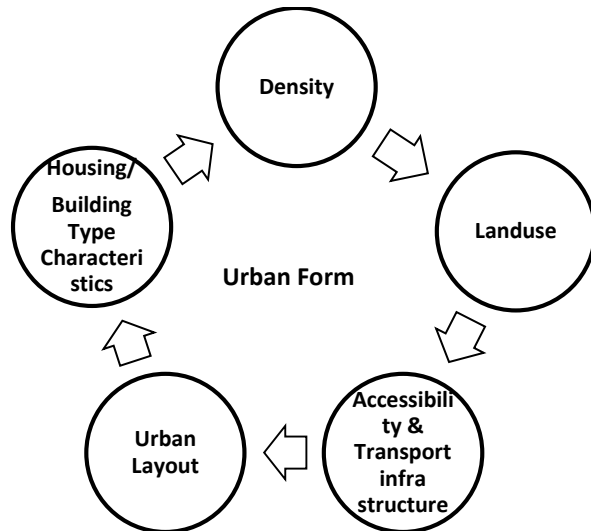
The role of the city form in creating sustainable neighbourhoods, has become more prominent in urban neighbourhoods, (Friedman, 2015) due to the rapid growth in urban population and urban sprawl. Dense urban forms specifically have its own physical geometry of elements giving birth or influencing its 'identity' and 'character' as specific 'social units'. Consequently, these social units or the neighbourhoods become a dominant physical manifesto in the 'city figure', or the 'urban form'. The relationship and the issues of relationship between 'sustainable development' and 'urban form' are important to be identified, to overcome the sustainability related issues of urban form.

Research Problem Statement

In a close analysis, urban form of any neighbourhood is composed of several elements which are physical as well as non-physical. Those city forms or the compositions are crucially important in claiming sustainability of such neighbourhoods. What are the key values of urban form that facilitate its sustainability? What is the urban form of sustainable neighbourhood?

Literature review

In this study, the first attempt is investigation on analysis of urban form of a neighbourhood. As Dempsey (2010) describes the term 'urban form' is used simply to describe a city's physical characteristics. At the broad city or regional scale, urban form is defined as the spatial configuration of fixed elements. Features of urban form at this scale would include urban settlement type, such as a market town, central business district or suburbs. Also, characteristics range from; a much localized scale, with features such as building materials, façades and fenestration, to, at a broader scale, housing type, street type and their spatial arrangement, or layout (Dempsey, 2010) Urban form generally encompasses a number of physical features and nonphysical characteristics including size, shape, scale, density, land use distribution (Kotharkar, 2014) housing/building types, urban block layout and distribution of green space. These are categorized as five broad and inter-related elements that make up urban form in a given city or a neighbourhood.



Sources: Dempsey N, Brown C, Raman S, Porta S, Jenks M, Jones C, Bramley G, (2010)

Accordingly, the urban form is understood as spatial configuration of physical elements of a city or neighbourhood. It plays the major role in demonstrating its character and identity. Identity of a neighbourhood, provides intangible statements manifested by the urban form. Cities are composed of neighbourhoods of different scales, which collectively contribute to make-up the city form. In a close analysis, it is the physical geometry or spatial configuration of different physical elements and non-physical components of urban form.

These elements of urban form are identified on the basis of their influence on sustainability and human behaviour. In developing countries, infrastructure (e.g. water, roads, gas etc.) is also discussed as an element of urban form, and it is noted that infrastructure would also form an important part of examinations of urban form in developing countries such as Sri Lanka.

As per Dempsey's explanation, (2010) **Density** is a complex concept with a number of inter-related dimensions. It has two components; residential density and building density. Density is closely related with other land use and access to services. For a service or facility to be viable, it needs to serve a population of a particular size. As for compactness in Urban Density, Friedman (2015) states that several factors determine what would be considered low, medium, or high density neighborhood. Dwellings and other building sizes, type of parking and the amount of private and public outdoor spaces affect the resulting densities.

Land use indicates the functions of the environment. (Dempsey, 2010) In the urban context, the dominant land use tends to be residential but a functional urban area requires industrial, retail, offices, infrastructure and other uses. The spatial pattern of land uses is crucial realizing the efficiency of a city and potential 'sustainable' urban forms in influencing urban travel patterns and the quality of life. A key concern of local land use is the availability of local neighbourhood services and infra-structure facilities. The provision of services and facilities is dependent on the demand of resident population and a particular land use mix therefore differs from one neighbourhood to the other.

Accessibility and Transport infrastructure determines the ease with which buildings; spaces and places can be reached. The level of accessibility is described as the ability of an area that residents and users are able to reach, and the extent to which they have the means to access places, services and facilities that are located outside their local area. (Dempsey, 2010) Accessibility is not simply the close proximity, though distance is one contributing factor.

Factors such as the location of potential destinations relative to an individual's starting point, how well and conveniently the transport system connects to spatially distributed locations, how the individual uses the transport system, options etc. are important concerns.

Urban Layout is the spatial arrangement and configuration of elements of streets, blocks and buildings. Referred to at the street scale, it could be grid or organic with 'cul-de-sac' street patterns. Layout influences on pedestrian movement and the way in which different places and spaces are connected to each other. (Rashid, 2017) Permeability of a layout influences the ease of finding the way, controls access and movement for pedestrians, and could be effectual on other aspects of urban form such as land use and density.

Characteristics of housing and other buildings in urban settlements can have an important bearing on everyday living. The influence of building characteristics extends beyond the density of urban living. Factors such as building type, character, function and age may have an effect on urban form, which demonstrate the social and cultural identity. Elements and Composition of elements in urban form provides the identity to neighbourhoods. According to Jabareen (2011), urban form is a spatial composition of elements that repeat, and if based on certain sustainable concepts, can lead to the sustainability of cities.

Concept of neighbourhood sustainability has different forms and definitions. As per the definition by Beauregard (2003) sustainability is situated at the intersection of environmental protection, economic growth, and social justice. General understanding on the meaning of sustainable development is the balance of social, economic and environmental requirements linked with urban development measures. As per Bruntland (1987), Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs. Tan Y., Kamruzzaman and Suharto (2015) point-out that Neighbourhoods are considered as the building blocks of cities, where most development including new buildings takes place, and therefore, the overall sustainability of a city depends on the sustainability of its neighborhoods. Based on these broadly applicable definitions, sustainable development at the neighbourhood level is a place that facilitates peoples' living today, and in the future; socially, environmentally and economically healthy; safe, well planned and built to last long.

Main principles of Sustainable Neighbourhood and their compatibility with Urban Form

There are several principles and concepts suggested by different scholars in creating sustainable neighbourhoods. Jabareen (2011) analyses and identifies seven design concepts related to sustainable urban forms as compactness, sustainable transport, density, mixed land uses, diversity, passive solar design, and greening. UN-Habitat as an organization that has support for better urban future, recommended five principles in creating sustainable neighbourhoods which include adequate space for streets and an efficient street network, High density, Mixed land-use, Social mix and Limited land-use specialization. (UN Habitat, 2011) Apart from these, achievement in social goals of living (Hamiduddin, 2015) and environment related practices (RTPI, 2015) are also important. Accordingly, main principles of sustainable neighbourhoods concluded through the literature review as follows;

(1) Adequate space for streets and an efficient street network

Developing a suitable and efficient level of street network, which works for vehicle, public transportation and especially for pedestrian and cycling are the main concerns. Apart from that, the street network plays in formation and shaping the neighborhood structure which defines the pattern of development blocks, buildings, open public spaces and landscape which collectively provides the basis for sustainable neighborhood development. (Engel-Yan,

2005) Focusing on mobility dimension of a sustainable neighbourhood, characteristics such as walkable and cyclist friendly streets, efficient public transportation, interconnected street hierarchy and adequate parking are important concerns in street design. These concerns have direct impacts on the urban layout and transport infra-structure of urban form.



Fig.1: Long- wide avenues providing adequate space for pedestrians & mixed functions; Pedestrian precinct in the mid of city center Aachen, Germany (source google images)

(2) High Density

Density is a prime element in urban form. Jabareen (2011) explains that urban forms contribute differently in making cities sustainable, and conceptually compact city is more convincing than other urban forms. As a result of issues emerging with rapid urbanization, global population explosion and urban sprawl, achieving high density is essential and fundamentally important in the design of sustainable neighborhood. High density concentrates people and their activities. This has many economic, social and environmental benefits and it is a smart choice placed in the central of sustainable urban planning. According to UN Habitat (2011), main benefits of high density developments are identified as efficient use of lands accommodating more people per unit area, reducing the cost of public services including emergency response, school transport, water, sewage and roads, better community services, reducing car dependency and parking demand, support public transport, pedestrian and cycling modes. However, it is important to note that densification must have parallels with development of infra-structure, for high dense neighbourhoods to be sustainable.



Fig.2: High dense neighbourhoods in Hong Kong city leaving 3/4 of land as green space (source: Author)

Fig.3: Mixed Land-use in Amsterdam city promoting combination of matching activities (source: google Images)

(3) Mixed Land-use

Land use as an element of urban form may have several options in promoting neighbourhood sustainability. Principle of mixed land-use concentrates on developing a range of well-matching flexible activities and land uses next to each other within appropriate distances. Apart from that, mixed land use attempts to create local jobs, enhance local economy, decrease car dependency,

encourage pedestrian and cyclist traffic, reduce landscape fragmentation, provide closer public services and support mixed communities. (Dehghanmoghaddi, 2014) Mixed land-use concept provides condition to combine of housing, commercial, industrial, offices and other functions. When variety of functions is mixed in one neighborhood, housing and economic activities are to be designed well balanced, well-matched and flexible enough to convene the residents.

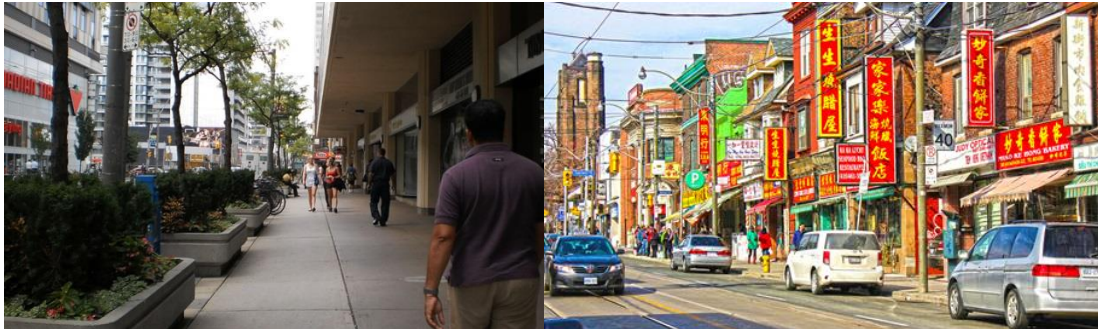


Fig.4: Combined residential, commercial & Institutional uses in Downtown Toronto (source: Author)
Fig.5: Social mix in Multi-cultural neighbourhood, China Town-East, Toronto (source: google Images)

(4) Social Mix

Predominantly housing and other building types and characteristics of urban form is the realization of social mix of a neighbourhood. This principle aims to promote the cohesion and interaction among different social groups within same neighborhood and provide equal accesses to existing urban opportunities and services by planning different kinds of residential houses. It provides a foundation for rich social networks. Mixed land-use and social mix are mutually dependent and support each other. Further, in mixed land-use neighborhood, opportunities for jobs are generated for diverse level of residents with different income levels, shaping a social network. (UN-Habitat, 2011) Accordingly, social mix is a socio-economic concept, promoting more social interaction, increasing social cohesion of different social classes, generating job opportunity, and attracts more services to the neighborhood.

(5) Limited land-use specialization

This focuses on land-use aspect of urban form, targeting limit use of single functional zoning to encourage mixed land-use strategies. In cities around the world, the individual application of land-use specialization generates numerous single function neighbourhoods that are the main source of contemporary issues in urban environments. (UN-Habitat, 2011) To create mixed land-use, limiting land-use specialization is essential. Accordingly, combining compatible land-uses into one block or neighbourhood, and introducing mixed land-use zoning while respecting each use, are identified as two strategies for achieving correct zoning.

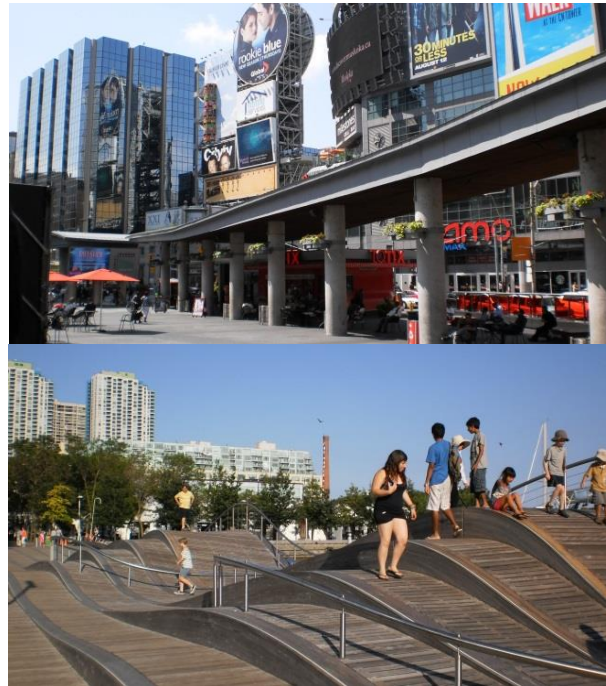


Fig.6: Residential apartments, Public & recreational spaces in the central business area of Toronto
(source: Author)

(6) Achievement in social goals

Social and environmental goals are often mutually reinforcing. Social sustainability is a wide-ranging multi-dimensional concept (Hamiduddin, 2015) Services and facilities of health and safety, user friendliness, convenience, security and crime retentiveness are social goals in any good neighbourhood. Human activities in the city are influenced by physical urban form and vice versa. (Omar, 2009)It is a mental process that could be explored only by observing user responses and understanding theirsatisfaction levels.



Fig.7: Best sustainable neighborhoods: Malmö city in Sweden (source: google Images)

(7) Positive Environment related practices and bio-diversity

Practices on main infra-structure facilities water and solid waste management and energy efficiency are also important (RTPI, 2015) in developing contexts such as Sri Lanka. Levels of positive and negative practices on urban water system, energy usage, air pollution & noise, storm water management, solid waste management etc. are significant in creating sustainable neighbourhood settings.

Urban Form of a sustainable neighborhood

The above principles depicted in urban form, play a crucial role to foster sustainable urban neighborhoods by encouraging livability. It is clear that these principles are extremely inter-related and supportive of each other. High density provides ease to residents for activities which are foundation for a sustainable neighborhood. Adequate street density is the physical base whereas mixed land-use and social mix shaped the land use and quality of social life within a neighborhood. The initial step toward mixed land-use within neighborhood is limited land-use specialization.

Accordingly, these principles create a balance among, population growth, economic changes, rapid urbanization, and human centered sustainable urban development. Besides, they are supportive to launch a new urban system, (Dehghanmongabadi, 2014) in which all factors which mentioned above could be developed collectively. This provides conditions where urban residents live and urban spaces develop in harmony.

A theoretical inquiry based on literature on the application of principles and guidelines for neighbourhood sustainability has been carried out, to understand the sustainability levels of urban form. Resulting relationship of sustainability principles and urban form were intended to be explored, with exploiting the real satisfactory levels and issues confronted by urban form, based on successes and failures in community wellbeing and satisfaction in case study research.

Research design

Case study, Wellawatta, a Colombo suburb, from developing tropical Asian context, would be studied in detail, looking at the urban form, in terms of sustainability principles in application; social, economic and environmental concerns. Importance of study on Wellawatta neighbourhoods as case study is that, it shows an identifiable established urban form, which is shaping gradually and continuously with urbanization. As per the development information from Local Authorities, Wellawatta shows 1.22% increase of net residential density from 1997 to 2010 and considerable increase in non-residential developments as well. (UDA, 2010) As a result, single tenant buildings and detached houses turn into multifunction and apartments, to accommodate the increasing demand for space.

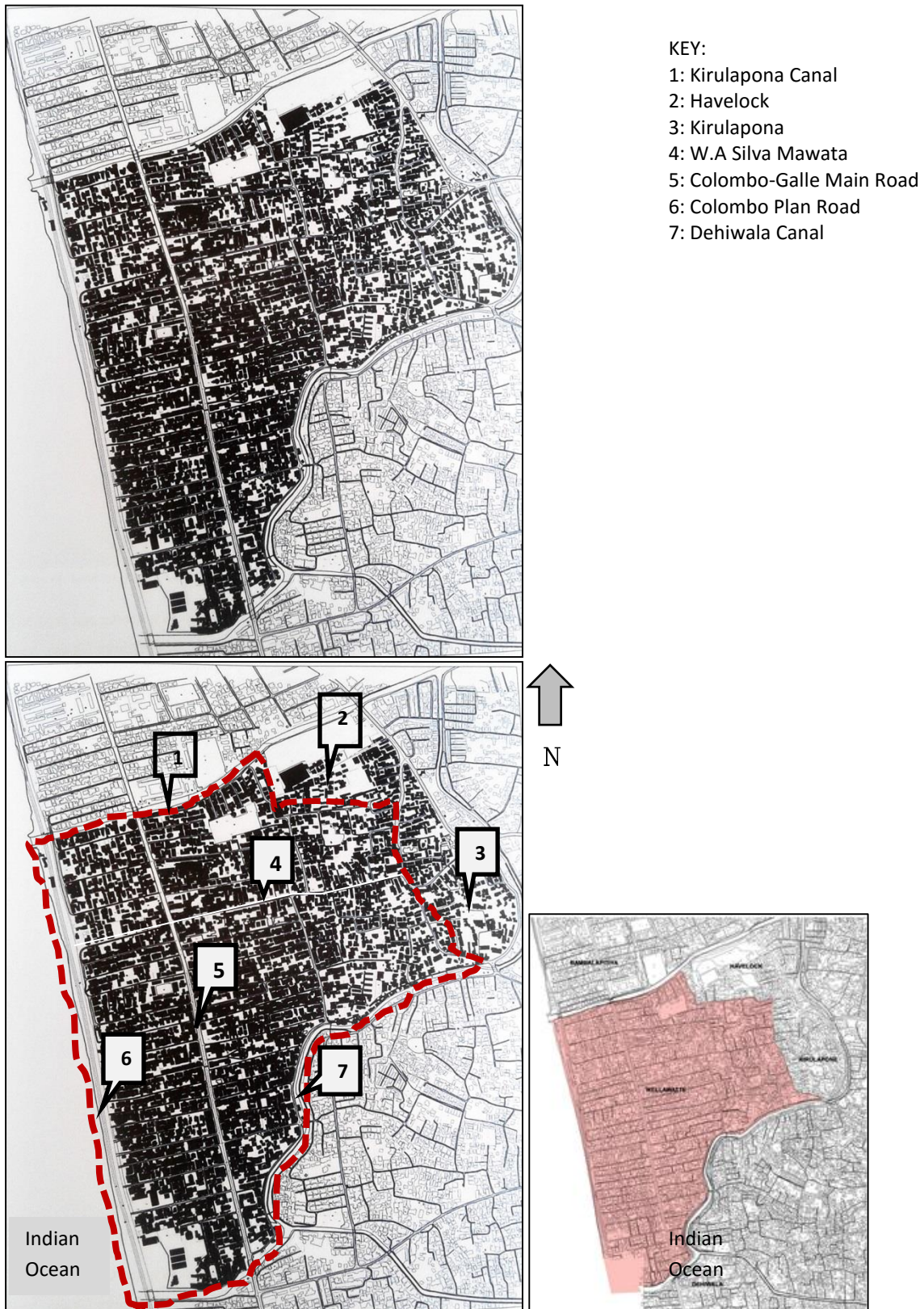


Fig.8: Wellawatta, Study area(source:Google maps)

Current urban form will be analyzed with its elements; density, housing/building type, layout, land use, and transport-infra structure. Spatial composition and community values are judged on empirical investigations, based on the physical and non-physical features. In-depth data

collection on case study, involving multiple sources on information, such as observations, interviews, documents and reports are proposed.

Data collection for Research will be conducted confirming to ethical norms. A mix method; both quantitative and qualitative research methods will be executed out in collection of data and analysis. Conducting structured interviews and structured observations, in-depth interviews with focus groups and participant observations are to be carried out to collect data in a systematic manner. Data will be collected towards analysis as follows;

1. Analysis on current Urban form of Neighbourhood (Refer table-01)
2. Analysis on application level of Sustainability Principles (Refer table-02)

On conclusion, sustainability principles in application and levels of sustainability of prevailing urban form are the final outcome findings of the research study.

Proposed method of analyzing data & results

Step-1: Analysis of elements and configuration of urban form: This is studied and recorded as numerical values or descriptions based on Table-01. Sources of information of research are ordinance surveys, Site survey, Census data, Local authorities, personal observations and questionnaire, depending on the item.

Table -01: Analysis of current Urban Form of Neighbourhood

1.0 Measure and analyze the configuration of Urban form

1.1 Density: (Physical density)-quantitative data

Residential Density

Gross Residential density: Number of persons, households, or dwelling units per hectare (or unit area) of the total neighbourhood area

Net Residential Density: Number of persons, households or dwellings per hectare (or unit area) of the total land area devoted to residential land use

Building Density

Floor Area Ratio: Ratio of floor area to site area

Coverage Ratio: Ratio of building footprint to site area

1.2 Housing/ building type and characters- quantitative & qualitative data

Predominant housing type per street: Detached housing, Semi-detached housing, Terraced/row housing, Tenements, Flats/apartments

Characteristics of individual dwellings: Lowest level of living accommodation, Access to garden, Number of bedrooms, Condition of building, services.

Building type according to land use categories: Commercial buildings, Offices, Community buildings, religious buildings

Street characteristics: Dimensions, provision of pedestrian paths, Quality Level. Level of

maintenance; Extent of litter, Instances of graffiti, vandalism, & no street lighting, level of safety for public, women and children

1.3 Lay-out: Urban layouts are difficult to quantify. Spatial configuration will be studied -*quantitative data*

Spatial network analysis: spatial layouts, relationships between spaces and building, patterns and the relationships between spaces. E.g. Compact or sprawling neighbourhoods

1.4 Land-use: Uses of lands/plots-*quantitative data*

Residential/ Individual and group: Sheltered accommodation, Care homes, Accommodation for education institutes (hostels), orphanages.

Commercial and retails: Retails & Supermarkets; Shops, Storage & Warehouses, Restaurants/cafés

Offices: Business parks, Banks and building societies, Other offices

Industrial: Factories/Workshops/Ware houses/production related; Industrial storage facilities (depots etc.)

Community; Buildings used for community purposes; educational, health, community services, schools, Health centers/Hospitals, Community centers, Places of worship, Police stations, railway stations, bus- stops

Leisure and recreational buildings: Buildings used for leisure and recreational purposes; Museums, Libraries, Cinemas, Indoor sports facilities and fitness centers

Outdoor recreational: Outdoor amenity and open spaces; Football pitches, Golf courses, Sports grounds, children's parks, public parks, Allotments

Mix use: Buildings with multiple land-uses/Vertical mixed uses; flats above shops/offices above commercial

Vacant lands for developments: Derelict land, vacant land

1.5 Transport infra-structure lay-out and connectivity- *quantitative & qualitative data*

Public transport infrastructure (Street): Location of public transport features, bus stops, Bus routes, Frequency of services

Private transport infrastructure (Street): Location of private transport features (i.e. parking), Location of off-street parking and types, Location of on-street parking and types

Pedestrian/cycling infrastructure (Street): Location of cycle or pedestrian paths/alleyways/underpasses etc., Location of routes inaccessible to motorized transport

Road management (Street): Route management, One-way systems, Traffic management, Speed restrictions

Journey time/distance (Individual buildings/Institutes/inter-cities): Journey to out-stations, work, other services etc. in terms of time and distance

Step-2: Analysis/ Research on sustainability principle and levels of achievement

The neighbourhood sustainability is being best assessed on the satisfaction of inhabitants on facts; how safe, friendly, convenient, livable, crime preventive and long lasting their neighbourhoods are. Quantifying these aspects is to be carefully done and in-fact is a long, effortful process.

Each and every element of urban form with which the neighbourhood is composed, is compatible with basically one or more of the sustainability principles identified. Measuring the application of the principles will be carried out by interviewing selected groups of general public with setting of questionnaire and transformed the findings into numerical values. Users' responses are recorded as grading; good/ satisfactory but improvements necessary/and poor. For evaluation purposes, numerical values are given for each grading as; Excellent>75-100%, good>65-75%, satisfactory but improvements necessary>65-45%, and poor<45. Around 15-25 interviews are intended to be carried out on each fact. Recorded information from ordinance surveys and statistics are used for quantitative information. Tentative data on questionnaire is as follows;

Table -02: Measure/Analyze the Application Level of Sustainability Principles

1. Adequate space for streets and an efficiency of street network		
Surface coverage, sufficiency for public requirement, concern on public transportation, road hierarchy, parking, walkability, and characteristics reflected in street design- <i>quantitative & qualitative data</i>		
Query	Answer	Rating
Area allocated for street net-work (Ordinance survey, statistics) <i>Assumption: Network should occupy at least 30 % of the land (UNHabitat,2011)</i>		
Road widths & connections; comfort, convenience, shadiness, finishes		
Catchment of transportation forms and adequacy		
Concern on pedestrians; availability of pavements or walkways, bicycle lanes		
Convenience & comfort in street network & connectivity; well connectedness, permeability		
Safety in any time of the day (specially for children & women); street light levels, security		
Uniqueness (observation)		
Development opportunities (Observation)		
Concluded rating & score		
2. High density		
Population to built-up area ratio, Concentration levels of people & their activities- <i>quantitative & qualitative data</i>		
Query	Answer	Rating
Population to built-up area ratio (Ordinance survey, statistics)		

<i>Assumption: At least 15,000 people per km², or 150 people/ha (UNHabitat,2011)</i>		
Adequacy of public services/ infra-structure; basic services		
cost of transportation to closest city center& availability		
school transport; availability, affordability, necessity		
Adequacy of community services; parks, open spaces		
parking demand; availability of spaces, paid or non-paid parking		
Provision for pedestrian and cycling modes; facilities & possibilities		
Concluded rating & score		
3. Mixed land-use		
Integrated land uses; open, residential, commercial, institutional, religious, other- <i>quantitative & qualitative data</i>		
Query	Answer	Rating
Percentages of land uses-open, residential, commercial, institutional, religious & other (Ordinance survey) <i>Assumption: At least 40% of floor space should be allocated for economic use (UNHabitat,2011)</i>		
Availability of local jobs; availability, adequacy, possibility		
Distance to work places/shopping & marketing/café or restaurant/school/temple or church/play ground		
Car dependency; necessity, parking		
pedestrian and cyclist traffic; facilities & possibilities		
landscape fragmentation, adequacy of open spaces		
Closeness of public services; availability in close proximity		
Concluded rating & score		
4. Social Mix		
Basic Housing types; High, upper middle, middle, lower middle, low income- <i>quantitative & qualitative data</i>		
Query	Answer	Rating
Percentages of different housing types (Ordinance Survey – Site survey) <i>Assumption: 20- 50% of the residential floor area should be for low cost housing; and each tenure type should be not more than 50 % of the total (UNHabitat,2011)</i>		
Availability of houses in different price ranges & affordability		
Availability of low cost housing		

Level of Cohesion of and interaction across different social groups		
Concluded rating & score		
5. Limited land-use specialization		
Single function and multifunction blocks- <i>quantitative & qualitative data</i>		
Query	Answer	Rating
Single function & multifunction blocks (Ordinance survey, questionnaire) <i>Assumption: single function blocks should cover less than 10% (UNHabitat,2011)</i>		
Public satisfaction		
Concluded rating & score		
6. Social goals		
levels of health and safety, user friendliness, convenience and crime preventive- <i>qualitative data</i>		
Query	Answer	Rating
street life enabling a variety of activities; availability, affordability, accessibility		
conducive frontage and street width; safety, security, convenience		
presence and role of private transport; availability, necessity		
Walkability, security, safety; whether encouraged		
Congestion; levels of crowdedness		
boost on local economy and interactions		
services and public facilities; transportation & infra-structure, community facilities		
Concluded rating & score		
7. Environment related practices and concerns on bio-diversity		
Practices on water and solid waste management and energy efficiency- <i>quantitative & qualitative data</i>		
Query	Answer	Rating
Urban water system; availability, usage, disposal, treatment		
Energy usage; availability, usage, natural systems		
Air pollution & noise; health effects, stress conditions		
Storm water management; disposal, harvesting, treating		
Solid waste management; collection, storage, disposal, recycling		
Concluded rating & score		

Preliminary Analysis on findings

Relationship between 'sustainability criteria' and 'compatible element of urban form' is structured, to identify the issues in relationship. Preliminary analysis is not detailed with data on the case study, since the case research and data collection is still in process.

Levels of achievements based on data could be at different levels as very good, good, acceptable & poor. Once the achieved level of sustainability criteria are determined, suggested improvements in terms of urban form (physical and non-physical) could be formulated as follows;

- ⊕ Understanding prevailing sustainability issues; which principle to be incorporated or enhanced in the compatible element of urban form and how.
- ⊕ Suggestions on Improvements or changes required in urban form (element/s) in development proposals, achieving sustainability.

Conclusion

Since the study is not inclusive with actual data collected on case neighbourhood, this is a preliminary conclusion. The research examines the effect that urban form has on sustainability in a holistic manner. Indicators employed to measure urban form, and its compatible sustainable principles, describes the levels of satisfaction of real inhabitants of the neighbourhood, both physically as well as psychologically.

Relationships that the elements of urban form, both individually and as a whole, have on the different aspects of sustainability are outlined, as findings. Sustainability levels of case urban form are the final outcome which is useful in design for future. With the findings and analysis, the remaining issues in sustainability and the compatible element of urban form is recorded. Changes or improvements necessary in the urban form could be clearly understood.

Physical Density which is further analyzed as Residential Density (Net Residential Density and Gross Residential density) and Building Density (Floor Area Ratio and Coverage Ratio) determines the level of achieving high density. Land-use analyzed as Residential (Individual and group), Commercial and retails, Offices, Industrial, Community, Leisure and recreational buildings, Outdoor recreational, mix use, and vacant lands designated for future developments, indicates the efficiency of Mixed land use and Limited Land use specialization. Housing further analyzed as Detached housing, Semi-detached housing, Terraced/row housing, Tenements, Flats/apartments and other buildings types according to land use categories; Commercial buildings, Offices, Community buildings, religious buildings indicates the level of social mix. Urban Layout and Transport infra-structure are closely inter-connected in urban neighbourhoods. They collectively contribute to connectivity and accessibility. This indicates the levels in adequacy of space for streets and efficiency of street network in the neighbourhood. Overall configuration of urban form and sufficiency of infra-structure services fulfills the social goals in good or facilitated living of inhabitants. Environment related practices and concerns on Biodiversity within the community contribute to overall sustainability of the neighbourhood.

Above findings determine the relative influence that differing elements of urban form; land use, density, accessibility, housing/building characteristics and layout, makes on sustainability of the neighbourhood, its overall economic, environmental and social sustainability. Simply, it provides the requirements in an urban form facilitating neighbourhood sustainability.

It would be rather fruitful forecasting on urban form addressing the sustainability principles, than looking at sustainability issues and back-casting the urban form. This is important in

developing urban contexts. It will be a positive contribution towards the struggle in forming solutions to crisis of neighbourhood sustainability at local or national levels, which has also become a global concern today.

References

- Dempsey N, Brown C, Raman S, Porta S, Jenks M, Jones C, Bramley G, (2010), Elements of Urban Form, Oxford
Institute for Sustainable Development, Oxford Brookes University, Oxford, UK
- Anderson, W. P., Kanargoglou, P. S. and Miller, E. (1996) Urban Form, Energy and the Environment: A Review of Issues, Evidence and Policy. Urban Studies
- Abolfazl Dehghanmongabadi, Şebnem Önal Hoşkara, Nina Shirkhanloo, 2014, Introduction to Achieve Sustainable Neighbourhoods, International Journal of Arts and Commerce ISSN 1929-7106, www.ijac.org.uk
- Blum, A. and Grant, M., 2006, Published as: Sustainable neighbourhoods, Journal of International Research Publications, Issue Ecology, Vol 1, ISBN/ISSN: 1311-8978
- Bruntland, G. (ed.) 1987 Our common future: The World Commission on Environment and Development, Oxford, University Press,
- J. Engel-Yan, C. Kennedy, S. Saiz, and K. Pressnail. 2005, Toward sustainable neighbourhoods: the need to consider Infrastructure interactions, <http://cjce.nrc.ca>
- UN-HABITAT, 2011; Teed, et al., 2013; Falk and Carley, 2012, For a Better Urban Future, <https://unhabitat.org/a-new-strategy-of-sustainable-neighbourhood-planning-five>
- Jenks M, Jones, C A (Eds.), 2010, Dimensions of the Sustainable Cities, <http://www.springer.com/la/book/9781402086465> Springer, London
- New urbanism- Creating livable sustainable community , Urban Design, Center for design excellence, Urban Design.org, <http://www.newurbanism.org/sustainability.html>
- Friedman A. Fundamentals of sustainable neighbourhoods, 2015, ISBN 978-3-519-10746-2, <https://www.bookdepository.com/Fundamentals-Sustainable-Neighbourhoods>
- American Planning Association, Characteristics and Guidelines of Great Neighborhoods www.planning.org/greatplaces/neighbourhoods/characteristics.htm
- Tan Yigitcanlar, Kamruzzaman, Suharto Teriman, 2015, Neighborhood Sustainability Assessment: Evaluating Residential Development Sustainability in a Developing Country Context ISSN 2071-1050, www.mdpi.com/journal/sustainability
- Hamiduddin, I, 2015, Social sustainability, residential design and demographic balance: Neighbourhood Planning Strategies in Freiburg, Germany. Town Planning Review, Retrieved from UCL Discovery: <http://discovery.ucl.ac.uk/1461694>
- Rajashree Rajashree Kotharkar, Pankaj Bahadure, and Neha Sarada, 2014. Sustainability; Case Report Measuring Compact Urban Form: A Case of Nagpur City, India ISSN 2071-1050 www.mdpi.com/journal/sustainability
- Yosef Rafeq Jabareen, 2011, *Sustainable Urban Forms Their Typologies, Models, and Concepts*, <http://jpe.sagepub.com>
- Omar D, B., 2009, Urban form and sustainability of a hot humid city of Kuala Lumpur, <https://uitm.pure.elsevier.com/.../urban-form-and-sustainability-of-a-hot-humid-city-ofKualalumpur>
- Leeds City Council, 2003, *Neighbourhoods for Living*, A Guide Residential Design in Leeds, United Nations Population Fund, 2007, Royal Town Planning Institute, 2015, www.rtpi.org.uk/media/urbanform
- Mahbub Rashid, 2017, The Geometry of Urban Layouts, A Global Comparative Study, <https://www.springer.com/gp/book/9783319307480>
- UDA, 2010 City of Colombo Development Plan, 1996 Land Use Survey, 1996, UDA, 2010