ATTRIBUTES OF URBAN FORM FOSTERING SUSTAINABILITY: AN ANALYSIS OF RESIDENTIAL NEIGHBOURHOODS IN COLOMBO, SRI LANKA

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ABSTRACT

Despite increasing number of studies on evaluation of sustainable neighbourhoods and urban forms, only a few have paid attention to the identification of the components that influence the degree of inhabitants' gratification. A neighbourhood is a built entity that lays the experiences of daily lives of a group of inhabitants in an identifiable geographical space. The neighbourhood sustainability is the process of nurturing its environment to support and meet both economic and social needs of its inhabitants. A sustainable neighbourhood should ensure the desired quality of life and satisfaction of the inhabitants by intertwining the local; social, cultural, environmental, and economic facets enabling its sustenance as an appealing place to live. However, observations show that most neighbourhoods in the context of Southeast Asia poorly addressing this need.

'Urban Form' of such neighbourhoods is the physical manifestation, expressing respective sustainability appeal sensed by the inhabitants. This is the intangible, significant finding, demonstrated in the physical design. This study attempts to explore the determinants of Urban Form that contribute to the Neighbourhood Sustainability for the inhabitants' appeal.

Specific intent of the research is to conduct a detailed investigation on the urban form of three urban residential neighbourhoods of Colombo, selected from the city core, intermediate city, and outer city. While it examines the degree of inhabitants' appeal based on their evaluations, it assesses the neighbourhood sustainability under the three main sustainability parameters: environmental, social, and economic facets. Physical and non-physical attributes of the neighbourhood form, such as density, layout, land-use, connectivity, transport infrastructure, building typology and architectural character, were investigated by using secondary data. Structured interviews were carried out with thirty-five inhabitants; household representations, in each neighbourhood to ascertain inhabitants' perception while physical observations were made to identify the deterministic attributes.

This research develops an integrated approach recognizing the fact that environmental, social, and economic goals in appealing neighbourhoods are often mutually reinforced with the urban form of a neighbourhood. It recognizes the physical and non-physical attributes of the urban form of a neighbourhood and each of their contribution in fostering sustainability to create an appealing environment for its inhabitants. Consequently, it establishes an overall sustainability rating on the inhabitants' perception and validates through case studies with reference to the attributes of urban form. This leads to formulate the requisites of an exemplary urban form; verbalizing its attributes that are determining the sustainability of neighbourhoods.

Key Words: Environmental Social and Economic facets, Urban Form, Attributes, Sustainability, Urban Neighbourhoods, Inhabitant, Colombo, Sri Lanka.

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Abbreviation	Description	Page
AARP	American Association of Retired Persons	37
APA	American Planning Association	51
CCDP	City of Colombo Development Plan	59
CEC	Commission of European Communities	27
CNU	Congress for the New Urbanism	35
DTCP	Department of Town & Country Planning	42
FCM	Federation of Canadian Municipalities	76
GIS	Geographic information System	07
GND	Grama Niladhari Division	106
ICLEI	International Council for Local Environmental Initiatives	39
LEED-ND	Leadership in Energy and Environmental Design-Neighbourhood Design	12
MUD	Master of Urban Design Program	124
NRDC	National Resources Defense Council	71
RTPI	Royal Town Planning Institute	21
SGD	Sustainable Development Goals	72
SOC	State of California	23
SPSS	Statistics package for Social Sciences	8
TND	Traditional Neighbourhood Design	68
UDA	Urban Development Authority	59
UN	United Nations	2
UNCSD	United Nations Conference on Sustainable Development	72
UNGA	United Nations General Assembly	2
UOM	University of Moratuwa	124
US-EPA	United States Environment Protection Agency	73
USGBC	United States Green Building Council	44

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CHAPTER 1: INTRODUCTION

The aim of a sustainable neighbourhood must be to create a 'user-friendly' and 'resourceful' living entity, with energy-efficiency in its form, and a favourable place to live a satisfying life as its function. A neighbourhood physically manifests sustainability, with its people's acuity as 'good' or 'bad' localities. In the context of developing countries, the residential developments are commonly identified as; Subdivisions, Piecemeal or Master Planned developments (Teriman, 2012). In any circumstance, the neighbourhood form plays a significant role in determining the neighbourhood sustainability (Bramley et al., 2006). The broader intension of this study is to recognize the neighbourhood sustainability in the inhabitants' point of view and to identify the determinant attributes of the urban form.

1.1 Background to the Research

'Urban form' is considered as the generalized physical indicator or the manifestation of a built-up urban area. It demonstrates physical patterns, layouts, and structures of neighbourhood (Anderson et al., 1996; Dempsey et al., 2010). On an overall perspective, the urban form of a city or neighbourhood is constituted and with a set of elements, which could be identified as streets, street blocks, plots, buildings, and open spaces (Moudon, 1992; Engel-Yan, 2005). These configurations are formed by combining elements in a particular scheme or approach, with definite qualitative and quantitative measures, originating an identifiable character, unique to every neighbourhood or city (Clifton, 2008).

'Neighborhoods' as extreme local community entities, holding a strong physical identity in cities, are possessed with uniquely identifiable physical, social and economic characteristics (The Young Foundation, 2010; Dehghanmongadabi, 2014; Swisher, 2016;). As the key 'unit' of a city, neighbourhoods embrace a significant role in city formation and development (Kullus, 2000; Dehghanmongadabi, 2014).

Elements and composition of the urban form of a neighbourhood are identified as key factors that are appealing to stimulate sustainability and human behavior (Bramly et al., 2006), which demonstrate its distinctive identity. Neighbourhood design demonstrates the physical character of neighbourhoods and communities within the city. The 'urban form' is defined as the 'physical statement' of a neighbourhood, signifying its positive and negative characteristics of sustainability (Kotharkar, 2014). Sustainability of neighbourhoods demonstrated by its urban form fosters the overall sustainability of a city (Choguill, 2008). UN, (1992) promotes the understanding of 'sustainable urban form' at the local or communal level. It is due to the reason that the neighborhoods are contemplated as the key constituent parts of cities where any upcoming development schemes including buildings, streets and open spaces take place. In other words, with the development activities, the urban form constantly faces challenges (UNGA, 2018), and therefore, should with-stand upcoming social, environmental, and economic requirements of the neighbourhoods; the people who live and work in them.

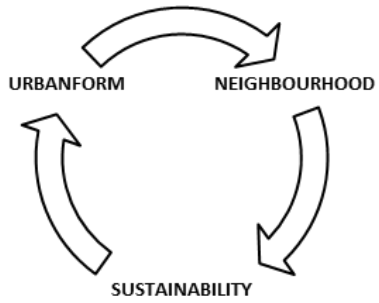


Figure 1.1: 'Urban Form' of a 'neighbourhood' as the physical manifesto of 'sustainability'

This study is focused on making a strong definition to 'sustainable neighbourhood' operationalizing and illustrating key elements and attributes of its 'urban form', which are affective in creating sustainable neighbourhood. It investigates elemental composition of urban form that attempts to demonstrate uniquely identifiable characteristics as sustainable neighbourhoods; in other terms, 'great' neighbourhoods in human perception.

Inhabitants' sense and experience the urban form of the neighbourhood in their day-to-day living. This phenomenon is considered to assess the distinctiveness of sustainability of the neighbourhood. Hence, the urban form can be considered as the important 'physical assembly', in the accomplishment of a sustainable neighbourhood.

1.2 Research Problem

Hypothetically, Urban Form; understood as spatial configuration of physical elements of a city or a neighbourhood, plays a significant role in achieving its identity as sustainable, and 'appealing as great' by the inhabitants. It is also identified as a combination of several elements such as density, street lay-out, land-use pattern, housing, and other building characteristics (Dempsey et al., 2010; Bramley, 2006;). In a nutshell, the identity of a neighbouhood, perceived by people, is closely, the physical intervention of its' urban form. (Beske, 2007)

As an important concept in the fields of Planning and Architecture, Sustainability has become vital in the contemplation of cities. But in the development of neighbourhoods, it has received lesser attention particularly in the context of developing countries (Yigitcanlar, 2015; Moroke et al., 2019). However, since neighbourhoods are components of cities that cannot be considered sustainable if the constituent neighbourhoods do not meet sustainability criteria. These criteria are identified as adequate connectivity with street network, appropriate layout, land-use patterns, and density measures, appealing housing and building characteristics etc.(Dempsey et al., 2010; UN-Habitat, 2011).

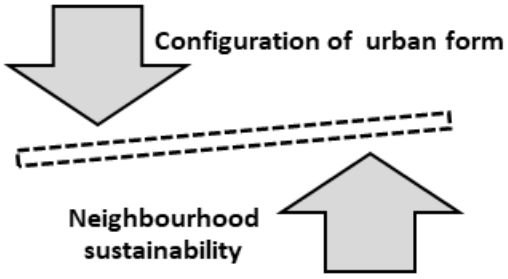


Figure 1.2: Sustainable neighbourhood as the physical intervention of its' urban form

Neighbourhoods are the physical manifestation and the indication of sustainability, with their own identification based on people's perception as 'great' or 'bad' localities. Such identities have a major bearing on how particular neighbourhoods are viewed as places to live (Robertson et al., 2008). This directly affects the behavior of its inhabitants as users, though there could be several other influencing factors. People: user or the inhabitant get influenced and adapted into the living setting by intuitive realization of the purpose that it is created for. Hence, inhabitants' judgment over the neighbourhood refers to the degree of contentment experienced by them regarding the socio-economic and environmental conditions at present. Inhabitants' experience and behavior imposed by the living setting acts over the quality and the standards of their living.

Examination on quality in urban form has become fairly passionate researches, focusing urban environments that facilitate the residents and users with both functional and aesthetic appeal (Lewin, 2012). For example, with the New Urban Agenda (2016), the United Nations emphasizes the importance of qualitative indicators, such as the prospects of human well-being and the improvement of the quality of life in cities. People-centered cities, in addition to providing the infrastructure to secure the necessities of life has been accentuated. The urban living space should also be livable and enable participation, promote civic engagement, and create a sense of belonging and ownership of the urban space.

The scope of the field has stretched out in practical as well as in academic pursuits. Mouden (1992) explains, scholars, architects, and urban designers try to figure 'what should be done' and 'what will work'. Researches and studies on 'sustainability' and 'neighbourhood forms' have been carried out extensively by scholars in the fields of planning and architecture. However, while the Urban form is comprehensively analyzed as elements and the concepts of sustainability is broadly recognized, exactly what a sustainable neighbourhood means in terms of urban form, has not been evidently defined or argued principally.

More significantly, the potential contribution or intervention of urban form in establishing the identity of sustainable neighbourhoods are yet to be discussed and agreed upon. Hence it is important to draw conclusions on this in order to come up with tools for design of new neighbourhoods or in re-instatement of existing ones as 'great' or 'appealing' neighbourhoods.

The conception of sustainable communities and the related notions of livable or good neighbourhoods have led us to several stimulating explorations. It offers several indicators in focusing on to the neighbourhoods and communities. Therefore, it is essential that sustainability is analyzed in a neighbourhood level, for not only to make assessments or comparisons, but also, more importantly, to find the determinant features or attributes of their urban form that determines the sustainability for a promised livability. The key questions answered in this study are:

- How can neighbourhood sustainability be defined in terms of the inhabitants' engagement and how does it correlate with their urban living experience?
- How is neighbourhood sustainability manifested through the urban form of neighbourhood and what are the deterministic attributes, that embark on this interconnection?
- How do the urban forms vary in different localities in the city; inner, intermediate, and outer city areas, for their inhabitants to sense them as sustainable?
- What are the major requisites of an urban form of a neighbourhood that meet with inhabitant's appeal on desired quality, in the long term in urban living?

The research is based on the inhabitants' experience of the sustainability of their living neighbourhood. The questions are aiming to recognize the requisites of urban form for sustainable neighbourhoods.

1.3 Research Aim and Objectives

The research analyses the urban form of a neighbourhood, and it examines the level of sustainability as recognized by the inhabitants. These are combinedly carried forward to achieve the intension of the research.

The research aim is formulating the determinants of 'Urban Form' for 'Sustainable Neibourhoods'. The study identifies the attributes of urban form of neighbourhoods and their role in resulted level of sustainability, for its' inhabitants or users to perceive them as great, good, or bad neighborhoods. It reveals the transfiguration of urban form; its' physical and non-physical elements, configuration, and composition, into sustainable neighbourhood features, attempting to promote sustainable neighbourhoods for inhabitant's satisfaction. This is concentrating on an exemplary urban form confronting the following corresponding objectives. They are sequentially interrelated leading to the final objective.

- To Identify attributes of urban form that indicate sustainability in a neighbourhood.
- To Review the expanses of sustainability level of a neighbourhood in the residents' perception.
- To Analyze the implication of the deterministic attributes of urban form in the resulted sustainability.
- To Reveal the implication of such attributes over sustainability in a relative location of the city; inner, intermediate, and outer city areas.
- To Identify the determinants of sustainability, as major requisites of sustainable urban form.

To accomplish the objectives, a research method is composed to administer the research in the practical parameters.

1.4 Brief Research Methodology:

As Mills (2010) states, appropriate sampling best portrays the research problem. This is centralized in the research methodology and is composed as multiple case study method allowing a comparative analysis. It has selected three case studies: neighourhoods from three different urbanities from Colombo. The case studies selected are 'Newham Square', 'Chitra lane' and 'Veluwanarama Road' from Colombo inner, intermediate and outer city areas respectively.

Boundaries were confined to self-defined vibrant community models, and are exemplary cases of residential neighbourhoods in the key development zones of Colombo. The research is executed through two key steps.

(1) First, it analyses the urban form of the neighbourhoods. The focus is to understand the neighbourhood form technically, in terms of its physical and non-physical components such as location, density, land use, layout, connectivity, transport infra-structure, housing and building types and architectural character. This employs secondary sources and personal observations. Secondary sources of information are ordinance surveys, site surveys, census data, and information from local authorities, followed by onsite personal observations.

Accordingly, physical density, housing typology and building character, lay-out, land-use, transport infra-structure and connectivity are physically studied and data at the macro context are obtained by spatial analysis utilizing latest GIS based information available with local authorities.

(2) Secondly, it assesses neighbourhood sustainability as reflected in the inhabitants' perception. Data was collected using the following procedure.

Structured interviews: This was administered by a questionnaire survey. 35 random samples of households were selected, and the questionnaires were

responded by one adult of each household, who has been a living resident in the neighbourhood for a period of more than 10 years and 30-75 year in age.

Structured observations: Systematic personal observations were carried out without any involvement of the participants.

Considering real living situations, a set of 50 queries examine the inhabitants' perception of the neighbourhood. Questions are structured and simple. They probe three main sustainability parameters: environmental, social, and economic. Each query examines determinant components of the urban form of the neighbourhood under each sustainability parameter as demonstrated below. Their respective qualitative outputs are assessed under the same subcategories in respect of physical and non-physical attributes.

Environmental parameters:	Physical structure: Density, Layout, Land use, Connectivity/transport infrastructure.
Social parameters:	User Satisfaction: Layout, Land use, Connectivity/transport infrastructure, Building types and Architectural character.
Economic parameters:	Living Standard and Affordability: Layout, Land use, housing types and accessibility to services.

The questions included a Likert Scale to ascertain the levels of appeal or satisfaction as: very poor [1], poor [2], moderate [3], good [4] and very good [5].

The responses were manually recorded as a 'scorecard' for the analysis, which was then carried out with the aid of the Statistical Package for Social Sciences (SPSS) to obtain mean values of inhabitants' levels of contentment. Respective mean values are considered as the level of inhabitants' appeal on the particular neighbourhood that indicate the level of neighbourhood sustainability. Accordingly, the three neighbourhoods are compared on inhabitants' appeal with reference to the determinant attribute of urban form.

Finally, it offers concluding notes with recommendations on the determinant attributes of urban forms rationalizing the sustainability goals of neighbourhoods from different localities. Though this has not been a standard method of measuring sustainability, the inhabitants' appeal, or the satisfaction over their living neighbourhood is considered as a prime factor to be evaluated, as they are the primary stakeholders, directly experiencing it while living in it.

1.5 Research Outline:

The research intends on formulating the Urban Form for sustainable neighbourhood, on which the research objectives are based. The research plan is simplified towards three (03) distinct techniques as follows.

1. Investigating the 'urban form' of neighbourhoods; analyzing it into its physical and non-physical elements and attributes.
2. Understanding the 'neighbourhood sustainability', as reflected in the inhabitants' perceived level of appeal; based on inhabitants' likeliness and level of satisfaction.
3. Discover the physical and nonphysical attributes of urban form of the neighbourhoods that determine the sustainability; that are pertinent to different aspects of sustainability.

The research is carried out in the first instance to understand the urban forms of the neighbourhoods, analyzing with the attributes in its composition. Secondly, it assesses the sustainability of the neighbourhood, as expressed by the inhabitants, in their experience, with reference to prevailing urban form. Finally, it combines both research data together to find out the deterministic attributes of urban form that foster the sustainability in each neighbourhood. The research is specifically combined with inhabitants' participation in rating their own living entity, and their perceptible level of satisfaction on the physical and the non-physical setting of it. Accordingly, the research flow is as shown in figure 3 below:

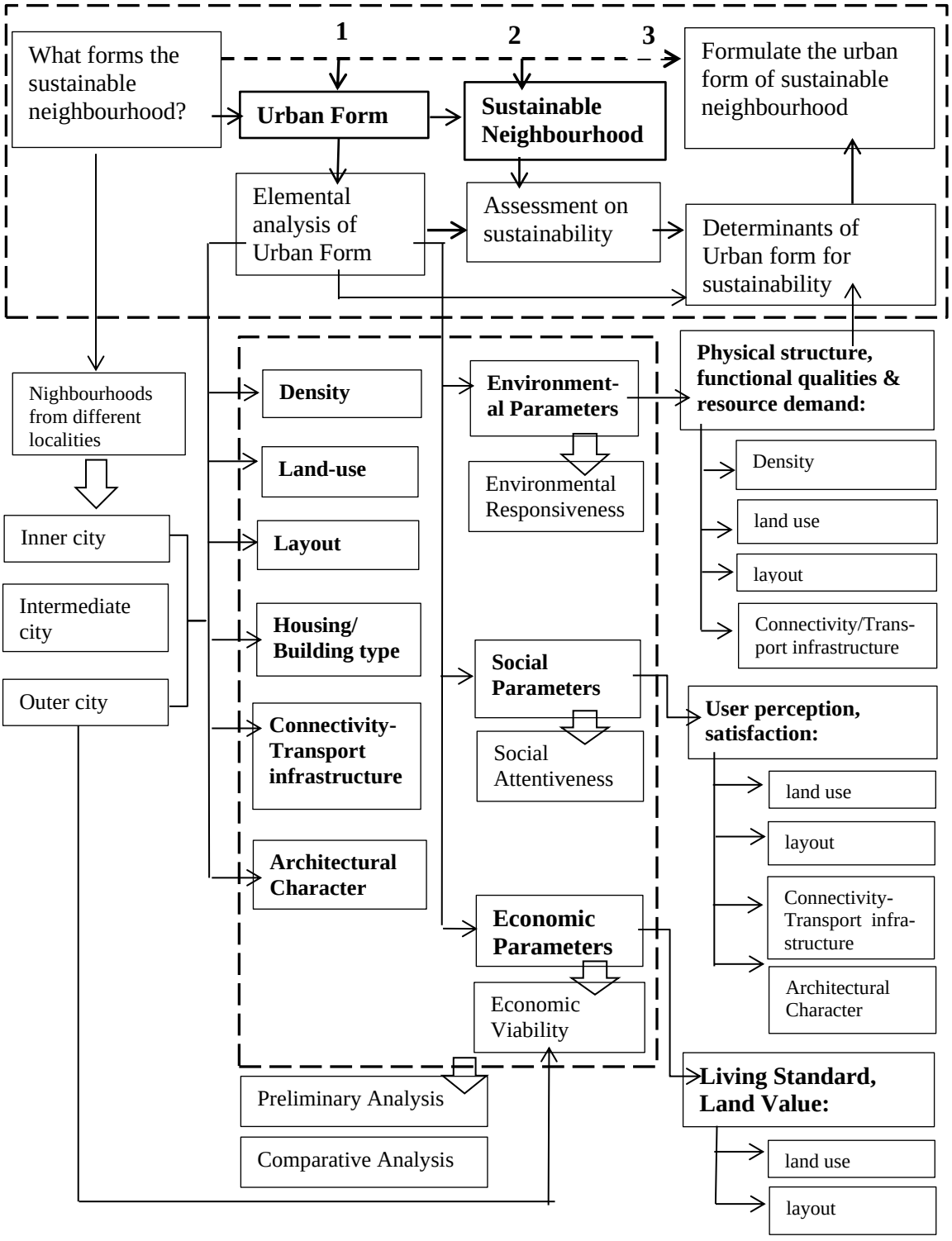


Figure 1.3: Research Outline; diagrammatic structuring of the research

1.6 Contents of the thesis:

This research thesis is organized in six (06) chapters, which carry Introduction, Literature Review, Method of Study, Presentation and Preliminary Analysis of Research Data, and Comparative Analysis of Urban Form for Sustainability, followed by the Conclusion as the closing chapter of the study. Chapter One delivers an Introduction and a brief overview of the research. The body of the chapter is a discussion on the background to the research, research problem, research aim and objectives, research method in brief, research outline, contents of the thesis, delimitations of scope and key assumptions, and finally research outcomes and Remarks.

Chapter Two presents the review on relevant literature. This mainly includes four (04) sub sections and initially attempts to discuss on Urban Form and Sustainability, and further elaborates the Urban Form as the physical statement of Sustainability. Secondly, it discusses the Sustainability indicators on Urban Form, and thirdly, Sustainable Neighbourhoods, including definitions and characteristics, zoning, rating, and its physical manifestation on urban form. Next, it discusses the manifestation of neighbourhood sustainability on its urban form. Then it discusses the conceptions on resident participatory approach in research and finally, the Key findings of the review conclude with the Research Gap.

Chapter Three delivers a detailed description on Research Methodology, including Objectives, Research Strategy, and Research Design. The structure of research design provides a conceptual framework on the analysis of Urban Form and a scorecard on Neighbourhood Sustainability. It explains the embedded and combined methods, selection of three neighbourhoods as case studies with a justification. The chapter explains the procedures and methods for collection of primary and secondary data in detail. Then it describes the processing of data; the evaluation criteria including analysis of data, reliability, descriptive statistics and discusses the evaluation procedure. Finally, it states the ethical considerations.

Chapter Four presents the Data collected on three case neighbourhoods individually. It presents the analysis of their urban form, background of sustainability level as perceived by inhabitants, and identifies the pattern of data, on research questions, to understand the achievement in sustainability and corresponding attributes of urban form. Finally, the analysis verbalizes and endorses the key attributes of urban form for neighbourhood sustainability in terms of Environmental Responsiveness, Social Attentiveness, and Economic Viability.

Chapter Five is a further extended analysis of research data on comparative basis. It comparatively analyses three neighbourhoods in terms of the urban forms, and sustainability assessments. Consequently, it provides an analytical Comparison of sustainability assessment with reference to urban form and composes a sustainability rating. Secondly, it examines the implication of attributes on the relative location within the city. It makes remarks on transformation of urban form into sustainability, reiterating the measurable standards of sustainability particularly considered in LEED-ND and relates its credit categories to attributes identified of urban form. It extends the discussion further, generalizing the research findings to other urban centers and town centers in the country. It draws attention to the necessities of developing residential neighbourhoods in outer city areas of a city or town, making a discussion on how to create appealing and conveniently functioning neighbourhoods in locations distant to city or town cores. Also, it describes the features of unplanned neighbourhoods that are commonly identified in local context, and it attempts to outline fundamental requirements that the policy decisions be essentially prepared for. It concludes with the author's perspectives on suggestive requisites of an exemplary Urban Form for Sustainable Neighbourhoods for varying contextual conditions.

Chapter Six discusses the results and conclusions of the study. First it summarizes the overall research study in line with objectives and aims. Implications of the findings are discussed with the contribution to the knowledge in terms of theory and practice.

Pertinence is discussed in forecasting the urban form for sustainable neighbourhoods for new designs or improvements in existing neighbourhood developments. Based on the case studies, it supposes connotations on impact of each attribute of urban form identified in the study, on the neighbourhood sustainability. It concludes with pointing the prerequisites of urban form for appealing urban neighbourhoods. The chapter closes with an epilogue with an emphasis on the recommendations for further research.

1.7 Delimitations of scope and key assumptions

Sustainability principles are considered universal. Realistic observations and investigations on varying types of neighbourhoods with their immediate environs are considered as study samples. Therefore, it progresses as case study research. Case studies are widely accepted as atypical examples of a prevailing issue. In order to fit the research in a distinct time framework, manageable in the individual study, the research focuses on selected case neighbourhoods and is limited to three (03) best appropriate cases. A detailed study on their urban form is carried out, analyzing every compatible aspect of the respective level of their sustainability.

The limitations of this research are recognized at the inception of the origination of research design. Thus, the sample case studies are essentially small in area, but are significant portions of three (03) administrative wards, in a single Planning Division of the Colombo Municipal Council. They are relevant to much recent developments in the Colombo city and are quite significant in current and upcoming densification. It is assumed that the research findings can be generalized into the other compatible urban neighbourhoods within the country. There cannot be a definitive set of sustainability goals, or strategies for a complete achievement that could be applied commonly to all communities or neighbourhoods. Objectives may vary from one community or neighbourhood to the other and can have changes over time. Hence, the generalization of the research intends to progress a sense of key concern in a significant study area in both urban design and architecture.

1.8 Research Outcomes and Remarks

Arguably, the urban form of a neighbourhood, could be analyzed and measured in terms of the constituent elements, and its composition or the structuring of its physical configuration. Parallelly, sustainability measures too are evident in its negative, moderate, or positive form in any neighbourhood, which could be qualitatively dignified.

Sustainable development means much more than environmental conservation. It embraces the inhabitants' need for equity and quality. This research claims that the inhabitants' level of satisfaction is a sensible indicator of sustainability of a neighbourhood. The approach recognizes the fact that environmental, social, and economic goals in appealing neighbourhoods are often mutually reinforced with the neighbourhood form. Facts on actual data based on analysis of urban forms and interviews with inhabitants, create a structure for the transfiguration of attributes of urban form into sustainability appeal of inhabitants. These can be used to formulate and verbalize the requisites for an exemplary urban form for sustainable neighbourhoods.

CHAPTER 2: LITERATURE REVIEW

Emphasis of the literature review is to comprehend the Urban Form as the physical statement of Neighbourhood Sustainability. Discussion on Urban Form, Sustainability, and Sustainable Neighbourhoods follows up to realize the attributes of Urban Form that indicates the sustainability distinctiveness of a neighbourhood.

2.1 Framework of Literature Review

Literature review is based on identifying the Urban Form, Residential Neighbourhoods, Neighbourhood Sustainability, and significance of Urban Form in Sustainability. At the end it convinces the research gap, following the research questions.

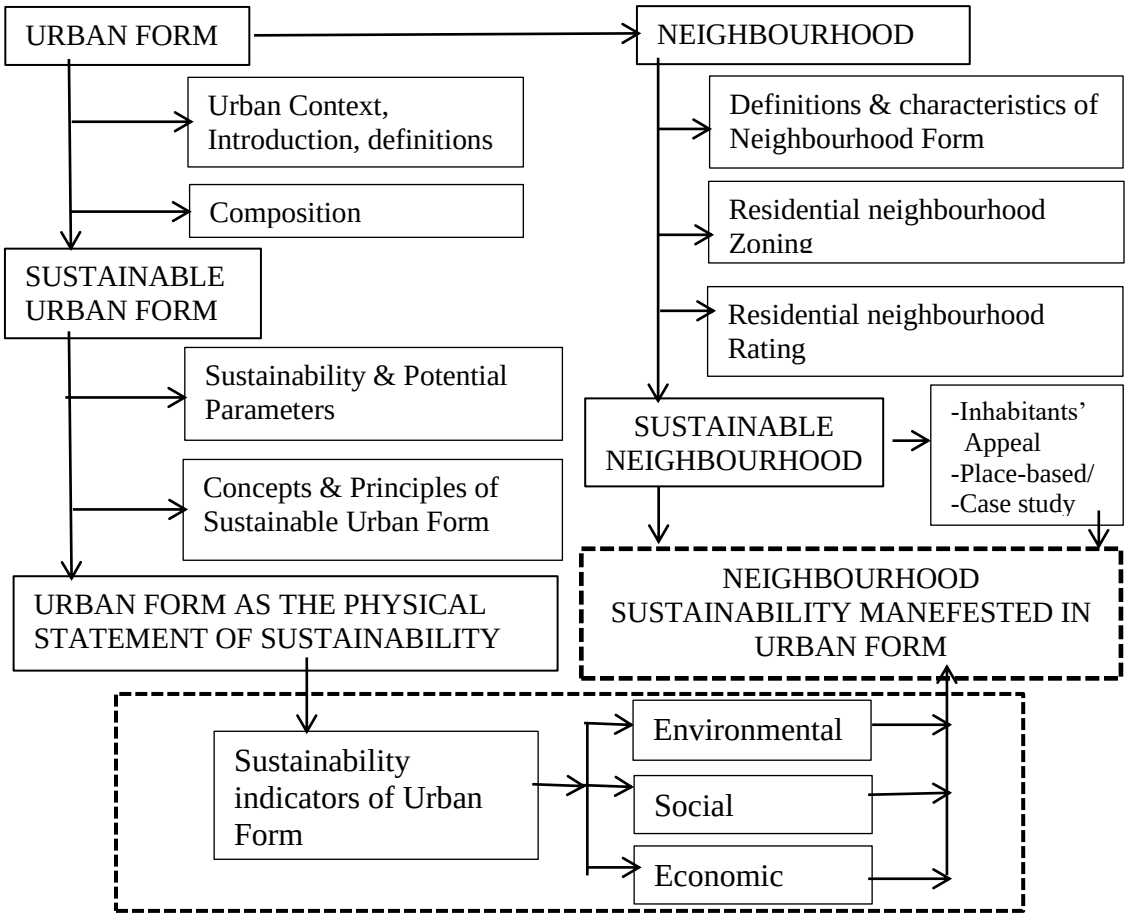


Figure 2.1: Framework for Literature Review

2.2 Urban Form and Sustainability

'Urban form' simply describes the physical characteristics of a built environment (Dempsey et al., 2010) in the urban context. Urban form may encourage and establish the fact of neighbourhood sustainability, amicably with social, environmental, and economic factors, possessing the potential to create areas safe and secured, user-friendly, convenient, and long lasting.

2.2.1 Defining 'Urban'

An urban environment, urban area, or built-up area is considered as a human settlement with a high population density and infrastructure of built environment. These high dense areas are created through urbanization and are categorized by urban morphology as cities, towns, conurbations, or suburbs (Wikipedia, 2021). In urban studies, the term urban, contrasts to rural areas such as townships, villages, and hamlets.

> *"Moving elements in a city, and in particular the people and their activities, are the important as the stationary physical parts. We are not simply observers of this spectacle, but are ourselves a part of it, on the stage with other participants. Most often, our perception of the city is not sustained, but rather partial, fragmentary, mixed with other concerns. Nearly every sense is in operation, and the image is the composite of them all."* (Lynch, 1960: p.2)

As Lynch (1960) claims, the built environment is perceived through its identity, structure and meaning. Problem of the meaning of urban environment is in its dialectics (Krampen, 2007). The meaning of a city should not be considered merely a reflex response of cultural and symbolic practices (Krupat, 1985; Krampen, 2007). They perform an important role in that but have their foundation in the material and economic process of human production (Krampen, 2007). The limitation of the meaning in the 'urban environment' to its material functions would neglect the human conditions of its production. These conditions vary according to different social structures in the course of history. (Krupat, 1985; Krampen, 2007)

In the urban context, the city is the ultimate creation of the human mind. It is an aggregation of people and activities unparallel in the history of civilization. Twenty-five years back, Krupat (1985) states that the city is only a recent invention. Rappoport (1980) stated that the city has been an object of curiosity for a very long time. The development of the city and the spread of its influence have occurred swiftly, so that its effect on city people have been failed to be observed carefully (Krupat, 1985). Today, this influence had gone way beyond its physical boundaries.

But cities as places have meanings (Lynch, 1960; Krupat, 1985; Krampen, 2007; Gehl, 2010). They are seen and interpreted through a social-cultural filter. (Krupat, 1985; Krampen, 2007). Defining a place in urban context at the social-cultural level endows it with certain characteristics known to most of the members of a given social group though not all (Krupat, 1985).

> *"The current interest in the quality of urban environment is in large part a convergence of two other evolving public concerns. One is the quality of the natural environment- the quality of air, water , land, wilderness areas, and other resources. The other is a concern with the development of our urban communities-with all the matters coming under the rubric of more traditional city planning, but recently refocused to a special concern for the human beings in the city."* (Perloff, 2015: p.3)

The quality of life of all the people who are clustering into urban communities within the cities are clearly affected by occurrences in both the natural and man-made environments due to direct interrelationship with each other (Perloff, 2015). The urban space contains public and private domains for urban dweller. The relationship between public and private spheres is one of the key concerns of the modern society. As Madanipour, (2003) explains this relationship with its social and psychological significance is well manifested in the physical setting of the urban space.

Madanipour, (2003) explores that the urban space of human societies is subdivided into 'public' and 'private' segments. It starts with the private; interior space of the mind and sequentially moves step by step, through the body, home, then neighborhood and the city, outwards to the most public, impersonal spaces, discovering the nature of each realm (Madanipour, 2003). This human-to-urban space relationship is complex, and interdependent. It explores the physical as well as psychological correlation of the human being to the living environment at its different scales of the urban parcel concerned. Accordingly, the perception of urban area or the city can be investigated in two different point of views (Krampen, 2007). It could be either by the process of which the citizens classify the urban environment in their experience and knowledge (Rappoport, 1979; Krampen, 2007), or as the projection of conceptual schemata of the founder planners and designers, based on their specialized knowledge (Krampen, 2007).

Accordingly, the spatial configuration of built-up urban area; cities and its relationship to the urban environment has continuously been a subject of empirical, theoretical and policy research. Certain principles, concepts and relationships are involved, to critically evaluate the prevailing state of knowledge about urban environment, city and urban form, energy utilization and the environment. Urban form can support efforts to design user friendly, resource efficient, clean, health-promoting cities.

2.2.2 Introduction to Urban Form and its Components

Dempsey (2010) states, the term 'urban form' describes city's physical characteristics and Kotharkar (2014) emphasizes that it generally embraces a particular set of physical features and nonphysical characteristics including size, shape, scale, density, and land use distribution. Further, it considers housing and other building types, urban block layout and dissemination of open or green space (Dempsey et al., 2010; Park & Rogers, 2015). According to Jenks (2010) it is a combination of a multitude of characteristics, which includes transportation infra-structure and urban design features of the city.

Connectivity through built form and transportation infra-structure contributes immensely to urban form influencing quality of place. These are categorized by Dempsey (2010), as following five (05) comprehensive and inter-related elements that structure the urban form in a city. (Figure 2.2)

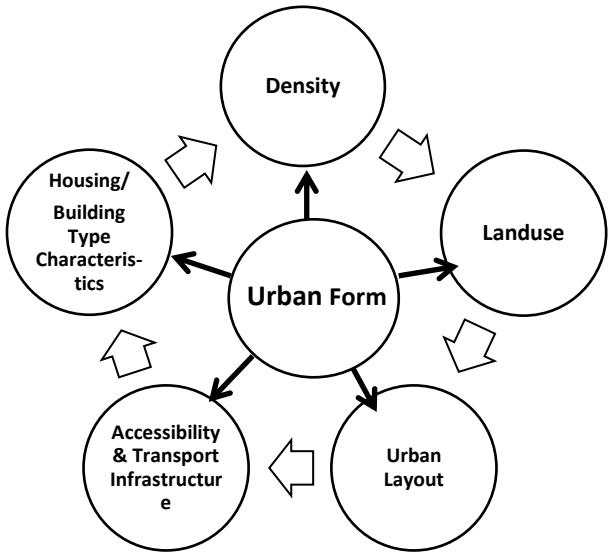


Figure 2.2: Inter-related elements that structure the urban form
Source: Dempsey et al., (2010), Elements of Urban Form

(a) Density: As per Dempsey's (2010) explanation, Density is a multifaceted concept by means of several inter-related dimensions. Mainly, it has two components: residential density and building density. Density is closely related with other land uses, in common access to services. For a service or facility to be viable, it necessitates serving a population of a particular size (Dempsey et al., 2010). As for compactness in Urban Density, Friedman (2015) states that several factors would determine the consideration of low, medium, or high-density neighbourhood. Dwellings and other building sizes, nature of parking and the expanse of private and public outdoor spaces affect the resulting densities.

(b) L**and use:** This indicates different functions of the environment (Dempsey et al., 2010). The dominant land use in the urban context tends to be residential, although a

functional urban area necessitates industrial, retail, offices, infrastructure, and other uses. The spatial configuration of land uses is central, realizing the efficacy of an urban area, and potential 'sustainable' urban forms in influencing urban travel patterns and the quality of life (Dahlstrom & Polikov, 2014). A major concern of local land use is the availability of local services and facilities within the neighbourhood. The provision of services and facilities is reliant on the demand of resident population and thus, land use often differs from one neighbourhood to the other.

(c) Accessibility and Transport infrastructure: This can be defined as the ease with which places; buildings and spaces can be reached. The degree of accessibility is described as the ability of an area that inhabitants and users can reach, and the extent that they ought to access the places, services, and facilities (RTPI, 2015) which are located beyond their local area (Dempsey et al., 2010). Accessibility is not purely the proximity, though the distance is one contributing factor. It is inclusive with good connectivity as against the distance. Kamble and Bhadure, (2019) refers connectivity to the ability to reach the location from several directions, deliberating easy access for goods, services, activities, and destinations. Factors such as the location of prospective destinations in relation to the user's starting position, how well and conveniently the transportation system connects with spatially dispersed locations, in what way the commuters use the system, and available options etc. (Jenks et al., 2005) are important concerns.

(d) Urban Layout: Based on Dempsey's (2010) explanation, Layout is the spatial composition and configuration of elements such as buildings, streets, and blocks. Denoted as the scale of streets, it could be grid, or organic with 'cul-de-sac' street patterns. Layout influences upon pedestrian movement, and the mode that various places, and spaces are connected to each other (Rashid, 2017). This denotes as the permeability of a layout which influences the ease of finding the way, movement of pedestrians and controls access, and could be effectual on other facets of urban form such as density and land use (Dempsey et al., 2010).

(e) Characteristics of housing and other buildings: Generally, in urban settings overall character can have an important bearing on routine living (Dempsey et al., 2010). The effect of building characteristics stretches beyond the density of urban living and offers the identity and the uniqueness to the urban entity. Factors such as type of buildings, architectural character, function, and the age are effective on urban form, which demonstrate the social and cultural distinctiveness of the setting (Dempsey et al., 2010; Ghoomi et al., 2015). Elements and elemental composition in urban form are equally important and collectively provides an identity to neighbourhoods.

According to Jabareen (2011), Urban Form is described as spatial composition of reappearing elements, besides it takes lead to the sustainability of cities once grounded on certain sustainable concepts. At the broader scale, urban form is identified as the spatial configuration of fixed elements in the urban setting (Anderson et al., 1996). It is identified that any of the urban settlement type, namely a central business district, market town, or suburbs are appropriately inclusive with characteristics of urban form at that level or scale (Dempsey et al., 2010). The consideration could be at different scales such as regional, city or town, neighbourhood, block, or street.

Urban form changes constantly, responding to its social, environmental, economic, and technological development (RTPI, 2015); such as planning, and urban policies on housing health, transport, and economy. It is theoretically defined as the physical and non-physical attributes that structure the built-up urban areas, comprising the size, shape, density, layout, connectivity, along with overall configuration of the urban setting. As Lynch (1981) states, normative theory of 'urban form' directly deals with 'settlement form' and its 'qualities' and nothing related to diverse application of concepts or notions from any other fields. Accordingly, characteristics could vary from, a much-localized scale, with characteristics such as building profile, colours, materials and façade details, to, a broader scale; with housing, or building type, street type, spatial arrangement, blocks, and layout.

> *"The form must be somewhat noncommittal, plastic to the purposes and perceptions of its citizens. Yet there are fundamental functions of which the city forms may be expressive: circulation, major land uses, key focal points. The common hope and pleasures, the sense of community may be made flesh. Above all, if the environment is visibly organized and sharply identified, then the citizen can inform it with his own meaning and connections. Then it will become a true place, remarkable and unmistakable."* (Lynch, 1960: p. 91-92)

It is identified that the built environment has three (3) parts: identity, structure and meaning (Lynch, 1960). Emphasizing on identity and structure, several people of widely diverse backgrounds hold many varied images in relation to the same physical form. Spatial configuration, therefore, not only creates hierarchical relationships, but it also helps producing patterns of social relationships (Bafna, 2003) and behavior within the community.

Urban form is also defined as the convergence of three corresponding elements, that are the street plan, sub-division, and built entities (Scheer, 1998), and house forms, lot sizes, and street lay-outs define the essential elements of urban form (Moudon, 1992). Overall, Urban form is understood as spatial configuration of physical elements of a city or neighbourhood, which plays the major role in demonstrating its identity as a 'great' or 'bad' place; sustainable or not. But the most suitable or appropriate urban form in achieving sustainability is yet on debate and unsolved to date . Architecture and Urban design as development activities are concerned with shaping and arranging built and un-built city spaces (Hess, 2004). Accordingly, they carry out both directly and indirectly with many institutions and professional input and incorporates multiple goals. Some of them include creating spaces that support a range of activities, encouraging or discouraging a variety of behaviours including social interaction; evoking emotional responses such as sense of place, beauty, tranquility, nostalgia, or awe; and improving the ecological or economic viability of built form. Understanding what is necessary and how to achieve is the application of theory.

In reality, research and theories address some of the selected important issues. A particular view of philosophy is always stressed, which is the 'important concerns' in city design (Moudon, 1992). Lynch (1960) highlighted on peoples' perception and sense on their environment, Rappaport (1977, 1982, 1990) emphasizes on the practice of use and connotations in built environment and elaborates people's interaction with their living environment. Spirn (1984) concerns mainly on the physical health, safety, and welfare of the city dweller, and Gehl (2010) focuses upon the influence of urban form on human behaviour etc. All these provide deep and interesting insight on qualitative aspects of urban form which influence human life; perception and responding behaviour. It is evident that the issues are identified and theories on those are raised based on the urban form on different phenomenal, at different locality scales. How these could be looked particularly at neighbourhood scale in its practical application is the experimentation.

2.2.3 Definitions of Sustainability and Potential parameters

The term 'Sustainability' does not have a simple definition. Widespread acceptance is that the environmental quality, economic health, and social equity must be balanced to maintain long-term community, economic vitality, and resident's quality of life (State of California [SOC], 2010; Kotagama, 2019). There is no definitive set of sustainability goals, or strategies for a complete achievement (SOC, 2010), that could be applied commonly to all communities or neighbourhoods. Objectives may vary from one community or neighbourhood to another based on several internal and external factors, which can have changes over time.

As per the definition by Beauregard (2005) sustainability is positioned at the intersection of environmental responsiveness, economic progress, and social integrity. Similarly, 'sustainable design' is explained by Kotagama, (2019) as the art of designing the built environment to conform with the ideologies of economic, social, and ecological sustainability, incorporating sustainable planning: cities and infra-structure, architecture, landscape, agriculture, and technology.

Sustainable development links together with the concerns for carrying capacity of natural systems, with the social challenges facing humanity (Bombugala, 2010). Concept of neighbourhood sustainability takes different forms and definitions. According to Elkin (1991), aim of sustainable urban developments is to create a user friendly and resourceful city, in terms of its form and energy efficiency, as well as a good place for living as its function.

Falk and Carley (2012) argue that a sustainable neighbourhood has a value as a place to live over several generations, simply long lasting. It is generally examined how the resourceful communities have been designed, and physically structured. Accordingly, Falk and Carley (2012) have conveyed the inferences composed into four themes. They are healthier and stronger communities, secured, safer streets and living places, better choice of homes, favourable environmental conditions and features adding value to a good quality living.

Accordingly, if the form facilitates the city to function with its natural and man-made carrying capacities, user friendly, and safe for its occupants, and encourages social equity, to be considered sustainable (Williams et al., 2000).

The meaning of sustainable development in general understanding is the balance of environmental, social, and economic requirements (SOC, 2010) linked appropriately with prevailing urban development measures. To maintain the link with a balance, the changes in development should be socially equitable, environmentally bearable, and economically viable (Bombugala, 2010).

To realization of this link, the inclusive Governance; in terms of managerial dimension, establishment of policies, their proper implementation and continuous monitoring is essential, regardless with the scale of development.

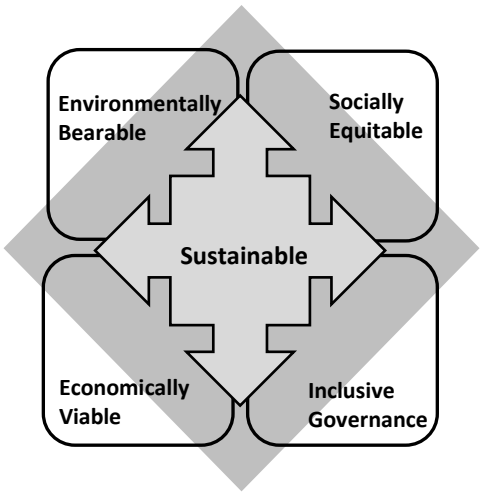


Figure 2.3: Major Inter-connected Sustainability Parameters and potentialities
Source: By Author based on Bombugala,2010

Referring to European evaluation approaches, Blum, and Grant (2006) proposed six guiding principles of sustainable development. They are briefly, Economic efficiency, Social equity encircling the principle of inter-and intra-generational equity, Environmental caution, Precaution, and long-term consideration, Globality in relation to the locality, and Governance on the local level. Globally comprehensive approach and governmental responsibility for citizen participation; particularly residents, users and key socio-economic decision makers are essential in this achievement.

> *"Governments are key players in creating more equitable societies, protecting the most vulnerable from the negative effects of these trends and ensuring that their benefits as well as adaption costs are broadly and equitably shared. But, in our increasingly interconnected world, the decisions of other countries can constrain national policy-making."* (UN-World Social Report, 2020; p. II)

These are within possible and practical parameters for design professionals, if strategic and appropriate policy making is positively involved. City life, safety, sustainability, and health are integrated with city policy (Gehl, 2010). A single city policy will strengthen living quality and key social objectives. Though most Sri Lankan urban and suburban neighbourhoods are generally not planned exactly at master contexts, the upcoming new developments and improvements of existing developments are to be designed based on

lessons learned by looking at good and sustainable examples and their planning policies. Since local authorities are currently set with the understanding of the matters and related issues, looking at the requirements of urban form in creating sustainable neighbourhoods within all its environmental, social, and economic parameters are vigorous.

2.2.4 Concepts and Principles on Sustainable Urban forms

Exploration of the definitive sustainable urban form has reoriented searching for several sustainable urban forms, responding to a multiplicity of prevailing settlement patterns, contexts, and circumstances (Jenks et al., 1996). There are several principles and concepts suggested by different scholars in creating sustainable neighbourhoods. Jabareen (2011) analyses and identifies a set of design concepts in relation to sustainable urban forms, particularly seven. They are described as compactness, sustainable transport, density, mixed land uses, diversity, passive solar design, and greening.

In mid-1990's it was investigated and recorded that the compact city as the dominant model for urban sustainability (Jenks et al., 1996). Referring to popular conventional high dense European cities such as Barcelona and Paris, this model was realized as sustainable solutions for urban forms commonly in most developed countries, and was introduced into policy (Williams, 2000). Neuman (2005) states that the Form is a consequence of evolution and is a snapshot of progression. Further he states that it can be a static situation at any point in a time stretch, and it is not quantifiable or assessable in terms of sustainability in his opinion.

Concepts of sustainable Urban Forms are deeply discussed at city level, based on compactness. It attempted to explore on links with provision of infrastructure with their inferences and the management of relationships among users, buildings, and territories in cities (Guy & Marvin, 1996). Referring Haughton (1997), Kate Williams (2000) states that works on models of sustainable urban developments are useful in helping to think through the relationships between competing visions of the type of sustainable city.

That would support different ways of management in infra-structure. She further states, each model represents a competing strategy of which urban form and functions are constituted to avoid environmental consequences of resource use within the city. Much research on sustainability have focus on the mobility behavior which significantly impacted by urban form and consequential social and environmental impacts (Boarnet & Crane, 2001). Resulted with different approaches and methodologies, specifically three types of urban structures have been recognized; as the compact urban form, the polycentric urban form and the sprawl urban form (Coppola et al., 2014).

The Compact Urban form was the mostly promoted model as the most sustainable in urban development context (CEC, 1990; Williams, 2000). Several researches uncover, that the compact cities are encouraging sustainability by preventing the damages, losses and disturbance for neighbouring natural, agricultural and unindustrialized land areas, reducing distance and travel time, car dependency and energy usage in transportation (Newman & Kenworthy, 1999; Mobaraki, 2012). Further, it reduces energy use, and consumption of building materials on infrastructure. It retains the diversity and opportunities for options in employment, services, amenities, and social interactions.

On its downside, other studies stated that compact developments are roots to severe congestion in traffic and transport network. It increases land value and dwelling rates and generate social exclusion consequently (Breheny, 1997). It is evident that highly dense urban settings remain frequently expose to noise and pollution from local traffic, consequently vulnerable to undesirable health effects (Coppola et al., 2014).

In Polycentric urban model, the activities are located mainly in and around dense and mixed sub centers (Coppola et al., 2014). This model has become a much discussed and argued subject in contemporary urban planning. Some researchers indicate that in polycentric urban configurations, networks of public transport are generally envisioned for radial tours, and consequently it encourages car use (Schwanen et al., 2001).

Opposing, others proclaim that polycentric developments are better in reducing car usage and travel distances, and it consequently conserves land. Some studies propose that polycentric arrangements help to reduce commuting distance and travel times (Levinson & Kumar, 1994; Gordon & Richardson, 1997). But some researchers disprove this positive view (Ewing, 1997) of the polycentric model specifically on travel behaviour. Some empirical surveys demonstrate that it would discourage car dependency, where sub centers are situated close to metro stations (Pivo, 1993). However, credible supportive evidence remains limited.

Sprawl urban structure is a spread-out development outside of more compact development centers (Squires, 2002) which induces auto-oriented lifestyles and higher urban management costs according to most studies. It negatively impacts on servicing such as energy supply and distribution, service provisions, waste collection etc. And it is accompanied by extensive travel movements and related environmental impacts (Travisi et al., 2010). They are decentralized and clearly distinguished from compactness. More of local sprawl can impose discontinuity in urban central relationships and may cause strip development.

The concepts on sustainable urban forms were long discussions for more than three decades by now. Sustainable development means much beyond the environmental conservation and it embraces the human requirement for equity and quality. Within this context, both inter and intra-generational equity, ensuring a fair and rational concerns for future as well as present generations are needed to be well considered (Elkin et al., 1991).

As emphasized in the Brundtland Report (1987) sustainable development is described as a progress that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs. As an organization supporting for better urban future, UN-Habitat (2011) recommended five (05) principles in creating sustainable neighbourhoods which embraces adequacy of space provided for streets and an efficiency

of street network, with high density, social mix, mixed land-use, and limited land-use specialization. It further states that in sustainability analysis of a neighbourhood, following units can be used as benchmarks under each of above five principles:

Table 2.1; Benchmarks for sustainability analysis,

Formula-%	Unit: range, minimum	Applicable Principle
Street land-use / Total floor area	(30-45%)	Principle 1: Provision of adequate space for streets and street network
Population density	(150 people/Hectare)	Principle 2: High Density
Economic floor area / Total floor area	(40-60%)	Principle 3: Mixed Land-use
Residential floor area / Total floor area	(30-50%)	
Single ownership/tenure / Residential floor area	(0-50%)	Principle 4: Social Mix
Affordable housing / Residential floor area	(20-50%)	
Single function block area / Neighbourhood area	(0-10%)	Principle 5: limited land-use specialization

Source: UN Habitat, 2011

Apart from those, achievement in social goals of living (Hamiduddin, 2015) and environment related practices (RTPI, 2015) are also indispensable concerns. Social goals are the prime factors of inhabitants' perceptual satisfaction and are indirectly effect on all aspects of sustainability. Accordingly, main principles of sustainable neighbourhood concluded through the literature review can be presented as follows and achievements are impressive in their real application by referring to examples.

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

Developing an appropriate and effective level of street network, that suits with public transportation, private vehicles, and particularly pedestrian and cycling are the main concerns. Apart from that, the street network plays in formation and shaping of the structure of neighborhood . That defines the pattern in the development of streets, blocks, buildings, open public spaces, and landscape which collectively tend to create the basis

for sustainable neighborhood development (Engel-Yan, 2005). Focusing on mobility dimension of a sustainable neighbourhood, Dehghanmongadabi, (2014) states, the characteristics such as walkable, safe pedestrian and cyclist friendly streets, efficient public transportation with interconnected street hierarchy and adequate parking are important concerns in street design (Figure 2.4, 2.5)

Figure 2.4: Long- wide avenues providing adequate space for pedestrians in Copenhagen ;(left)
Figure 2.5: Pedestrian precinct in the mid of city center Aachen, Germany; (right)
Source: http://footage.framepool.com

These concerns have direct impacts on the urban layout and transport infra-structure of urban form. Further, a careful balance between built and un-built areas, openness, and appealing street environment are attractions of a neighbourhood for inhabitants' satisfaction. Pedestrian friendly street network reducing driving lanes and parking places in a deliberate process creates better and safer conditions for walking and bicycling (Gehl, 2010). Expanded sidewalks, pavements, street furniture, and lighting collectively create a pedestrian-friendly urban profile, promoting walkability in cities which is not an isolated activity, but it must be integrated to the entire structure of a city (Dayaratne, 2011).

(b) High Density

Density is a prime element in urban form that is considered as a significant principle in sustainability. Jabareen (2011) explains that in creating cities sustainable, urban forms contribute contrarily, and theoretically where compact city is more conclusive than other urban forms. As results of issues emerging with rapid urbanization, outburst of global population and urban sprawl, accomplishing high density, is vital and fundamentally

important in the design of sustainable neighborhoods. It concentrates people and their activities, and possesses many economic, social, and environmental benefits. It is considered as a smart choice globally, placed in the central concern of sustainable urban planning.

Figure 2.6: High dense neighbourhoods in Hong Kong city leaving 3/4 of land as green space;(left) Source: Author
Figure 2.7: Dense urbanities creating more people move about and stay; Amsterdam city; (right) Source: https://amsterdamsmartcity.com

According to UN Habitat (2011), key advantages of high-density developments are identified as land use efficiency, accommodating a greater number of people per unit area appropriately, reducing the cost for public services including emergency responses, transportation, infrastructure services, and improved community services. It reduces car dependency and associated demand for parking, encouraging public transportation, pedestrian; walking and cycling modes. The potential for lively and resourceful urbanities is strengthened when more people are invited and convened to live, walk, bike, and stay within the setting. This can be used to encourage the use of public transport systems when people feel safety and comfort. Thus, it indicated benefits to economy and environment, reducing resource consumption, decrease emissions and reduce noise levels (Gehl, 2010).

Nevertheless, it is important to note that densification must have parallels with development of infra-structure, for high dense neighbourhoods to be better sustainable. The achievement of high density alone, in absence of the provision of services and infrastructure, is detrimental to both neighbourhood equity and quality life.

(c) Mixed Land-use

Land use as an element of urban form and a sustainability principle, may have several options in promoting neighbourhood sustainability. Dehghanmongabadi (2014) describes that the principle of mixed land-use concentrates on combining a series of well-matching flexible land uses and activities close by, within appropriate distances. Apart from that, mixed land use attempts to generate local employments, enriching a better local economy. It encourages movements of pedestrian and cyclist traffic, decrease car dependency, lessen disintegration of landscape, provide more public services in proximity, promoting inter-active communities. This concept provides a state combining of housing, commercial, institutional, industrial, and other functions. Mix of functions and land uses in a single neighborhood, are to be designed in a well-balanced, well-harmonized manner. It must be flexible enough to convene the residents in their housing and economic activities. (Figure 2.8, 2.9)

Figure-2.8; Combined residential, commercial & Institutional uses in Downtown Toronto; (left)
Source: Author
Figure-2.9; Social mix in Multi-cultural neighbouhood, China Town-East, Toronto; (right)
Source: https://www.flickr.com

Predominantly housing and other building types and characteristics of urban form is the realization of social mix of a neighbourhood. Principle of social mix intends to stimulate the inter-connection and interaction amongst diverse social clusters, within a single neighborhood. It is delivering equal privileges and accesses to prevailing urban opportunities, and services by planning housing of diverse types. It offers a basis for rich social networks. Social mix and mixed land-use are supportive to each other and are mutually dependent. Further, in mixed land-use neighborhood, opportunities for jobs or

livelihood are diverse, serving residents with different income levels, and shaping a social network (UN-Habitat, 2011; Dehghanmongabadi, 2014).

(d) Limited land-use specialization

This as a principle, focuses on land-use aspect of urban form, which targets at limiting single functional zoning, and encouraging mixed land-use strategies. Application of land-use specialization in many cities globally, creates neighbourhoods endorsed with numerous single functions that are one main cause of contemporary issues in urban localities (UN-Habitat, 2011). It creates restrictions for residents in reaching communal activities and functions. It confesses that single land uses in isolation do not create long term sustenance. They have to be integrated with other appropriate activities for people to be involved with them.

Figure-2.10, 2.11: Residential apartments, Public & recreational spaces in the central business area of Toronto, limiting land-use specialization.
Source: Author

Limiting land-use specialization is an essential practice in creating mixed land-use. Accordingly, combining compatible land-uses within a single neighbourhood, with introducing mixed land-use zoning in respect of each use, are identified as two strategies for achieving resourceful zoning: (Figure 2.10, 2.11). A clear core pattern emerges with a good diversity of activities in an urban setting. As Gehl (2010) illustrates, one simple way of achieving it is putting together the most important activity categories according to their degree of necessity.

For this, single function areas in the urbanity are to be made purposefully limited. Obviously, commercial, and recreational uses are fundamentally necessitated in residential zones for resourceful functioning. Thus, the urbanities and neighbourhoods become self-sustained with walkable facilities, and improved adoptability to public transport, reducing car dependency. Further, the activity mix would accentuate the social mix, encourage social interaction, increase social cohesion and linkage among different social groups, while generating diverse job or livelihood opportunities, and attracting better services to the area.

e) Achievement in social goals

Social and environmental goals are jointly supportive to each other. 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; (Figure 2.12, 2.13). Human activities in urban settings are influenced by the physical standing of urban form and vice versa (Omar, 2009). It is a mental process that could be explored only by observing user responses and understanding their satisfaction levels.

Figure 2.12, 2.13: Best sustainable neighborhoods: Malmö city in Sweden
Source: https://sweden.se

Many social changes particularly in the wealthiest parts of the world as well as highly urbanized dense areas in developing context, can explain the increased interest in social goals of urban life (UN-World Social Report, 2020). Electronic means of contacts,

working, teaching, and learning, etc. made major changes in social life with remarkable renaissance by today, with special conditions.

(f) Positive Environment related practices and biodiversity

Practices on main infrastructure 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 and noise, storm water management, solid waste management etc. are significant in creating sustainable neighbourhood settings. In current practice in sustainable energy usage, solar and wind power, biogases, rainwater harvesting, waste and sewerage treatment, recyclability etc. have become thorough concerns.

Consequently, the concerns of relationship between urban form and sustainable development have originated new paradigms of design approach in new urbanism today (CNU, 2020), which is simply understood as the urban design movement. The role of the city form in creating sustainable neighbourhoods, has become more prominent in urban neighbuourhoods, due to the rapid growth in urban population and urban sprawl.

Looking at the US traditional neighbourhood pattern, Duany, Plater-Zyberk and Jeff (2000) suggest six fundamental rules that were considered around for centuries. It has been provided a valid conceptual framework for the design of neighbourhoods and reshapes their communities. Main concerns are on the neighbourhood center; five-minute walk to needs of life; street network with good connectivity; narrow- versatile streets that traffic can be shared and smaller streets and boulevards; mix of uses; special sites for community functions such as civic buildings, schools, libraries, community facilities, town and city halls, and places of worship.

It is to be stated that the anticipating degree of the urban form's influence on sustainability are great (Williams, 2000). It also has been predicted, nearly 70% of the energy supply

is conditional on the impact of the land use formation (Barton, 1990). Manipulating land uses and their formation is seen as a valuable technique in achieving sustainability in urban settings. However, it is not clearly stated of the exactly preferable forms, (Williams et al., 2000) as an application model. One form or partiality for high or low densities, dispersed or centralized growth, small or large settlements have not been immediately suggested as the most appropriate. Broadly, concerns of sustainable urban form are not merely protecting the natural environment. It involves with the correct use of land to convene the human living in neighbourhoods in terms of physical connectivity, safety, social equity, and consequently creating pleasant and livable cities, that are lasting for generations, being adaptable for continuous development.

2.2.5 Urban Form as the physical statement of Sustainability

Most literature comprehends sustainability as a process determined by a group of guiding ethical principles (Crabtree, 2005), rather than a goal or an end result. Therefore, sustainability is an apprehension with qualitative performances (Grosvenor, 2013) rather than a set of environmental, social, and economic measures. It is agreed that for any advancements in urban sustainability, relations amongst urban form and a range of elements or attributes of neighbourhoods, towns, or cities, at every geographical scale, are needed to be recognized (Williams et al., 2000).

The quest for more sustainable communities or neighbourhoods is that what will endure or be livable and requires qualities exploring what can be done to reinvigorate areas. It is essential that sustainable communities are to be understood as places where people desire to live in and work at, today and in the upcoming future (Bruntland, 1987). Places and spaces are created by the elemental formation of the neighbourhood; simply the ‘urban form’. They encounter the varied needs of residents; at present and in the upcoming future, those are sensitive towards their living or working setting, and contribute to enjoy a good quality of life.

In human perception, they are safe, secured, and inclusive, well planned, assembled, built and function, and offer equality of opportunity and good quality services for residents (AARP, 2005; City of Pickering, 2011).

For neighbourhood communities to become sustainable, it asserted that they must be offered with decent and affordable homes, good public transport, walkable streets, public facilities, and amenities such as schools, hospitals, shops, community spaces, etc. in a clean and safe environment (AARP, 2005; Metlife, 2013). Those should be applicable to both new planned as well as developing existing neighbourhoods, for them to be expressed as sustainable neighbourhoods. A livable community for all residents, senior citizens alike, would include aspects that are helping to maintain the independence and quality of life (AARP, 2005). Hence, the physical characteristics of a neighbourhood possess a main attraction in facilitating and assisting personal independence of residents of all ages.

These ideologies have been implemented in certain cities and neighbourhoods as development guidelines. An Eastern Toronto city council: City of Pickering has currently established separate two sets of guidelines for new neighbourhood designs and existing neighbourhoods (City of Pickering, 2007, 2011), addressing their environmental, social, and economic requirements. Guidelines for new neighbourhood designs are mainly focusing on; pedestrian scaled compact and mixed-use community structure and transit supportive, linked system of open spaces; preservation of natural environment and cultural heritage; remarkable areas for employment; routs for pedestrian and bicycle; minimized impacts to natural features, landscape, and stream crossings (City of Pickering, 2007). For existing neighbourhoods, it proposes a 'Sustainability Scorecard' to evaluate sustainability level in neighbourhoods mainly centered on six attributes as complete and connected; land-efficient and transit-friendly; safe and comfortable; adaptable or resilient; energy and resource efficient; green and healthy (City of Pickering, 2011).

On this framework the neighbourhood form can be assessed for its sustainability, in which the inhabitant's judgment can be a method of evaluation. All these proposed sustainability aspects are based on the 'design of' and 'read through' urban form. In the detailed discussion on the literature review on concepts of sustainable urban forms, it is clearly convinced that sustainability is laying on the type of urban form, as it is the 'visual statement' on the 'physical structure' of any 'good' or 'bad' built environment within an urban entity.

Accordingly, the sustainable neighbourhood is identified and recognized by its form. Lynch (1981) describes urban form in a diverse and a multi-faceted manner. Overall spatial arrangement of human-social activities, consequential spatial flows and movements of people, goods, information, and physical elements and features, would adjust, modify, or amend the space appropriately in particular way significant to those activities, including enclosures, channels, surfaces, ambiences, and objects.

Therefore, this broad and comprehensive explanation of the urban form exemplifies social, cultural, economic, political, and physical realms of urban life (Beske, 2012). Therefore, the urban form with its dimensions or the features is diverse realms in which the sustainability is emblazoned upon.

Urban forms are designated as successful when they strengthen the functioning of urban systems, consume resources sustainably, and deliver a comprehensive economic base, enabling a 'good quality of life' for its inhabitants. Also, they are capable in withstanding shocks of changes (UNGA, 2018), and can bounce-back or advance their conditions within the situation (RTPI, 2015); simply are 'long lasting'. The shocks could be mostly environmental, economic, or social related, shrinking, densification, peak energy, and climate catastrophes.

Recent crisis of COVID-19 entails an outstanding opportunity for designers, planners, as well as policy makers to consider on transformative actions in the direction of creating cities and neighbourhoods that are more just, resilient, and sustainable. (Sharifi et al., 2020). It has pointed necessities in planning for certain new requirements of community living, public places, workplaces, educational and religious edifices, and even personalized housing to withstand pandemic situations.

Finally, it can be stated that the framework or the structure of elements defines 'urban form' and states the general pattern of land use, urban lay-out, density, connectivity, architectural input on housing and building types, and development intensity. Those define the quality of urban form on its physical elements, such as natural features, transportation corridors, and open space, built masses, public facilities, in addition to activity centers and focal elements. Overall, the urban form is a statement of the physical character of neighborhoods and communities within the city and be recognized as 'great' and 'sustainable'; or 'bad' and 'failed' living units.

2.3 Sustainability indicators of Urban Form

The 'Brundtland report' (1987) remains still as one of the most remarkable consensus recorded documents on sustainability. Its emphasis on futurity or inter-generational equity in terms of access to beneficial aspects of the environment is the essential and defining characteristic of a sustainable development.

Three (03) overlapping circles, signifying concerns related to the economy, society and the environment is the greatly predominant and highly influential means of expressing and presenting the concept of sustainable development. The center, in the three-fold overlap, integrating the three areas of concern symbolizes the sustainable development. This demonstration, which was said to be developed by the International Centre for Local Environmental Initiatives in the early half of 1990s, has become abundant and long-lived (ICLEI, 1996; Connelly, 2007).

The Commission accomplished integrating concepts of environmental and economic needs sufficiently, appropriately to convince people around the world that sustainable development was a challenge that relates to everybody. Elliott (1999) confesses the ongoing argument over definition, meaning and practice, claims that sustainable development is "fundamentally about reconciling development and the environmental resources on which society depends" (p.34). Thus, the environment, economy and the society are equally important with relevant imperatives in sustainability.

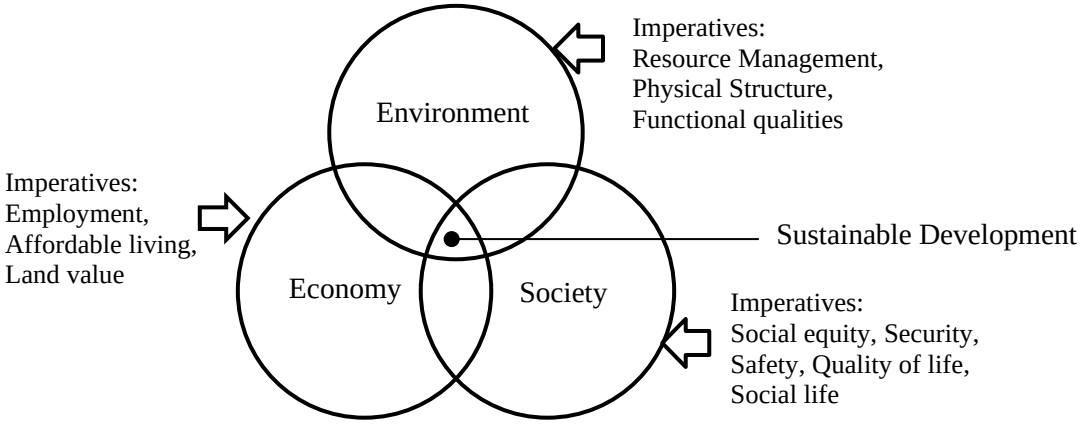


Figure 2.14: Three overlapping circles; concerns related to sustainability
Source: By Author based on ICLEI,1996: Connelly, 2007

Understanding the 'sustainable development' as a phrase plays several roles, and it can be mapped as several delimitations of the central, 'sustainable' region of the field (Connelly, 2007). In this study on sustainability indicators on urban form of neighbourhoods specifically, it is suggesting the characteristics of sustainable development and its integration in real living situations. Thus, the holistic scope of the concept is derived with neighbourhood related aspects of sustainability focusing on the community living. The sustainability aspects are discussed with reference to the deterministic attributes of urban form of neighbourhoods.

2.3.1 Environmental Sustainability:

In the development process, cities are continuously experiencing environmental problems, with respect to congestion; air, water, and noise pollution; inferior sanitation; and deprived housing. Those complications are long-recognized and endure virtually in almost all cities. They are increasingly continuing and become apparent as urban issues or problems that are intimately linked up with the concerned matters of environmental sustainability, globally (Haughton & Hunter, 1994). Environmental caution for sustainability is seen as the usage of resources minimizing the impact of pollution from several causes. Deteriorations and nuisances of climate; in local as well as global levels, must be the prior considerations, and consequently the flora and fauna that depending on their environment. Reconsideration must be on the human consumption of energy and materials, which are recognized as the main cause of environmental pollution (Blum & Grant, 2006; Smith & Metternicht, 2021). Therefore, the total physical structure including human behaviour of a neighbourhood holds the weight of its environmental sustainability.

This research operationally defines the environmental sustainability as best appropriate, responsive arrangement of physical features and neighbourhood design. It offers and supports the existence of a healthy, safe, and convenient neighbourhood environment for its inhabitants along with the surrounding habitat. The indicators for the study are considered under physical structure, functional qualities, and resource demand in the area. They are carried forward to be rated in terms of density, land use, layout, connectivity, infrastructure, streetscape, and environment related practices performed, to explore environmental trait.

2.3.2 Social Sustainability:

Social sustainability remains on well-balanced social mixing in neighbourhoods. Primary principles of social sustainability are considered as developed conceptions of sustainable community, and social equity (Dempsey et al., 2012; Hamiduddin, 2015). Both concepts of sustainable community and social equity represent the terms more strongly, tying with

a series of associated secondary aspects including social capital, social inclusion, residential stability, and safety (Dempsey et al., 2011). Therefore, the two (02) concepts form a configuring framework for a variety of interrelated and interdependent factors and strengthened the significance of social sustainability for all societies, cultures, and communities. It creates communities composed of different social categories, which strengthens the capabilities and vision towards living, of vulnerable groups. This concept has attracted the interest on benefits of social mix and social balance, across urbanized societies, (Hamiduddin, 2015) ultimately convincing social sustainability within the neighbourhioods.

Similarly, the aptitude of the society itself as a local community, to sustain and reproduce itself at an appropriate level of functioning is defined as sustainability of a community (Dempsey et al., 2009). Concepts of social capital and social cohesion are strongly interrelated with and originate the trust and social relations established over residents' interaction, participation in community associations, comparative strength of the community, and desirable identity of the place as livable, safe, and long lasting (Bramley & Power, 2008; Dempsey et al., 2011). This makes the physical setting, a strong place of identity with a memorable character, that create a convenient living and movement in and around the place for all social categories involved. Further, it facilitates routine living for all age group categories within a peaceful living atmosphere.

In that sense, the provision of amenities convening a neighbourhood is a key contributing factor, creating a neighbourhood socially sustainable, as it is significant in offering quality of life to the inhabitants. Mainly, provision of community centres, religious centres, and sports and recreational facilities (Mackay, 2001; DTCP-KL.2003; AARP, 2005) are considered as three types of amenities significant in achieving social sustainability in a living neighbourhood. It also includes safety and security, crime prevention and precautions, concern on pedestrian movement among motorized traffic and traffic calming measures (DTCP-KL, 2003; Teriman, 2012).

All these factors are affecting on social equity, and social well-being, which are fundamental in achieving social sustainability of a neighbourhood entity.

Enriching the principles of inter-generational and intra-generational equity, satisfying needs of the present-day generation, without compromising the ability to meet the own needs of upcoming future generations (Brundtland, 1987; Blum & Grant, 2006) is described as social equity. The principle of intra-generational equity, states that current inhabitants alive, possess equal right to benefit from the prevailing resources and amenities. In the status of inter-generational equity, it offers pertinence to the future generations, fostering long lastingness. It describes the long-term sustenance of the neighbourhood for generations, while satisfying them all during their time of living offering social equity. Social equity possesses a strong emphasis on issues of employment and housing options, availability and accessibility to services and the disputes against poverty and social exclusion (Blum & Grant, 2006) in the context of neighbourhood development. The goal is facilitating the social life of the community.

In the research, the social sustainability is mainly focused onto social goals including social life, social diversity, social-mix, social equity, social inclusion, security, and safety within the neighbourhood experienced by the residents. It refers in the study, to the layout, land-use diversity, connectivity, transportation, and architectural character of the neighbourhood as pertinent attributes demonstrated in the urban form.

2.3.3 Economic Sustainability:

Economic Sustainability with reference to Urban Planning narrates the concerns about the funding and financing of infra-structure facilities; transportation and service facilities convening the built environment, to accommodate its development progression (Deakin et al., 2002) optimizing employment of resources. In the context of neighbourhood planning, the expectation is utilizing the available resources efficiently and providing options for people with diverse economic experience (Blum & Grant, 2006).

Accordingly, the economic sustainability is defined in the study, as the quality of being in a place specifically a neighbourhood, in which economic capital is well distributed and maintained, and human capital is utilized (Teriman, 2012). Simply, it functions as a resource-efficient living entity for maintaining a quality life.

The existence of these indicators enriches overall sustainability of a neighbourhood though, directly they are non-related to physical urban layout. Researches have uncovered several indicators enriching sustainability of a neighbourghood, which are mainly: diverse range of commercial establishments, provision of affordable housing, diversity of housing options, and availability of employment opportunities close-by (Teriman, 2012). Diverse range of commercial establishments refers to different types of business and commercial activities, in the neighbourhood such as convenient store, laundry, bakery or restaurant (USGBC, 2009) for day-to-day functioning. Diversity of housing option denotes residential developments which offer variety of choice in housing for people (Aurbach, 2005) from varying socio-economic backgrounds. Affordable housing denotes the availability of housing types (Metlife, 2013), as options, offering affordability for people within the clusters of low-income categories (Teriman, 2012). Housing options and affordable housing is considered as fundamentals in a liveable community, which offer personal independence of residents within the society.

> *"A livable community is one that has affordable and appropriate housing, supportive community features and services, and adequate mobility options, which together facilitate personal independence and the engagement of residents in civic and social life."* (Pollak, 2005: p.2)

Availability of employment opportunity within the vicinity (Mackay, 2001) offers opportunities for self-sustained communities. Adequate mobility option (Pollak, 2005) would facilitate this indicator to a great extent. Economic efficiency of a neighbourhood demands that determinations should concentrate on solutions representing the greatest social well-being for the entire entity (Blum & Grant, 2006).

In the study, the economic sustainability is considered the viability, as indicated by affordable living, housing options, close-by facilities, amenities and employment, and business activities.

2.4 Sustainable Neighbourhoods

This Chapter proceeded a discussion to understand neighbourhood and sustainable neighbourhoods. Neighbourhood is much supplementary to a terrain contained with an established boundary. In the best understanding, it is a place possessing its own unique character appropriate with function, in which people prefer to live; work, shop, and can interact with their neighbours. As indicative in citizen's guide to LEED-ND for neighbourhood development the most sustainable neighborhoods demonstrate high levels of walkability, a sense of place, social cohesion and social stability, and neighborhood resiliency within fluctuation of economic and sociopolitical conditions (Welch, et al., 2010). The discussion recognizes the definitions, characteristics and development of neighbourhoods, and its facets of sustainability.

2.4.1 Concept of neighbourhood in urban context

Urban neighbourhood is understood and described diversely. The dimensions of identity of a neighbourhood are not limited to its topography, land use, sociological context, and administrative categories. Prominently, neighbourhoods are considered as the localities that connect social, economic, physical, and environmental factors of a community (Dehghanmongabadi, 2014).

In many countries, conceivably, the neighbourhood concept is one of the main landmarks in planning and architecture, that shaped the urban form of twentieth century city. Circumstantially, two neighbourhood ideas; Clarence Stein and Henry Wright in their plan for 'Radburn', and the neighbourhood unit idea of Clarence Perry were published in early 1900's (Patricios, 2002). As main urban design principles, Stein and Wright included the notion of superblocks of residential units, surrounding a central garden.

Vehicles and pedestrians were separated, and the road hierarchy is achieved with cul-de-sac for local access roads. The superblocks were clustered, and a self-contained neighbourhood was formed. The city would be comprised with a group of such neighbourhoods overlapping with each other (Patricios, 2002). (refer Figures 2.15, 2.16)

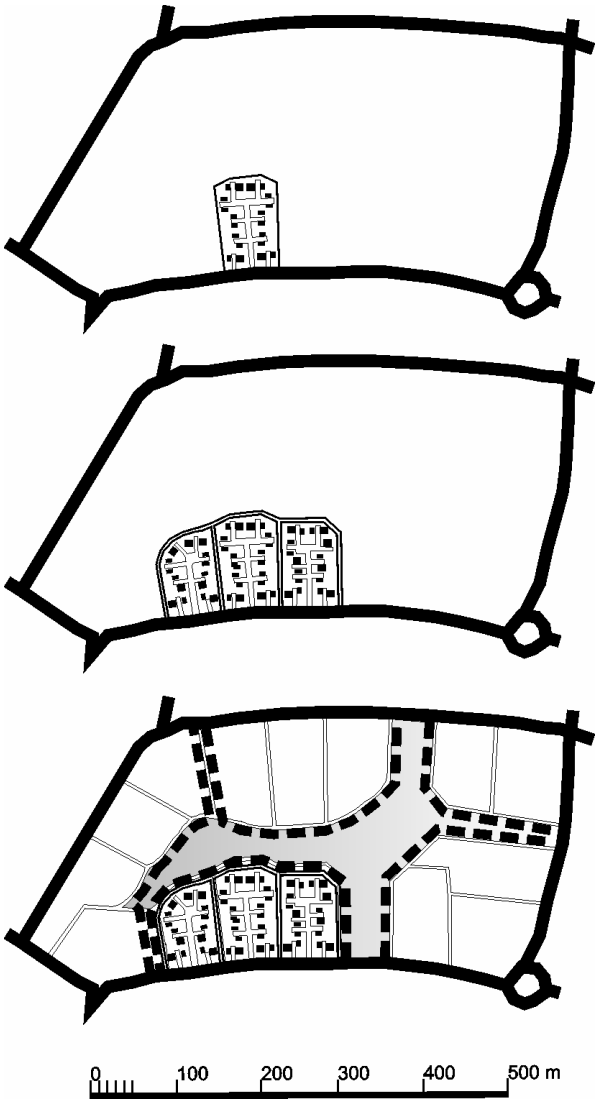


Figure 2.15: Concept of Radburn enclave by Stein and Wright
Source: Patricios (2002), Urban Design Principles of the Original Neighborhood Concepts

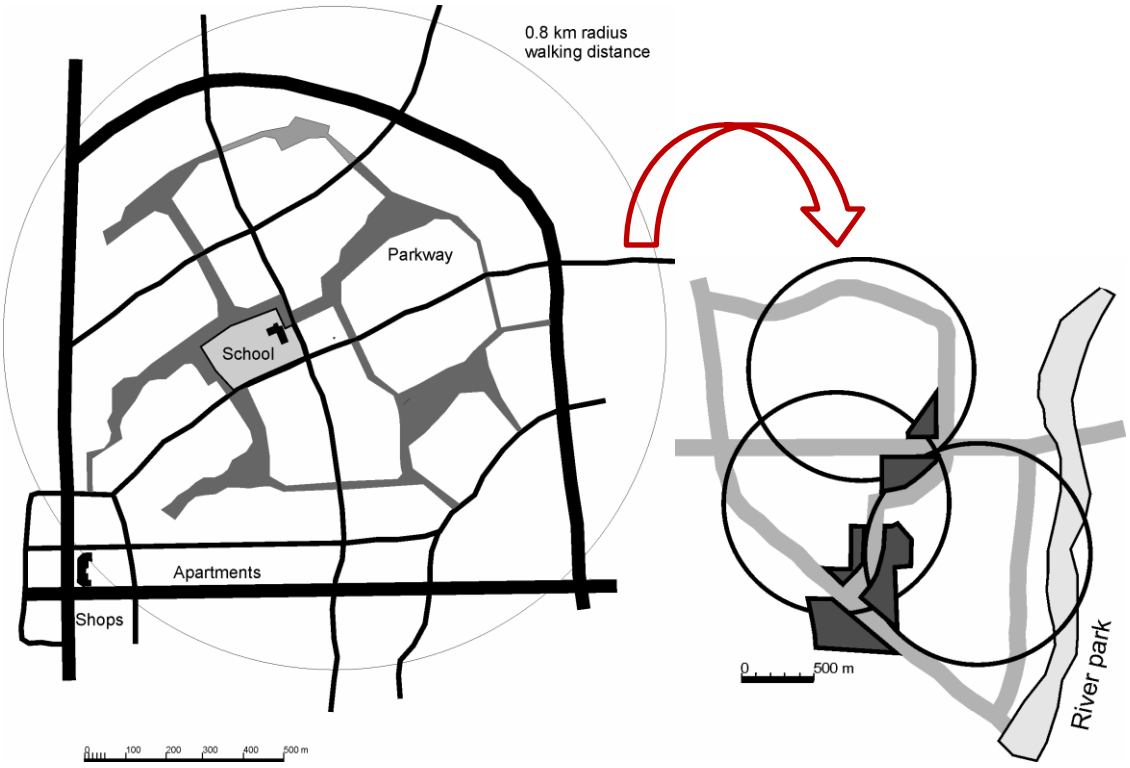


Figure 2.16: Radburn, Typical Neighborhood (left); Overlapping neighbourhoods forming the city (right)
Source: Patricios (2002), Urban Design Principles of the Original Neighborhood Concepts

Concept of neighbourhood introduced by Clarence Perry in 1910 (Azmi, 2012, Brody, 2013) was mainly with the intention of resolving the problem of transportation in the urban centers with housing. Overall, the main concerns can be observed as walkability, safety, and convenient functioning.

This concept evolved and advanced with the Garden City theory of Ebenezer Howard aiming at a social reformation in growing urban population (Perry, 1910; Patricios, 2002; Mehaffy et al., 2014; Lee & Park, 2018). The physical arrangement of the elementary school, small parks and playgrounds, and local shops was the basis of his neighbourhood idea (Patricios, 2002). The concept of neighbourhood projected by Clarence Perry (1910) has considerations specifically on the accessibility of residents, to elementary schools and community center from their homes.

Accordingly, he recommended six main principles for neighbourhood design as follows.

a) Determining the size of a residential neighborhood, based on the population desirable for one elementary school.
b) Provision of wide arterial roads bordering, eliminating through traffic.
c) Planning layouts of streets discouraging through traffic.
d) Allocation of about 10% of the total area for open space and recreation.
e) Positioning of the school at the center of neighborhood within proximity of quarter (1/4) miles, enabling walking from home.
f) Locating local shop on the periphery, serving around four neighbourhoods.

The 'neighbourhood unit' illustrated by Perry emphasizes the relationships between the residential components and non-residential components or areas of a neighbourhood within walking distance. It is well-defined as a scheme of arrangement for the family life community, in which residents enjoy a convenient access to the public or community facilities namely the elementary school, retail shop and facilities, adequate common recreational spaces (Ratcliff, 1975) and were regulated to walkability, disregarding automobile (De Chiara et al., 1984). It was predetermined in size, embracing specified boundaries, open spaces, institutional uses including schools, local shops, and internal street network, as fundamental principles of establishing a neighbourhood unit (Watson, et al., 2003). Perry's (1910) introduction of the neighborhood unit as a principal component of planning for communities or neighbourhoods was centered the needs of family life. Each neighbourhood was to be a 'unit' of the city (Patrios, 2002). The unit is expected to be reasonably self-sufficient, and the inhabitants are afforded the opportunity to walk from homes, (Beske, 2007) towards prime amenities in proximity, within a quarter (1/4) mile, or a five-minute walk.

The neighbourhood in urban context is realized as the most imperative urban component that determines the environmental, social, and economic sustainability of a given area, with the provision of community bonds that promises holding it together (Neal, 2003).

Typical ideal neighborhood size as stated by Azmi (2012) would be an area of ¾ to 1 square mile (1.16 to 2.56 sq. km) and containing 6000 to 8000 people. (refer Figures 2.17, 2.18)

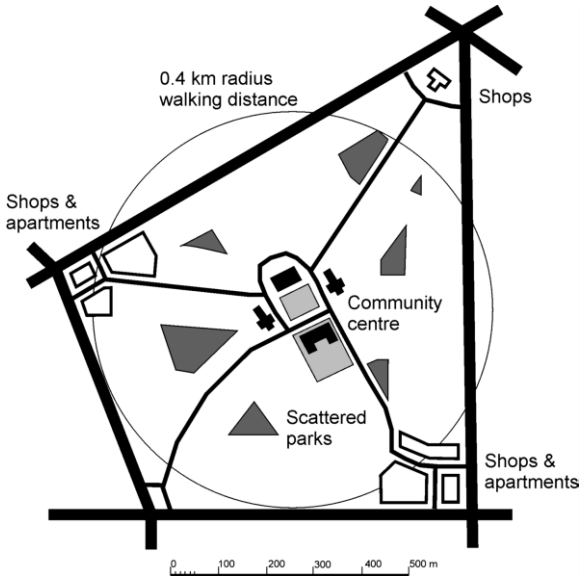


Figure 2.17: Neighborhood Unit of Clarence Perry
Source: Patricios, 2002, Urban Design Principles of the Original Neighborhood Concepts

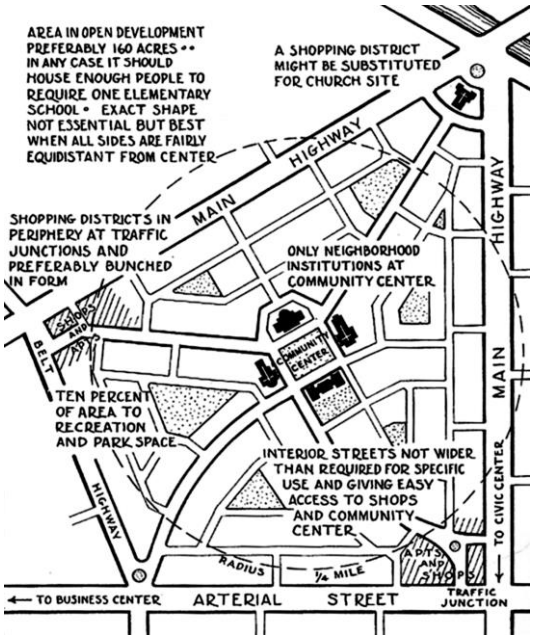


Figure 2.18: The Clarence Perry "neighborhood unit" diagram of 1929
Source: Mehaffy et al.,2014, Journal of Urbanism

Since in the years of 1900s, the concept of neighbourhood development had been strengthened. The configuration methods were related to the 'neighbourhood structure' and the 'neighbourhood facilities', and in most of the circumstances, improved to be adapted with walkability (Beske, 2007). Neighbourhood unit model proposed by Clarence Perry, has had a lasting impact on the design of residential developments worldwide (Patricios, 2002; Lee & Park, 2018). Initially, it was conceptualized to source house building supplies and decentralized the population. This neighbourhood-unit planning has strongly contributed on the shaping of new towns (Lee & Park, 2018).

During 1990s, the demand for 'sustainable residential neighbourhood developments' was gradually increased (Lee & Park, 2018). Thus, new planning models for neighbourhood units were progressively emerged from housing developers all over the world (Jacobs, 2010; Jin, 2010; Kang et al., 2010; Lee & Park, 2018).

The original neighbourhood-unit concepts introduced in Radburn and in Perry's models highly contributed to the increase of urban sprawl though the conceptual models were conceived with the principles of walkability (Rogers, 1999; Patricios, 2002; Lee & Park, 2018). Remarkably, concerns of constrains to economic, social, and environmental sustainability were caused largely, due to the consideration of the neighbourhood as a fixed physical entity to deal with automobile traffic and arterial roads (Mehaffy et al., 2010; Jabareen & Ziberman, 2017; Lee & Park, 2018).

The size of the neighbourhood, the hierarchical structure, the layout with the road network, and facilities of it are the guiding principles that became integral planning elements in establishing residential areas globally (Brody, 2013; Mehaffy et al.,2014). Another point attempted by Lee and Park (2018) referring Barton (2000) concludes that the basic goal of the neighborhood unit concept, produced residential areas in consideration of children and housewives' daily physical activities in the neighborhood, safe against disruptive automobile traffic.

Another was about the physical components of the neighborhood unit, and which intuitively contributed to making the space pedestrian friendly. These discussions including the history of conceptual background are all profound in enriching the discourse of neighborhood-unit concept, which had been initially promoted for low-rise, low-density neighborhoods in North America and the United Kingdom. However, it was adopted and utilized in Asian cities with high-rise, high-density developments (Mehaffy et al.2014). As Mehaffy (2014) claims, "it may well be that within modern urban planning and design, no single practice has had greater influence - and in some quarters, provoked greater controversy - than the use of the 'neighborhood unit' as a standardized increment of urban structure" (p.1). With the neighbourhood concepts developed globally, it started possessing definitions in diverse perspectives.

2.4.2 Definitions, Characteristics and Neighbourhood Form

Neighborhoods are defined generally at multiple scales, depending on their size, level of cohesion, and services shared. The American Planning Association [APA], (2006) presented mainly three levels explicitly with physical requirements to operate within the planning process (Park, & Rogers, 2015) as follows.

a) **Face-blocks:** These are consisted of and bounded with houses along either side of a street between the intersections.
b) **Residential neighborhood:** This consists of several face-blocks, and generally shares services and amenities such as parks, community spaces, commercial establishments, and access to transportation.
c) **Institutional neighborhood:** This includes several residential neighborhoods and is bordered by a certain degree of official limits of institutions. Typically, it is provided with services, mainly such as schools, hospitals, clinics, government agencies, and financial establishments.

A neighborhood can be originated with a specific plan or as a result of a more organic process. Different types of neighbourhoods are recognized prominently as downtown, urban, suburban, exurban, town, and small village etc., with having a definable sense of

boundary (APA, 2016). In most towns and cities, neighbourhoods merge into each other, as a result of development and change over several years (City of Pickering, 2011). Edge that one neighbourhood begins, and other ends can be a matter of self-defined boundaries among the locals, justifying the size and the feeling of the neighbourhood. Neighbourhoods are often viewed as a venue for a specific set of functions, such as a base for home life, employment, retail activities etc. Residents often associate with specific experiences, expectations and refer values to an area (Barton, 2000). This sense of localness and distinctiveness provide residents a sense of place. Also, it links for feelings and emotions of community that provide the locale for several types of relationships, interactions and networks which is termed neighbourhood.

Neighbourhoods are the most-local communities of human habitat. Inhabitants sense that they intuitively realize what a 'good neighbourhood' mean, with the degree of neighbourly interactions such as mutual support, communal and gathering places, and appealing environment, or in a 'bad neighbourhood'; anti-social interaction, danger, exclusiveness, isolation, and dereliction (The Young Foundation, 2010). In understanding the demarcation of a neighbourhood, mainly two models were found as dominate. One is mainly concerned with administrative geography, and the second, is focused on mental maps and subjective identifications. The models of concerns can be simplified as follows.

(1) Administrative Geography: The ward is often considered as a key unit of area in establishing and maintaining any neighbourhood arrangements. However, this does not define the ward as the neighbourhood. Depending on the case, a ward might be the neighbourhood, or else, it could be either part of a ward, or an area comprising of several wards.

(2) Self-defined community: This is an area that residents consider specifically as their neighbourhood for certain concerns and events. In this approach, neighbourhoods are effectively self-defined by the dwellers that live in them (The young Foundation, 2010).

Technically, Neighbourhood is an immediate geographical area surrounding a place of residence of a family, and it is bounded by physical elements or features of the environment such as streets, open spaces, water bodies, train tracks, and political divisions (Raymond et al., 2016). As a community parcel it emerged as a concrete urban component. Hence, it is constantly a part of a larger whole and, more importantly a system, having its own definite mechanisms and functions (Kullus, 2000).

But rich descriptions of what neighbourhood means, are combined with a variety of physical as well as social characteristics. Similarly, it is socially defined as a natural pedagogic unit, replicating larger units of human culture, offering visions into human interaction, behavior, settings of affection, friendship, and trust (Nelischer,1997), and affecting the social capital; physical and mental health (Leydon,2003). Development of social contacts among neighbours (Momoud, & Tassinary, 2004) is an important concern in neighbourhood context.

It has been argued that increasing relationships outside the neighbourhood loses the local neighbourhood social ties. This was affected by problems such as safety, density, crowdedness, proximity, traffic volume and lack of homogeneity of inhabitants' lifestyle, life cycle and background (Appleyard & Lintell, 1972). However proximal neighbourhoods hold an important place in peoples' lives, (Unger & Wandermann, 1985) and it is a social as well as spatial phenomenon, which connects people themselves with their community.

In describing a neighbourhood, it is essential to recognize its geographic, demographic, and social physiognomies. According to American Planning Association (2016), it states as the location, (in terms of urban, suburban, or rural, etc.); density, (in terms of dwelling units per area); street layout and connectivity, (in terms of design and linkages); economic, social, and ethnic diversity, (in terms of social characters); and functionality (in terms of residential, commercial, retail, etc.). It further states the circumstances on

the plan or specific planning efforts contributed to or sustained the character of the neighborhood, and the formation of neighborhood, whether its organically or through a formal planning procedure. Neighbourhoods are introduced as the setting for influences of social, economic, physical, and environmental aspects. Dehghanmongabadi, (2014) defines neighbourhood with reference to diverse social, psychological, mental, perceptual, physical, architectural, and political points of view. Accordingly, each of these different fragments presents its own meaning and definition for the neighbourhood.

Thus, there is no consensus definition or description answering the query, 'What is a neighbourhood?' It is further to the design of single houses, and planning of urban totality, and is in-between; creates a recognizable urban unit having its own logic. Generally, in Sri Lankan urban context, neighbourhood in general is not all inclusive, with commercial center, transit node, school, community facilities, religious centers, health care and employment facilities, but essentially ensures them in close proximity, which are serving number of residential neighbourhoods. The study defines the neighbourhood as a local level living entity with self-defined boundaries by the residents living in them. They are a part of an administrative ward.

Therefore, the research is focused on well confined identifiable residential neighbourhood communities. At operational levels, for the study purpose, Neighbourhoods are defined as administrative settlement parcels; typically, a strong physical component in urban locality. They are characterized by social interaction among neighbours, with a sense of collective identity, and similar demographic characteristics such as life patterns and socio-economic statuses.

2.4.3 Residential Neighbourhood Developments and Land Use Zoning

'Zoning' came into practice in 1916, in New York with the adaptation of citywide zoning ordinance as a tool for mitigating negative health effects from undesirable uses (Jayasinghe et al., 2018). Goal was to separate land uses with negative impacts, from the

residences, and is a universal form of development control (Ervin et al., 1977). It is practiced as the fundamental guiding regulation of a governmental or administrative entity to control the land uses as a major guideline in comprehensive development plan. Zoning regulations have undergone through significant modifications over the last decades adapting to constant changes in market conditions (Dahlstrom & Polikov, 2014) and to appropriately adjust with upcoming development themes. Zoning of various land uses indicates that people are made to travel often longer distances to work, shopping or marketing areas and for leisure activities etc. (Williams et al., 2000).

Urban land use is a fundamental determinant of the physical world that surrounds urban dwellers. This determines how and what locations the urban dwellers visit or would like to visit, that are organized and connected with each other (Duranton & Puga, 2015; Burdett, 2018). Urban land use literally refers to what takes up the physical space of a town or city. The main urban land uses are considered as:

Residential
Industrial
Commercial and administrative
Infrastructure (including transport)
Open space (including planned open space like parks, and derelict space)

Generally, Urban land use is described as the land use at ground level. Typically, this is what is shown on land use maps (Burdett, 2018). However, in land use, in addition to horizontal ground level variation, vertical variation has also to be considered. For example, residential towers are designed with a shopping mall at the ground levels. This kind of vertical variation is mostly found in the city core areas (Burdett, 2018).

Variations in urban land use are shown using geographical models. Leading models of urban land use forecast that different types of activities are found around the city. There are primarily two main types of models as Monocentric and Polycentric (Burdett, 2018).

‘Monocentric model’ of urban land use became popular in the 1920s and 1930s (Burdett, 2018). In general, monocentric models assume that there is a single Central Business District in the city (Richardson, 1988; Huang, 2015; Burdett, 2018; Schmidt et al., 2020). As stated by Burdett (2018), there were three (03) famous models found as Monocentric; as Burgess’s ‘Concentric Zone Model’ (1925); Hoyt’s ‘Sector Model’ (1939) and Harris and Ullman’s ‘Multiple Nuclei Model’ (1945). He illustrates and describes those models clearly as follows. (refer Figure: 2.19)

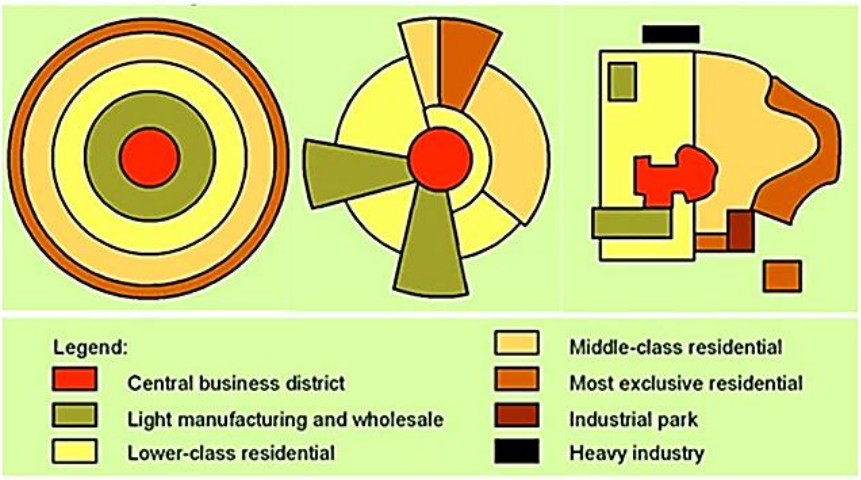


Figure-2.19: Spatial Models of Urban Land use; Concentric Ring Model (left), Sector Model (mid), and Multiple Nuclei Model (right)
Source: Burdett (2018), Urban land use patterns and models

In the ‘Concentric Zone Model’, Ernest Burgess identified a series of concentric rings coming out from the center of the city and correspond to different types of land uses. The center was the Central Business District. The inner-city area is recognized as the transition zone, with light manufacturing; and a series of residential zones gradually becoming wealthier towards the edge of the city.

Homer Hoyt recognized that city functioning was more complex than simple rings of land use. He suggested that industrial land use is linked to transport routes and the location of transport and industry within the city affects the location of residential districts. This stemmed ‘Sector Model’ of the city with diverse land uses.

Chauncy Harris and Edward Ullman continued the models of Burgess and Hoyt and announced ‘Multiple Nuclei Model’ of the city (Burdett, 2018). They recognized that as cities grow, smaller settlements around the edges are swallowed into it. In the interim, as the city becomes larger, travel between the outskirts and Central Business District becomes difficult and impractical. Consequently, smaller centers grow throughout the city.

Idea of ‘Polycentric model’ was formed in the 1980s to 2000s (Burdett, 2018). That oppose the fact that the cities grow around the Central business district. In fact, it sees that the city grows haphazardly, in a sprawling fashion, as a multiplicity of commercial, industrial, and residential areas spread outward without noticeable pattern (Florida, 2013). This means, instead having a main Central Business District, many centers are formed with similar mix of land use, having different functions (Yue et al., 2010; Huang et al., 2015; Burdett, 2018; Schmidt et al., 2020).

According to the above analysis of urban land use development, it is proven that urban functions, and specializations: focused economic activities seek locations with the best competitive advantages (Sliwa, 2001). This approach helps the urban land use development to determine on the best appropriate land use patterns, to achieve the most competitive support to the city and its people. The internal structures formed by specialized urban functions such as wholesale, retail, service activity, etc. within the city, and their market orientation. Evidently, urban locations that are best suited to meet the city's needs and are the points of focus (Sliwa, 2001).

Considering the city in its micro scale, the analysis of city core areas and different types of residential neighborhood developments have received priority. Most obviously, urban land use, as the heart of extremely important decisions of allocating functions within the city, makes residential function; household primely important. Households engage in a range of activities that take place in various locations: they work, sleep, play, go to school,

shop, visit friends, go to the dentist, etc., (Duranton & Puga, 2015) and they experience diverse activities. Physically, to perform these activities in different locations, in the real-life people must travel between them. Thus, land use and transport are intimately connected.

Hence, the land use pattern affects the resources devoted to residential function necessitated with commercial property, open space, community facilities and transport etc. In turn, these broader effects of land use may have serious implications for prosperity and equity for the residents (Duranton & Puga, 2015).

Usually, new zoning plans or proposals concentrate on matters such as urban form, mixed land uses, higher densities, flexibility in development regulations, transit-orientation, and preservation of prevailing environmental and cultural facilities and amenities, coordinated street infrastructure and encourage compact or concentrated developments (Dahlstrom & Polikov, 2014). Thus, zoning can be considered as an urban planning guide; a method employs in planning land-uses and a tool used by local governments in developing urban context appropriately with diverse functions.

Modern Town Planning in Sri Lanka has its roots related to British Town Planning systems, whereas the earliest documented city plan was formulated by a renowned British Town Planner, Sir Patrick Geddes in 1921 (Colombo City Development Plan History, 2013). Conceptually, it is to preserve the existing rural spirit of the town, and to make Colombo, a Garden City. Though the plan had not been fully implanted in the city, it had subsequently influenced certain successive planning interventions.

In 1948, Sir Patrick Abercrombie made a focus on the development of selected suburban areas, as satellite towns (Colombo City Development Plan History, 2013) that help decentralize urban activities in the region. It has been realized by the local authorities, that with the complex planning concerns in the context of city, a

comprehensive and sophisticated planning approach is indispensable, integrating entire prevailing urban issues as well as the issues likely to emerge in the future. Consequently, development plan for the city of Colombo was prepared and gazetted by the Urban Development Authority (UDA) in 1985 enabling to carry out 'zoning and building regulations'.

In Colombo Development Plan History (2013) it states that its focus is largely centered on physical development, so that environmental, social, economic, or other qualitative issues that were correspondingly important in developing a comprehensive plan, were not sufficiently concerned.

Consequently, the city of Colombo instigated to experience a critical set of issues. Some of them are associated with inadequate infrastructure facilities. Others are with regarding urban environmental issues; pollution of noise, air and water, traffic congestion, urban sprawl, and inappropriate land use distribution within the city, which directly effect on city's sustainability. City of Colombo Development Plan of (CCDP) 1999, amendment in 2008 (Gazette, 2008) and compiled edition of 2018 are suggesting timely necessary improvements on 'zoning and planning regulations' (CCDP, 2018) with the aim of creating sustainable neighbourhoods in the city. These interventions primarily act as mechanisms for development control within the city of Colombo, in terms of land use and built area ratios, and consequently to maintain an appropriate balance between built and un-built areas among the increasing land value.

In the City of Colombo, Land use zoning as per the Gazette, (2008) consists of nine (09) major zones, out of which every zone except 'Public Open Space zone', are permissible for Residential dwelling houses, dwelling units, and Apartments (CCDP, 2018). The idea must be the limiting of land use specialization, and promote mix land use, with combining several matching activities appropriately.

Therefore, the whole Colombo Municipal area consists of residential neighbourhoods of different types of social, cultural, and economic ranges. It is understood that necessary updates as amendments in zoning, are trying to facilitate the resilience of the 'existing urban form' towards sustainability. The Sri Lankan approach to a New Urban Planning would thoroughly concern the inclusion of sensitive and essential aspects of being people-friendly, sustainable housing neighbourhoods (UN Habitat III, 2015). The intention was to protect peoples' rights to physical and emotional well-being, public and private open spaces, interact with nature, natural light, and fresh air. These were the main concerns in planning regulations under each zone (CCDP, 1999; Gazette, 2008; CCDP, 2018). The goal is creating sustainable; user-friendly, environment friendly and long lasting neibourhoods by establishing regulated urban form.

Land use zoning categories in City of Colombo developed by the Urban Development Authority are indicative as follows (Gazette, 2008); (refer with Figure 2.15).

a) Special Primary Residential Zone
b) Primary Residential Zone
c) Special Mixed Residential Zone
d) Sea Front Zone
e) Mixed Development Zone
f) Port Related Activity Zone
g) Commercial Zone
h) Concentrated Development Zone
i) Public Open Spaces

Under each of the zoned area, the Colombo Development Plan enacts specific development guidelines (CCDP, 2018). It has a control over the type and scale of the development including permissible uses, minimum and maximum plot coverages, maximum floor area ration (FAR), and heights of masonry boundary walls etc. for development projects in each zone.

Apart from that, the Urban Development Authority holds the right to define or designate any area comprised in the Development Plan as a Special Project Area, Redevelopment Area, Under-Served Settlement Area, Slum and shanty Area, Cultural Area, Scenic Area, Conservation Area or any other areas for special treatment appropriately. Thereby, the Authourity be able to restrict or prohibit the use of such sites or areas and construction of any such type of building or projects. This requirement is being checked and assessed during the process of preliminay planning clearance. The proposed construction of the building or the building project has to be in accordance with the activity designation within the city. There may be special cases, where the authority act in accordance with future development planning proposals with reference to approved master plan proposals.

In such cases, the Authority may relax the above specifications of zoning, and impose new regulations or formulate separate sets of regulations according to the Urban Development Authority Law to attain the purpose for which the specific area has been in fact defined and designated for (CCDP, 2018). Any new development project carried out within the city, is subjected to the UDA law, building and regulations, to regulate and control the development process.

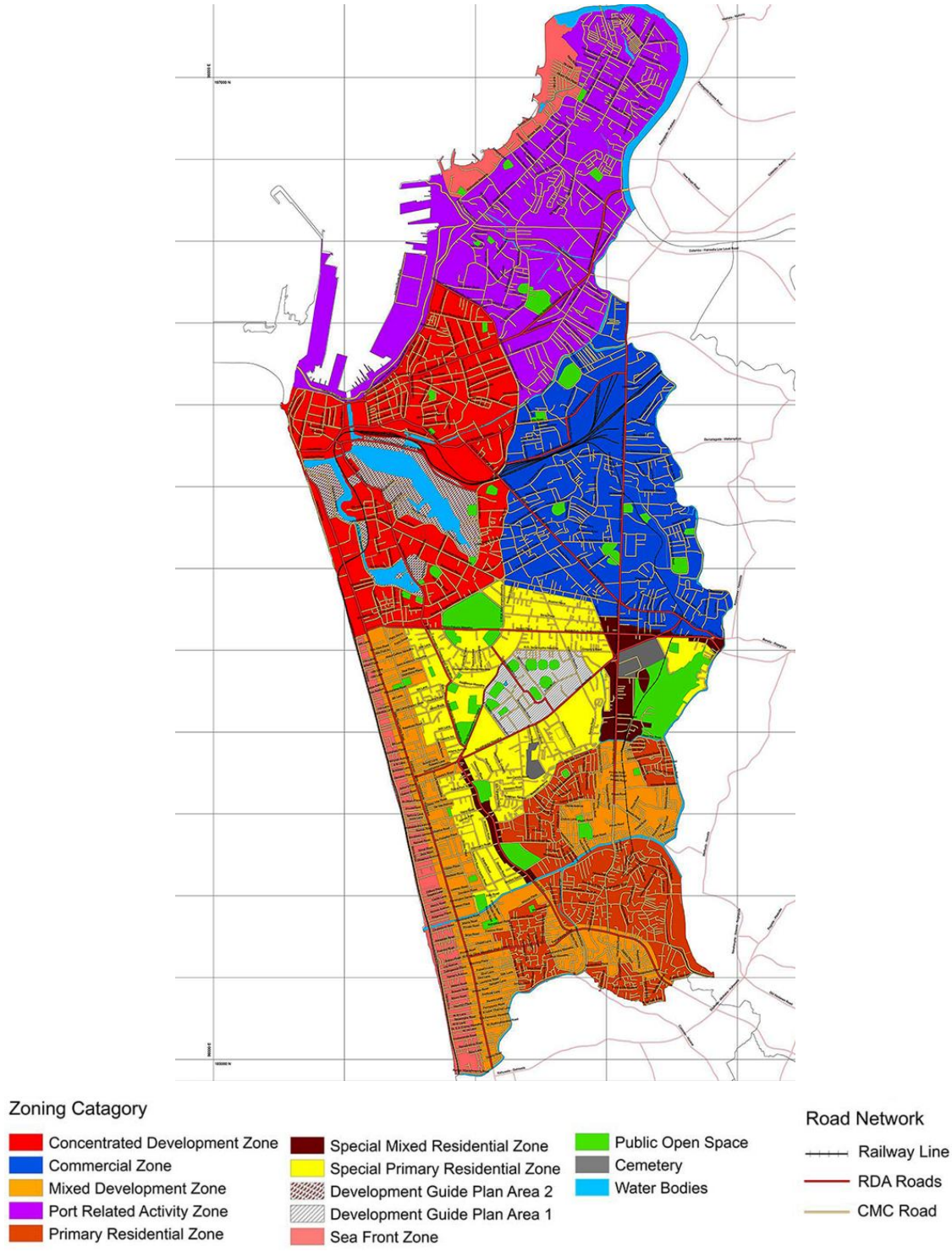


Figure 2.20: Zoning Plan; 2020-Colombo Municipal Council area
Source: City of Colombo Development Plan, (Compiled edition), 2018, Urban Development Authority, Ministry of Mega-polis, and Western Development

2.4.4 Understanding Sustainable Neighbourhood

Despite sustainability being a compelling consideration in the development of cities, it is allocated with far less attention at neighbourhood levels, particularly in the context of developing countries (Yigitcanlar, 2015; Moroke et al., 2019). It has been agreed that, at the neighbourhood scale, no clear definition is formed for sustainable development universally, and definitions and principles for good and sustainable neighbourhood may change over time (Dehghanmongabadi, 2014). As per Brundtland, (1987) Sustainable development meets the needs of the present-day user generation without compromising the ability for future generations in satisfying their own needs. Universally, it is accepted that this can be applicable to development at any scale including neighbourhoods.

Neighborhoods are visualized and physically composed as the built masses and open spaces linked with street system as components of cities and therefore, broadly, the overall sustainability of a city, stands on the sustainability of its neighborhoods (Tan et al., 2015). It is specifically raised that the sustainable urban form is required to be developed along with infrastructure. Effective infrastructure facilitation fulfills demand and offers reliable, cost effective, and high-quality services (RTPI, 2015). However, Optimum functioning or malfunctioning of the neighbourhood depends on the factors of sustainability, evolved with its urban form. The fact is that any urban development procedures taken place in any urban setting are always linked with continuous re-shaping in urban form.

As indicated previously in the literature review, neighbourhoods are spatial sensations. They possess and occupy particular regions of earth's surface in various sizes and mean more than the existence in space. Sustainability aspect of neighbourhood is indicated by its' identity, the distinctiveness. The identity of a neighbourhood often ensures more with its sociological context, than the characterization based on topography, land use or administrative classifications (Blum & Grant, 2006).

Its physical arrangement or the configuration of physical and non-physical elements is collectively sensed by the inhabitants as a one entity where they are mostly attached in their living. It takes on a definite form in two senses (Hiller & Hanson, 1984), which are important concerns in this study.

a) **Arrangement of people in space**: It positions people in relation to each other, with a certain degree of combination and separation, provoking unique patterns of movement and encounter dense or spares within or between varied groupings.
b) **Arrangement of space itself:** It is arranged in terms of buildings, boundaries, paths, open spaces, markets, zones and blocks etc., defining the physical milieu of that community on a definite pattern.

Neighbourhood as a social unit secures a definite and recognizable spatial order in both senses. The relationship between public and private spheres is a key concern of the modern urban society. Madanipour (2003) claims that this relationship, especially manifests in the urban space with its social and psychological significance. Through theoretical and historical examination, he explores 'how' and 'why' the space of human societies is subdivided into public and private sections. It starts with the private, interior space of the mind and moves step by step, through the body, home, neighborhood and the city, outwards to the most public, impersonal spaces, exploring the nature of each realm and their complex, interdependent relationships (Madanipour, 2003).

Similarly, Charles Correa (1989) states that a human needs four (4) types of living spaces; private space, intimacy space, neighbourhood space and principal urban space, out of which, first three are offered by the neighbourhood itself within the fourth; the principal urban space. What is needed to find is the best suitable framework of neighbourhood that brings the most sense from the viewpoint of inhabitant engagement (Hiller & Hanson, 1984). It is important to understand, that the most favourable living experience and community value, relates with the local service provisions.

Since residents spend a great deal of time in their individual neighborhoods (Gildroy, 2008), they often, more strongly recognize with those local areas, more than with the city. Thus, the physical design of these local individual communities determines, the residents' quality of life, to a rather considerable extent. Issues are identified as, identity, livability and accommodating projected growth (cityplanning.la, 1996). It is the physical body, which engraved social, economic as well as cultural identification of its inhabitants. As Dehghanmongabadi (2014) points out, neighborhoods always possess distinctive physical, social, and economic characteristics and they indicate a strong physical reality within cities. Gildroy (2008) states that they perform a significant role as key units in formation of cities. Therefore, sustainable neighborhood must be comprehensive in satisfying the requirements of current residents and accommodating new improvements by accepting the needs of forthcoming generations.

Urban neighborhood is a significant social geographic unit that holds central role in creating sustainable cities (Al-Hagla, 2008). Sustainable neighbourhoods are perceived as essential components of a sustainable city (Sharifi & Murayama, 2013). Jacobs (1961) states that, a sustainable way of living should effortlessly derive from the way we design our neighbourhoods. Thus, obviously, sustainable neighborhoods are the initial steps towards achieving sustainable urban settlements.

Planning theories on sustainable neighbourhood, approach to offer creating new mutual relationships between urban dwellers and neighbourhood entity, and eventually to maintain the quality of life. They promote three (03) key features, namely compact, integrated, and connected, for sustainable neighbourhoods and cities (UN-Habitat, 2011). Sustainable neighbourhoods are convinced on their time existed, since they are to be adaptable over generations. Neighborhoods selected and designated as great neighbourhoods, must be essentially more than ten (10) years old (APA, 2016). American Planning Association identifies certain characteristics of great or sustainable neighbourhoods as follows:

a) Ensure variety of functional characteristics; residential, commercial, mixed-uses etc.
b) Provision of multi-modal transportation; pedestrians, cycling, driving, public transport.
c) Possession of visually pleasing design and architectural features.
d) Encouraging human interaction and social activities.
e) Stimulating community participation and maintains a secure and safe environment.
f) Promoting maintenance and responsive to climatic demands.
g) Expression of a memorable character.

All inclusively, quality of life of residents is decided in residential neighbourhoods by the facilities and amenities available in proximity; (see Figure 2.16). Especially in the developing country context, every common facility such as school, commercial center, recreation facilities, transit stop etc. would not be practical in developing within new residential neighbourhoods in the urban locality but providing them in close proximity is mandatory. It is an essential aspect of urban form, in assessment of sustainability of a neighbourhood.

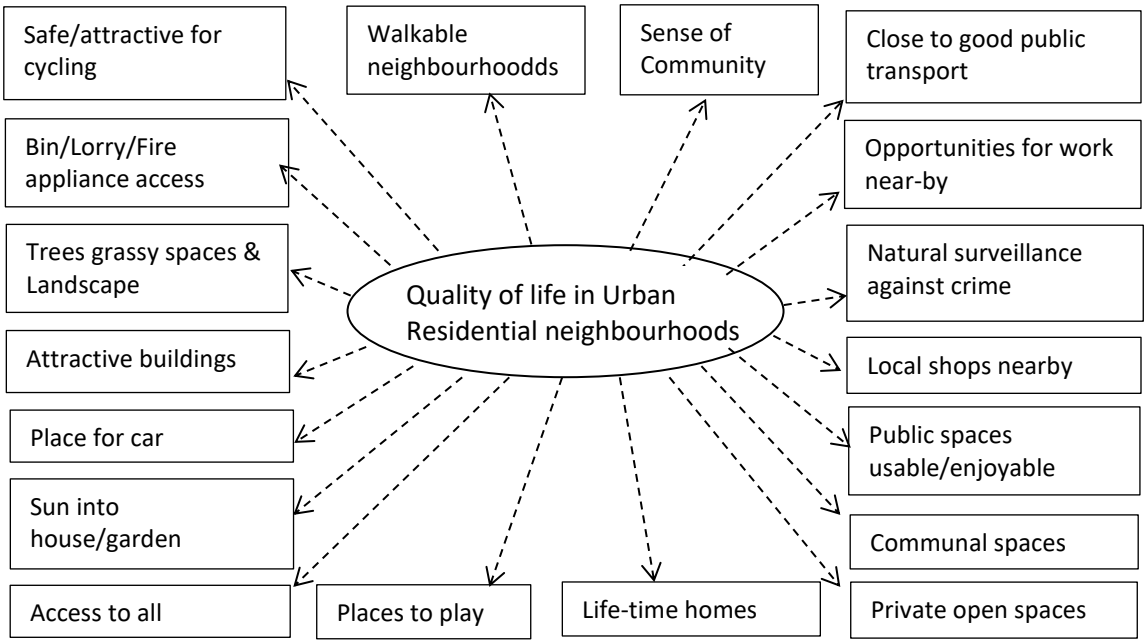


Figure-2.21: Sustainable residential nieghbourhood designs
Source: Leeds City Council, 2015, A Guide for Residential design

It is clearly exemplified how strong a neighbourhood form means to its inhabitants and users to sense them as convenient in their living. Further, it is important to understand how far it overlaps with sustainability concepts, for the inhabitants to recognize them as 'great' neighbourhoods. It would help governing the behavior of the inhabitants to a greater extent, including the passion towards social relationships, interactions, and mutual understanding on sharing, protecting, and maintaining the communal facilities within the setting.

Centered to these broadly applicable definitions and discussions, at the neighbourhood scale, sustainable development is a place that facilitating peoples' living today, and in the future; socially, environmentally, and economically healthy; safe, secured, well planned, and built to last long. They are visually pleasing, aesthetically appealing, conveniently functioning and overall, a user-friendly community environment. Briefly, Sustainable Neighborhoods are fit-to-user, safe and long lasting.

2.4.5 Rating on Neighbourhood Sustainability

As key planning units of great potential contributing to sustainable development, neighbourhoods are progressively gaining attention. Certification systems for sustainable neighbourhoods started to emerge around nearly a decade ago (Wangel et al., 2016). Many assessment tools such as follows have been established to inspect the sustainability gauge of neighbourhood development projects:

- LEED-ND; 'Leadership in Energy and Environmental Design-Neighbourhood Development' launched in 2007 (Diaz-Sarachaga et al.,2018; Sharifi & Murayama, 2015):
- BREEAM; 'Building Research Establishment's Environmental Assessment Method' developed in 1990, UK (Nguyen & Altan, 2011):
- CASBEE-UD; 'Comprehensive Assessment System for Building Environmental Efficiency-Urban Development' developed in Japan in 2001 (Berardi, 2013; Nguyen & Altan, 2011; Sharifi & Murayama, 2015):

These tools are recognized to be suitable for evaluations in varying contexts, and LEED-ND has already been utilized in several countries (USGBC Ref. Guide, 2014; Sharifi & Murayama, 2015). Its focus is to promote developing sustainable urban environments; specifically, neighbourhoods, emphasizing on major community concerns, integrating adequate infrastructure into existing systems, and the consideration of resilience indicators (Sarachaga, 2018). Other than that, project level assessment standards such as Traditional neighbourhood design (TND) are used to rate neighbourhood developments in different places. Both are discussed in detail as appropriate with the study.

2.4.6 LEED-ND Rating System:

Initial experimental version of LEED-ND was formulated in 2007 (Sarachaga, 2018) and it was fully launched in 2010 (Welch et al.,2010). Its present version, termed LEED-ND v4, was released in 2014. The LEED-ND contains a set of measurable standards that is collectively used to identify an existing development or proposed development in terms of its environmental superiority, location and access, internal pattern and design, and application of green technology and construction techniques (Welch et al., 2010). Neighbourhood developments with minimum two habitable buildings and smaller than 1500 acres in extent, can only be qualified for the rating system (Sarachaga et al., 2018).

In the framework, following three (03) categories of credits are deliberated.

(a) Smart location and linkage (SLL):

Principal objective is developing the existing communities and public infrastructure systems in urban spaces and to control over the urban footprint, which signifies 'where to build'. Selecting a location for a neighbourhood development and planning for it is fundamental in environmental sustainability. The most important factor is reducing the driving. It tends to cluster housing groups, jobs, stores, and open, public spaces together. Then it makes public transit, cycling, and walking more feasible, when these conveniences are within easy reach. When the location is feasible, it is sensitive to the existing natural setting and undoubtedly protects the environment.

(b) Neighbourhood pattern and design (NPD):

Main emphasis is on pedestrians, walkable streets, access to public, open, and green areas, and promotion of compact, efficient and mixed-use developments encouraging walking and bicycling, signifying 'what to build'. Neighbourhoods with efficient land use means that destinations like schools, shops, parks, other services, and amenities are closer together, making walking and travelling more efficient.

(c) Green infrastructure and buildings (GIB):

The intention is execution of efficient green practices in the design, and construction, exemplifies 'how to manage environmental impacts'. Green building concepts are significant in here, with concerns on reusing of old buildings, reducing pollution, thermal comfort, energy efficiency and reusing and recycling materials; (Welch et al., 2010; Benfield et al., 2011; Sarachaga et al., 2018)

Innovation and Design Process (IDP), and Regional Priority Credit (RPC) are also counted in LEED, but above three are deliberated; (Welch et al., 2010) rating system; (Figure 2.17).

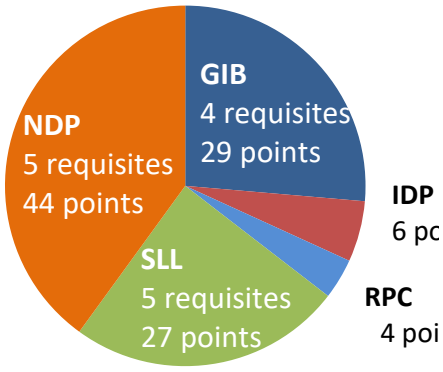


Figure-2.22: Key strategies of the LEED-ND Rating System
Source: Welch, et al.,(2010).A Citizen's Guide to LEED for Neighborhood Development

These standards allocate 'prerequisites' which are mandatory as a baseline for sustainable neighbourhood development and 'credits' that are supplementary best practice standards for sustainable neighborhood development (Welch et al., 2010). Table-2.2 below illustrates the list of 'prerequisites' and 'credits' encompassed in LEED ND version 4 (Sarachaga et al., 2018)

Table 2.2: List of prerequisites and credits covered by LEED ND version 4.

SLL Smart Location and Linkage		**NPD Neighbourhood Pattern and Design**		**GIB Green Infrastructure and Buildings**	
Prerequisite/ Credit	**Concept**	**Prerequisite/ Credit**	**Concept**	**Prerequisite/ Credit**	**Concept**
SLL P1	Smart Location	NPD P1	Walkable Streets	GIB P1	Certified Green Building
SLL P2	Imperiled Species and Ecological Community Conservation	NPD P2	Compact Development	GIB P2	Minimum Building Energy Performance
SLL P3	Wetland and Water Body Conservation	NPD P3	Connected and Open Community	GIB P3	Indoor Water Use Reduction
SLL P4	Agricultural Land Conservation	NPD C1	Walkable Streets	GIB P4	Construction Activity Pollution Prevention
SLL P5	Floodplain Avoidance	NPD C2	Compact Development	GIB C1	Certified Green Buildings
SLL C1	Preferred Locations	NPD C3	Mixed-Use Neighbourhoods	GIB C2	Optimize Building Energy Performance
SLL C2	Brownfield Remediation	NPD C4	Housing Types and Affordability	GIB C3	Indoor Water Use Reduction
SLL C3	Access to Quality Transit	NPD C5	Reduced Parking Footprint	GIB C4	Outdoor Water Use Reduction
SLL C4	Bicycle Facilities	NPD C6	Connected and Open Community	GIB C5	Building Reuse
SLL C5	Housing and Jobs Proximity	NPD C7	Transit Facilities	GIB C6	Historic Resource Preservation and Adaptive Reuse
SLL C6	Steep Slope Protection	NPD C8	Transportation Demand Management	GIB C7	Minimized Site Disturbance
SLL C7	Site Design for Habitat or Wetland and Water Body Conservation	NPD C9	Access to Civic and Public Space	GIB C8	Rainwater Management
SLL C8	Restoration of Habitat or Wetlands and Water Bodies	NPD C10	Access to Recreation Facilities	GIB C9	Heat Island Reduction
SLL C9	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies	NPD C11	Visit ability and Universal Design	GIB C10	Solar Orientation
		NPD C12	Community Outreach and Involvement	GIB C11	Renewable Energy Production
		NPD C13	Local Food Production	GIB C12	District Heating and Cooling
		NPD C14	Tree-Lined and Shaded Streetscapes	GIB C13	Infrastructure Energy Efficiency
		NPD C15	Neighbourhood Schools	GIB C14	Wastewater Management
				GIB C15	Recycled and Reused Infrastructure
				GIB C16	Solid Waste Management
				GIB C17	Light Pollution Reduction Sustainability

Source: Sarachaga et al., (2018)

Natural Resources Defense Council (NRDC) together with US Green Building Council (USGBC) has developed a Citizen's Guide (2010) as a reference guide designed to assist citizens to assess and improve their community and neighborhood (Welch et al., 2010) along with sustainability. All the credits and prerequisites in the LEED-ND Rating Systems are summarized in this informal checklist. Primarily, it can be used as a guide in assessing the strengths and weaknesses of a new development proposal, site plan, existing neighborhood, or even a zoning code or a neighborhood plan. Secondly, it provides a basis for standards and thresholds to comprehend the plans, regulations, designs, and to practice subject specific policy determinations (Welches, et al., 2010).

Table 2.3: Sustainability Check list summarizing credits and Prerequisites in LEED-ND

Smart Location and Linkage	**Neighborhood Pattern and Design**	**Green Infrastructure and Buildings**
Location	Walkable Streets	Construction Techniques
Ecosystems and Open Spaces	Compact Development	Energy Efficiency and Conservation
Contaminated Sites	Neighborhood Connections	Energy Production and Distribution
Transit-Accessible Locations	Mixed Uses	Water Efficiency and Conservation
Cycling Facilities	Affordable and Diverse Housing	Storm water and Wastewater
Jobs and Housing Proximity	Parking and Transportation Demand	Green Building Process
	Parks and Recreation	Historic and Existing Building Reuse
	Universal Design	Heat Islands
	Community Participation	Recycling and Reuse
	Local Food	Light Pollution
	School Access and Design	

Source: Welch, et al., 2010

Quick move through the checklist is possible in rough assessment to obtain an approximate impression of performance, acquiring responses in 'Yes', 'may be' or 'No' scale. Or else, by spending pre-planned time, a more detailed and accurate assessment is possible, by undertaking research, constructing calculations, and mapping site conditions. In both cases, it is recommended to move through the checklist, particularly for improvements of the proposal, plan, or neighborhood.

Estimation of a score under the LEED-ND Rating System is an optional second step to uncover the sustainability rating of neighbourhood (Welch et al., 2010). In common, the eco-efficiency of the neighbourhoods based on various standards counting urban density, access, connectivity, site-ecology, energy efficiency and water management are assessed by using these rating tools, which are often promoted globally. However, in terms of climate, legislative, economic, cultural, and ecological conditions etc., different regions of the world diverge significantly (Säynäjoki et al., 2012).

Due to deficiency of resources and limited economic power, small-scale urban neighbourhoods are facing challenges to achieve their sustainability goals (Haider, 2018). United Nations Conference on Sustainable Development-2012 termed as Rio+20 (UNCSD, 2012) sanctioned the 2030 agenda for Sustainable Development. Addressing environmental, social, political and economic issues, known as 'Sustainable Development Goals' (SDGs), seventeen (17) objectives included (Sarachaga et al., 2018) are as follows.

Table 2.4: Sustainable Development Goals (SDGs) list

	Concept		**Concept**
1	No Poverty	**10**	Reduced Inequalities
2	Zero Hunger	**11**	Sustainable Cities and Communities
3	Good Health and Well-being	**12**	Responsible Consumption and Production
4	Quality Education	**13**	Climate Action
5	Gender Equality	**14**	Life Below Water
6	Clean Water and Sanitation	**15**	Life on Land
7	Affordable and Clean Energy	**16**	Peace, Justice and Strong Institutions
8	Decent Work and Economic Growth	**17**	Partnership for the Goals
9	Industry, Innovation, and Infrastructure		

Source: Sarachaga et al., (2018)

Urban sustainability indicators are the assessment tools of the social, economic, and environmental impacts on infrastructure, noise, air and water pollution, investor involvement, access to essential services and management of natural resources. According to the ending score reached, four (04) certification levels are resulted as; Certified, Silver, Gold and Platinum (Welch et al., 2010; Sarachaga et al., 2018).

2.4.7 TND Design Rating Standards

TND Design Rating System, Version 2.2 (2005) by Laurence Aurbach (2006) published by United States Environmental Protection Agency (US-EPA) is a comprehensive, project-level assessment tool that can be used to support users to rate development projects in a range of locations. It can be used to make comparisons with proposed or new development projects. The tool is also designed to clarify the elementary principles of traditional neighborhood development.

Traditional Neighbourhood Development termed as TND is a wide-ranging Planning system that encompasses a variety of land uses including housing types in a distinct area (Aurbach, 2005). Promoting mixed use, variety of uses such as educational facilities, civic edifices, and commercial establishments etc., are permitted to be positioned within walking distance from residences (Firoozi, 2017). Network of paths, streets, and lanes served in a TND are formed appropriate for both pedestrians as well as vehicles. The residents are offered the option of walking, bicycling, or driving, to several locations or places within the neighbourhood. Community identity and value system is enhanced by the inclusion of civic buildings and spaces, in the form of plazas, greeneries, parks and squares (Aurbach, 2005).

TND Rating is a simple and a practical assessment system, convenient in several means enabling to recognize the performance of architects, designers, planners, and real estate developers etc. It can be used as a stratagem or tool, to investigate necessary improvements in neighbourhoods. It can be considered as an acceptable approach to link and communicate respectable urban design concepts and principles, by complementing guidelines. Case studies, worksheets and checklists are providing an impartial classification to neighbourhood rating.

Rating system is based on housing choice in options, mixed use, connectivity, external connection, proximity, potencies in location, streetscape, public or civic space, and architectural aesthetics. Accordingly, the qualitative aspects of urban form are basically looked at in the rating. Rating is indicated with number of stars subsiding the standards from five (5) to one (1) are as follows; (Table 2.5).

Table 2.5: TND Rating Key

	Rating Key:	**Alternative Rating Key:**
Five Stars	Excellent	Laudable
Four Stars	Good	Respectable
Three Stars	Acceptable	Acceptable
Two Stars	Fair	Regrettable
One Star	Poor	Deplorable

Source: Aurbach, 2015

Inclusiveness for the system is considered based on size or the scale of the neighbourhood, as follows established in TND rating.

a) **Neighbouhood scale development:** Neighbourhood developments of minimum fifty (50) acres (06 Hectares) are considered under this category for full standards.
b) **Block scale development:** Consideration is for developments that are smaller, lesser than fifteen (15) acres, but larger than two (02) blocks with minimum of forty (40) dwellings. Streetscape, proximity, mix of housing types and other activities, and architectural aesthetics are mainly considered as standards. However, connectivity and civic space standards are not applied.
c) **Lot scale development:** This considers developments that are smaller, lesser than fifteen (15) acres, but larger than two (02) blocks with minimum of forty (40) dwellings. Effects on neighbourhood character only are considered, whereas the Effects on Neighbourhood Structure are deliberately ignored. Hence, streetscape; frontage only, location, proximity and architectural aesthetics are considered as standards (Aurbach, 2005).

The scope of this rating system is deliberately restricted to the physical design with the intentions of providing a sharp focus on design aspect and keeping the system development at a manageable level. Expedient, cost, and time effective assessment ability is centered in the system. The main objective of the system is the simplicity and manageability, compared to other comprehensive rating systems; such as Geographic Information Systems (GIS) based classifications, and advanced academic researches.

According to the Congress for the New Urbanism (CNU) charter, a complete evaluation concerns several supplementary standards such as affordability, codes, social capital, social cohesion, cultural identity, environmental performance, financial performance, balance in residential to non-residential land uses, vertical mixing of activities and uses, mixing of building categories and typologies and quality of overall construction etc. (Aurbach, 2005). The system recommends the consideration of a certain portion of the total development in the evaluation.

Table 2.6: Summarized work sheet, TND Rating Key

	Summarized work sheet (based on point weight)			
	Standard		**No. of Stars**	**Rating**
1	Housing Choice (Probability of any two dwellings are different in type) or size			
2	Mixed Use (number of function Categories)			
3	Connectivity (Intersections per square mile or square Kilometer)			
4	External Connections (Number of entrance/exit points per foot or meter) in perimeter length)			
5	Proximity	Town/neighbourhood center		
		School		
		Parks		
		Transit		
6	Civic space (Evaluation of overall quality of civic space)			
7	Architectural Aesthetics (Evaluation of overall quality of architectural exteriors)			

Source: Aurbach, 2015

This rating system is quite simple, based mainly on sustainability principles (RTPI, 2015), and green buildings and infrastructure is not thoroughly considered. The rating key is commonly applicable in local neighbourhood contexts and the point system could be decided by the author on a particular basis justifiable, depending on different urbanities. Due to the need of frequent updates, the rating system is better to be simple, quick, and low cost in operation. Overall, the sustainability rating systems are already established and internationally acclaimed by now. What is more important in our urban context is that, identifying and forecasting the principles of urban form as necessities in application of neighbourhood design. Then it will always be recognized and rated as sustainable, livable.

2.5 Neighbourhood Sustainability manifested in Urban Form

City performance ensures references to the spatial form of the city. The quality of a place is resulted by the combined effect of the place and society that inhabits in it (Patil, 2016). For researchers it is important to understand behavior of different social groups reflected in urban formation and transformation. Several performance dimensions are identified in Good City forms by researchers. As per stated by Lynch (1984) it should be vital, sensible, well fitted, accessible, well controlled and all of these are achieved with integrity and internal efficiency. They are the collective features or attributes of urban form, at local community space levels, giving birth to neighbourhood sustainability. Sustainable neighbourhoods originate in numerous different forms, nonetheless they share some common characteristics. They are relatively compact and concentrated, mixed-use communities with good access or proximity to transit. They incorporate a range of housing types as options, workplaces, parks, shops, amenities, and services; (see Figure 2.18). As such, they are highly resource efficient and support a high quality of life for all residents (FCM, 2016).

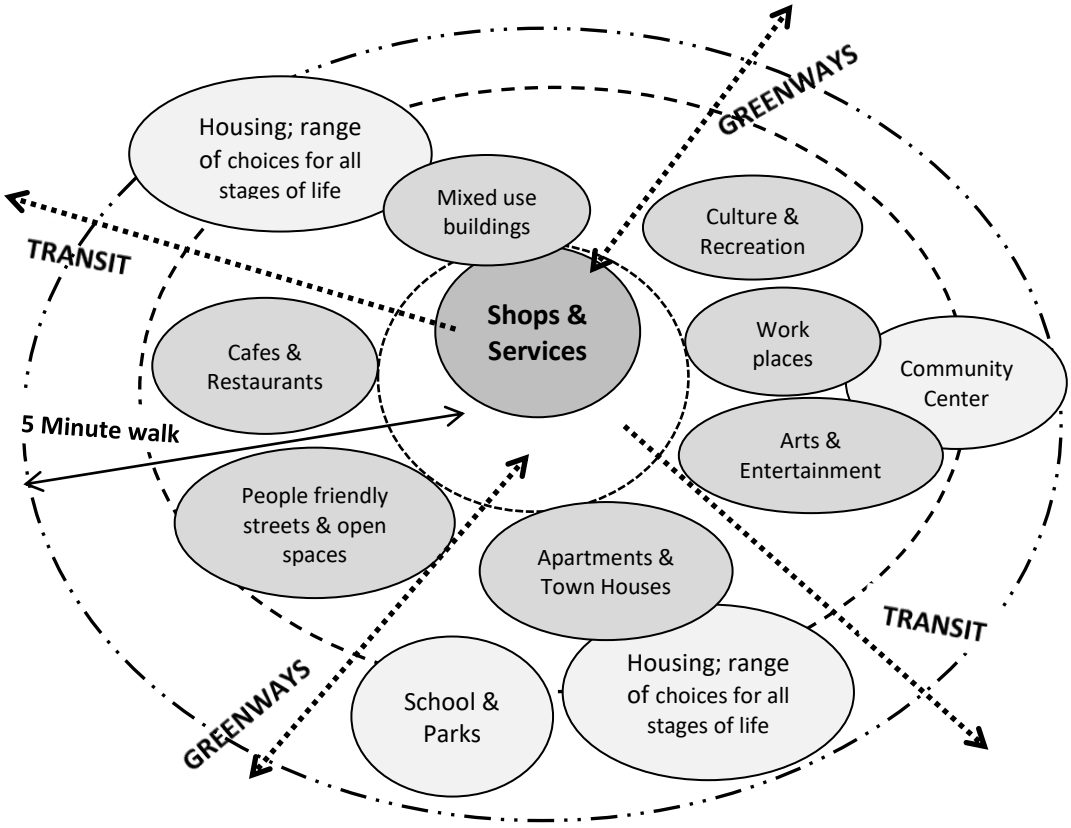


Figure-2.23: Practical Solutions to Common Challenges in stainable Neighbourhoods
Sources: Federation of Canadian Municipalities, Green Municipal Fund (2016)

The practice of developing urban form or built environment at the neighborhood level, meeting with the requirements of its inhabitants, that avoid undesirable social and environmental consequences (Hamilton et al., 2002) is understood as neighborhood sustainability. Appropriate land use and adequacy of infra-structure are primarily important in the context of neighbourhood sustainability.

Spatial dispersions of diverse land uses linked together with physical infrastructures and related transportation networks (Bertolini, 2005) are denoted as urban form. Distribution system of these features within a neighborhood bears a deep effect on sustainability of such neighbourhood. It is clear, that the availability and reachability of goods and services could be resulted by various land uses, within local areas allow inhabitants to engage wholly in the society. Also, it satisfies local needs for employment, recreation, health, social, and community activities, and subsequently, takes part in economic and social sustainability at local scales (Hine et al., 2012).

Contrastingly, inadequacy of opportunities locally in proximity promotes motorized travel, and indirectly distresses the environmental sustainability. In the local or the neighbourhood context, it originates noise, strain, habitat fragmentation, increased impervious surface, and consequently harms the water and air quality, and helps creating urban heat islands (Jabareen, 2006; Newman, 1996). Global effects in long-term would be air pollution and adverse climatic effects such as global warming (Jabareen, 2006).

Responding to unsustainable conditions of residential neighbourhoods in early 1900's, the Garden City concept by Ebenezer Howard emerged as a starting point. Consequently, the concepts on three main pillars were developed, combining environment with economic and social milieu (Howard, 1902). Formerly, numerous models of neighborhood developments have emerged and merged into practice in diverse settings, namely, cohousing, gated and smart communities, traditional and neo-traditional neighborhoods, conventional-suburban neighborhoods, eco-communities, subdivisions, piecemeal and master-planned developments etc.(Yigitcanlar et al., 2015).

All these neighbourhood types provide housing mainly, but respective urban forms are diverse, in terms of its elements such as lay-out, density, street network, pedestrian movement, transportation, commercial area, parks and recreational spaces and other features effectual in characterizing a neighbourhood (Song, et al., 2008). Evidently, diverse urban forms featuring sustainability in different means and research studies world-wide indicates that the formation of built environment; the city and the neighbourhood form is the most reassuring fragment for a swift changeover to sustainability (Berardi, 2013). Accordingly, it is convinced in research literature that neighbourhood sustainability of any neighbourhood is in-fact best signposted by their urban forms.

2.6 Resident-Participation as a Research Approach

According to Brundtland (1987), a sustainable, appealing neighborhood must be comprehensive in satisfying its current residents' needs and accommodating improvements to provide for the needs of forthcoming generations. Rau and Fahy (2013) in their discussion on current trends in the theory and practice of social-scientific sustainability research, claims that "calls for development that is capable of sustaining more than seven billion people on a planet with finite resources and that ensures a good quality of life for current and future generations have shaped political agendas in the late twentieth and early twenty-first centuries" (p.3). They confess that the broader questions relate with the nature of human experience and knowledge and describes how people make sense of their socio-cultural and physical environment. Simply, the human sense, how they know, what they know, also continue to emerge in the context of social-scientific sustainability research, though often only as a subtext.

Krampen (2007) states "The question whether the citizen should participate in the planning of their environment is itself a question of style" (p.5). It seeks whether citizens are allowed to participate in urban planning, which is an indication of how and for whom urban planning is conceived in a given society. Different viewpoints of citizen and designer should in fact be more complementary, rather than mutually excluding one another (Krampen, 2007).

Weck, Madanipour and Schmitt (2021) state that the Territorial Agenda 2030 highlights that a place-based approach is a key to territorial cohesion in the developments. The expectation is promoting strategic shift towards more place-sensitive, cross-sectoral, and socially inclusive urban settings. They argue that several distinctive national and local mechanisms that the inhabitants are at play are prevalent, of which the academics, planning professionals and policy makers need to be aware.

Similarly, The New Urban Agenda (2016) signifies a shared vision for a better and more sustainable future, within which all people possess equal rights and access to the benefits and opportunities that cities can offer. Accordingly, International community reconsiders the urban systems and physical form of our urban spaces to achieve this target. It states, Urbanization is a powerful process, for sustainable developments for both developed and developing countries, if it is well planned and well managed.

> *"The New Urban Agenda presents a paradigm shift based on the science of cities; it lays out standards and principles for the planning, construction, development, management, and improvement of urban areas along its five main pillars of implementation: national urban policies, urban legislation and regulations, urban planning and design, local economy and municipal finance, and local implementation."* (New Urban Agenda, 2016, p. iv)

It underlines specifically the improved 'quality of life' of inhabitants with the linkages between good urbanization and job creation, livelihood opportunities, which should be included in every urban renewal policy and strategy. This implementation of Sustainable Development Goals and targets aims at making cities and human settlements inclusive, safe, resilient, and sustainable. It acknowledges "that culture and cultural diversity are sources of enrichment for humankind and provide an important contribution to the sustainable development of cities, human settlements, and citizens, empowering them to play an active and unique role in development initiatives." (New Urban Agenda, 2016: p. 4)

The expectation is participatory; promote civic engagement, engender a sense of belonging and ownership among all their inhabitants. It prioritizes safe, inclusive, accessible, green, and quality public spaces that are friendly for families and enhance social and intergenerational interactions. It accepts cultural expressions and political participation, as appropriate, and foster social cohesion, inclusion, and safety in peaceful and pluralistic societies. This expects that the needs of all inhabitants are met, recognizing the specific needs of those in vulnerable situations. The implementation is expected to be at regional, national, subnational, and local levels, with the participation of all relevant actors specially including people, the inhabitants, who possess the decision-making right.

Highlighting on peoples' perception and sense on their environment, Lynch (1960) states that the living environment should be geared to the appropriate cultural type or shaped in many ways to satisfy the varying demands of the individuals who inhibit in it. Gehl (2010) identifies respect for people, dignity, and zest for life as issues in urban environments. Focusing on residential areas, Savasdisara (1988) finds that the physical and socio-environmental components of a neighbourhood affect resident's satisfaction.

Combining the residents' appeal and sustainability, Howley (2009) in his investigation on sustainability versus liveability, claims that the public may support sustainability principles in the context of 'neighbourhood satisfaction'. Similarly, Dehghanmongabadi, (2014) states that public participation is a key factor to achieve sustainability in communities. Hence, the inhabitants must have an appeal, a satisfaction about their living setting, to be livable and sustainable.

Consequently, this research is based on the fact, that the inhabitants' level of satisfaction is a sensible indicator of sustainability of a neighbourhood. Though it has not been a standard method of measuring sustainability, considering the neighbourhood, the inhabitants' satisfaction is a prime factor in its evaluation. They are the primary stakeholders, directly experiencing it as manifested by its urban form.

Accordingly, Rau and Fahy (2013) claim; who decides what counts as sustainable? Finally, who are the 'winners' and who are the 'losers' of sustainability initiatives and policies, both now and in the future? These are pressing questions and are central to the achievement in sustainability. However, they rarely receive adequate attention from politicians, practitioners, and academics (Rau & Fahy, 2013).

Kindon (2007) explains the importance of people, participation, and place, in participatory researches where researchers and participants together recognize an issue or situation in need of change. Then they initiate research that draws on capabilities and assets to precipitate relevant action. Specifically, both researchers and participants reflect upon, and learn from this action. Participatory and Action Researches are rapidly becoming a leading paradigm within the context of social and environmental sciences at present (Brydon-Miller et al., 2004; Jason et al., 2004; Reason & Bradbury 2006). Characteristically, participatory approaches prioritize the concerns of local community, and the immediate social and natural environments in which they are located, are ground up processes in it (Kindon et al., 2007).

As Rau and Fahy (2013) argue, its contributors can draw on extensive experience and expertise regarding both the conceptualization of 'society–environment relations' and the empirical studies of 'people and places'. Neighbourhoods are extreme examples as places of living, that are strongly bound with inhabitants' living routine.

Thus, this research has been conducted as social research in which the benefits of research accrue more directly to the communities involved in the experimentation. Kindon (2007) confessed that the advocates have attempted to eliminate hierarchical role specifications, and empower ordinary people; residents, in and through researches. The aim is to transform a distancing mode of academic production, into a more flexible, practical, and socially owned process. Together, they develop context-specific methods to facilitate the participants' needs. These may include the adaptation of traditional methods of social science as structured and semi-structured interviews, focus groups and Geographic Information Systems (GIS), or innovations in visual or performative methods like diagramming, video etc.(Kindon et al., 2007).

2.7 Case-based intervention; Case study Approach

The notion of place-based development involves a policy approach which is anchored in a locality (Weck et al., 2021). Accordingly, in this place-based, resident-participated scenario, the living neighbourhood is considered as the best 'place' of experimentation. It enables the locality; the neighbourhood, to test its strategic capacity by utilizing its inhabitants' local and place-based knowledge. In such situations scholars such as Weck, Madanipour and Schmitt (2021) have applied comparative approaches on several case-based interventions. Accordingly, case study approach can be considered as well capable in delivering proven information on the real situation.

Case study methodology is described as a distinctive means of empirical enquiry particularly appropriate for exploring 'how' and 'why' aspects of contemporary phenomena within a context of real-life (Yin, 2004). It is understood that a case study comprehends a particular problem, contextualizing its practical application for in-depth analysis, consenting interpretation, and discussion, frequently following exact recommendations for action or for improvements in existing circumstances (Mills et al., 2010). Specifically, time frame and access to information, influence case selection practically (Seawright & Gerring, 2008), but methodological justification in identifying the case neighborhoods are to be convinced in the selection. Referring to Mills (2010), selection of case studies included following considerations.

a) **Representation of an atypical example of the research problem:** Cases represent the topic in different direction of understanding the research problem.
b) **Provision of important insight:** In-depth analysis of a case based on the problem, or the hypothesis reveals fresh and important implications; trends and issues for practice that has not been disclosed in research previously.
c) **Offering a counterpoint to prevailing assumptions:** Case studies offer opportunities to construct evidence that challenge prevalent assumptions and offers novel recommendations for practice which have not been previously uncovered or tested.

d) **Provision of opportunities to pursue action leading to resolve a problem:** Results from investigating the cases expose means to resolve a prevailing or emerging problem with its findings.
e) **Offering of new direction for future research:** Case studies can be used to implement further examination of the relevant research problems.

Case study is used as a research strategy, contributing to knowledge of individual, group, organizational, social, political, and associated phenomena (Yin, 2004). It is a virtuous approach if the case is distinguishable with boundaries (Creswell, 2007) and pursues to provide a detailed understanding of it. Case studies have successfully been employed as means of design research in architectural education and practices. They have also been instrumental in several other disciplines, such as law, business, medicine, psychology, sociology, cultural anthropology, engineering, and urban planning (Sarvimaeki, 2013). The goal of the examination in case studies is to successfully inform design decisions and solutions in the field of architecture, which is naturally an important part of evidence-based design. The focus of the investigation is on deep understanding of a case within its context, analyzed from multiple points of view in order to provide means of holistic interpretations of empirical inquiries within real-life contexts. Methodical comparative studies would suggest better results on varying contextual conditions.

In a case study research, modes of accumulating data are recommended as, documents, archival records, interviews, direct and participant-observations, and physical artifacts (Yin 2004). This is a qualitative approach, exploring a case through detailed, in-depth collection of data over time, expending multiple sources of information, that can be transformed into quantification for evaluation depending on the procedure of analysis.

2.8 Key Findings from the Literature Review and Research Gap

Recognizing theories and methodologies that made impact on modern-day residential development patterns, assists us to understand its rationale and impulse (Beske, 2007), reasoning the adaptation of current physical form by various communities.

It is obvious that the urban form plays a vital role in nurturing sustainability of urban neighborhoods stimulating livability, and the principles are extremely inter-related and supportive of each other.

High density or compactness provides ease to residents for activities which are foundation for a sustainable neighborhood reducing travel distance and have significant impacts on local environmental quality, economy, density, and social equity (Echenique et al., 2012). Adequate street spaces and efficient street network is the physical base while mixed land-use along with social mix, shape the land use efficiency and quality of community life within a neighborhood. It is convinced that the preliminary pace of mixed land-use within neighborhood can be suggested as limited land-use specialization. As such, several researches focused theoretically on elements of sustainable urban form comprising of density, magnitude, composition and configuration, comprehensive design, and its quality from macro to micro scale. However, as Omar (2009) argues, research studies on urban form and sustainability especially in the context of developing tropical cities is still requiring.

Consequently, expedition for achieving sustainability of residential neighborhoods become long-standing for more than a century by now, and mostly associated with integrated land use, efficient transportation systems (Yigitcanlar et al., 2015) and environmental responsiveness. Implication of sustainability is universally commended, and the sprawl is being provocatively denounced due to its negative environmental, social, and economic impacts. Principal acceptance on urban form of a neighbourhood or a city is that it can affect its sustainability (Rajashree et al., 2014). Numerous appraisals have tried to verify that sustainability of an area might be contingent on its physical attributes such as size, shape, density, dispersal of land- use and limitations of land-use specializations.

The urban form enforces positive and/or negative bearing on convenience level of accessibility to common facilities and amenities, and travel attributes in terms of distance and time, energy usage, social equity, land-use efficiency, monetary benefits, reduction or efficiency in gas usage, emissions and pollution, liveliness, vividness etc.

Accordingly, these principles create a balance among, the population growth, along with economic changes, within the rapid urbanization, and essentially, human centered sustainable urban developments.

Moreover, they are compassionate in launching new and more appropriate urban systems, (Dehghanmongabadi, 2014) within which entire subtleties could be developed collectively. This provides conditions where urban residents' living, and development of urban neighbourhoods are occurring in coherence. However, the argument on the most appropriate urban form to attain sustainability is yet unresolved. Declaring sustainability of urban neighbourhoods, the relevant attributes of urban form, its' contented elements and their configuration are obviously needed to be understood to forecast a sustainable neighbourhood form for any urban locality.

Recent researches already prove that the features of urban form significantly contribute to sustainable urban development (Friedman, 2007). Focusing on to a neighbouhood, its' uniqueness as a favourable place to live in or work at, provides intangible statements manifested by the urban form. Neighbourhoods of different scales with their own identities of urban form, compose the city. They collectively contribute to make-up the city's form.

In neighbourhood-based planning, the successes and weaknesses of the form are reasonably easy to understand as they are more responsive to local influences. In a close analysis, these unit urban forms or the neighbourhood forms are identified based on their influence on sustainability and human behaviour. Humans are naturally aware of their position of the environment, with the feeling of a need for a sense of place and they sense an identity (Cullen, 1996) of any location they experience. Human behavior is mutually related to their realization of the conditions of living atmosphere. Thus, as the most engaged stake holders, the residents; their behaviour and response towards the neighbourhood setting is the most effective expression to examine the pertinence. Also, as it is to be a place-based experimentation, case-based intervention combined with residents' experience, can be considered as the most appropriate.

2.9 Concluding Remarks

Scholarly studies of urban form at city levels with real cases as examples, and sustainability concepts are well useful in understanding the issues, strengths, and weaknesses of our built environment at any scale. Challenging explanations of sustainable developments in relation to each other, offers a 'visual representation of sustainable development' (Connely, 2007) as principally questioned concept with pretentiously influential and organized demonstrations.

In the context of sustainability, an infinite number of scenarios for a sustainable community can be imagined, and back casting from scenarios, in which a shared picture is evident of 'how' it has happened. It is a planning and designing approach with which an effectively positive outcome can be expected for the future. It is to be monitored by the question; 'what is needed to reach that positive outcome for today?' which is better effective than relying on forecasting.

For example, Barcelona, Amsterdam, and Malmö are considered as common European specimens that have been prefigured as best practice (Dempsey, 2011). Changes in internal form and function of cities are parallel to the implications of those changes, in promoting better sustainable forms of urban development (Haughton & Hunter, 2003). Similarly, to secure environmental sustainability and to improve human living environments, social and behavioral researches are essential. To place them into a broader context, an overview of global developments in environmental quality and tendencies in resource consumption is to be first prioritized (Vlek & Steg, 2007).

Today, planning and design related professionals have accepted the city formation with stronger normative visions, often representing concerns on greater communal purposes, and long-term future of local communities (Beske, 2007) and neighbourhoods. Criticisms by Jane Jacobs (1961) have summed-up that the cities are 'an immense laboratory of trial and error'; in learning failures and successes in design of cities, and in local scale, neighbourhoods are their constituents. Her opinion at the time was that the practitioners of relevant disciplines have ignored learning of

successes and failures and unconcerned of the reasons for those positive or negative outcomes. Today, practitioners of the planning and design disciplines are aware about the reasons for those positive or negative outcomes, and they are inquisitive on further refinements. Therefore, it is understood that, learning and testing of theories already applied in the existing formation of cities and neighbourhoods reveals the public need.

The practice of developing urban form or built environment at neighborhood level that meets the requirements of its inhabitants, avoiding undesirable social and environmental consequences (Hamilton et al., 2002) and uplifts the economic practicability is understood as neighborhood sustainability. Research on investigating collective expression of urban form; its elements creating unique 'goodness' of such neighbourhoods, influencing sustainability are indispensable in the fields of Architecture, Planning, and Urban Design. Examinations on attributes of the urban form; specific configurations with its fittingness in different urbanities, creating such sustainable uniqueness owned by neighbourhoods are yet to be emphasized in detail.

The process of literature is graphically presented in the Figure 2.24. It conceptualizes the key findings of literature review, that are compatible with the main concerns in the research study. The research gap is emphasized based on the other research findings as an extended component centered on Colombo residential neighbourhoods as cases.

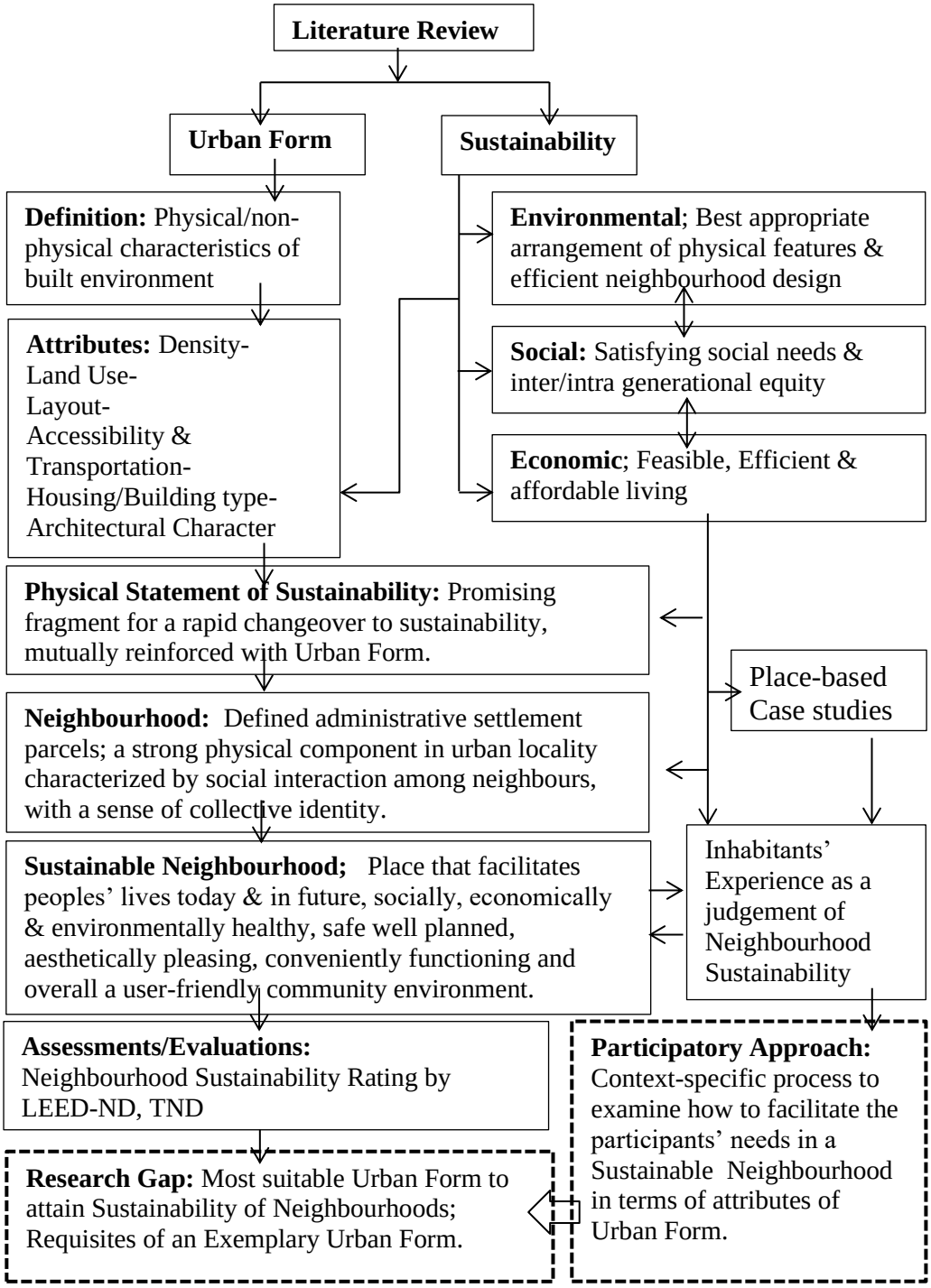


Figure 2.24: Conceptualization of the key findings of Literature Review

As per the key findings of literature review, deep research on cases, and analytical comparisons on cases of different urban localities; inner, middle, and outer city areas, accumulate more resourceful and inspiring outcome.

Especially, when the physical formation is assessed through the social sensation and behavior, the public evidence is proven. Hence this study makes a next step in filling a gap along the resulted findings and discussions in relevant researches, as an evidence component. It is crosschecking the context of human judgment, towards the sustainability of their living setting, deliberating on Colombo residential neighbourhoods from varying urban subtleties. Methodological process is discussed in the next chapter.

CHAPTER 3: RESEARCH METHOD

This chapter delivers a detailed explanation on the method of study applied in the research to achieve the stated research objectives, with a justification. The study targets to understand the determinants of urban form, indicative of sustainability features in varying residential neighbourhoods. This investigation requires specific primary and secondary data to achieve the objectives. Thus, for this purpose, up-close examination on neighbourhoods in terms of their urban forms and sustainability is essentially required. Best way for investigation is understood in research plan as case study approach, based on case neighbourhoods of three selected administrative wards, which are selected from three different zoning categories in Colombo.

3.1 Consolidation of Objectives

Specific Objectives are investigating sustainability features; the indicators as perceived and experienced by users under three main sustainability parameters; environmental, social, and economic, to develop a conceptual framework for assessing Neighbourhood Sustainability in terms of Urban Form. Finally, the framework is tested by using it, for rating sustainability under each parameter in 3 different residential neighbourhoods of 3 administrative wards: from 3 different zones, analytically, comparatively. The case studies are fundamental in obtaining relevant data on their urban form and the sustainability as experienced and perceived by the inhabitants. They are used as the specimens in this research to verify the inhabitants' expectation in neighbourhood sustainability in terms of urban form.

The final objective is formulating, verbalizing the sustainability determinants of Urban Form as 'the physical indicator' of the sustainability. Finally, it should formulate the sustainability determinants on each case urban form; (Figure 3.1). The way, sustainability assessment would diverge with the varying attributes of urban form in different cases will be analyzed. This can be used in creating new urban neighbourhoods and developing existing urban neighbourhoods for sustainability, which are the utilitarian value and could be adopted into policy decisions.

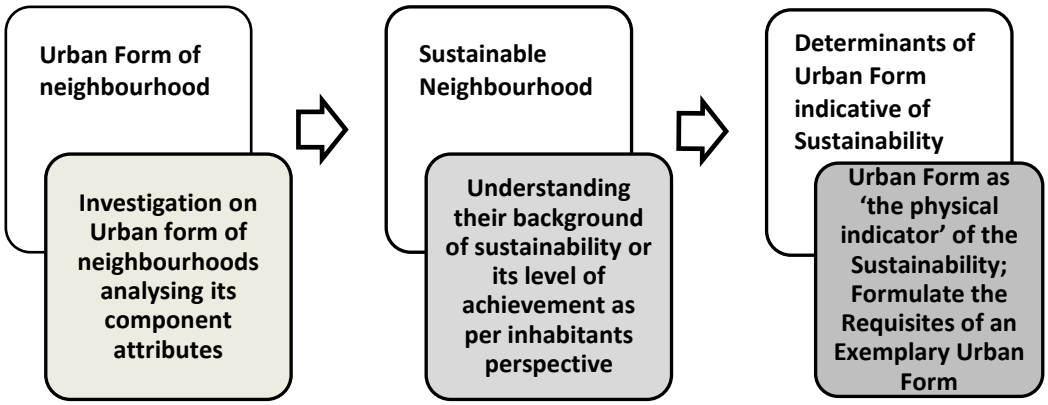


Figure-3.1: Approach to Research and Research Focus

3.2 Research Strategy

It is agreed that the city, town, or neighbourhood can be understood and analyzed through its physical formation or the urban form. Its morphological analysis is based on 3 principles at its utmost elemental level. (Mouden, 1997).

a) Urban form is defined by three (03) physical elements fundamentally, which are buildings and their related open spaces, plots or lots and streets.
b) Urban form can be understood at different levels of resolution, of which four (04) are commonly, recognized as building/lot, street/block, city, and region.
c) Urban form can only be understood historically since the elements of which it is comprised undergo constant transformation and replacement.

Human experience on their living setting: how they sense it, and its' changes, is the most important consequence of the built environment at any of above resolutions. As per Lynch (1984) the degree to which the physical living locale can be evidently perceived, mentally distinguished, and structured in time and space by its residents, is the sense of place. In researching, phenomenological inquiry in peoples' behaviour within the physical environment, one must realize that there is also a growing body of qualitative, descriptive research focusing on actual places, built environments, and environmental experiences (Seamon & Mugerauer, 1985). It prioritizes the community concerns and strengthens by 'society–environment' and 'people-places' relations (Kindon et al., 2007; Rau & Fahy, 2013). Appropriate sampling to best portray the research problem is centralized in the research design.

Neighbourhoods are the most appropriate piece of built environment ensuring the living atmosphere for inhabitants as communities. Inhabitants are the mostly affected party or the active stakeholder in evaluating the provisions of the neighbourhood.

The research is to be realistic and observational for understanding the successes and failures in urban form and its' compassion with resulted sustainability of such neighbourhoods. It is essential to involve up-close, in-depth, and detailed examinations on subject study based on varying contextual conditions. The approach relies on the descriptive materials on neighbourhoods as social units (Lucas, 1974) and their sustainability professed by urban forms as recognized by human. Therefore, on literature basis, case study method is chosen as the stratagem, as opportunities are to be made available for real aspects of problems to study in-depth within a pre-planned time search.

To enable the extraction of data that discourses the research question most rationally, a comparative case study approach is chosen. Therefore, the multiple case study method is particularly appropriate since the context is strongly related to the subject matter. Henceforth the rationale for choosing this approach allow for cross-contextual comparisons between case neighbourhoods from different urban localities.

3.3 Research Design

Sri Lankan urban districts are experiencing problems such as rapid growth of population, over-crowding, inadequacy of urban facilities and services, pollution, and lack of identity and meaning, similarly, to many large cities and metropolises around the world. The rapid growth of population is associated with rapid increase of housing demand and expansion of residential areas (Ministry of Housing and Construction-Sri Lanka, 2015). They are mostly street-oriented urban architecture, which consider the motorized transport and provision of built spaces as the most dominant factors in neighbourhood formation. This was a voice made by Jane Jacob; a journalist (1961) more than 65 years ago, emphasizing the separation of 'city' from 'city living'.

In this changing context, essential qualities for a healthy life; either physical or social, have been neglected to a considerable extent from the neighbourhood level. This ends up with cluster of questions. In realistic observations: can our neibourhoods be considered as sustainable? Are people living in or using it, are optimally facilitated by their living or working environment? What people really expect as sustainable neighbourhood? Accordingly, the study is conducted with three elementary research questions, with inevitable fourth major question:

1) How can neighbourhood sustainability be defined in terms of the inhabitants' engagement and how does it correlate with their urban living experience?
2) How is neighbourhood sustainability manifested through the urban form of neighbourhood and what are the deterministic attributes, that embark on this interconnection?
3) How do the urban forms vary in different localities in the city; inner, intermediate, and outer city areas, for their inhabitants to sense them as sustainable?
4) What are the major requisites of an urban form of a neighbourhood that meet with inhabitant's appeal on desired quality, in the long term in urban living?

The questions are simplified towards three distinct techniques in the methodology, with reference to the case studies, as follows:

a) Investigating the Urban Form of urban neighbourhoods:
b) Understanding their background of sustainability or its level of achievement:
c) Discover the determinants of Urban Form in such neighborhood sustainability:

Thus, the research is designed with three key stages based on the case studies: three neighbourhoods. Initially, it is focused to understand the urban form technically with its physical and non-physical attributes by using secondary data. Secondly it converses and explains about the levels and background of neighbourhood sustainability realistically by using the inhabitants of the neighbourhoods as key percipients. This is done using primary data, based on structured surveys. In the final stage, it analyses the findings on preliminary and comparative bases. It provides concluding notes on the determinants of urban form as requisites, rationalizing the sustainability goals of neighbourhoods.

3.3.1 Structure of Inquiry:

For a close analysis of Urban Form, realistic local neighbourhoods are to be looked at in detail, for the analysis to be true to the real life. Urban Form and the consequential sustainability indication are to be observational, in varying contextual conditions. Thus, the case neighbourhoods are selected from inner city, intermediate city, and outer city areas in Colombo. They are representing varying urban zones. The inquiry is on urban form and pertinent sustainability appealing of the inhabitants. The required data are related to the analysis of urban form of the neighbourhood, and sustainability indications as percieved by the inhabitamts. Therfore, Case study method is utilized with the specific concerns of the study, and the structure of process is as follows.

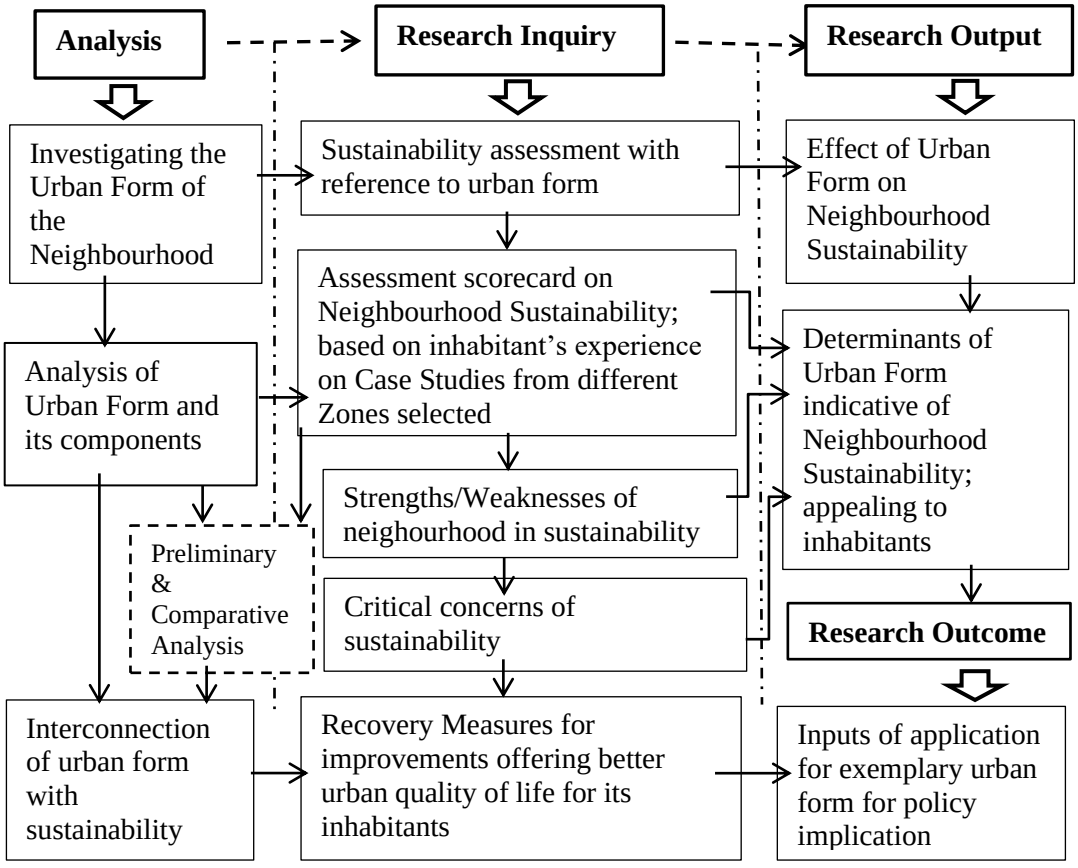


Figure-3.2: Structure of Research Process

Data collection for Research is conducted confirming to ethical norms recommended by the University of Moratuwa. Conducting structured interviews and structured observations are being carried out to collect data in a systematic manner.

Data are collected towards the analysis as follows.

a) **Step-1:** Investigation on current Urban form of case study neighbourhoods:
b) **Step-2:** Understanding the distinctiveness of sustainability based on inhabitants' perspective: identify variables, measuring indicators, strengths-weaknesses, forming a sustainability scorecard:
c) **Step-3:** Compromising at the ending with requisites of an exemplary urban form with its determinants of sustainability, as a guiding tool for application in design:

Analysis of Urban Form (step 1) and the Sustainability scorecard based on inhabitants' perception (step 2) are carried out, structured on specific frameworks grounded on literature. Step 3 synthesize both steps 1 and 2 subsequent to the analysis.

3.3.2 Framework for analysis of Urban Form

Referring the literature, current urban form of case neighbourhoods is spatially studied, analyzed, and assessed with its major components or elements such as density, land use, layout, connectivity and transportation, housing/building type and architectural character (Dempsey et al., 2010); (see Figure 3.3). Multiple sources of information, such as observations, site surveys, interviews, ordinance surveys, documents and reports are utilized in collection of in-depth data on case neighbourhoods,

In the analysis of urban form, findings on technical information are based on the best available and accurate secondary sources. They are mainly of geospatial vector data in shapefile format for Geographic Information System software mapping (GIS), commercial Computer Aided Design software (AutoCAD) and census and statistics information available in most updated ordinance survey records. Calculations and revelations are grounded on those sources, for macro and micro contextual analysis. The neighbourhood specific research data are based on personal observations in depth, annotations, and inquiries. Hence, the calculated and revealed figures in the analysis within the research are to be considered as estimated, and they are not verifiably documented information. Benchmarks for each element of urban form are based on UN Habitat guides (2011) as indicated in the design framework; (see Table 3.1).

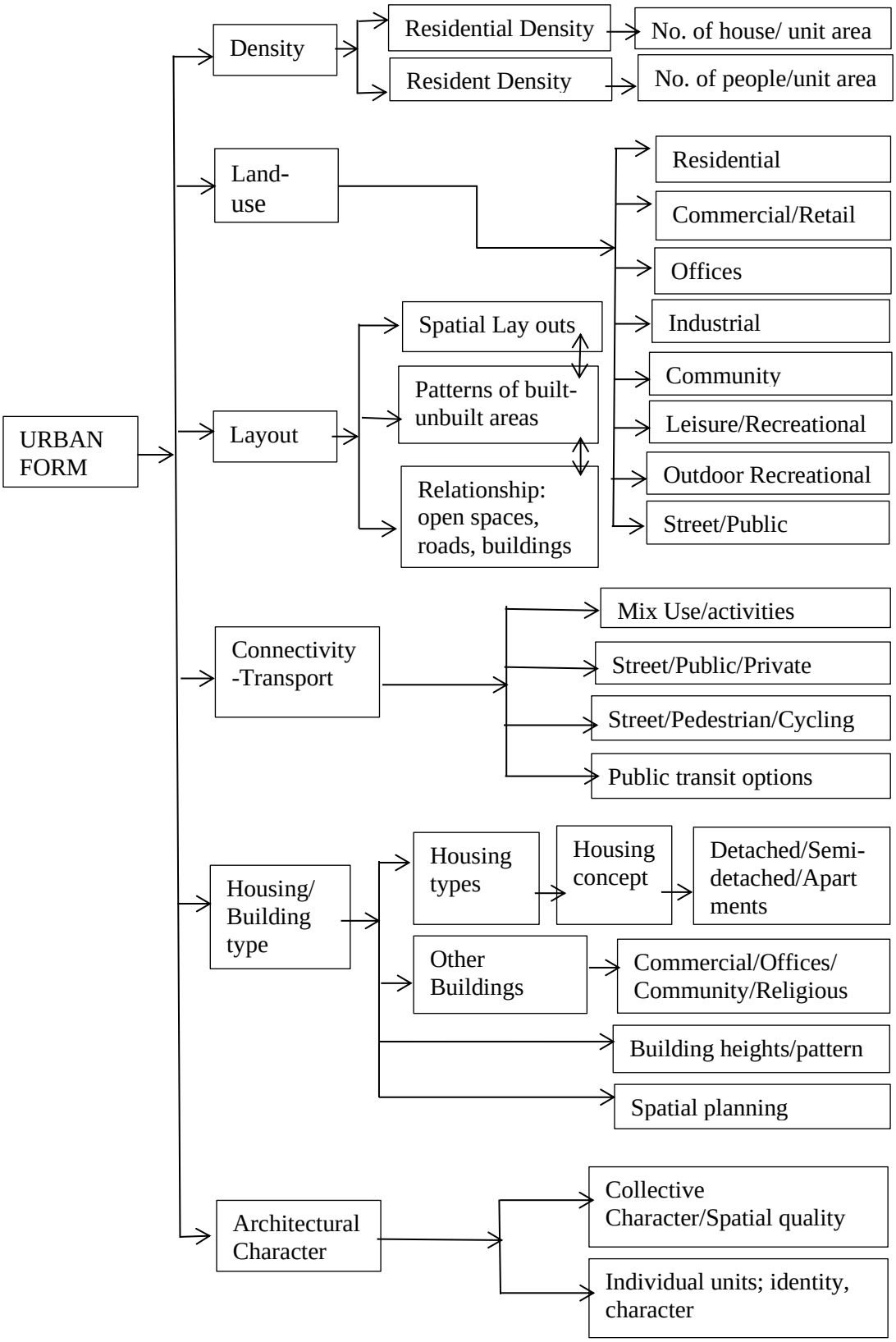


Figure-3.3: Analytical Framework for assessing Urban Form
Based on Aurcach,2005; Bertolini, 2005; Dempsey et al, 2010; UN Habitat,2011; Song, 2008; RTP, 2015; Tom, et al.,2018

Table 3.1: Design Framework for Analysis of Urban Form with recommended benchmarks

Element of Urban Form	Research Matrix	Research data	Benchmark
Physical density	Resident density	▪ No. of People per unit area	**Density:** Population density; 150 people/Hectare
	Residential density	▪ No. of Houses per unit area	
	Other Building types	▪ Commercial, Offices, Community, Religious	
Lay-out	Spatial layouts/ Spatial Analysis	▪ Dimensions; spaciousness, provision of streets, lots, pedestrian paths, ▪ Level of quality and maintenance; litter, vandalism, street lighting, ▪ Level of safety for public, women and children	Qualitative variable Experiential convenience to the user is rated.
	Relationships between spaces and building		
	Patterns and the relationships between spaces		
Land-use	Residential/ Individual and group	▪ Sheltered accommodation, Care homes, ▪ Accommodation for education institutes, orphanages	**Land-use Specialization:** Single function block area/Neighbourhood area: 0-10% **Mix Land-use:** Economic floor area/ Total floor area : 40-60% Residential floor area/ Total floor area: 30-50%
	Commercial and retails	▪ Retail shops, Supermarkets ▪ Stores, Warehouses, Restaurants, cafés	
	Offices	▪ Business plots, ▪ Banks, Other offices	
	Industrial	▪ Workshops/Warehouses/production related, Industrial storage facilities ▪ (Depos etc)	
	Community	▪ Schools, day-care, and health centers/ hospitals, ▪ Community centers, Places of worship, Police stations, railway stations, bus-stops	
	Leisure and recreational buildings	▪ Museums, Libraries, Cinemas, ▪ Indoor sports facilities, fitness centers	
	Outdoor recreational	▪ Sports grounds, children's' and public parks,	
	Mix use	▪ Buildings with multiple uses	
Transport infra-structure & connectivity	Public transportation infrastructure (street)	▪ Location of public transit stops transport features ▪ Bus routes, Frequency of services	**Efficiency of street network:** Street land-use/ Total floor area: 30-45%
	Private transportation	▪ Private transport features, ▪ Parking; off-street and on-street	
	Pedestrian and cycling	▪ Cycle or pedestrian paths and alleyways/ ▪ Routes inaccessible to motorized transport	
	Road management	▪ Route management; One-way systems, ▪ Traffic management; Speed restrictions	
Housing typology & **Architectural character** (Qualitative)	Predominant Housing type per street	▪ Detached housing ▪ Semi-detached housing Apartments	**Social-Mix in Housing:** Single ownership/Residential floor area: 0-50% Affordable housing/Residential floor area: 20-50%
	Other Building types	Commercial, Offices, Community, Religious	

Sources: Aurcach,2005; Dempsey et al,2010; UN Habitat,2011.

3.3.3 Conceptual framework for the assessment of Neighbourhood Sustainability

Based on the sustainability criteria remarked based on literature, current neighbourhood environment is studied, of each neighbourhood for the purpose of understanding sustainability indicators in human experience and behaviour. Following research areas are perused (Southworth, 1993; Teriman, 2012) to find indicators on prevailing density, land use, layout including connectivity, infra-structure, social goals, (Homoud & Tassinary, 2004) and environment related practices and management. These are laid under each of neighbourhood sustainability category; within Social, Environmental and Economic parameters, which are strongly inter-connected and hardly unmanageable to be assessed separate. However, the variables are operationally formed under each parameter and for evaluation purposes, following criteria is being applied.

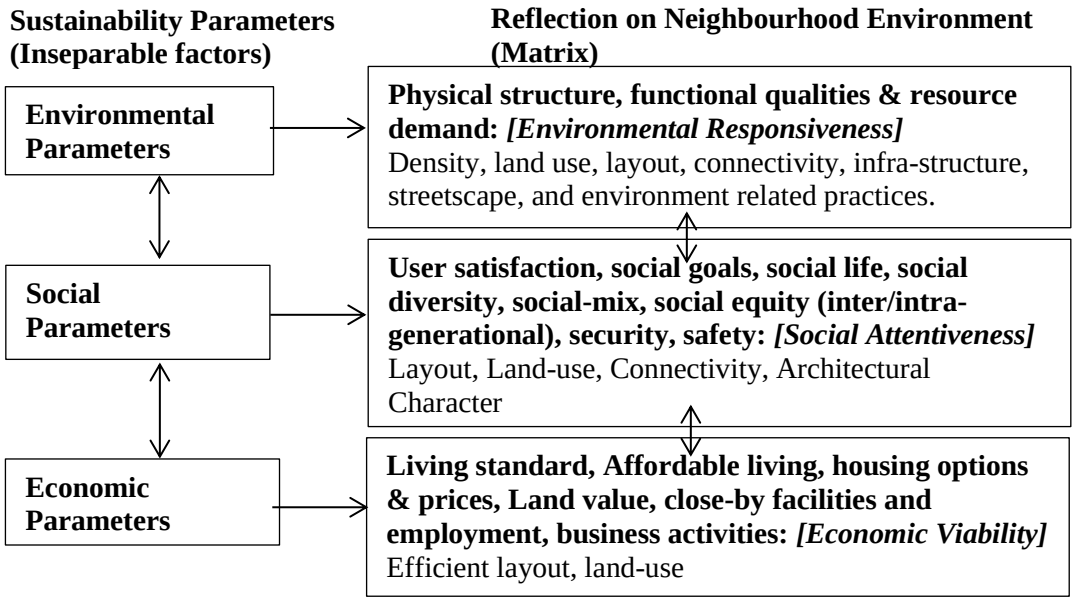


Figure 3.4: Conceptual Framework outlining strategy of assessing neighbourhood sustainability

Considering the real living situations, Queries are drafted to understand the overall sustainability of the neighbourhood based on the framework, as derived from the literature review (figure 3.5); to form a sustainability scorecard for each case study, based on residents' perception. However, conceptually those quires are categorized under main three sustainability parameters and their respective qualitative output.

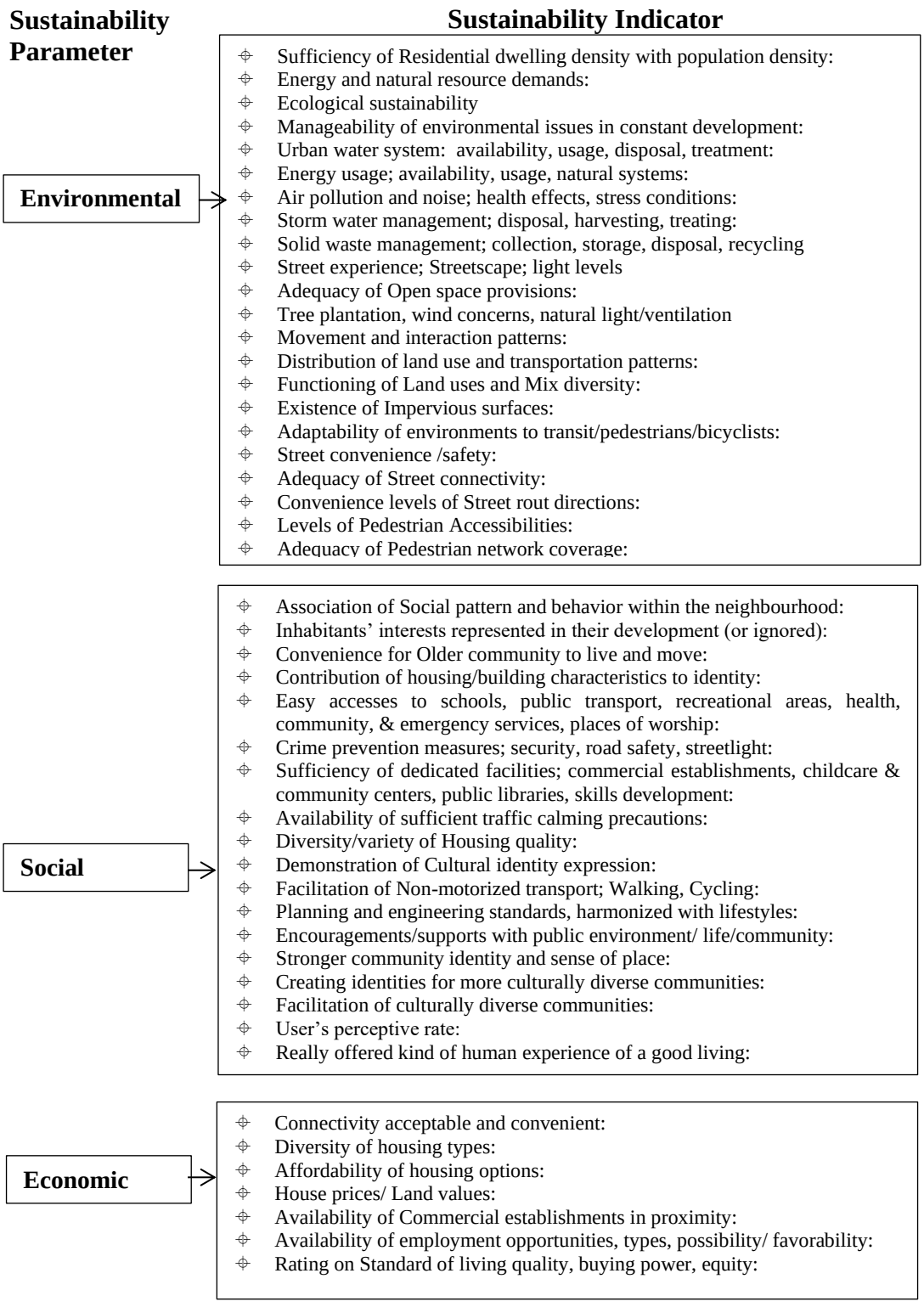


Figure 3.5: Identification of Parameters and Variables for examination on sustainability assessment

Sources: Bafna, 2003; Blum & Grant, 2006; Jenks, 2010; Welches, 2010; City of Pickering, 2011; Jabareen, 2011; Teriman, 2012; Dempsey et al.,2012; APA, 2016; Sarachaga, 2018

3.3.4 Design framework of Questionnaire

Under **Environmental Parameters** the physical structure will be revealed for evaluation of functional qualities and resource demands. Design criteria are based on assessing density, land use, layout, connectivity, infra-structure, streetscape, and environment related practices, under their determinants of urban form, density, layout, land use and connectivity. Queries are sub-categorized with reference to responsive elements.

Table 3.2: Framework for Questionnaire; Environmental Parameters

SUSTAINABILITY ON ENVIRONMENTAL ASPECT		
The level of quality perceived by the resident on the favourability of physical environment: Physical structure, functional qualities & resource demand; resulted by density, land use, layout, connectivity, infrastructure, streetscape, and environment related practices;		
Matrix	**Qs**	**Assessment indicator-based questions**
Density	1	Sufficiency of Residential dwelling density with population density;
	2	Energy and natural resource demands tally with supply;
	3	Ecological sustainability; (observation)
	4	Manageability of Environmental issues in constant development;
	5	Urban water system: Adequacy of availability-for usage, disposal,
	6	Energy usage: adequacy of availability, for usage, natural systems;
	7	Air pollution and noise: favourability in terms of health effects, stress conditions;
	8	Storm water management; Efficiency of disposal, harvesting, treating;
	9	Solid waste management; Efficiency of collection, storage, disposal;
Layout	10	Rating on Street experience;(within neighbourhood)
	11	Rating on Streetscape;
	12	Adequacy of Light levels of streets;
	13	Adequacy of Open space provisions;
	14	Rating on tree plantation, wind concerns, natural light/ventilation within the neighbourhood;
Land-use	15	Favourability of Movement/ interaction patterns in and around
	16	Appropriateness of distribution of land use and transportation patterns;
	17	Functioning of Land uses and Mix diversity; (observation)
	18	Existence of Impervious (water-tight) surfaces; (observation)
Connectivity/ transportation	19	Adaptability of environments to public transit/pedestrians/bicyclists;
	20	Rating on the street safety;
	21	Appropriateness/ Adequacy of Street connectivity;
	22	Convenience levels of Street rout directions;
	23	Rating on the street's convenience;
	24	Rating on the levels of Pedestrian Accessibilities;
	25	Adequacy of Pedestrian net-work coverage;

Sources: Vlek & Steg, 2007; Dempsey et al., 2010; Welches, 2010; City of Pickering, 2011; Teriman, 2012; RTPI, 2015; APA, 2016; Sarachaga, 2018; Kotagama, 2019

Under **Social Parameters,** Question of overall user perception and satisfaction, impact of prevailing physical structure on social structure will be assessed. Design criteria is to assess the achievements in social goals, social life, social diversity, social-mix, social equity, security, safety under relevant determinant factors of its form, layout, land use, connectivity, and architectural character.

Table 3.3: Framework for Questionnaire; Social Parameters

	SUSTAINABILITY ON SOCIAL ASPECT	
	User perception, satisfaction: Social goals, social life, social diversity, social-mix, social equity (inter/intra-generational), security, safety; resulted by layout, land-use, connectivity, and transport infrastructure, building typology and architectural character	
Matrix	**Q**	**Ranking indicator-based questions**
Layout	26	Association of social pattern and behavior within the neighbourhood;
	27	Representation of Inhabitants' interests in their development (or ignored);
	28	Convenience for older community to live and move;
	29	Contribution of housing /building characteristics to collective identity;
	30	Easy accessibility to schools, public transport, recreational areas, and health, community, & emergency services, places of worship;
	31	Levels of Crime prevention measures, security, road safety, streetlight;
Land-use	32	Sufficiency of dedicated facilities; commercial establishments, childcare centers, community centers, public libraries, skills development facilities available; (in proximity)
Connectivity /Transport	33	Availability of Sufficient traffic calming precautions;
	34	Representation/demonstration of Cultural requirements;
	35	Facilitation of Non-motorized transport, Walking, Cycling;
	36	Planning and engineering standards, harmonized with lifestyles;
	37	Encouragements/supports with public environment and public life of a community;
Architectural character	38	Diversity/variety of housing quality;
	39	Development of Stronger community Identity and sense of place;
	40	Creation of Identities for more culturally diverse communities;
	41	Facilitation of Culturally diverse communities;
	42	Users perception/rating on their neighbourhood;
	43	Really offered kind of human experience of a good living;

Sources: Cullen, 1996; Dempsey et al., 2010; Welches, 2010; City of Pickering, 2011; Teriman, 2012; RTPI, 2015; APA, 2016; Sarachaga, 2018

Under the **Economic Parameters** affordability of living related to the living quality will be assessed; Design criteria are to assess rating on Affordable living, housing

options, housing price, land value, close-by facilities and employment, business activities, under relevant elements of urban form; Layout and Land Use.

Table 3.4: Design Framework for Questionnaire; Economic Parameters

	SUSTAINABILITY ON ECONOMIC ASPECT	
	Affordable living, housing options & prices, Land value, close-by facilities and employment, business activities resulted by; Layout, land-use	
Matrix	**Qs**	**Ranking indicator-based questions**
Layout	44	Acceptability and convenience of connectivity;
	45	Diversity of housing types for variety of economic/social categories;
	46	Affordability of housing options;
	47	House prices/ Land values;
Land-use	48	Availability of commercial establishments in proximity;
	49	Availability of employment opportunities, types; possibility/ favorability;
	50	Rating on Standard of living quality, buying power, equity;

Sources: Dempsey et al., 2010; Welches, 2010; City of Pickering, 2011; Teriman, 2012; RTPI, 2015; APA, 2016; Sarachaga, 2018

The urban form evokes identities for neighbourhoods where the inhabitants and users recognize them as appealing neighbourhoods, or otherwise. On Remarks, this is to be understood under each indicator as a scorecard. More importantly, how far the inhabitants have perceived the uniqueness of their neighbourhood as a favourable place to live is the question answered. The above framework is converted into a simple question format for residents' convenient understanding, (refer Appendix-A) and the answers are obtained/recorded as a rating based on five level Likert scale. This forms a scorecard of inhabitants for each neighbourhood, which creates a clear sustainability assessment of the neighbourhood. Higher degree of rating means higher appeal. Preference at Level 5 [very good] is considered as highly appealed and level-1 [very poor] as least in it. Level-3 is moderate in its concerns. Turning back to the analysis, the contributory factors of urban form responsible in resulted uniqueness of sustainability could be understood. The strengths and weaknesses could be identified and how they have transformed into physical form are to be matched. Changes to be made in the urban form in fixing and improving them is the final moderation, which is to be used as tools in application of design.

3.4 Justification for the paradigm

Since it is a case study based observational research, appropriate three (03) significant case neighbourhoods were selected. These neighbourhoods that are from different urban contextual conditions, have not yet studied in terms of sustainability. This section discusses in the selection criteria and profile of case studies.

3.4.1 Selection criteria for Case Studies:

High population density and physical development potential in terms of the growth and expansion of residential neighbourhoods is central in the selection of case studies. Current tendency of creating new residential neighbourhoods and improving the existing areas to cater to the high demand in urban housing, is evident in Colombo District. It shows the highest population density in the Western Province and is considered in the broader picture. Colombo district contains 2,309,809 of population, and it is 11.42% of the total country population. The population density is recorded as 3440 persons/Sq. Km with 77.6% of urban population in the year 2012 (Statistics, 2012). As the commercial and administrative capital of the country, Colombo district is consisted of five (5) Municipal Councils and five (5) Urban Councils. The highest population is found in Colombo Municipal Council, which is nearly 31% of total district population; (Table 3.5, Figure 3.6). With the new upcoming development potentials, urban areas in Colombo Municipality, can be identified as more vulnerable to urban development related issues.

Table 3.5; Distribution of Colombo District Population

	Municipal/Urban Council (MC/UC)	**Male population**	**Female population**	**Total population**
1	Colombo MC	281,458	279,856	561,314
2	Dehiwala-Mt. Lavinia MC	89,987	94,481	184,468
3	Moratuwa MC	85,957	82,323	168,280
4	Sri Jayewardenepura Kotte MC	51,992	55,933	107,925
5	Kaduwela MC	123,572	128,469	252,041
6	Kolonnawa UC	29,713	30,331	60,044
7	Seethawakapura UC	14,655	15,653	30,308
8	Maharagama UC	94,117	102,306	196,423
9	Kesbewa UC	89,872	95,250	185,122
10	Boralasgamuwa UC	29,050	31,060	60,110
	Colombo District	**886,739**	**919,296**	**1,806,035**

Source: Census & Statistics, 2012

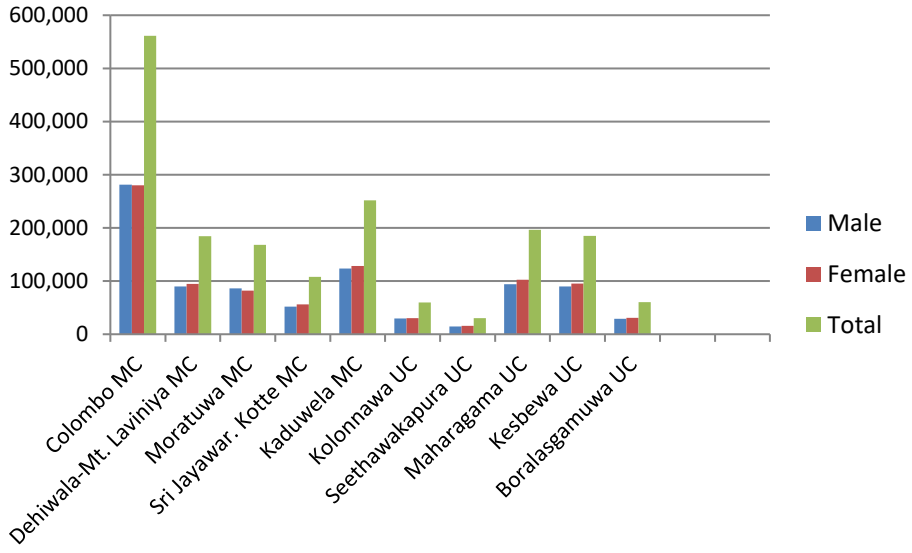


Figure 3.6; Population Distribution in Colombo District
Source: UDA-City of Colombo Development Plan, 1999, 2010; Land Use Survey, 1996

Colombo Municipal Council, which consists of an area of 37.31 Sq.Km. is divided into 47 wards (Ministry of Local Govt. & Provincial Council, 2016) in order to execute administration purposes. Alternatively, it is apportioned into 14 planning divisions in order to achieve planning purposes (UDA-Colombo Development Plan, 1999). There, the most important aspect is the population density and the pattern of its increase. Based on the increase of population, the other facilities and services are needed parallel improvements. In this process the changes or the re-shaping on the built form is inevitable, and concerns on sustainability becomes crucially important. Whatever the development take place in the country, the convenience, happiness and wellbeing of the inhabitants and users are the main concern in sustainable urban development.

Within the municipality, some planning divisions contain extremely less population densities, whereas some have nearly more than 3-4 times higher densities than some of the others; (see Figure 3.7). Out of 14 planning divisions, Cinnamon Gardens, Bambalapitiya, Wellawatta, Narahenpita and Kirulapone seem to be more sequentially developed with smoothly increasing residential and net-residential densities, comparing to the total development in Colombo Municipality.

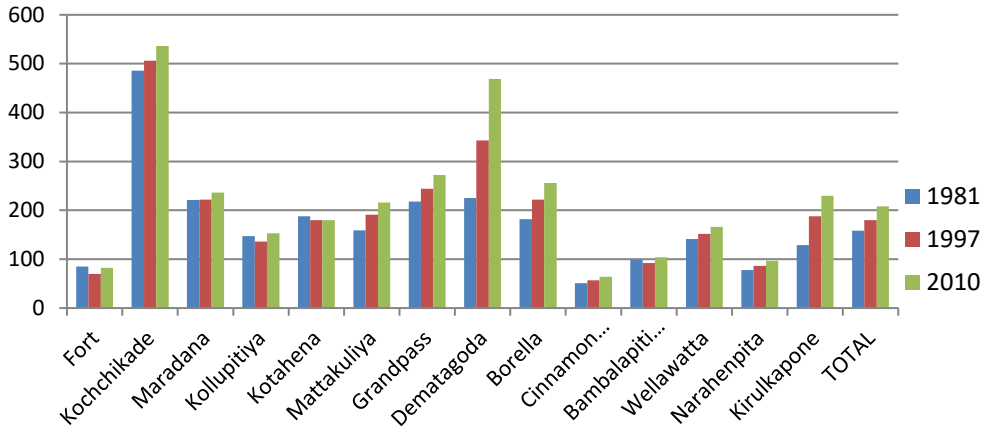


Figure 3.7; Colombo Planning Divisions: **Population Density** (Persons/Hec.);1981-2010
Source: City of Colombo Development Plan, 1977-1985; Land Use Survey, 1996; UDA, 2010

With reference to the development in space utilization for non-residential activities, Fort, Kochchikade, Maradana and Kollupitiya shows a drastic increase during last 15 years recorded. In last 5 years-recorded, Cinnamon Garden and Narahenpita have not faced many changes whereas Grandpass, Dematagoda, Wellawatta and Kirulapone show a decrease in using land for non-residential activities. However, the Net residential density shows a gradual increase in all planning divisions except in Fort; (Figure-3.8, 3.9). In studying on the administrative wards, which are constituent particles of different zones, it is reasonable to explore residential neighbourhood patterns form different zones.

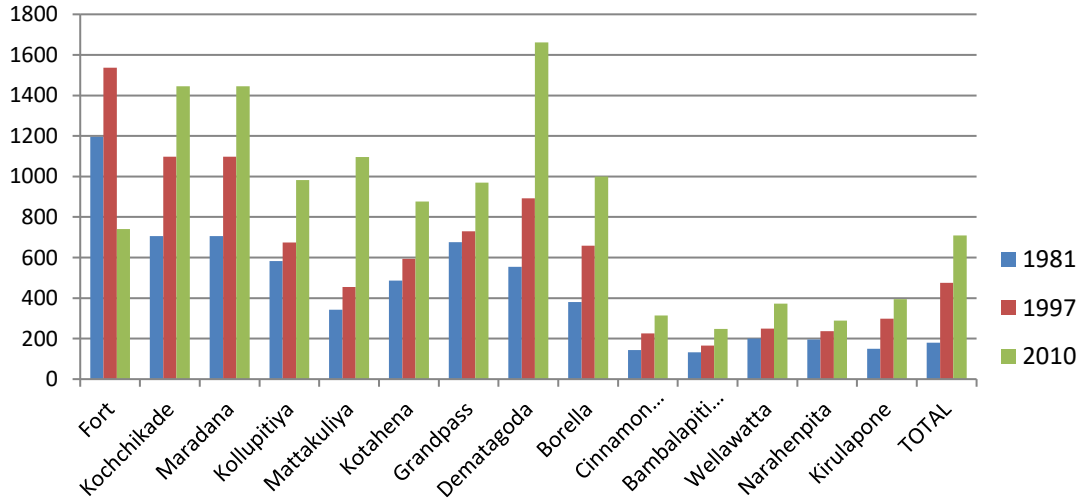


Figure 3.8; Colombo Planning Divisions: **Net Residential Density** (Persons/Hec.);1981-2010
Source: City of Colombo Development Plan, 1977-1985; Land Use Survey, 1996; UDA, 2010

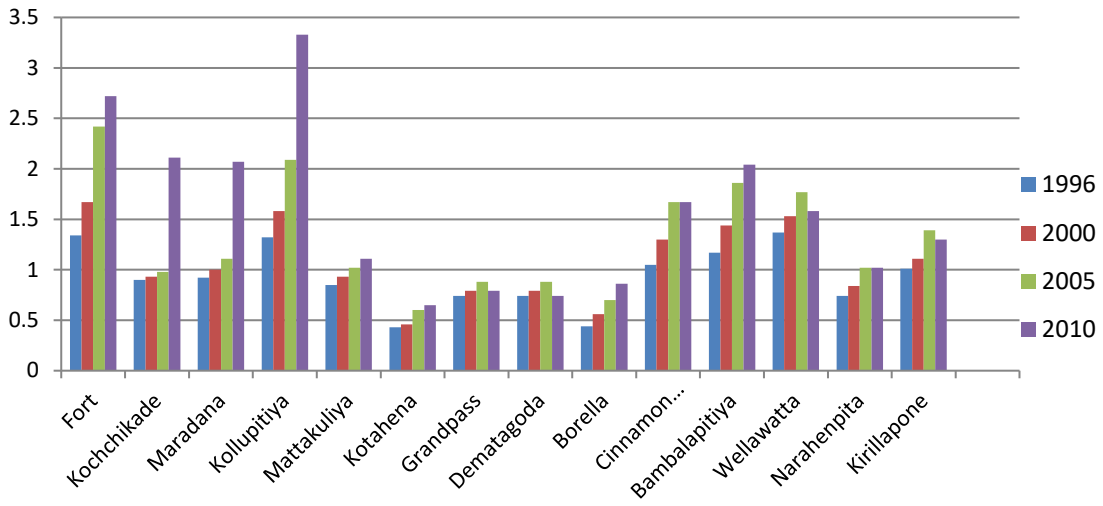


Figure 3.9; Colombo Planning Divisions; Floor space distribution (Mn. Sq.m) of **Non-Residential activities**
Source: City of Colombo Development Plan, 1977-1985; Land Use Survey, 1996; UDA, 2010

In this research, the Neighbourhood is conceptually regarded as a self-defined community, with specific boundaries of a particular administrative ward. In other words, each neighbourhood selected as a case study is a substantial portion of an administrative ward. A comparative study is more fruitful when considering residential neighbourhoods from significantly different residential zones, in different urbanities. Accordingly, the case residential neighbourhoods are chosen from following administrative wards within different activity zones in Colombo Municipal Council; physically, from inner city (concentrated development zone), intermediate city (mix residential zone) and outer city (primary residential zone) (see Table 3.6). Neighbourhoods are termed, based on the name of respective access roads. Each neighbourhood is a part of a different '*Grama Niladhari'* Division (GND), which is the most local administrative unit.

Table 3.6: Zoning and planning profile of Case Neighbourhoods

No	**Zone**	**Ward/GN Division**	**Neighbourhood**
1	Concentrated Development/	Ward:19 (GND 055) (Kochchikade North)	Newham Square neighbourhood, Colombo-13
2	Mix Devepopment/ Intermediarte city	Ward:42 (GND 186) (Kirula)	Chitra Lane neighbourhood Colombo-05
3	Primary Residential/ Outer city	Ward:45 (GND 189) (Pamankada West)	Veluwanarama Road neighbourhood, Colombo-06

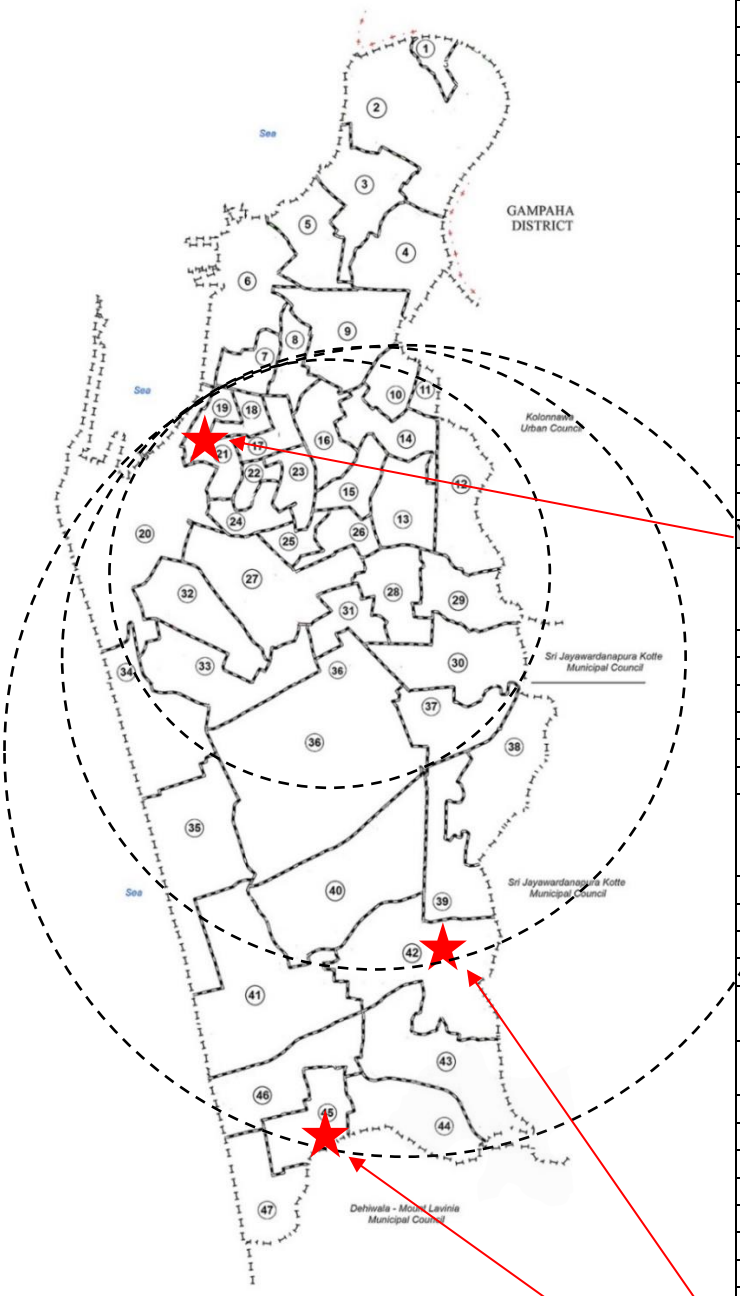
Possible variances are studied in neighbourhood profiles of varying contexts to refine the framework that accommodate generalized legal and planning regulations applied in respective planning divisional context. Hence, the framework of profile could also be a part of the research that studies portions of planning divisions as cases. This enables to understand any provisions of variations and refinements to national design and planning guidelines, which will be significantly important with current Colombo Development Plan.

3.4.2 Case Study Profiles:

A Case study profile is described as Colombo urban neighbourhoods with self-defined boundaries, which are portions of administrative wards. Subjected to in-depth, complete detailed analysis on its urban form and research on its' sustainability application, they are outlined with following criteria.

a) Case neighbourhoods are selected from Colombo Municipal Council area, and they are dense:
b) They are significant in sustainability concerns, long lasting for more than 20 years, and unique in its location and architectural character:
c) The case neighbourhoods include numerous households, a mix of land-uses, a range of housing types or options and street patterns, proximate public transportation, and households with a reasonable range of socio-economic backgrounds and environment-related practices:
d) Case neighbourhoods are prioritized with residential use in land use distribution:
e) They are manageable units; accessible, part of single Administrative Ward under single Planning Authority:
f) Accumulation of data in this case study research is wide-ranging, drawing on multiple sources of information; observations, structured interviews, documents, and their geographic, demographic, and other technical statistics are available in ordinance surveys:

Wards of Colombo Municipality (47 no.s) is illustrated in figure 3.10 and 3.11. The case neighbourhoods located in ward 19, 42 and 45 as highlighted in stars, within inner, intermediate, and outer city limits.



Ward No.	*'Grama Niladari'* (GN) Division Name
1	Sammanthranapura
2	Mattakuliya
3	Modara
4	Madampitiya
	Mahawatta
5	Aluthmawatha
6	Lunupokuna
7	Kotahena west
8	Kotahena East
9	Bloemendhal
10	Grandpass North
11	Navagampura
12	**Dematagoda**
13	Maligawatta East
14	Grandpass South
15	Kettarama
16	Newbazaar
17	Masangasweediya
18	Jinthupitiya
19	**Kochchikade North**
20	Pettah
	Fort
	Galle face
21	Kochchikade South
22	Aluthkade West
23	Aluthkade East
24	Keselwatta
25	Panchikawatta
26	Maligawatta West
27	Suduwella
	Maligakanda
	Maradana
28	Kuppiyawatta east
29	Wanathamulla
30	Borella North
31	Kuppiyawatta West
32	Slave Island
	Hunupitiya
33	Ibbanwela
	Wekanda
34	Kollupitiya
35	Bambalapitiya
36	Kurunduwatta
37	Borella South
38	Gothamipura
39	**Narahenpita**
40	Thimbirigasyaya
41	Milagiriya
	Havelock Town
42	**Kirula**
43	Kirulapone
44	Pamankada East
45	**Pamankada West**
46	Wellawatta North
47	Wellawatta South

Figure 3.10; Wards of Colombo Municipality with selected wards highlighted, marked with stars
Source: Ministry of Local Government and Provincial Councils, 2016

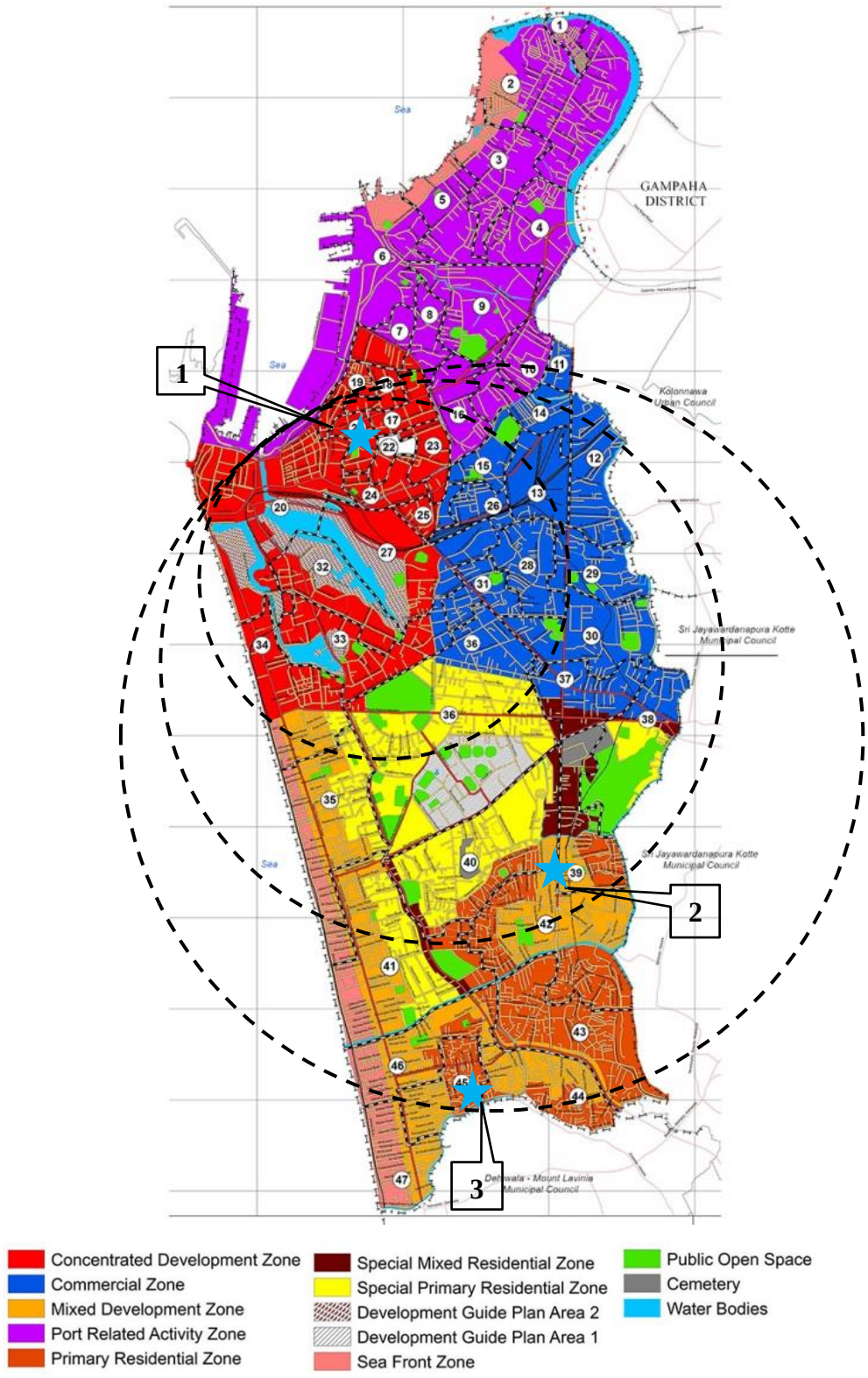


Figure 3.11; Case Neighbourhood Locations on Zoning Map for Colombo Municipality
Source: Colombo Development Plan-2020/UDA

3.5 Collection of Data and implementation of the statistical evaluations

Collection of data is organized under two lines of inquiry. Firstly, the Urban form is analyzed based on secondary data. Secondly, the neighbourhoods are studied for sustainability score using primary data (see Figure 3.12).

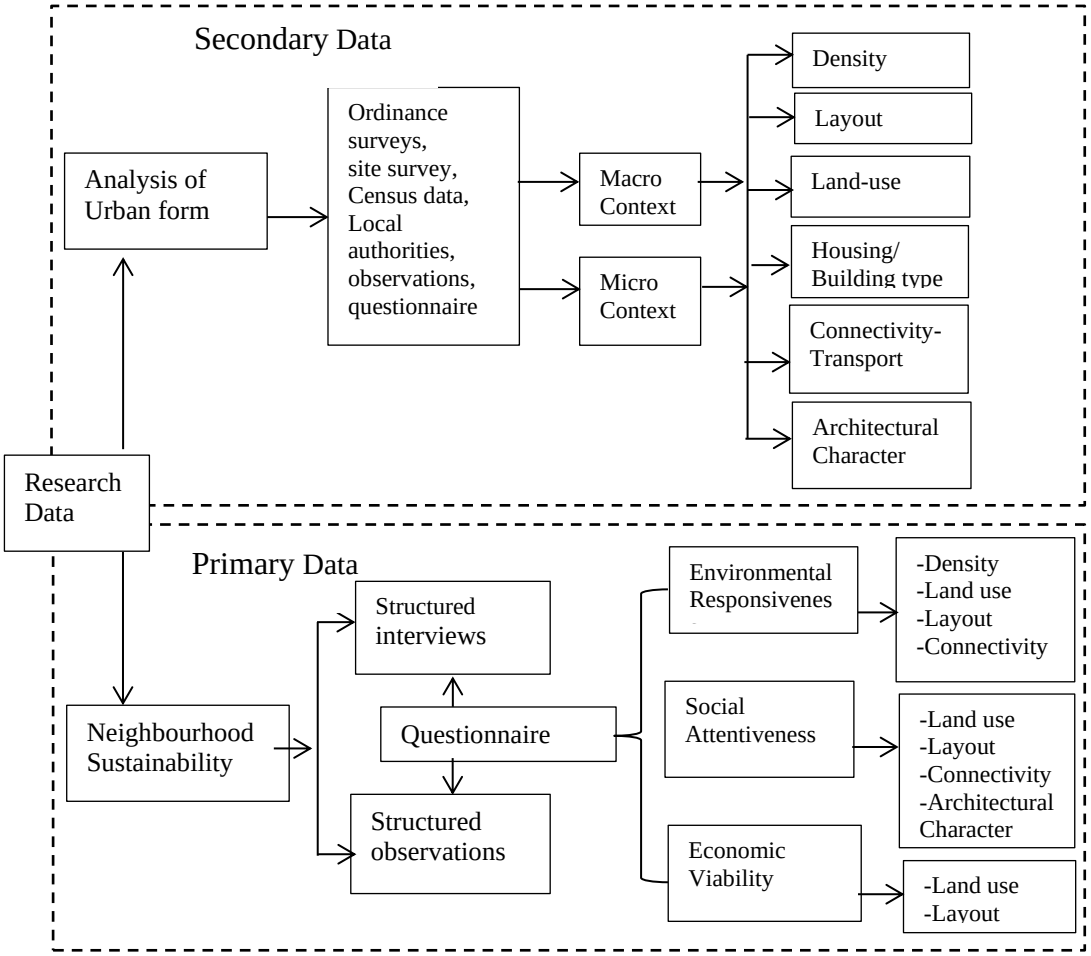


Figure-3.12; Sources of data and Procedure

Questionnaires are designed as close-ended, to obtain user perception on each fact under sustainability criteria; Environmental, Social and Economic as framed above with respect of most related components of Urban Form. The answers are expected to be specific on given alternatives based on Likert scale (see Table 3.7). The questions are drafted in a way to rate sustainability in user's view at the scale, under each sustainability criteria, framing an unbiased close. This is used as the 'scorecard' under each neighborhood for comparative analysis.

Table 3.7; Format of a typical five-level Likert item

Score weight	Rating	Rating
1	Strongly disagree	Very Poor
2	Disagree	Poor
3	Neither agree nor disagree	Moderate
4	Agree	Good
5	Strongly agree	Very Good

In the survey, this rating levels are processed as Very good, Good, Moderate, Poor and Very Poor, and the answers are recorded as 5-1 respectively for each question.

3.5.1 Procedure for collection of Data/information

Based on Literature Review, case studies; neighbourhood units were identified in three diverse localities. The administrative geography is considered as the main concept physically defining the neighbourhood; a part of an administrative ward with defined boundaries. However, this can be indirectly considered as a self-defined community.

Data on Analysis of Urban Form:

Sources of information for research on analysis of form are ordinance surveys, site surveys, Census data, Local authorities, and observations, depending on the variable. Physical density, housing typology and building character, lay-out, land-use, transport infra-structure and connectivity are physically studied and data in macro context are collected on neighbourhoods, followed by a spatial analysis utilizing GIS information.

Data on Neighbourhood Sustainability:

Approach for assessing the indicators of neighbourhood sustainability is based on user perception and data are collected by following procedures.

a) **Conducting structured interviews:** Household is the research unit. A limited set of interviewees; 35 household owners from each neighbourhood is considered for interviews. The questions are standardized, aiming at limited set of response categories and the arrangement and phrasing of the questions are kept consistent from one interview to another. Each interviewer is met individually on a preplanned time slot within the respective neighbourhoood, to make the conversation. Each question was asked from the interviewee, and the answer is

obtained as a rating based on the Likert scale and recorded manually on the chart given in Appendix A. The questions were simplified for better understanding and facilitated with Sinhala and Tamil translations as if necessary.

b) **Carry out structured observations:** Systematic personal observations without direct involvement with the participants is carried out. Collection technique is structured compatible and integrated with the same questionnaire based on sustainability score structure in each case unit. The inquiry is formulated as a query that inserted into the question (Refer Appendix A) .

3.5.2 Research unit, Interviewee Profile, and sampling technique

The intention of the research exercise is revealing the inhabitants' perception of sustainability level of their own neighbourhood, where the resident is the focus. The finest unit of a neighbourhood containing the smallest group of residents is the household, which can be considered as a refined research unit. Research unit is a critical item that represents a large cross-section of understanding and assessments on the case. Therefore, it is decided as the household of neighbourhood; representation is considered as the household ownership; a leading adult in the household. Household owners considered for the interview are within 30-75 years age categories and are living in the respective neighbourhood for more than ten (10) years at the time of field survey. Overall, this is a sensible method supporting to equip with a rational to the answers focusing the research subject.

Referring to the process of observations and conversations carried out with residents of each individual neighbourhood, it was found that the population is homogeneous and mutually inclusive, irrespective of the exact location of the household within the considered area. Obviously, every household in the neighbourhood should be able to consider as a sample, and therefore, probability sampling techniques are considered. Within that, the selection of samples is a combination of simple random and stratified sample techniques.

As the neighbourhoods are homogeneous, simple random sampling is carried out and as to consider every location, covering the whole cross section, including the

households at upper levels within the neighbourhood it is stratified. Since the population size is known in its extent of area, and number of households, the sample size is to be neither large nor small and is considered as 35 households in each neighbourhood in this research exercise. This is considered as population mean, which is around 20% of the total number of households, and the confidence interval is calculated as 15 in 95% confidence level (surveysystem.com).

3.5.3 Evaluation Criteria

Statistics Package for Social Sciences (SPSS) is used as the statistical software in the data analysis. Variables in the analysis of urban form are mainly quantitative, as well as qualitative. Research data on sustainability in inhabitants' experience are qualitative variables in ordinal scale based on the queries and answers that are converted into quantitative data in Likert scale enabling numerical evaluation.

Final evaluation on sustainability score is based on the quantified responses under each grading criteria. This final sustainability grading is not the intended final research outcome. The sustainability score is cross-checked with the data recorded in the analysis of Urban Form to understand its respective determinant or the attribute. Therefore, the outcome is a critical statement of analysis and comparison, on the attributes of Urban Form of case neighbourhoods, indicative of prevailing particularity in sustainability. Analysis of data accumulated in the interviews are analyzed using the following procedure.

3.5.4 Analysis of Research Data in SPSS

In the process of data collection, upon 50 variables, 35 responses were accumulated from each of three (03) neighbourhoods. Manually recorded 35 sets of interviews are then processed and recorded as three (03) sets of data on Excel sheets (Refer Appendices G, K, P), as derived in the research method. Data were analyzed with the aid of SPSS to express the full reflection in figures through compatibility with the quantified rating level in each response. Data analysis is a significant exercise in this research experiment; however, descriptive statistics is made use to analyze the research data in the analysis of sustainability appeal and its comparison.

3.5.5 Reliability Analysis of data

Proceeding with a comprehensive preliminary data analysis, a reliability test of accumulated data with reference to the variables defined is conducted. Every single question out of 50, is separately answered in each of three neighbourhoods and answered by 35 residents to maintain the data integrity. The widely accepted cut-off level in SPSS is the Cronbach's alpha, that should be 0.70 or higher for a set of items to be considered as reliable and others go as low in reliability (Griethuijsen et al., 2015; Taber, 2018). It is considered that when alpha is 0.70, the standard error of measurement will be over half (0.55) standard deviation. In the data collection in this research the Cronbach's alpha value is 0.872 in Case-1, 0.929 in Case-2 and 0.959 in Case-3 which indicates the richer reliability and credibility of data. Important numerical figures and data in the analysis are taken into the text appropriately, and rest of the significant supportive information necessary is provided as Appendices.

3.5.6 Analysis of Descriptive Statistics

Descriptive statistics are used to define the basic characteristics in the data of the study, such as minimum, maximum, mean values, and standard deviation. It has been used in this study to describe what the data indicates, in a more general sense in a better manageable manner. The 'mean' is used to describe the central tendency of the accumulated sets of data in the research. As answers to the questionnaire ranged from 1 (Very poor) to 5 (Very good), a higher mean score reflects higher degree of appealing and vice versa. The standard deviation is employed to demonstrate the relation that the set of responses partakes to the mean of the sample, and it serves as a statistical measure. Fundamentally, a smaller standard deviation means that the values in a statistical data set are close to the mean of the data set, on average. And a larger standard deviation means that the values in the data set are farther away from the mean, on average.

3.5.7 Evaluation Procedure

Evaluation procedure aims to assesses the neighbourhood sustainability as reflected in the inhabitants' perception of their satisfaction. Based on the data obtained in the questionnaire survey, and subsequent simple descriptive analysis obtained with the aid

of SPSS, a briefing is arrived. There, the environmental responsiveness, social attentiveness, and economic viability are assessed with the inhabitants' 'mean' level of appeal of the neighbourhood, under each sustainability aspect, with reference to the attributes of its form as the analysis.

Based on the mean value of the answer for each query, it is remarked that the standard deviation is constantly a small decimal figure. Effectively, it indicates that the values in the dataset are formed closely around the mean value. Therefore, centered to the mean values of the inhabitant's rating on satisfactory level or the appeal, the inferences on sustainability are arrived. In the Likert scale, rating-5 is considered as the highest appeal (very good), and rating-4 as the next level (good). If the mean value is in between 5-4, the rating level is in between 'very good' and 'good'. Thereby, the sustainability remains plentiful. Vice-versa when the mean value is in between 2-1, the appealing is 'poor' and 'very poor'. Thus, it is unsustainable. Rating-3 means 'moderated'. Thereby, if the mean value sets around 3, it is acceptable; neither sustainable nor unsustainable. This mean value is considered under each questionnaire, and then it is taken forward to each of the sustainability aspect. Henceforth, the mean value is obtained under environmental, social, and economic sustainability and proceed up to overall mean value (Appendix-I, M, R).

3.6 Ethical Considerations

As laid out in the research design, in each case study, research unit is the household; 35 numbers of random samples are considered. The structured questions on perception are answered by an adult; the head of each household, who is willingly participating in a short, face-to-face, responsive, and intimate discussion within a time slot preplanned (for 35 -45 minutes) as per the convenience of both parties. The research does not involve any foreseeable risk, harm, or discomfort for any party. The collection and use of research data are recorded only anonymous. The research was carried out as per the conditions and guidelines recommended by the University Ethics Review Committee. (Refer Appendix B, C, D and E)

CHAPTER 4: PRESENTATION AND PRELIMINARY ANALYSIS OF DATA

The Chapter carries the procedural presentation of data on each case study including introduction to case studies, investigation of respective urban form, and explore the sustainability level as indicated in factual human perception. These information and data lead to the analytical study on uniqueness of sustainability level and the influence of related attribute of urban form in each case (neighbourhood). Process of preliminary analysis of research data is briefly explained with reliability and descriptive statistics. Patterns of data obtained with the answers for each question in the research questionnaire are used for the analysis. They are set as profound guide to understand the necessities for a sustainable urban form in each urbanity as the end remarks. In other words, they are used to reveal the requisites of a sustainable urban form of an urban neighbourhood in three different urbanities. It is leading to a comparative analysis of three case neighbourhood forms in the following chapter.

Case study Neighbourhoods are planned developments. They were selected from three different administrative wards; *'Grama Niladari'* (GN) divisions, from three different zones; concentrated development, mix development and primary residential zone; (refer Figures 3.10, 3.11). Case study profiles show high level of residential usage in the mid of varied activity zones. Case studies are introduced with their profile and urban form is analyzed in the investigation below under each case.

4.1 Case Study-1: Newham Square Neighbourhood

First case neighbourhood considered for research study is Newham Square, in the ward; Kochchikade-North, (GN division/Ward no.19). It is located within the concentrated development zone in the Colombo Municipality. A detailed analysis is carried out on its urban form and the sustainability level based on human perception is revealed, by research-oriented references, observations, and interviews. Consequently, a rationale for the sustainability level of the neighbourhood, in terms of its urban form is established.

4.1.1 Introduction to the Case Neighbourhood

Newham Square neighbourhood is a multi-racial and multi religious community situated close to well-known St. Anthony's Church and Jampettah Street. It is accessed by Ratnam road, close to harbour wall in North Colombo, within the concentrated development zone. By the location, formation, and inherent architectural character, the neighbourhood has become an attractive and striking urban community in the urban fabric of the existing context. It encounters a friendly and livable urban environment for inhabitants and a popular home for a group of urban residents.

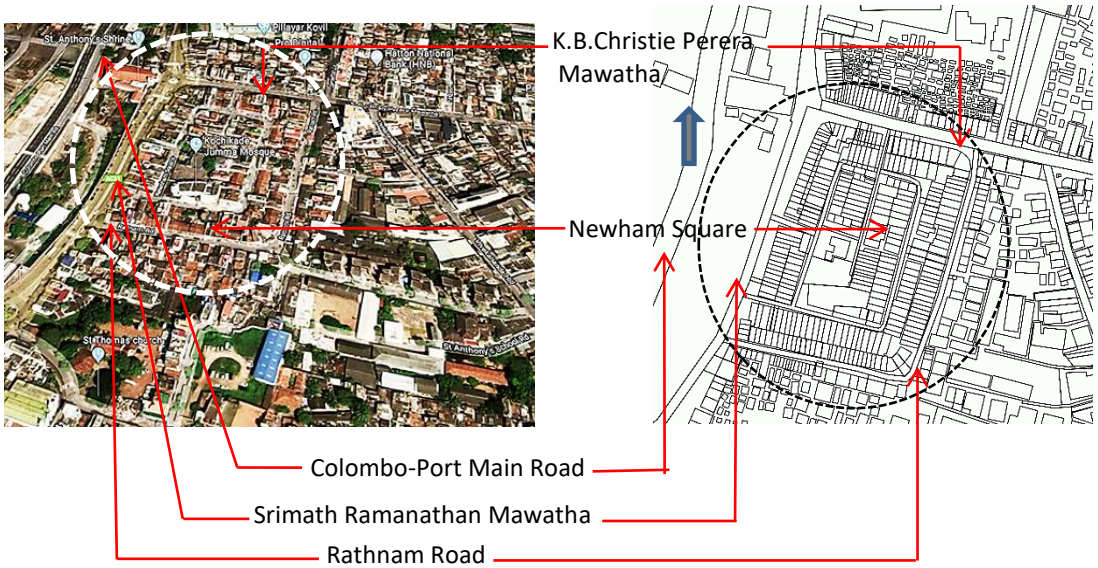


Figure 4.1: Physical location of Newham Square Neighbourhood
Source; Google maps,2021; GIS-UDA,2015

The neighbourhood is bounded by Srimath Ramanathan Mawatha running parallel to Colombo Port Main Road on the West. Further it is demarcated by K.B. Christie Perera Mawatha on North and Ratnam Road on both East and South. This neighbourhood with a unique identity was said to have been built in 1930, by the British government to settle the working labourers of Colombo harbour. With a total population of 9,333 in the entire Kochchikade North GN division, Newham square neighbourhood is a highly dense, planned residential neighbourhood (Dept. of Census & Statistics, 2012). The land value of this neghbourhood area is stated as Rs.7.5-8.5 Mn. average per perch (Valuation Dept., 2019; Lankapropertyweb, 2020).

Out of the total population of entire Kochchikade North ward, 54% is male and female count is 46%, whereas employed and economically active group is considered as 50%. (Census and Statistics, 2012). Considering the proportionate distribution of age group categories, child population is lower than the middle age group; and the population of elderly and senior citizens, is identified as proportionately very low in the area (refer Figure 4.2)

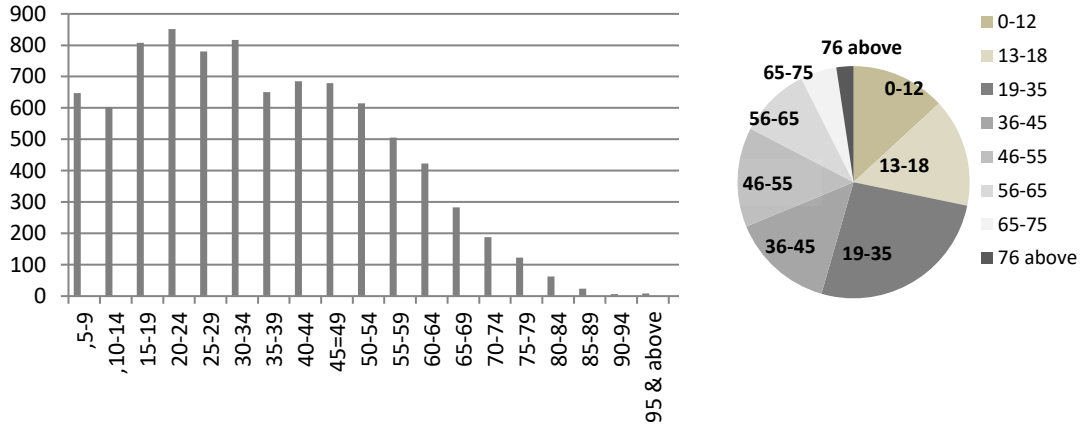


Figure 4.2; Population by Age (years) in Kochchikade North ward/GN Division
Source: Department of Census & Statistics, 2012

Accordingly. economically active groups are categorically higher in population. The demographic data are indirectly reflected in the urban form with the density and following investigation proceeds the analysis of urban form of the neighbourhood,

4.1.2 Investigation and Analysis of Urban Form

Urban form of the neighbourhood is analyzed with reference to its physical and non-physical components; density, land-use, layout, connectivity and transport infrastructure, housing and building type and architectural character.

4.1.2.1 Density

As a neighbourhood located within a concentrated development zone in the city core, both housing and resident density is comparatively very high in the neighbourhood. Within the neighbourhood, the built footprint area is nearly 85% of the neighbourhood area, out of which, 70% are found as residential buildings.

Residential density of the considered area is 125 households per hectare approximately, and the population density can be identified as nearly 600 persons per hectare. Open area can be considered as less than 5% of the total land area.

In overall Kochchikade North ward/GN division, the population density is nearly 410 persons per hectare, (Census & Statistics, 2012) and in the extent of area, Newham square neighbourhood is almost 10.5% of total ward or GN area (CAD; GIS-UDA, 2015). Hence, it is obvious that the case neighbourhood holds a high density of housing and residents, when compared with the overall area of the ward or the GN division. Findings are summarized and tabulated at two levels as; ward and neighbourhood area in the table below; (Table 4.1). This is a reasonable prototype for high dense neighbourhoods, which shares common urban facilities amongst a larger group of urban residents.

Table 4.1: Details on density of Newham Square neighbourhood

	Ward /GN Division	**Neighbourhood area**
	Kochchikade North/No.19	Newham Square
Total Area	22.8 hectare	2.4 hectare
Proportionate size	n/a	10.5% of total ward or GN area
Resident density	410 persons per hectare	600 persons per hectare
Residential density		125 households per hectare
Building footprint area		85% of total neighborhood area

Source: Department of Census & Statistics, GIS-UDA, 2015; Personal observations 2018-2019

The strategy used here in achieving high density is recognized as the minimization of plot size and building footprint. The number of floors in buildings is limited, economizing the building structures.

4.1.2.2 Land use

In a spatial analysis at macro context, it is observed that the fundamental land uses which are important to be essential for a convenient functioning of the neighbourhood is available in close proximity, specifically within one (01) Kilometer radius from the neighbourhood (refer Table 4.2, Appendix-F).

In the neighbourhood itself, a clear mix of uses are identifiable. Residential usage is the most significant, commercial usage and roads are at the next level; (Figure 4.3).

Table 4.2; Main Land use Distribution within 1KM radius of the Newham Square neighbourhood

	Land Use within 1KM Radius	**% of Total land**
1	Residential	28
2	Commercial	22
3	Institutional; Banks-allied, Offices	27
4	Health	<1
5	Educational	4
6	Industrial	2
7	Religious	3
8	Main Road/ Roads/Transportation	10
9	Open space/Parks/Play grounds	2
10	Vacant land	2

Source: GIS-UDA, 2015

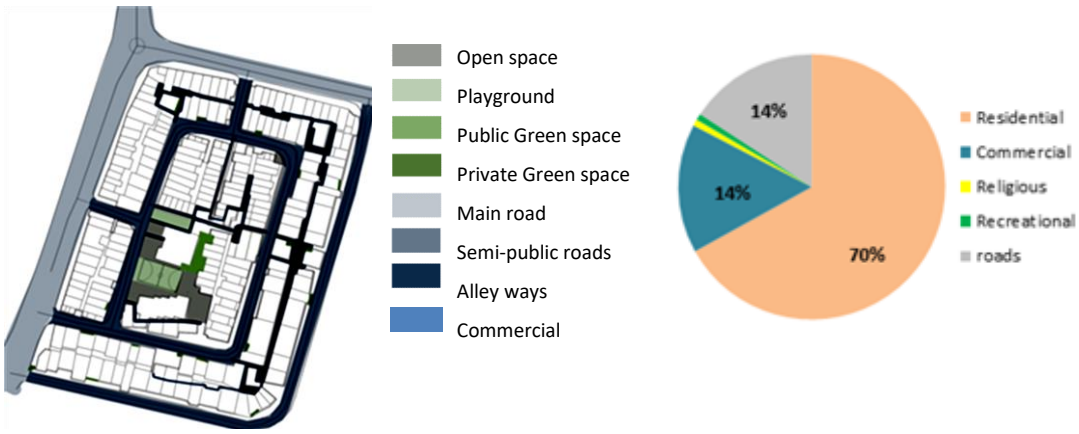


Figure 4.3: Land use within the Newham Square neighbourhood
Source; GIS; UDA, 2015; Personal observations

Private Green space or garden is lessened, enabling community sharing of open spaces within the neighbourhood. Public open space and community spaces are centralized but limited. Edging to the main arterial roads and direct connecting roads, commercial establishments are originated, facilitating the day-to-day shopping and marketing activities of residents. It facilitates local food and the close by employment destinations to a certain extent.

4.1.2.3 Layout

Lay out of the neighbourhood is compact, and simple, with outer main arterial roads; namely Srimath Ramanathan Mawatha, K.B.Christie Perera Mawatha and Ratnam Road, and inner semi-public road; namely the Newham Square, accompanied by pedestrian alleyways; (Figure 4.4). Every house block possesses a narrow road frontage and are accessible directly from the road at ground level. This is a significant feature of the layout, where, every plot is edging, and a house unit are facing a road; mostly, ground level houses from their living area side and upper-level houses from their bedroom sides. This makes every house unit equally connective and communicative with the activities on road, irrespective of the location, whether ground level or an upper level.

Upper-level housing has entrance from upper-level passageways on opposite roadside, which is above the alleyway. Upper-level passageways are accessible from stairs starting from main access roads (refer Figure 4.7). Thereby, rear passages form a circulation lane above the alleyway for residents living at upper level. Private garden spaces are extremely limited, but tiny landscape patches are visible at most house fronts, balconies, and in rear areas.

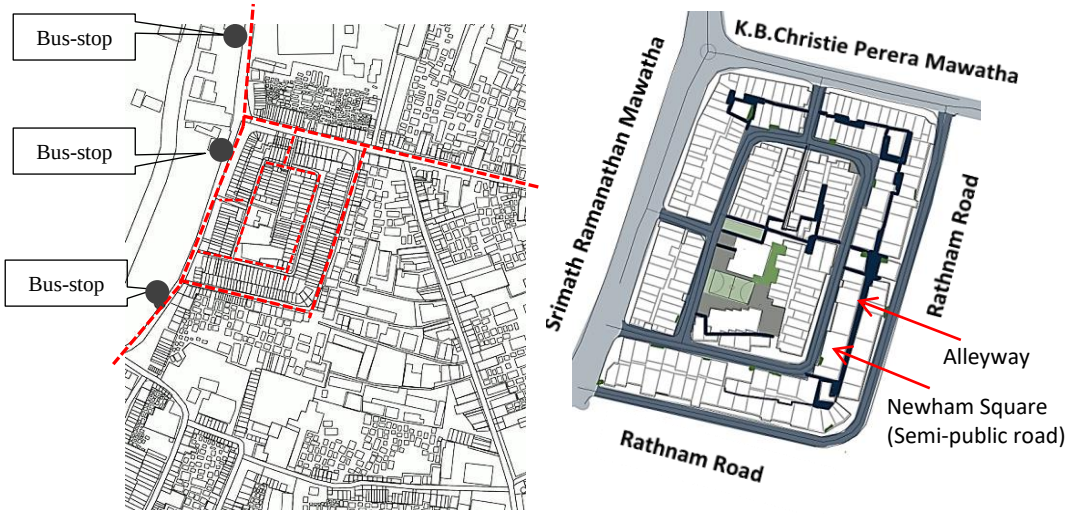


Figure 4.4: Layout, with well-established connectivity
Source; ; GIS-UDA, 2015; Physical observations, 2018-2019; Google maps,2021

Internal streets are narrow and do not contain separate or designated pedestrian space. Parking is provided on the side of the road which is also used as an extended part of the residents' living space at front. This made the road a common community space in the neighbourhood. Rear space of residences forms a narrow alleyway common to pedestrians, which is unique to the neighbourhood. Narrow entryways from main arterial roads to alleyways are special features, forming a shared community space; (Figures 4.5, 4.6, 4.7).

Figure 4.5: Narrow entryways from main arterial roads to Alleyways

Within the neighbourhood, pedestrians are prioritized. Though pedestrian pavements are not provided on internal semipublic roads, they are transformed into pedestrian spaces within the neighbourhood community.

4.1.2.4 Connectivity and Transport infrastructure

The neighbourhood layout demonstrates a highly relatable level of connectivity within the neighbourhood itself as well as with the surrounding urban context. In the spatial arrangement in macro context, it can be observed that the transportation nodes, commercial centers, schools, health centers, community areas, and religious centers are in proximity. Effectively, all amenities required for living, including shopping, education and travelling are available within 500-1000 meters radius. Each household of the neighbourhood is well connected to its immediate surrounding context by public roads, semipublic roads, and alleyways. The Neighbourhood is well adapted to well-used public transportation. Private vehicle use is minimal; (refer Figure 4.4).

4.1.2.5 Housing and Building Type

Narrow road frontages and tight building plot arrangement are significantly identifiable, unique facets of the fabric. It creates a specific identity collectively with the pattern of low scale building heights. Bordering to the outer main arterial roads, building heights are comparatively high, varying from two (02) to six (06) levels. Facing the inner roads, it varies from single height to four (04) storied in height. Most residential buildings are of two storied, and each unit is planned in a single level. Ground level unit is entered directly from road and upper-level houses are entered from a common passage running at rear side above the alleyway; as discussed in detail previously in the explanation of layout (refer Figures 4.6, 4.7).

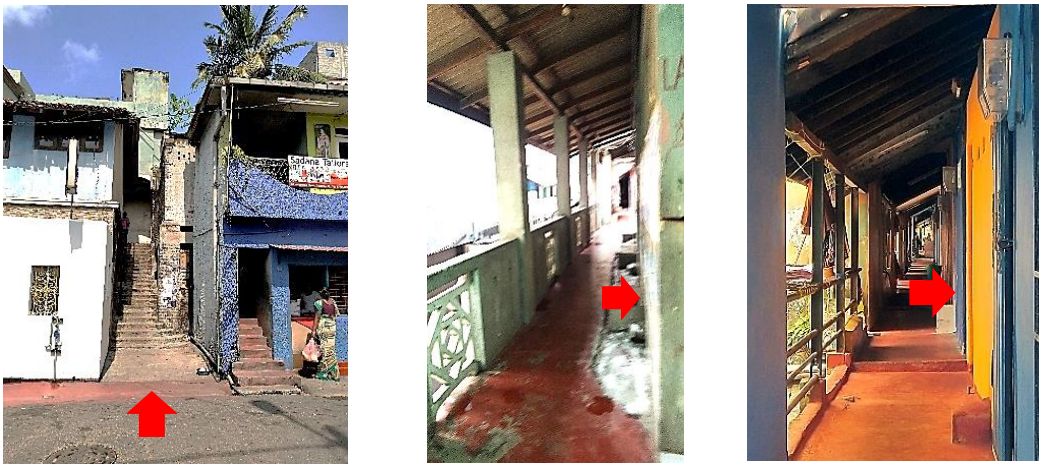


Figure 4.6: Entrance stairways from road to upper-level passage, above alleyway, and passage creates the entrance to upper-level house

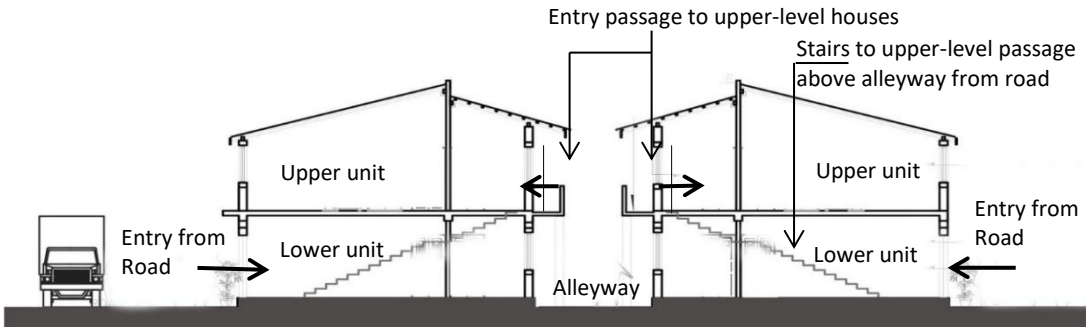


Figure 4.7: Concept of providing entrance from road to lower-level houses, and from passage above alleyway to upper-level houses

Figure 4.8: Typical elevations of original and renovated facades
Source: MUD-2017, UOM

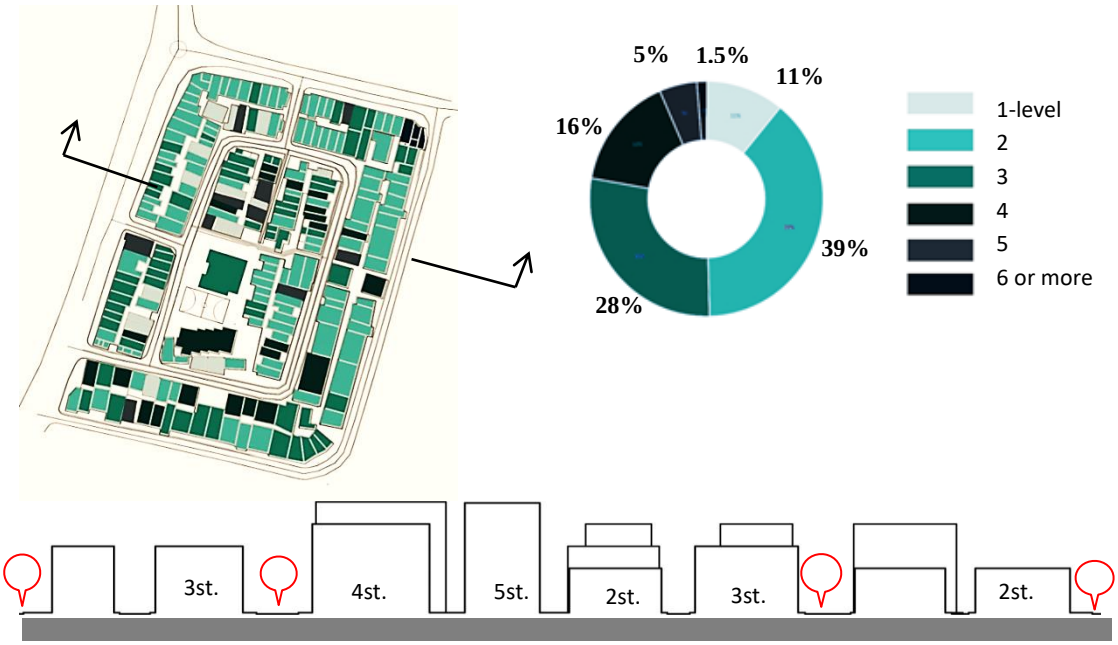


Figure-4.9: Pattern of Building heights (Not to scale)
Source; GIS- UDA, 2015, Physical Observations

4.1.2.6 Architectural Character

Houses are densely placed and are highly compacted. Old buildings of the area have followed a unique design, but new renovations have added certain elements and made changes from time to time on the facades of the buildings. Some of the buildings have upper floors as new additions. Landscape features, façade colours, protective grill devices, and railings etc. expresses individuality of household. However, the changes are not architecturally much distracting, and it stamps yet a unique identity and creates a significant character on the neighbourhood (Figure 4.10).

Figure 4.10: Unique architectural character as an urban neighbourhood; well defined individual households, still a collective charisma on street facade

Most housing structures and facades carefully, collectively protect the unique architectural character of the neighbourhood. Combinations in façade colours make a significant self-identity as a neighbourhood, which contributes to the uniqueness among the existing urban environment. It was convinced by the residents that the nieghbourhood has been lasting for more than eighty (80) years by now with minor changes in the internal arrangements to be suited to the increasing interior space requirements.

The houses are of permanent structures, and in general, walls are made of brick, plastered, and painted. Nearly 75% of the houses have cemented floors and the rest are finished with tiles which are recent renovations. Originally the houses had tile roofs, currently, 50% of them are replaced either with asbestos roofs or tile on asbestos roofs. However, the recent renovations have been able to maintain the uniqueness of existing architectural significance.

4.1.3 Background of Sustainability and level of achievement

As detailed in the research method, understanding the level of sustainability achievement is carried out through the questionnaire-based survey. The research unit is considered as the household; residence, as per the methodology and the interviewee is the head of each household. A formulated questionnaire is answered by the household resident (given in Appendix A). Accordingly, the neighbourhood is assessed by the residents' experiences as laid out in research design. Recorded data are tabulated enabling the analysis. (refer Appendix G)

Beneath three main sustainability aspects Environmental Responsiveness, Social Attentiveness and Economic viability, are assessed under sub-categories in terms of urban form component, and the research findings are recorded and analyzed using SPSS. Number of cases are 35 and, in this case, reliability of statistics is indicated as 0.872 Cronbach's Alpha. This is recommended as a rich data collection and the number of items is 50; (refer Appendix-H). Following analysis on the Case is based on output of the research findings based on descriptive statistics; (Appendix-I).

4.1.3.1 Environmental Responsiveness

This is assessed in Q1-Q25 of the questionnaire. In the assessment of sustainability within the Environmental aspect, in terms of density related concerns (Q1-Q9), inhabitants' rating on the sufficiency of current residential density with the population density, scores at 3.71; in between good to moderate. Air and noise pollution related health effects are identified with adverse concerns by residents, who are vulnerable to relevant non-communicable diseases, and stress conditions; this is rated 3.40, in the moderated range. The supply of energy and services are recognized as highly favourable, rated 5.0 evaluated as very good including solid waste disposal, in keeping the neighbourhood clean and tidy. This is specific, to the semi-private roads at frontage which are used as communal space, and an extended space of the residences; (refer Figure 4.11).

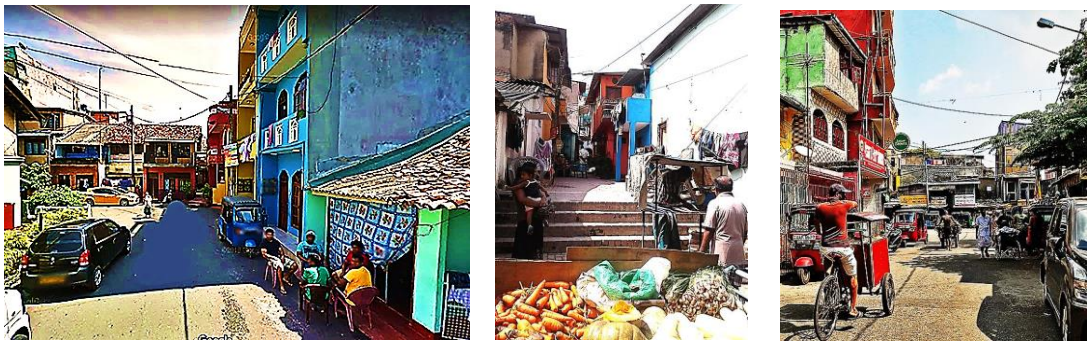


Figure-4.11: Road fronts use as communal spaces; for social gathering, selling vegetable/fish carts/bakery items… etc.

Environmental aspects in terms of lay-out (Q10-Q14), demonstrate that the street experience including light levels are desired by inhabitants; this is rated at 4.29,

evaluated as ‘good’. However, adequacy of open space provisions, tree plantation, wind concerns, natural light, and ventilation provisions are evaluated as insufficient, rated at 2.91-2.97, just below ‘moderate’. It is observed during the research, that the residents try to maintain some greenery, in front of their residences; (Figure 4.12).

On the contrary, responsiveness in terms of land use distribution structure (Q15-Q18), movements and interaction patterns, transportation patterns, and functioning of current land uses are perceived as convenient, with a rating above 4.66. Existence of impervious surfaces is found as being barely minimum and thereby storm water management systems are considered as highly efficient even during heavy rains, with the rating of 5.00 in the Likert Scale.

Connectivity and related transportation matters (Q19-Q25) are evaluated by the residents as the neighbourhood adapting well to the immediate context. Public transit, pedestrian and bicycle movements are accepted as optimally encouraged and in use, with ratings at 4.89-5.00 in the Likert Scale, although the pedestrian and bicycle lanes are not physically provided or demarcated. Street safety and convenience are perceived to be highly desired, rated at 4.66-5.00. Street connectivity is accepted as adequate and appropriate, rated at 5.00, and the availability of route directions is regarded as convenient, rated at 5.00 too. Further, it is important to note that the residents’ insight on adequacy of pedestrian accessibility is rated at 4.89, and pedestrian network coverage is rated high at 5.00.

Figure-4.12: Some green features maintained by residents within the premises

Corresponding to the above numerical analysis of findings, the effects of constituent elements of urban form, related to environmental sustainability could be briefed as follows focusing onto the necessary improvements.

a) Density:
   - The residential density proportionately to the population density is low.
   - Environmental issues are to be managed with constant development within the neighbourhood.
   - Health issues related to air and noise pollution are necessary to be addressed.

b) Layout:
   - The rate of tree plantation and solutions regarding wind, natural light and ventilation concerns are barely satisfactory.
   - Provision of open space in the layout and within the neighbourhood is found to be inadequate.

c) Land Use:
   - Circumstances are accepted as favourable, despite the issue of open space provision in layout.

d) Connectivity:
   - Settings are highly acceptable as favourable.
   - Neighbourhood is well adapted to public transit, as the location is by a main arterial and public road.
   - Proximity and accessibility to diverse activities are significant.

Remarks:

Though there are issues available in residential density to cater to increasing population, the matter is not possible to be resolved by expansions, due to the restrictions in land area. Vertical expansions are restricted due to existing provisions of structural stability. Currently, residents are admitting the outward movement of young generation. However, it is realized during the research, that even the youngers prefer to stay inside the neighbourhood, due to the convenience of connectivity and accessibility to city activities, schools, employment, business etc., by walking and by public transit. Those aspects are very high rated.

This is an important aspect to be concerned in neighbourhood design and designating areas for neighbourhoods in urban master plan proposals. Open space and recreational space provisions are obviously important concerns in improving quality of urban life. Since it is hardly practical within the specific planned neighbourhood, accessibility, and proximity of those facilities are important to be considered in creating future development plans and urban design proposals for surrounding urban area.

4.1.3.2 Social Attentiveness

In relation to the social sustainability of the neighbourhood, questions were directed to ascertain the inhabitants' concern towards social needs and aspirations. This is assessed by questions Q26-Q43 in the questionnaire. With reference to the layout (Q26-Q31), the association of social patterns and behavior within the neighbourhood is considered to represent inhabitants' interests well and is rated at 4.34. The collective identity of housing and building character is rated at 4.43, indicating its appeal to the inhabitants. Convenience of accessibility to public services, such as schools, public transit, healthcare, emergency services and places of worship, are rated high at 4.66. Further, it is noted that convenience levels for the elderly community to live and move about, is rated moderate at 3.74. Similarly, with the land-use distribution (Q32), residents are not satisfied with dedicated facilities for childcare, and community facilities. This is rated at 3.23.

Connectivity and accessibility in terms of social sustainability (Q33-Q37), with appropriate traffic calming precautions, expression of cultural identity and facilitation of non-motorized transportation, walking and cycling are perceived as favourable, rated at 5.00, 4.20, and 4.89, respectively.

It was observed that even though, designated pedestrian and cycling lanes are not physically available, a certain control is maintained as a culture within the communal living style, providing a safe and secured setting for females, children, and differently abled residents (refer Figure 4.13). Simultaneously, prevalent planning and engineering standards of building services, and public life of community are evaluated as moderate, at 3.89 and 3.46.

Considering the social aspect in terms of the architectural character (Q38-Q43), residents are of the opinion that they are offered a strong communal identity, a sense of place. This is rated at 4.74, and a reasonable human experience of a good living is rated at 4.60, though with few exceptions. They appreciate the identity of the neighbourhood as being of diverse cultural groups and the facilitation of such diversity rated at 4.83. Its architectural character, or the ambience created by the housing, buildings, and other built components is rated at 4.80. However, the diversity or variety of housing quality, which is rated at 3.51, does not offer a wide scope of options for residents.

Figure 4.13: Differently abled people, women and children relish safe and secured setting in movement in and around

Concurring to the above numerical analysis of findings, the effects of constituent elements of urban form, related to social sustainability could be briefed as follows focusing on to the improvements necessary.

a) Layout:
   - Though a secured atmosphere is created for all residents within the locality, the older community has not been offered committed consideration to live and move conveniently.

b) Land-use:
   - Sufficiency of certain dedicated facilities such as childcare, community centers, public libraries, fitness centers, playgrounds, skills development facilities for youth are not available at acceptable levels.
   - Provision of open spaces in proximity is a considerable facet.

c) Connectivity:

- Planning and engineering standards are to be in harmony with residents changing lifestyles. Even though the residents feel safety and security, the standards of pedestrian facilities are to be maintained in connecting spaces.
- Public life of the community is to be supported and encouraged by the public environment. These include public spaces, play areas and community facilities.

d) Architectural Character:

- Diversity or variety of housing types and quality maintenances is not induced.

Remarks:

Dedicated facilities for children, youth and senior citizens are primarily important within a neighbourhood, and they are social needs, as well as parts, and parcels of urban living. Though the atmosphere is safe and secured for kids, women and elders, their social expectations within the neighbourhood in which they are a part, are evidently beyond that. This is important to be considered in upgrading and maintaining the quality of urban life. Connectivity, accessibility, and transportation mode are primary concerns of urban residents, which is clearly convinced in the survey as highly desirable. At the same time, urban resident admires the cultural expression and the social identity outstared by their neighbourhood, and it is important to stamp a dignity in the residents' cognizance.

4.1.3.3 Economic Viability

In the research, economic viability is assessed in Q44-Q50 in the questionnaire. Within the economic sustainability in terms of the layout, connectivity, accessibility, and the available modes of transportation, are highly desired. This is rated at 5.00. In that sense, this neighbourhood is a good example, where people experience the optimum benefit of living in such a location. House prices and land values are well recognized and rated high, at 4.86. However, diversity and affordability of housing types show a lower rating, which is at 3.51, evaluated as moderate.

Convenience in reaching employment destinations is rated high at 4.06, and the availability of commercial establishments in the proximity, is highly valued, rated at 4.91. However, the overall rating on living quality is placed 'moderate', at 3.86 in the Likert Scale.

In that sense, this neighbourhood is a suitable example, where people experience optimum benefit of living in a good location and layout. Availability of commercial establishments in proximity, improves credibility of the smart location. Due to the favourable location, approachability to employment opportunities and proximity to workplaces are convinced, with convenient transportation. This fact has made the neighbourhood well appealed by the young and working resident groups.

Overall, the neighbourhood provides a living setting which facilitates residents' convenience and appropriately maintains within the resources available. Being viable, the neighbourhood has been carefully planned, robustly utilized and self-sustained over a long period of time. Though there are certain downfalls found with the modern-day requirements, it can be recommended as well-designed where the value is considered in the long-term.

Based on the numerical analysis of findings, the effectiveness of constituent elements of urban form, related to economic sustainability is briefed as follows focusing on to the improvements required.

(1) Layout:
- Diversity of housing types are perceived as necessitates improvements.
- Affordability of housing options, which enables social mixing and social diversity, needs better considerations.

(2) Land-use:
- Standard of living quality needs improvements with the changes of urban lifestyle.
- Building standards and quality are needed to be continuously upgraded, maintained in all activity types.

Remarks:

Diversity of housing types is not significantly offered in the neighbourhood and will not be possible as well within the original plan. The plan was to provide equal types of housing within the proximity of employment, convening residents' day-to-day fundamental living requirements. With the increasing needs of the urban society, the economic viability they look for their living setting changes based on new living requirements, such as diversity in house type, affordability disparities, and quality of housing.

These aspects, particularly, are not possible achieving by changing the basic structure of houses. It was reveals that the quality of housing needs urgent upliftment appropriate with the changing lifestyles. That is necessitated in the reflection of peoples' quality of urban life. Thus, various houses have undergone renovations within their interiors. They are to be considered as timely requirements of residents in achieving a novelty in their home setting. Exterior facades too have experienced similar situations. However, they are to be carried out carefully in a setting like this specifically, due to its existing unique character. This neighbourhood is observed as one exceptional urban example that has been long lasting within a city core area.

Therefore, this neighbourhood is valuable for both its inhabitants as well as for the city itself. For the time being, this has not been identified as a conservable urban neighbourhood, as it has undergone certain changes from its original status, time to time continuously. Each household is legally owned by the resident.

Yet there are possibilities to make improvements in quality of houses, within strictly designated design guidelines, to avoid deterioration of existing striking character. Though the ownership belongs to individual residents, as an urban component, overall design control power is to be taken over by the relevant authorities.

4.2 Case Study-2; Chitra Lane Housing Neighbourhood

Second case study is selected from ward 42; GN division Kirula in mix development zone. It is a residential neighbourhood by the Chitra Lane. Chitra lane is a popular, well accessible mix residential lane with comparatively high land value, which states as Rs.10.0 Mn. average per perch (Valuation Dept., 2019; LankaPropertyweb, 2020).

4.2.1 Introduction to case Neighbourhood

Case study-2; Chitra Lane housing neighbourhood is a planned neighbourhood with 200 households originated and developed replacing shanties, during late 1990's. It is located by the Chitra Lane on West, edging to well-known Anderson flats, an upper middle-income housing development, to East, and visually a small-scale development, mainly for lower middle and middle-income community.

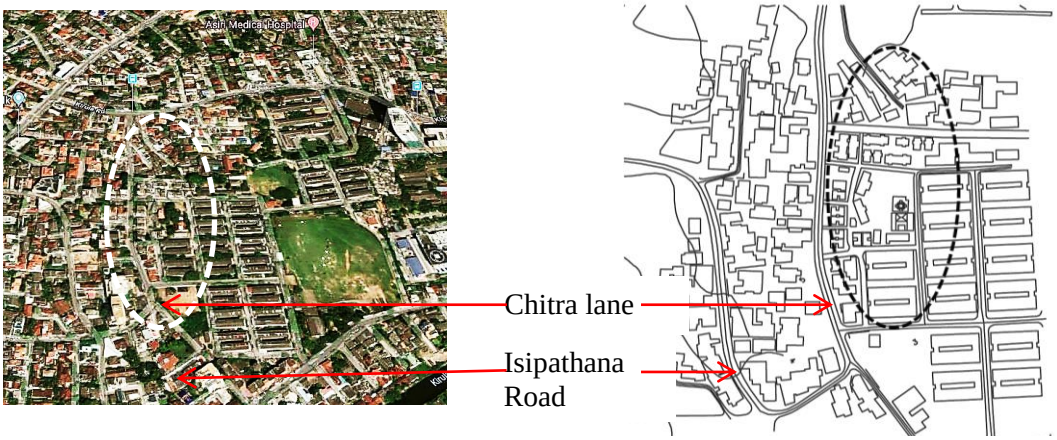


Figure 4.14: Physical location of Chitra Lane Neighbourhood
Source; Google maps, 2021; GIS-UDA, 2015

With a total population of 20,237 within the entire Kirula ward or GN division, this development is a dense, planned residential neighbourhood area. Based on the census and statistics (2012), out of the total population of the ward, 47% is male, and female count is 53%, whereas employed and economically active group is considered as 54%. Considering the proportionate distribution of age group categories, child population is lower than the young age group, which is still higher than the middle age group. The elderly and senior-citizen population is proportionately very low in the area. Thus, the highest population category is the young age in between 20-35 years.

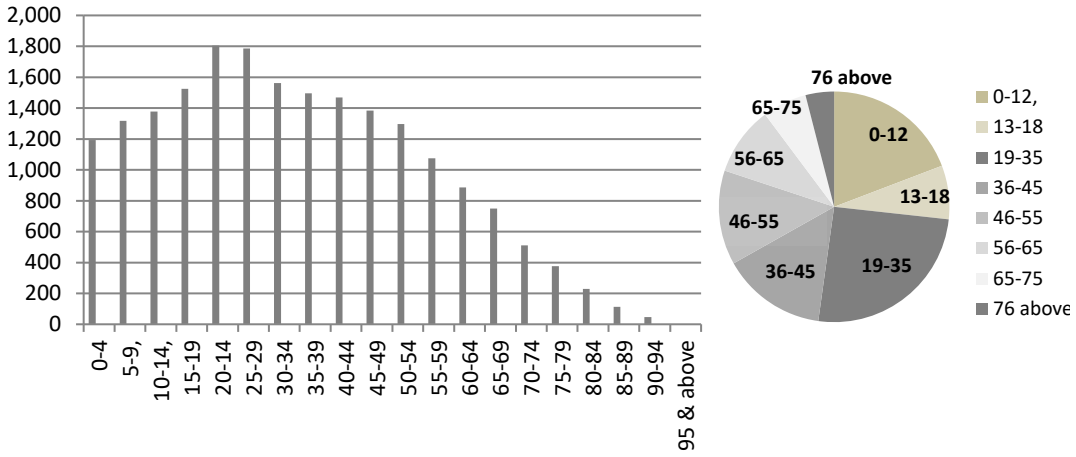


Figure 4.15: Population by Age (years) in Kirula GN Division
Source: Department of Census & Statistics, 2012

It is remarked that, the physical structure of the area must be provided with adequate facilities and amenities for younger age categories. The analysis of urban form reveals its attributes and confirms the provisions within the physical structure.

4.2.2 Investigation and Analysis of Urban Form

Similar to the proceedings with case study-1, Urban form is analyzed with reference to its physical and non-physical components; density, land-use, layout, connectivity and transport infrastructure, housing and building type and architectural character.

4.2.2.1 Density

As located in the mix development zone, residential use is comparatively high in the neighbourhood. Within the considered area of the neighbourhood, nearly 35% of the area is built, and rest is allocated for roads, open public spaces, and parking. Out of the built area, 85% are found as residential buildings.

Residential density of the considered area is 200 households per hectare and the population density is nearly 800 persons per hectare. Considering overall Kirula ward or GN division, the population density is nearly 106 persons per hectare. In consideration of the extent of area, the neighbourhood is around 0.5% of the ward/GN Division. The data is summarized and tabulated below for straightforward examination.

Table 4.3; Details on density of Chitra Lane neighbourhood

	Ward /GN Division	Neighbourhood area
Identification	Kirula/42	Chitra Lane Neighbourhood
Total Area	191.2 hectare	1 hectare
Proportionate size	n/a	0.5% of total ward or GN area
Resident density	106 persons per hectare	800 persons per hectare
Residential density		200 households per hectare
Building footprint area		35% of total neighbourhood area

Source: Department of Census & Statistics, 2012; GIS-UDA, 2015; Personal observations, 2018-2019

Hence, it is observed that the case neighbourhood holds an average density of housing and residents, when compared with the overall GN division. This is a standing prototype for balanced dense neighbourhoods, which shares common urban facilities amongst considerably a large group of urban residents. The strategy used in this neighbourhood for achieving high density is vertical space planning, optimizing of plot size and footprint. The number of floors of the buildings is limited to four (4), economizing building structures and services. It optimizes maintainability.

4.2.2.2 Land use

In a spatial analysis at macro context, it is observed that the fundamental land uses which are important to be essential for a convenient functioning of the neighbourhood is available in proximity, specifically within one (01) Kilometer radius. Land use for health care is significantly identifiable; (refer Appendix-J).

Table 4.4; Main Land use Distribution within 1KM radius of neighbourhood

	Land Use within 1KM Radius	% of Total
1	Residential	56
2	Commercial	9
3	Institutional; Banks-allied,Offices	7
4	Health	3
5	Educational	4
6	Industrial	<1
7	Religious	2
8	Main Roads/Roads/Transportation	10
9	Open space/Parks/Play grounds/water bodies	7
10	Vacant land	2

Source: GIS-Urban Development Authority, 2015

In the neighbourhood area itself, a clear mix of residential and commercial uses are identifiable. Residential usage is the most significant, and commercial usages are at the second level. Roads and transportation occupy a large amount of area, with institutional and recreational activities alike. Considering the dispersion of different activities within the ward, it could be considered as a diverse mix of uses.

4.2.2.3 Layout

Lay out of the neighbourhood is convenient, and quite simple, with main arterial roads, and internal roads, both private vehicular and pedestrian. Every house block possesses a road frontage at different levels, and accessible directly from the internal roads. Units at ground level are accessed direct from the road level and upper levels by common staircases.

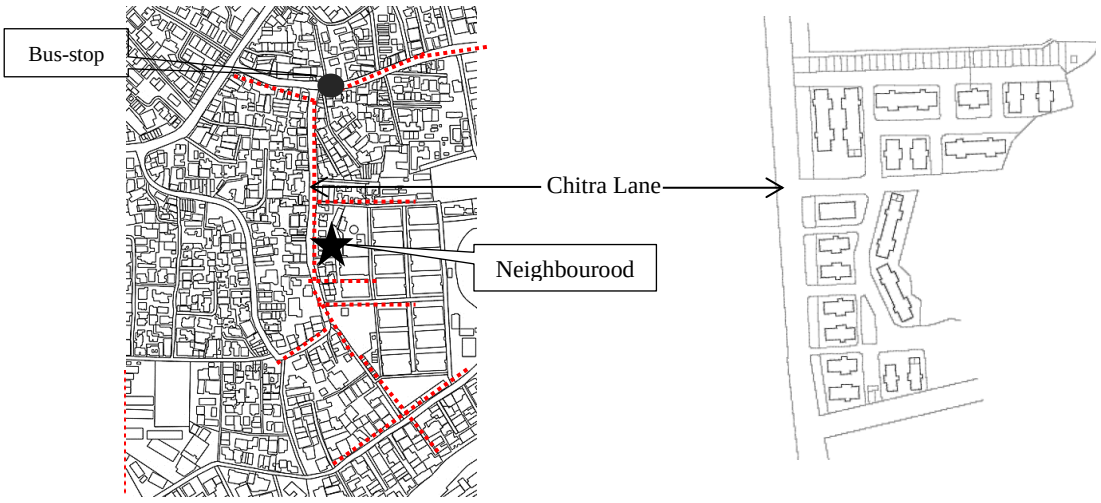


Figure 4.16: Physical Layout and links to context
Sources; GIS-UDA, 2015; Physical observations, 2018-2019; Google maps, 2021

Internal streets are wide with a designated pedestrian space. Parking is on the road, which is made wider in connecting points. These spaces are used as extended parts of the residents' living space in between households. This makes the road a common community space in the neighbourhood. Widened circulation areas at certain intervals are special features, forming shared community spaces allowing kids playing and adults spending leisure time. It adds provisions to the ability of social interaction, and results vitality in the urban setting.

Figure 4.17: Internal roads and extended open areas create interactive communal spaces within the neighbourhood; for children to play and adults to hang-around

Every household of the neighbourhood is well connected to its immediate context by internal/private roads, internal/ semipublic roads, and then public road. Within the neighbourhood, mostly the pedestrians are prioritized. Pedestrian space is provided on both public and internal semipublic roads, and they are transformed into interactive social spaces within the neighbourhood community; (Figure 4.17).

4.2.2.4 Connectivity and Transport infrastructure

The neighbourhood layout demonstrates a highly standing level of connectivity within the neighbourhood itself as well as with the surrounding urban context. In the spatial arrangement in macro context, it can be observed that the transportation nodes, commercial centers, schools, institutes, health centers, community areas, and religious centers are in proximity. Effectively, all amenities required for living, including shopping and marketing, education, health, and travelling are available within 500-1000 meters radius.

It was revealed at the observations and surveys, the residents feel that their neighbourhood is highly preferable in terms of location for families with school aged kids, youth and employed people in Colombo. The neighbourhood is well adapted to public transportation with close by transit stops, and convenient linkages (refer Figure 4.16). Public transportation is mostly in use at highly convenient level as the location is by a main public road, and private vehicle usage is minimized.

4.2.2.5 Housing and Building Type

Wide road frontages and vertically planned housing arrangement are significantly identifiable, unique facets of the fabric, which creates a specific identity collectively with the pattern of middle scale building heights; of four storied. Bordering to the outer main arterial road, buildings consist of commercial usage at ground level and residential use is kept at the upper rest.

Figure 4.18: Housing types; Single bedroom-4 units, Typical floor plans, elevation

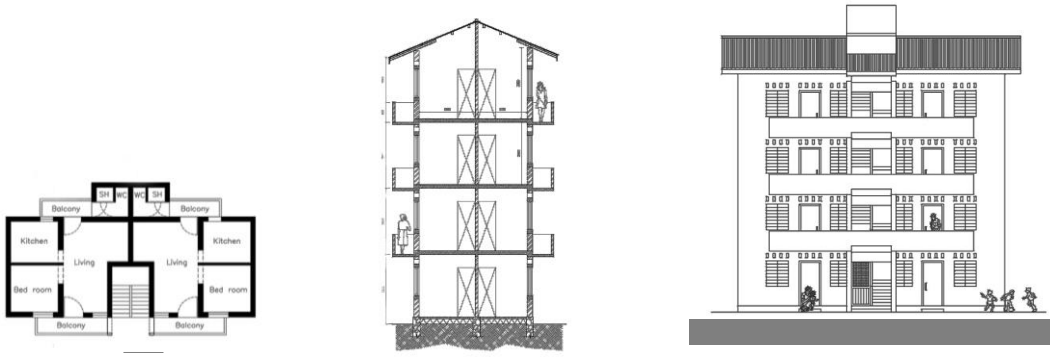


Figure 4.19: Housing types; Typical floor plan; Single bedroom/ 2-unit plan, section elevation

Figure 4.20: Housing/building types; Typical floor plan; Two bedroom/ 4-unit plan, elevation
Source: National Housing Development Authority, 2018

Most residential buildings are of four storied, and each house unit is planned at a single level, with single- and two-bedroom options; (Figure 4.18, 4.19, 4.20). Ground level units are entered directly from private roadside and upper levels are entered with a common staircase and connecting passage parallel to road. Every upper unit has balconies to front and rear sides with ample natural light and ventilation provisions.

4.2.2.6 Architectural Character

Houses are densely placed in building units which were arranged in an orderly manner. Original buildings of the neighbourhood have followed a unique, simple, and economic design but new renovations have slightly added certain elements and made changes on the facades of the buildings. Landscape features, façade colours, fenestration, and railings etc. expresses individuality of household.

Figure 4.21: Unique identity creates collectively, regardless of detailing in individual units

However, the changes are not architecturally disturbing the unique identity and yet maintain a significant overall character on the neighbourhood. Housing structures and facades overall, collectively protect the original architectural character of a middle-income neighbourhood. It was convinced by the residents that the nieghbourhood was long lasting for more than fifty (50) years by now with minor changes in the external facades creating individuality and internal arrangements to be suited to the changing interior space requirements. The structures are of almost totally prefabricated system involving precast concrete loadbearing walls and precast floor slabs of pre-stressed concrete .

Nearly 65% of the houses have cemented floors and the rest are finished with tiles which are recent renovations, upgrading interior quality. Originally the houses had corrugated asbestos roofs, which remain the same.

4.2.3 Background of Sustainability and level of achievement

The procedures followed are exactly similar to that in Case study-1. Level of sustainability achievement is understood through questionnaire-based survey. Household: residence, is considered as the research unit, as per the methodology and the interviewee is the head of household, qualified as per the technique. Formulated questionnaire presented in Appendix-A is answered by the household resident. The neighbourhood is assessed in residents' perceptions as laid out in the research design. Data collected were tabulated enabling the analysis. (refer Appendix-K)

Similarly, the three main sustainability aspects; Environmental, Social and Economic, are assessed under sub-categories in terms of urban form component, and the research findings are recorded and analyzed using SPSS. Number of cases are 35 and reliability of statistics is indicated as 0.929 Cronbach's Alpha, recommended as a rich data collection and the number of items is 50; (refer Appendix-L, M). Following analysis is based on output of the research findings.

4.2.3.1 Environmental Responsiveness

In the assessment of sustainability of the environmental aspect in terms of density related concerns (Q1-Q9), inhabitants' rating on the sufficiency of current residential density with the population density, scores at 4.91; close to 'very good'. Conditions on air and noise pollution related health effects are identified as highly preferable; this is rated 5.00. The supply of energy and services are recognized as highly favourable, rated at 4.83-4.89, evaluated as very good. However, the systems were identified as causing disturbances in supply during certain short irregular periods. This is a common situation for most of the areas in Colombo as well as outskirts, during severely dry weather seasons. The residents concern to have alternative solution for such situations particularly for the neighbourhood as a refinement. Storm water

drainage and Solid waste disposal, are responded as highly preferable in keeping the neighbourhood clean and tidy, having rated at 5.00 in the Likert scale.

Environmental responsiveness in terms of the lay-out (Q10-Q14) demonstrate that the street experience including light levels are highly desired by inhabitants; this is rated at 5.00, evaluated as 'very good'. Adequacy of open space provisions rated at 4.6 and, tree plantation, wind concerns, natural light, and ventilation provisions are evaluated as good, rated at 4.06. Residents prefer to have more planned open and recreational spaces within the neighbourhood with more pleasant streetscape. However, it was observed that in overall the neighbourhood is dynamic and peaceful; (refer Figure 4.22).

On the responsiveness in terms of land use distribution structure, movements and interaction patterns, transportation patterns, and functioning of current land uses are perceived as convenient, with a rating above 4.69 up to 5.00. Existence of impervious surfaces is found as being barely minimum and thereby storm water management systems are considered as highly efficient even during heavy rains, with the rating of 5.00 in the Likert Scale.

Figure 4.22; Glimpses of neighbourhood from Chitra Lane; a peaceful neighbourhood in a dynamic urban setting

Connectivity and related transportation matters are evaluated by the residents as the neighbourhood adapting extremely well to the immediate context. Public transit, pedestrian and bicycle movements are accepted as optimally encouraged and in use, with ratings at 5.00 in the Likert Scale. Street safety and convenience are perceived to be highly desired, rated at 5.00. Street connectivity is accepted as adequate and

appropriate, rated at 5.00, and the availability of route directions is regarded as convenient, rated at 5.00. Further, the residents' insight on adequacy of pedestrian accessibility is rated at 5.00, and pedestrian network coverage is rated high at 4.86.

Corresponding to the above numerical analysis of findings, the effects of configured elements of urban form, related to environmental sustainability can be briefed as follows focusing onto the residents' appeal.

a) Density:
   - Currently, the population density is appropriate with residential density,
   - It is preferred to have improvements in residential density proportionately to the population density in future as expansions, to accommodate more families.

b) Layout:
   - Internal roads and open spaces are used as provisions for communal gatherings.
   - It offers a physical space for social interaction to a greater extent.
   - Tree plantation, wind, natural light, and ventilation concerns are satisfactory.

c) Land Use:
   - Conditions are acceptable as favourable, except the issue in open space provision in layout, within the neighbourhood.

d) Connectivity:
   - Conditions are highly acceptable as favourable and appropriate.
   - It is considered as the best feature of the neighbourhood, resulted by location.

Remarks:

Environmental sustainability and residents' appeal on environmental aspect in terms of density, layout, land use and connectivity are at high foavourable ratings. Resource demand including energy and urban water system, common to the country in terms of common water and power disruptions are considered as issues. Residents' expectation expresses concerns on special sub-circuits of services within the neighbourhood. Further, they prefer to have more residential density with increasing population density, as the residents need their extended families also to have the benefit of living in the neighbourhood itself. However, it can have practical difficulties, as the space provisions are limited within the designated area, for further expansions.

4.2.3.2 Social Attentiveness

Within the concerns of the social sustainability of the neighbourhood (Q26-Q43), questions were directed to ascertain the inhabitants concern towards social needs and aspirations, similar to the case study-1. With reference to the layout, the association of social patterns and behavior within the neighbourhood is considered to represent inhabitants' interests far well and is rated at 5.00. The collective identity of housing and building character is rated at 4.80, indicating its high appeal to the inhabitants. Convenience of accessibility to public services, such as schools, public transit, healthcare, emergency services and places of worship, are rated high at 4.69. It is noted that convenience levels for the elderly community to live and move about, is rated good at 4.66. It was communicated that the older community live and move with safety and convenience in outdoors, but they experience difficulties in internal vertical circulation. This is a matter of internal planning arrangements, with unavailability of passenger lifts. With the land-use distribution (Q32), residents are considerably satisfied with dedicated facilities for childcare, and community facilities. This is rated at 4.49.

Within the parameters of social sustainability, related to connectivity, and accessibility, (Q33-Q37) appropriateness of traffic calming precautions, expression of cultural identity and facilitation of non-motorized transportation, walking and cycling are perceived as favourable rated at 4.49, 4.06, and 5.00, respectively. It was observed that within the prevailing communal living style, it provides a safe and secured setting for females, children, and differently abled residents (Figure 4.23).

Figure 4.23: Safe internal roads; Residents believe that the internal roads are safe for their children even to use as play areas

Simultaneously, prevalent public life of community is evaluated as good, rated at 4.17 and planning and engineering standards of building services, as moderate, at 3.86.

Considering the social aspect in terms of the architectural character (Q38-Q43), residents are of the opinion that they are offered a very strong communal identity, a sense of place. This is rated at 5.00, and a reasonable human experience of a good living is rated at 4.71. They appreciate the identity of the neighbourhood as being of diverse cultural groups and the facilitation of such diversity rated at 5.00. Its architectural character, or the ambience created by the housing, buildings, and other built components is rated at 4.89. However, residents themselves have tried to have an individual identity on their front façade detailing, and internal space arrangements; (refer Figure 4.24). The diversity or variety of housing quality, which is rated at 4.20, offers a reasonable scope of options for residents.

Figure 4.24; Fine tunings on front facades engraving individual identity

Concurring to the above numerical analysis of the findings, the overall effects of constituent elements of urban form, on social sustainability as met with inhabitants, could be briefed as follows.

a) Layout:

- Atmosphere created by layout within the neighbourhood is sufficiently secured for all residents, including kids, offering spacious and safe outdoor setting.
- Further it offers public space for social interaction with social inclusiveness.
- Though the outdoor environment within the neighbourhood is realized as sufficiently convenient, residents concern on internal vertical circulation is

highly important in providing convenient and quality living, especially for urban senior dweller.

- Planning and engineering standards are yet expected to be in better harmony with residents changing lifestyles.

b) Land-use:

- Sufficiency of almost all dedicated facilities such as childcare, community centers, public libraries, fitness centers, playgrounds, skills development facilities for youth are acceptable as they are available in proximity.

c) Connectivity:

- Connectivity and linkages to the surrounding urban context is well fulfilled.
- Well adapted to public transport with pleasant and convenient walkable roads.

d) Architectural Character:

- Diversity or variety of housing quality is an important feature to be induced, within the overall character and identity.

Remarks:

Safe and secured living environment within the neighbourhood for kids, women, and elders, are the main social expectations of the inhabitants. Dedicated facilities for children, youth and senior citizens are primarily important for a neighbourhood in proximity, and they are essential inclusions of urban living. Except the wide roads, the neighbourhood is not specifically provided with designated open spaces for recreation or as play areas. However, the extended areas of the private roads within the neighbourhood are used by kids as play areas, as well as communal spaces by adults. Since the traffic calming within the neighbourhood is convinced, parents do let their children play on the road. The fact brings a dynamic and lively appearance to the urban entity. Connectivity, accessibility, and transportation mode are primary concerns of urban residents, which impresses residents with the location of neighbourhood. Specifically, in this case study, it convinces that the convenient location is a fundamental factor of environmental, social, and economic superiority of a neighbourhood. Cultural expression and the social identity stamped by their neighbourhood, is important to dignify the residents on their status of living.

4.2.3.3 Economic Viability

Within the economic sustainability (Q44-Q50) in terms of the layout (Q44-Q47), connectivity, accessibility, and the available modes of transportation, are highly desired. This is rated at 5.00. In that sense, this neighbourhood too, is a good example, where people experience the optimum benefit of living in such a location. House prices and land values are well recognized and rated very high, at 5.00. However, diversity and affordability of housing types show a lower rating, which is at 3.80.

In terms of land use (Q48-Q50), availability of close by employment opportunities is rated low at 3.66, evaluated as 'moderated'. Availability of commercial establishments in the proximity, is highly valued, rated at 4.60. The overall rating on living quality is placed 'good', rated at 4.20 in the Likert Scale. Accordingly, the effectiveness of constituent elements of urban form, related to economic sustainability is briefed as follows based on the analysis of findings focusing on essentials.

a) Layout:
   - Diversity of housing types is perceived as necessary for economically feasible living.
   - Affordability of housing options, enabling social mixing and social diversity, is essential in the neighbourhood.

b) Land-use:
   - Diversity of uses in proximity are sufficiently well convinced.

Remarks:

Good location of a neighbourhood has a higher credibility for being attracted by urban dweller. Connectivity, accessibility, and the available transportation modes have become main concerns in assessing the location of a neighbourhood. This case neighbourhood is a decent example, where people experience high benefits of living in a good location. Availability of commercial establishments and community activities, in proximity, advances the value of location. House prices are realized as very high, offering a good land value for neighbourhood.

Diversity and affordability of housing types needs improvements for likelihood. Literally, those options were slightly considered in the original planning. and it provides single- and two-bedroom unit options. This encourages the diversity of social categories and family sizes. Also, it promotes the diversity of affordability. Living quality of the urban society needs to be transformed with the changes based on varying requirements, such as diversity in house type, affordability disparities, and quality of housing.

Some variations in internal unit plans have been added as solutions to increasing space requirements of extended families, as they value the location. User friendly designs of house units with concerns on older community, particularly for more convenient vertical circulation within units, would have been collectively add more economic value to the neighbourhood.

The housing is provided in equal types four storied housing flats, within a respectable location, convening residents' urban living requirements. It is convinced in the research that the convenient location of the neighbourhood is one of the main reasons for the inhabitants to value their living setting as sustainable at a higher rating. It has several benefits related to connectivity and transportation, accessibility to community facilities, services, and amenities. It facilitates convenient accessibility to the employment destinations and routine living.

This benefits to all age group categories and facilitates the personal independence. School aged kids, employed adults, senior citizens alike enjoy the benefit of the good location of their living in this neighbourhood setting. This is considered as a major attraction in the physical characteristics of a neighbourhood (AARP, 2005: Metlife, 2013). It is safe, inclusive, well panned for effective functioning. It offers equality of opportunities and good services for citizens of all age groups.

4.3 Case Study-3; Veluvanarama Road Housing Neighbourhood

Third case study is chosen from ward 45; ward/ GN division of Pamankada-West in the primary residential zone, which is a residential neighbourhood by the Veluwanarama road in Wellawatta electorate. Veluwanarama road runs parallel to Dehiwala canal from Hampdon Lane on West, and to Colombo-Horana (B84) road on East: (Figure 4.25). Both sides of road by the canal have developed as low-income community, and middle and upper middle-income level neighbourhoods are developed towards outer areas from the canal front.

4.3.1 Introduction to Case Neighbourhood

Veluwanarama housing neighbourhood is a multi-racial and multi religious community accessed by both Hampdon Lane and Veluvanarama road. It is located North to the Veluwanarama road, which runs parallel to the Dehiwala canal, within the primary residential zone of which the land value is stated as Rs.7.5-8.0 Mn. average per perch (Valuation Dept., 2019; LankaPropertyweb, 2020). By the location, formation, and inherent architectural character, the neighbourhood appears as an attractive, peaceful, and livable urban community in the area.

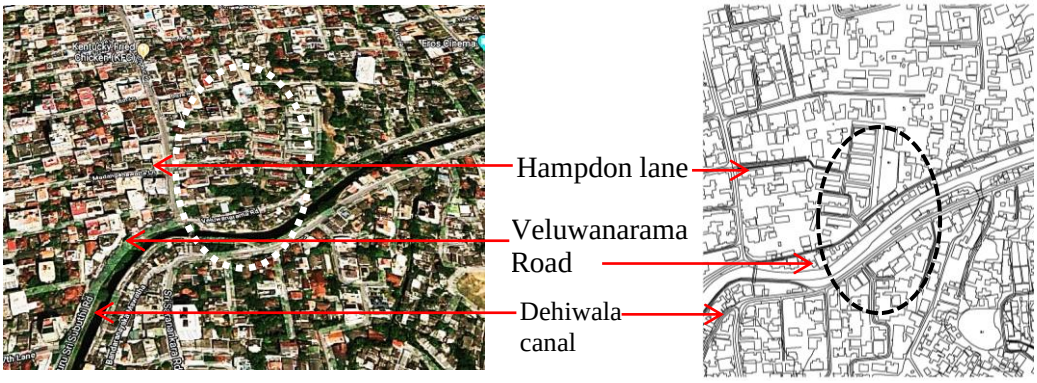


Figure 4.25: Physical location of Veluwanarama Road neighbourhood
Sources; Google maps, GIS-UDA, 2015

Comparing to the total population of 12,451 within the entire Pamankada-West ward/ GN division, Veluwanarama road neighborhood is a dense planned middle-income housing development. Out of total population, nearly 45% is male and female count is 55% (Census and Statistics, 2012).

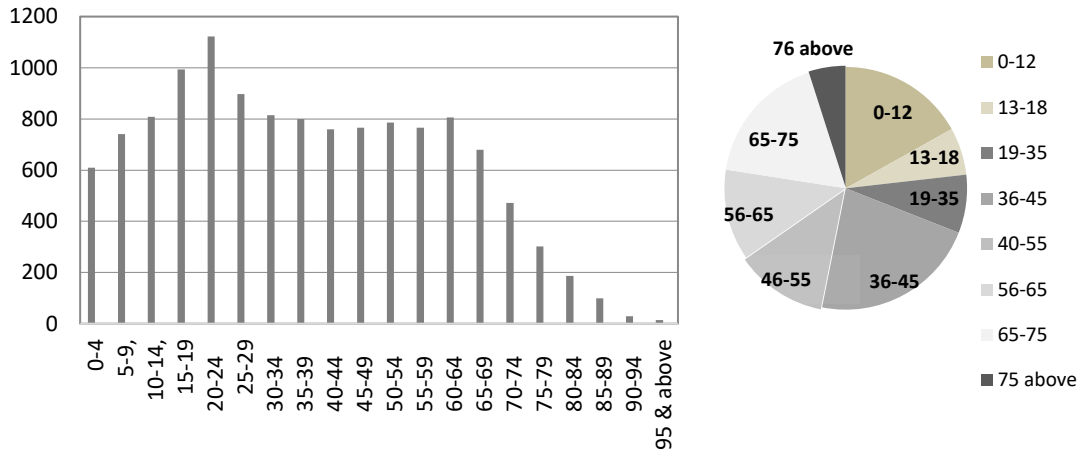


Figure 4.26; Population by Age (years) in Pamankada-West GN Division
Sources: Department of Census & Statistics

Though it is hard to define the age categories, it is clearly visible that the elderly age population is proportionately low in the area (Figure 4.26).

4.3.2 Investigation and Analysis of Urban Form

Urban form is analyzed similarly to case study-1 and 2, with reference to its physical and non-physical components; density, land-use, layout, connectivity and transport infrastructure, housing and building type and architectural character.

4.3.2.1 Density

As located in the Primary residential zone, residential use is prioritized in the neighbourhood. Within the considered area of the neighbourhood, built footprint area is nearly 28%, and almost 100% are found as residential buildings. Rest is left for roads and open spaces. Residential density of the considered area is 138 households per hectare and the population density is nearly 550 persons per hectare. Population density of the total ward/ GN division is around 183 persons per hectare, and in the extent of area, the neighbourhood area is approximately 1.5% of the total Ward area (Table 4.5). Hence, when compared to the total population of 12,451 within the Ward, the case neighbourhood holds a high density of housing and residents. This neighbourhood shares common urban facilities amongst reasonably a large group of urban residents, while providing green spaces, and several options of housing types.

The strategy used in achieving high density is vertical space planning, optimizing of plot size and footprint, keeping larger common open areas at ground level. The number of floors is limited to two to five (2-5), economizing building structures and services and optimizing ground connectivity.

Table 4.5; Details on density of Veluwnarama Road neighbourhood

	Ward /GN Division	**Neighbourhood area**
	Pamankda-West/45	Veluwanarama Road
Total Area	68.1 hectare	1 hectare
Proportionate size	n/a	1.5% of total ward or GN area
Resident density	183 persons per hectare	550 persons per hectare
Residential density		138 households per hectare
Building footprint area		28% of total neighbourhood area

Source: Department of Census & Statistics, GIS-UDA, 2015; Personal observations 2018-2019

4.3.2.2 Land use

In the neighbourhood area itself, a mix of uses are not identifiable. Only residential usage is significant, and commercial establishments are not available within the neighbourhood. Of the total neighbourhood area considered, nearly 70% area is allocated for roads, gardens, and open areas, forming a specious setting within the demarcation. In a spatial analysis at macro context, it is observed that the fundamental land uses which are important to be essential for a convenient functioning of the neighbourhood is available in proximity, though not abundant, within one (01) Kilometer radius (Table 4.6; refer with Appendix-N).

Table 4.6; Main Land use Distribution within 1KM radius of neighbourhood

	Land Use within 1KM Radius of the neighbourhood	**% of Total lnduse**
1	Residential	62
2	Commercial	5
3	Institutional; Banks-allied,Offices	1
4	Health	5
5	Educational	1
6	Industrial	<1
7	Religious	3
8	Main Roads/Roads/Transportation	11
9	Open space/Parks/Play grounds/water bodies	1
10	Vacant land	5

Source: GIS-Urban Development Authority, 2015

Comparing to the other functional land uses, residential land use covers 62% of the total land usage. Henceforth, this neighbourhood is located within a mix residentil zone where the residential use in predominent.

4.3.2.3 Layout:

Lay out of the neighbourhood is convenient, quite simple, with access from main arterial roads, and internal roads, for both private vehicles and pedestrians (Figure 4.27). Every house block possesses a road frontage at different levels, and accessible directly from the road at ground level, providing access to upper levels by common staircases.

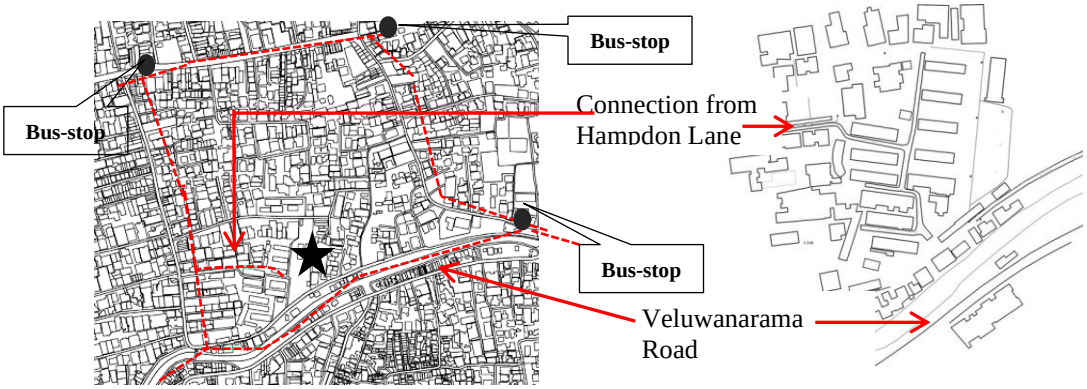


Figure 4.27: Physical layout and links to context
Sources; GIS-UDA, 2015; Physical observations, 2018-2019; Google maps, 2021

Internal streets are wide with a designated pedestrian space. Parking is on the roads which is made wide in certain intervals and are used as an extended open living space in between households. This made the road a common community space in the neighbourhood.

Figure 4.28: Wide internal streets forming spacious pedestrian space

Widened circulation areas at certain intervals are special features, forming shared community spaces allowing kids playing and cycling (Figure 4.28). Every household of the neighbourhood is well connected to its immediate surrounding context by semipublic/internal roads and then to public road. Pedestrians are prioritized within the neighbourhood with sufficient pedestrian space provided on both public and internal semipublic roads that are transformed into interactive social spaces.

4.3.2.4 Connectivity and Transport infrastructure

The neighbourhood layout demonstrates a highly acceptable level of connectivity within the neighbourhood itself as well as with the surrounding urban context by street layout. However, the connection to the city along the Veluwanarama road on south seems not very pleasing, as it runs with shanty[1] settlements on either side. Residents' main entry is laid from the Hampdon Lane on west. It was revealed at the observations and interviews, the residents feel that the connectivity of their neighbourhood to public transportation network is not that favourable in terms of its location. Hence, the private vehicle usage is profuse than the public transit.

4.3.2.5 Housing and Building Type

Wide road frontages and vertically planned housing arrangement with options of housing types and sizes are significantly identifiable, unique facets of the neighbourhood fabric. It creates a specific identity collectively with the pattern of two storied to five storied housing blocks. Each unit is planned in a single level, with single- and two-bedroom options; (see Figure 4.29, 4.30). Ground level units are entered directly from roadside and every upper unit is entered from common staircases connected with a common passage, laid onto roadside. Each upper unit has balconies on rear sides and open passage to front, with ample natural light and ventilation provisions.

[1] a small, rough shelter or crudely built dwelling.

Figure 4.29: Two storied block type with two-bedroom housing type option; Ground and Upper floor Plans, Elevation, Section

Figure 4.30: Five storied block type with single bedroom housing type option; Ground and Upper floor Plans, Elevation, Section
Source: National Housing Development Authority, 2018

Overall, the layout plan of the neighbourhood is quite simple, providing equal opportunities for every household. Exposure towards the surrounding is well offered to every building unit in the neighbourhood, in its architectural aspect.

4.3.2.6 Architectural Character

Original buildings of the neighbourhood have followed a unique simple and economic design, but new renovations have added certain new elements and made changes from time to time on the facades of the buildings. Landscape features, façade colours, features, and railings etc expresses individuality of household (Figure 4.31).

Figure 4.31: Unique identity and a character, collectively expressed by different types of housing

The changes are not architecturally much significant, and it still stamps a unique identity and creates a collectively significant character on the neighbourhood. Most of the housing structures and facades carefully protect the original architectural character of a middle-income neighbourhood collectively. It was convinced by the residents that the nieghbourhood has been lasting for more than twenty (20) years by now with minor changes in the external facades creating individuality and internal arrangements to be suited to the increasing interior space requirements.

The neighbourhood is comprised with diversity of housing types, sizes, and quality. Two storied building units are provided with two-bedroom units and 5 storied units are provided with single bedroom option. Originally each housing unit provides open balconies for both front and rear side elevations, which suffix with natural cross ventilation throughout the day. Colours used are mainly of earthen range and not much individuality could be identified in colour usage. The houses are of permanent column and beam structures, and in general, walls are made of cement block, plastered, and painted. Nearly 50% of the houses have cemented floors and the rest are finished with tiles which are recent renovations. Originally the houses had asbestos roofs, and some have currently covered with half round clay tiles.

4.3.3 Background of Sustainability and level of achievement

Procedures are exactly similar to that in Case study-1 and 2. Achievement in sustainability is assessed through the questionnaire survey. Household is considered as the research unit, as per the methodology and the interviewee is the head of household; an adult who were living in the neighbourhood for more than ten (10) years continuously. Formulated questionnaire presented in Appendix-A is answered by the household resident. Data collected were tabulated for analysis. (refer Appendix-P)

Three main sustainability aspects; Environmental, Social and Economic, are assessed under the sub-categories in terms of determinant component of urban form, and the research findings are recorded manually as a rating in Likert scale and analyzed using SPSS. Number of cases are 35 and reliability of statistics is indicated as 0.959 Cronbach's Alpha, recommended as a rich data collection and the number of items is 50; (refer Appendix Q, R). Following analysis is based on output of the findings.

4.3.3.1 Environmental Responsiveness:

In the assessment of sustainability of the environmental aspect in terms of density related concerns (Q1-Q9), inhabitants' rating on the sufficiency of current residential density with the population density, scores at 5.00, evaluated as 'very good'. Air and noise pollution related health effects and stress condition are identified as negligible and rated as 'very good'. The supply of energy and services are recognized as highly favourable, rated 5.0, evaluated as 'very good' including solid waste disposal, in keeping the neighbourhood clean and tidy (Figure 4.32).

Figure 4.32; Spaciousness in layout design clean atmosphere making residents appeal onto the living setting

Environmental aspects in terms of the lay-out (Q10-Q14) demonstrate that the street experience including light levels are highly desired by inhabitants; this is rated at 5,00, evaluated as 'very good'. However, adequacy of open space provisions, is rated at 4.17 evaluating as 'good'. Tree plantation, wind concerns, natural light, and ventilation provisions are evaluated as 'very good', rated at 5.00.

Responsiveness in terms of land use distribution structure (Q15-Q18), movements and interaction patterns, transportation patterns, are perceived as convenient, with a rating above 4.20. On the contrary, functioning of current land uses are perceived as 'moderate', with a rating of 3.43. Existence of impervious surfaces is found as being barely minimum and thereby storm water management systems are considered as highly efficient even during heavy rains, with the rating of 5.00 in the Likert Scale.

Residents' response on Environmental aspect in terms of connectivity and accessibility (Q19-Q25) shows an important finding. These matters are evaluated by the residents as the neighbourhood ineffectually adapting to the immediate context. Public transit, pedestrian and bicycle movements are regarded as not encouraged and in use, with ratings at 3.54-3.77 in the Likert Scale, although the pedestrian and bicycle lanes are physically provided with spacious layouts. Street safety is perceived to be highly desired, rated at 5.00. Street convenience and connectivity is recognized as inadequate, rated at 3.51, and the availability of route directions is regarded the same. Further, it is important to note that the residents' insight on adequacy of pedestrian accessibility is evaluated as 'moderate' rated at 3.54, and pedestrian network coverage is rated low at 3.17.

Considering the above numerical analysis of the findings, the properties of constituent elements of urban form, related to environmental sustainability is briefed as follows, focusing onto the positive and negative implications.

a) Density:
   - Residents' concerns on density within the neighbourhood are highly appreciated.

b) Layout:

- Adequacy of open and community space provisions within neighbourhood is in need, though large unbuilt areas are available.
- Urban experience on exterior of the setting; the neighbourhood space, is highly preferable.

c) Land Use:

- Conditions are specific as the total neighbouhood is designated for residential use.

d) Connectivity:

- Though the internal street safety is highly acceptable, circumstances on connectivity to public transit are not satisfactory.

Remarks:

Overall quality of the neighbourhood with spacious layout and a good level of residential density tally with the population density are highly appreciated by urban dwellers, especially within primary residential area. However, beneath all other positive features in the neighbourhood, rating overrides by the residents' concern on connectivity and accessibility to the public transit. In overall environmental sustainability assessment, it takes a significant concern, which emphasizes on the inevitability of the strategic location.

4.3.3.2 Social Attentiveness:

In relation to social sustainability of the neighbourhood, similarly to the case study-1 and 2, questions were directed to ascertain the inhabitants concern towards social needs and aspirations. With reference to the layout (Q26-Q31), the association of social patterns and behavior within the neighbourhood is considered to represent inhabitants' interests well and is rated at 4.80. The collective identity of housing and building character is rated at 4.89, indicating its positive evaluation of the inhabitants. On contrary, convenience of accessibility to public services, such as schools, public transit, healthcare, emergency services and places of worship, are rated 'moderate', at 3.46. However, it is noted that convenience levels for the elderly community to live and move about, is rated 'good' at 4.40.

Similarly, with the land-use distribution (Q32), residents are not satisfied with dedicated facilities for childcare, and community facilities such as public libraries and skills development centers or commercial establishments etc. They are not considered as essential social needs within the setting. This is rated at 3.83.

Concerns of the social sustainability in terms of connectivity (Q33-Q37), traffic calming precautions available are highly satisfying the residents' expectation, rated at 5.00. In this context, non-motorized transportation; walking, and cycling are facilitated, by providing pleasant shady environment within the neighbourhood evaluated as 'good' with a rating of 4.54. Simultaneously, prevalent planning and engineering standards of building services, and public life of community are evaluated as 'good', rated at 4.06. On the contrary, expressions on a cultural identity, and encouragements or supports with public environment and public life of community are evaluated low, as 'moderate', with a rating at 3.80 and 3.57. Distance to closest transit stop and route directions are not accepted by the residents as tempting. As the location of the neighbourhood is within the low-income housing stretch along Velwanarama road parallel to Dehiwala canal, the situation has aroused as per the inhabitants' explanation. These sorts of situations would have been resolved by implementing policies for continuous up-grading of urban housing for all; (refer Figure 4.33).

Figure 4.33: Entrance to the neighbourhood through the low-income settlements along Velwanarama road parallel to Dehiwala canal on south

In achievement of social expectations in terms of architectural character, residents' acceptance is that they are offered a strong communal identity: a sense of place.

This is rated at 4.83, and a reasonable human experience of a good living is rated at 4.63. They appreciate the identity of the neighbourhood as being of diverse cultural groups and the facilitation of such diversity rated at 4.69. Its architectural character, or the ambience created by the housing, buildings, and other built components is rated at 4.26. Further, they have introduced several features as modifications or alterations to express a novelty or a change on the facades, at the same time, for improving space requirements; (refer Figure 4.34). The diversity or variety of housing quality, which is rated at 4.31, offers a wide scope of options for residents. Spaciousness in the layouts is well recognized as quite positive features by the residents but is not very socially interactive as communal spaces. Overall, calm and a peaceful atmospheric character has been achieved through the neighbourhood design, as a recognizable prototype neighbourhood in outer city limits.

Figure 4.34; Additions and alterations including fencing, fulfilling the requirements of individual identity yet does not harm the overall character.

Consequent to the above numerical analysis of findings, effects of the elements of urban form, related to social sustainability could be briefed as follows focusing on to positive as well as negative considerations.

a) Layout:

- A highly secured atmosphere is created for all residents within the urbanity, and the older community has also offered committed concern to live and move conveniently.

b) Land-use:

- Sufficiency and proximity of certain dedicated facilities such as childcare, community centers, public libraries, fitness centers, playgrounds, skills

development facilities for youth and commercial establishments are not considered as acceptable.

c) Connectivity:

- Planning and engineering standards are in harmony with residents changing lifestyles to a certain extent.
- Pedestrian network coverage, adequacy of street connectivity and adaptability to the public transit is at a weak position.

d) Architectural Character:

- Diversity or variety of housing quality and sense of place is being created and maintained.
- Minor alterations in facades and interior, expressing individuality can be considered as important and necessitated, but overall character to be maintained.

Remarks:

The atmosphere is accepted as highly safe and secured for kids, women, and elders, facilitating their social expectations within the neighbourhood. Accessibility and transportation mode are primary concerns of urban residents, which is clearly convinced negative achievements in the survey. At the same time, it is to be stamped that all the positive features within the neighbourhood, overrides by the external connections and environs, public transit routes, directions etc. of a neighbourhood. Though the urban resident is made living with sharing facilities, they still admire the cultural expression and the social identity outstared by their neighbourhood. It is important to stamp a dignity within the immediate surrounding context as well.

4.3.3.3 Economic Viability:

Within the economic sustainability in terms of the layout, connectivity, accessibility, and the available modes of transportation, are less desired and is rated at 3.60. In that sense, this neighbourhood is a good example, where people do not experience the benefit of living a location, connected to public transit. House prices and land values are well recognized and rated high, at 4.54. Diversity and affordability of housing types show a ‘good’ rating, which is at 4.09-4.57.

In contrary, availability of employment opportunities is rated low at 3.00, and the availability of commercial establishments in the proximity, is also less valued, rated at 3.57. However, the overall rating on living quality is placed 'good', at 4.49 in the Likert Scale.

Concurring to the above numerical analysis of findings, the effectiveness of constituent elements of urban form, related to economic sustainability could be briefed as follows focusing on to the positive and negative consequences.

a) Layout:

- Connectivity to surrounding community and convenience of getting connected to public transit is a fundamental issue currently with the location.
- Unavailability of commercial establishments in proximity is a negative source.

b) Land-use:

- Mix of land uses is unavailable within the neighbourhood or in close proximity.
- Availability of commercial establishments in proximity is a requirement.

Remarks:

Diversity of housing types has been made available in the neighbourhood, within the original plan. Diversity in house types, affordability disparities, and quality of housing brings vividness to the setting which creates interaction of different social stratums. In those considerations this neighbourhood has scored more in human appeal. Unavailability of commercial establishments in proximity is identified as a negative in sustenance. Significance of convenience in transportation; especially convenient as well as pleasing, attractive links to public transit is fundamental in sustainable neighbouhood design, which is realized as negative in the case study. Specifically, in this neighbourhood, accessibility and the available transportation modes have become primarily important in assessing the location of the neighbourhood.

4.4 Synthesis on the Preliminary Analysis of Case Studies

In the preliminary analysis of data on urban form and the background of sustainability as perceived by inhabitants in three case studies brings out important insights of three different localities. Case study-1, situated within the city core in concentrated development zone, contains special urban features than the other two. It is highly dense, well mixed with different uses, and physically well connected to public transit. Case study-2, located within the intermediate city area in mix residential zone too, contains such urban features in a different level, but yet highly dense, proximate to mix uses, and conveniently combined with public transit. Case study-3 is in outer city, in primary residential zone. It contains positive features as low dense, well laid out with consideration on open area provisions, but not well connected to mix uses and to public transit. This differences on the urban form have caused changes in inhabitants experience on sustainability of their own living setting in a highly sensitive manner.

Next chapter proceeds the analysis, comparing the urban forms of three neighbourhoods. It comparatively discusses the analytical indicators of sustainability in three neighbourhoods, with reference to attributes of urban form in each setting, focusing to their macro and micro contexts.

CHAPTER 5: COMPARATIVE ANALYSIS OF URBAN FORM FOR SUSTAINABILITY

Consequent to the detailed investigation and analysis of Urban Form of three (03) case study neighbourhoods, the information from each case taken forward to this chapter, is subjected to a comparative analysis. The formations of case study neighbourhoods are diverse, as they are selected from different urban localities, and in different land use zones in the Colombo Municipality. Hence, a further investigation and a comparative analysis is carried out, to find out how each neighbourhood form is composed and administered by its elements or attributes in composition in fostering sustainability.

5.1 Comparative Analysis of Urban Form

Out of forty-seven (47) administrative Wards in the Colombo Municipality (Ministry of Local Government & Provincial Council, 2016), each Ward contains one or more GN divisions *('Grama Niladhari Kottasha')*. They are considered as the smallest section or area of administration. (Figure 5.1)

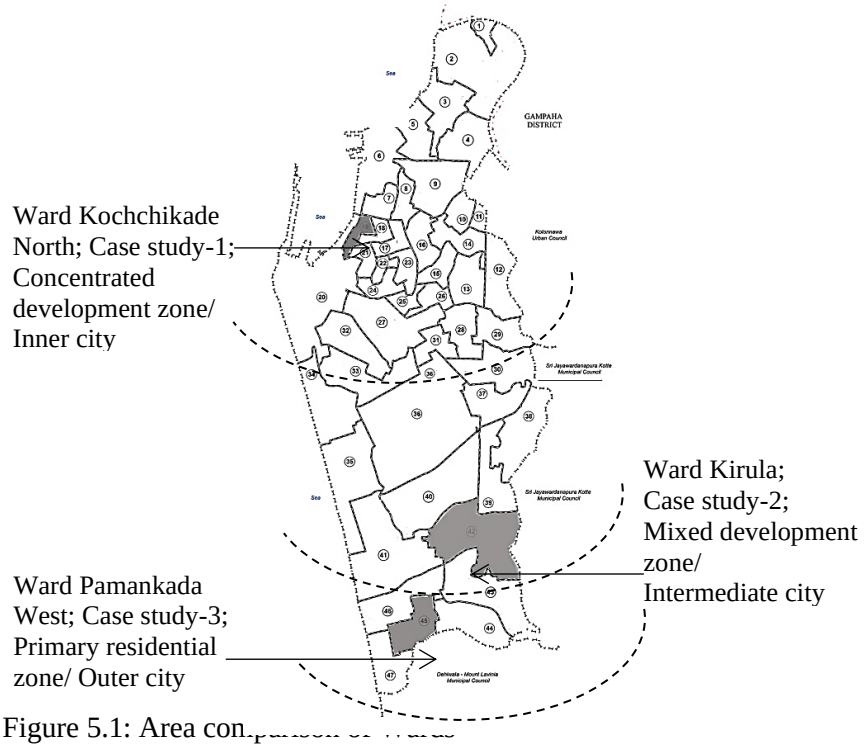


Figure 5.1: Area comparison of Wards
Source: Ministry of Local Government & Provincial Councils, 2016

Particularly in the study, the GN divisions to which the case neighbourhoods belong to are Wards themselves. In terms of the extent, the Ward-Kochchikade, where the Case study-1 (Newham Square) is located, is approximately 22.9 Hectares. Ward-Kirula, in which Case Study-2 (Chitra Lane) is located, is, nearly 191 Hectares, and Ward-Pamankada West, in which Case Study-3 (Veluwanarama Road) is located, is 68 hectares. According to the proportionate sizes, the Ward containing Case-2 in intermediate city location is the largest in area. Ward with Case-1 located in the inner city is comparatively the smallest in area and the highest in density.

Therefore, in the analysis of macro contexts, a similar area; one (01) kilometer radii, centering on the neighbourhoods were considered to obtain identical credibility on building and land usage within the context. As the Ward areas are comparatively different due to the urban location, the individual neighbourhood sizes, proportionate to the Ward areas are different. Compared to the extent of the Ward areas, Neighbourhood-1 is nearly 10.5%, Neighbourhood-2 is 0.5% and Neighbourhood-3 is 1.5% in area, of the total Ward area; (Refer Table 5.2; item 1.3 below).

5.1.1 Density

In the spatial analysis of the macro context, Ward with case study-1 possesses the highest resident population density, which is 410 persons per hectare; Ward with case study-3 is the second highest, and Ward with case study-2 is the lowest, with 183 and 106 persons per hectare respectively (Census & Statistics, 2012). Case neighbourhood-1; Newham Square is 2.4 hectares in extent, and case study-2; Chitra Lane and Case study-3; Veluwanarama Road are both 1.0 Hectare approximately (UDA, 2015). Focusing on the neighbourhood area, the approximate resident population density is 600 persons per hectare in case study-1, 800 persons per hectare in case study-2 and 550 persons per hectare in case study-3. In a comparative analysis, case study-2 has the maximum density of residents, and case study-1 is lower than that. The reason is that the mixed land use including commercial and institutional activities are given priorities in the context of case study-1, as the concentrated development zone. Case study-3 has the lowest resident population density, though it is within the primary residential zone.

Particularly in the study, residential density is defined operationally as the number of households per unit area, and the household is considered as a residence with an assessment number, within the Ward. Building area density is highest in case study-1 (80%), whereas the case study-2 (35%) and case study-3 (28%) are even less than 50% of case study-1 (Refer table 5.2; item 2.4). Apparently, case study-1 is extremely highly built-up, compared to case studies 2 and 3. Accordingly, both resident and residential densities are higher in case ttudy-2, than in the other two (refer Table 5.1).

Table 5.1; Analysis of density variation

Item	**Description**	**Case study-1. Newham Square**	**Case study-2. Chitra Ln**	**Case study-3. Veluwanarama Rd**
1	**Ward /GN Division**	Kochchikade North/19	Kirula/42	Pamankada-West/45
1.1	Ward area (Approx.)	22.79 hectare	191.21 hectare	68.1 hectare
1,2	Resident density	410 persons per hectare	106 persons per hectare	183 persons per hectare
1.3	Neighbourhood size in relation to Ward	10.5% of total Ward area	0.5% of total Ward area	1.5% of total Ward area
2	**Neighbourhood area**			
2.1	Total Area	2.4 hectare	1 hectare	1.1 hectare
2.2	Resident density	600 persons per hectare (approx.)	800 persons per hectare (approx.)	550 persons per hectare (approx.)
2.3	Residential density	125 households per hectare	200 households per hectare	138 households per hectare
2.4	Built footprint area	85%	35%	28%
Benchmark: 150 people/Hectare (min) UN Habitat,2011				

Source: GIS, CAD-UDA, 2015, Senses & statistics, 2012, Personal observations. 2018-2019

Referring to the benchmarks proposed by UN Habitat (2011), the recommended minimum resident density of a neighbourhood is to be 150 persons per hectare for efficacy. It is observed in this analysis that the condition is achieved, and all cases are sufficiently dense as urban neighbourhoods. Factually Case study-2, which is from the intermediate city or the mixed development zone is the highest in the density concern within its resident population and residential aspects. The built area density is highest in the Case study-1, which is from the inner city or the concentrated development zone.

5.1.2 Land Use

In the macro context, within the Ward areas, Case study-1 has the least residential usage which is 28%, Case study-2 has the second highest, which is 56% and the third Case study has the highest which is 62% of the total land use. The reason for this pattern of variation can be the concentration of other land uses, when moving to city core, from primary residential, to mix development and to concentrated development zones; (Figure 5.2).

But, focusing on to the neighbourhood area, the residential land usage is observed to be in the opposite direction. Accordingly, residential land use in case study-1 is the maximum (70%) in Case study-2 the second highest (33%) and in Case study-3 the lowest (28%). Commercial and retail usages are highest in Case-1 and gradually decreasing when coming to Case study-2 and Case study-3. The land use for public spaces including roads and streets get increased from case study-1 to 2 and further to case study-3 (Table 5.2).

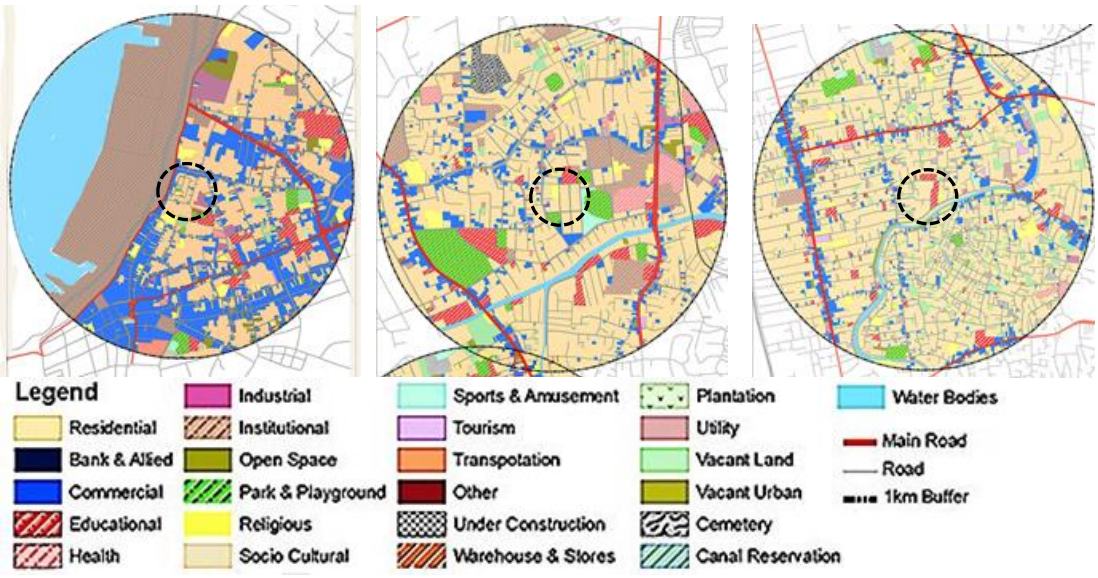


Figure 5.2: Land Uses of neighbourhood context, in a 1km radius.
From Left to Right- Case study-1; Newham Square, Case study-2; Chitra Ln., Case study-3; Veluvanarama Rd
Source; GIS-UDA, 2015

Table 5.2; Pattern of Land use distribution within the macro context and the neighbourhood

1	**Macro context/ 1m-radius** (100%)	**Case-1 Newham Square**	**Case-2 Chitra Ln**	**Case-3 Veluwanarama Rd**
1.1	Residential use	28%	56%	62%
1.2	Commercial use	22	9	5
1.3	Institutional	27	7	-
1.4	Educational	-	4	1
1.5	Roads	7	10	12
1.6	Industrial	2	-	-
1.7	Parks & Open	2	5	1
1.8	Health	1	3	5
1.9	Religious	3	2	3
1.10	Other	-	-	-
2	**Neighbourhood area** (100%)			
2.1	Residential	70%	33%	28%
2.2	Commercial & retail	14%	2%	0
2.3	Roads/streets	14%	40%	22%
2.4	Open/unbuilt	<1%	20%	50%
2.5	Religious	<1%	-	-
2.6	Community	<1%	5%	-
2.8	Leisure/Recreational	-	-	-
2.9	Offices	N/A	N/A	N/A
2.10	Industrial	N/A	N/A	N/A
Benchmark: Residential floor area/ Total floor area: 30-50% (UN Habitat,2011)				

Source; GIS-UDA, 2015; Personal observations, 2018-2019

As per the benchmarks for land use specialization proposed by UN Habitat (2011), ratio of residential floor area to total neighbourhood area is supposed to be 30-50%. Accordingly, the recommended ratio is achieved in all the cases. However, all three neighbourhoods have prioritized the residential usage, for which they are specifically planned and long used for.

5.1.3 Layout

In a spatial analysis of the macro context, the layout pattern of built masses is clear in a figure ground map. All three wards are apparently highly dense in terms of their built footprints. When focusing onto the neighbourhood area, the lay outs are clearly indicating a gradual loosening of built masses, from central city area to intermediate, and outer edges. Numerically, the built masses of neighbourhood areas, vary from 85% in Case-1, 35% in Case-2 and 28% in Case-3 approximately; (Figure 5.3).

Figure 5.3: Lay out pattern and built masses in macro context, in a 1km radius (top) and neighbourhood area (bottom); From Left to Right- Case study-1; Newham Square, Case study-2; Chitra Ln., Case study-3; Veluvanarama Rd
Source; GIS-UDA, 2015

In contrast, the proportionate land area used for streets and unbuilt/open areas is increasing from Case study-1 to Case study-2 and to Case study-3. This convinces that in neighbourhoods in city core zones offer lesser proportion of area for street function, and it increases towards outer city areas; (see Table 5.4).

According to the recommended standards provided by UN Habitat (2011) Case study-2 has provided maximum street network efficiency, whereas case-1and 2 has been ineffective in it, of which the land-use for streets is unpredictably low. Case-1, due to the location of high dense inner city, has minimized the utilization of land for street areas. However, Case-3 being located in the outer city zone, has not provided sufficient street areas, though with excessive unbuilt areas as non-designated open spaces.

Table 5.3: Comparison of street land use of neighbourhoods

	Case study 1 Newham Square	**Case study 2 Chitra ln**	**Case study 3 Veluwanarama Rd**
Total street/unbuilt	15%	60%	72%
Street-Public	8%	30%	15%
Street-Private	6%	10%	7%
Street-Pedestrian, Cycling			
Open/unbuilt	1%	20%	50%
Benchmark: Street Land use/Total Floor area: 30-45% (Efficiency of Street network) (UN Habitat,2011)			

Source: GIS-UDA, 2015, CAD based Calculations, Personal observations, 2018-2019

However, though the street land use is restricted in inner city neighbourhoods, the interaction and the intimacy of the street space is much more convincing. With the layout design itself they create the tendency of residents to use the street space as a place of their own. Comparatively this tendency is low in the outer city neighbourhoods, even though the spaciousness and safety are well convinced.

Figure 5.4: Human interaction created by lay out pattern and built masses in street context, in the neighbourhood area; From Left to Right- Case study-1; Newham Square, Case study-2; Chitra Ln., Case study-3; Veluvanarama Rd

Figure 5.5: Intimacy created lay out pattern in neighbourhood context; From Left to Right-A historic inner-city neighbourhood (Cabbage-town) in downtown Toronto; Outer city neighbourhood (Stuart Road) in Courtice, East Toronto
Source: https://www.google.com/search?- and by author

Neighbourly interaction and intimacy of street environment is a striking feature in urban neighbourhoods universally. Sri Lankan urban living is no exception in human expectation. Therefore, relevant examples globally, show how they have achieved what is expected. Though they are not exactly similar, they can be universally accepted as good examples in field of design. However, the interactive street context must be created by the design of lay out, which is supportive by both built features, built density and unbuilt area including urban landscape. This comparison clearly demonstrates the differences in the layout plan and resulted final output of the level of appeal reaching its sustainability.

5.1.4 Connectivity and Transport Infrastructure

It is made clear in the survey, that connectivity and accessibility related to transport infra-structure is a highly significant consideration of residents in all three urban contexts. Accordingly, the Case studies-1 and 2 are highly responsive, whereas Case study-3 takes a weaker stand in connectivity to transport. Main reasons are understood as being the weaker adaptability of the neighbourhood environment towards public transit, inadequate street connectivity, lesser convenience levels of route directions, and low rate on pedestrian accessibility and inadequate pedestrian network coverage. Hence, comparatively, Case study-3 is mostly dependent on private transportation modes, which does not prove as being environmentally sustainable, though the density and layout factors are highly favourable; (Figure 5.6, Table 5.5).

Figure 5.6: Lay out pattern, street layout and transit stop in micro context; From Left to Right; Case study-1; Newham Square, Case study-2; Chitra lane Housing, and Case study-3; Veluwanarama Road Housing
Source: GIS -UDA, 2015; Google maps, 2020

Table 5.4: Level of convenience for public transit in distance

	Case study-1 Newham Sq	**Case study 2 Chitra Ln**	**Case study 3 Veluwanarama Rd**
Walking distance to closest public transit stop	70-170m	300m	750-1200m
Walking time to closest public transit stop	1-2 minutes	4 minutes	8-15 minutes

Source: GIS-UDA, 2015, CAD based calculations, Personal observations, 2018-2019; https://www.google.com/maps/place/

Within the notion of connectivity, the community togetherness and coexistence of different cultural groups, encouragement of public life of the community with the public environment, and harmony in planning and engineering standards within the community lifestyle are observed as qualitative consequences of social sustainability. In physical facilitation of non-motorized transportation, walking and cycling has taken into consideration in the analysis of attributes and assessment on sustainability.

Availability of employment opportunities within the neighbourhood is a rare situation in these contexts. What could be achieved is to make provisions in proximity, and convenient accessibility. Overall, Case studies-1 and 2 are better facilitated in this respect, and the provisions are not satisfactory in Case study-3. However, upon consideration of the allocation of floor area for street land use and open space within the neighbourhood, it is observed to be minimized and the least in Case study-1, optimum in Case study-2 and excessively more in Case study-3 according to the benchmarks provided by UN Habitat (2011) as discussed under layout considerations. Accordingly, Case-2 is well nurtured in sustainability in street land usage, and both Cases-1 and 2 are fostered with excellent connectivity.

5.1.5 Housing, Building Typology and Architectural character

In the macro context, specifically considering an area of 1km radius, all three contexts have most middle rise buildings except a few buildings which are more than 6 stories. Comparatively, the height variation of buildings is more significant in the context of Case study-1, lesser in Case study-2, and minimized in Case study-3. Variation is clearly decreased from inner city to outer city areas; (Figure 5.7).

Figure 5.7: Pattern of Building height variation in macro context, in a 1km radius of neighbourhood area; From Left to Right; Case study-1; Newham Square, Case study-2; Chitra lane Housing, and Case study-3; Veluwanarama road Housing
Source: GIS-UDA, 2015

In all three neighbourhoods, each house has 100% of road frontage at least on one side, mostly on the entrance side. Case study-1 provides all individual or detached 2-3 storied houses, Case study-2 has all 4 storied flats and case study-3 is constituted with flats of 2-5 stories in height. Diversity of housing types is better offered in Case study-3, and all three neighbourhoods possess their own identifiable unique character; (refer Figure 5.8). In all three neighbourhoods, a few of the individual households have made changes to its facades. In the survey, it was revealed that the residents prefer to have a change on their own house façade, to have a special identity. Individualization of facades as renewals can be observed, in every case.

Most importantly, though with such changes and modifications, the collective identity of the neighbourhoods as a single residential component is still maintained. However, it is important to recognize that minor variations on facades, fenestrations, colours and textures etc. do not destroy or even harm the stamped unique identity of a neighbourhood if they are appropriately controlled with design and planning guidelines. This concept of customization in facades is commonly identifiable globally in developed country contexts, which has been considered as a key social requirement; (Figure 5.9).

Figure 5.8: Comparison on three neighbourhoods of own identifiable unique character: From Left to Right; Case study-1; Newham Square, Case study-2; Chitra Lane Housing, and Case study-3; Veluwanarama Road Housing

Figure 5.9: Own identifiable unique features, without harming the collective character. Residential neighbourhood from Ajax, East Toronto, Ontario

Though the households are owned by the residents, ratio of single ownership to residential floor area is less than 50% in all three neighbourhoods, as the average land usage for each residence is much less than the single household area. Originally, single storied houses are unavailable in any of the three neighbourhoods, and the utilization of the space within the footprint, can be identified as highly justifiable, in terms of land value. High built density and economic structural and services systems have been reached by using different strategies. In case study-1, it is achieved by minimizing the plot area, providing a limited road frontage, and limiting the building height. In case studies-2 and 3, the road frontages are wide, and building heights are increased. Yet, in case study-2 it is limited to 4 floors and case study-3 is provided with 2 and 5 floors. Internal planning arrangements are quite simple in all three, with optimum natural light and ventilation provisions and an open balcony to at least one side. Internal circulation within the buildings is always provided with an open corridor on one side.

None of the houses are provided with ease of vertical circulation except for the spacious, common staircases. Clearly, for 4 and 5 storied buildings in Cases-2 and 3, it is obligatory to provide a passenger lift, for senior residents, especially in older ages. However, the units are well functioning with safe staircases, viable in resource usage and economically maintainable. Data could be briefed comparatively as follows; (Table 5.5).

Table 5.5: Comparison of characteristic data

	Case study-1 Newham Square	**Case study-2 Chitra ln**	**Case study-3 Veluwanarama Rd**
Type of housing	individual or detached	flats	flats
Housing options	Single bed rm/converted to 2	Single-2 bedrooms	Single-2 bedrooms
Building type	2-3 storied	4 storied	2-5 storied
Provision of lift	Nil	Nil	Nil
Façade renewals-% (approx.)	35	10	5

Source; NHDA, 2019; Personal observations

5.1.6 Remarks on Comparative Assessment of Urban Form

In the comparative analysis of urban form, its constituent physical elements; density, land-use, layout, connectivity and transport infrastructure, and housing/building typology and architectural character, are revealed in detail, relatively to each other, based on the recorded information, further confirmed with point observations. Accordingly, following facts were reiterated.

a) **Density:** Though case study-1 physically appears as highly dense, case study-2 is the densest neighbourhood factually. case study-3 is relatively less dense and more spacious. Thus, the physical structure is much capable with resource demand. Hence, it is the most appealing with reference to density.

b) **Land-use:** In macro context, case study-1 shows a diverse land use distribution, but no educational activity. case study-2 is well balanced in all aspects in proximity, except for the nonexistence of industrial usage. Case study-3 has the least diversity including least proximal commercial usage. Focusing onto the neighbourhood area, case stduy-1 possesses a good balance in residential and commercial activities, but the least land usage is for roads and public spaces.

Case study-2 has a combination with commercial usage, whereas case study-3 provides only residential use.

c) **Layout:** All three layouts are quite simple, providing road frontages to every housing unit. They are well organized, carefully planned with promising connectivity within the neighbourhood itself.

d) **Connectivity and Transport infrastructure:** Total floor area for streets and internal circulation is least in case study-1, optimum in case study-2 and furthermore in case study-3. Connectivity to public transport is well achieved in case studies-1 and 2, whereas case study-3 demonstrated deficiencies in its successiveness.

e) **Housing, Building Typology and Architectural character:** Case study-1 has basically individual/detached houses; case sstudies-2 and 3 are residential flats. Single ownership to residential floor area ratio is minimum 0-50%, as every neighbourhood provides minimum of two or more layers of housing within a single footprint.

   Diversity of housing types is better provided in case studies-2 and 3, whereas in case study-1, residents have made the alterations. Architecturally, case study-1 appears vibrant, and case study-2 is bit monotonous, but concealing a busy urban setting. Case study-3 is highly residential, provided with shady landscaped frontages overall.

The contribution of each physical and non-physical attributes of urban form, towards a comprehension of the overall character of the neighbourhood is made clear. The comparison is mainly based on secondary information accumulated in the research study. The analysis is technically carried out with the data processed through various systems such as Geographical Information Systems, GIS based conversions of Computer Aided Design drawings and physical observations. This provides an inclusive record of comparison on the three case studies, which is documented in an organized technique, which has not been analyzed, compared, and recorded previously. The urban forms of each neighbourhood possess a unique overall expression relative to each other, due to the uniqueness of the variance of constituents.

In the next step of the research, divergence of human perception on each of these combinations towards sustainability is comparatively analyzed. Next sub chapter (5.2) carries a comparative analysis on the sustainability assessment based on the inhabitants' judgement, which are accumulated primary data in the research with the questionnaire based structured interviews. The analysis is conducted with the aid of SPSS statistical software platform.

5.2 Comparative Assessment of Sustainability

As per the methodology, the selection of three case studies from different development and zoning areas of Colombo, is deliberate. They are from inner, intermediate, and outer city limits to cover a whole cross section. Other than the sustainability assessment-based questionnaire carried out in individual neighbourhoods, in this chapter, they are comparatively analyzed, in relation to each other. The intention is to compare how, the similar elements of urban form, differently determine the residents' perception on sustainability, of the neighbourhood that they are living in; (Figure 5.10).

Figure 5.10: A brief visual comparison of neighbourhood contexts; From Left to Right-Case study-1; Newham Square, Case study-2; Chitra Ln., Case study-3; Veluvanarama Rd

The study draws stimulating insights on the overall expression and sustainability achieved in different urbanities with variations in their urban form. Analysis based on the three main parameters of sustainability are discussed over each individual neighbourhood; under Environmental Responsiveness, Social Attentiveness and Economic Viability. The analysis is conducted with the aid of SPSS, and the respective inferences are discussed under each parameter of sustainability with reference to determinant attributes of urban form in a comparative basis.

5.2.1 Environmental Responsiveness:

For residents to sense their living environment as appealing, the urban form of such a setting must accommodate the requirements to a considerable level. That level is investigated with reference to the components of urban form that are held responsible, specifically density, layouts, land-use, connectivity, and accessibility including relevant transportation modes (Vlek & Steg, 2007; Dempsey et al., 2010; Welches; 2010; City of Pickering, 2011; Teriman, 2012; APA, 2016).

Residents' desirability discovered in the interviews, are recorded based on the Likert scale as; 1-very poor, 2-poor, 3-moderate, 4-good, and 5-very good and analyzed under each case study in Chapter Four. They are carried forward here, and comparatively analyzed for a rating (Table 5.6). Since the standard deviation under each attribute of urban form lies under 0.55, the mean value can be considered as the central tendency; (refer Appendices S, T).

Table 5.6: Numerical comparison of environmental sustainability aspect with reference to corresponding attributes of urban form, derived in the descriptive analysis.
(Refer with Appendix-S)

Sustainability aspect	**Attribute of urban form**	**Newham Sq; Case study-1**			**Chitra Ln; Case study-2**			**Veluvanarama Rd; Case study-3**		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Environmental aspect of sustainability: (Physical Structure)	Density	4.11	4.78	4.34	4.44	5.00	4.95	5.00	5.00	5.00
	Layout	3.20	4.20	3.80	3.80	5.00	4.70	4.60	5.00	4.83
	Land Use	4.50	5.00	4.87	4.50	5.00	4.89	3.75	4.75	4.26
	Connectivity/ Transport.	4.86	5.00	4.93	4.86	5.00	4.98	3.14	4.43	3.86
Mean of Environmental Sustainability aspect		4.27	4.69	**4.48**	4.46	5.00	**4.88**	4.19	4.79	**4.49**

According to residents' perception recorded and analyzed, environmental responsiveness in terms of concerns about density, all case studies score above 4.00 at the Likert scale, rated as 'good', case studies-2 and 3 score above 4.95, at 'very good' rating. Comparatively, most desirable density conditions are convinced in case study-3. Reasons realized in the research analysis, based on points provided by the residents are taken into attention. People prefer a limited population density within the neighbourhood environment, at the same time; the residential density is expected to be optimum and proportionate to the population.

Overall, people appreciate the spaciousness of the neighbourhood, and the decisions on optimum density appropriate to the area concerned, are vital decisions depicting the urban living standard. This demonstrates contextual variances depending on behaviours and lifestyles of people in different urban localities.

With reference to layouts, case studies-3 and 2 are rated 'good', scored at 4.83 and 4.70, and case-1 is rated low. This demonstrates that appealing street network with pleasant streetscape, connected to open spaces, with sufficient natural light levels, tree plantation, and wind concerns are sensibly appreciated by inhabitants as sustainable. Case study-1 is necessitated with improvements, due to comparatively inadequate open space provisions and lesser concerns on tree plantation, natural light, and wind concerns.

The highest mean scores for land use concerns are obtained by case studies-1 and 2, rated at 4.87 and 4.89, closer to 'very good' level. That is due to the favourability of movement pattern within the neighbourhood, and distribution of land use appropriate with the public transportation network. Case study-3 is comparatively weaker in this context, rated at 3.80, due to the lack of mixed diversity in land uses. Especially the unavailability of commercial establishments and other communal facilities within the proximity is disadvantageous in its sustainability discerned by the inhabitants.

Connectivity and accessibility related to transport infrastructure is found to be a highly significant consideration of urban residents. Case studies-1 and 2 are well appreciated by residents, evaluated as 'very good', rated at 4.93 and 4.98. Case study-3 is rated low. Main reasons are implied to be the weaker adaptability of the neighbourhood environment towards public transit, inadequate street connectivity, lesser convenience levels of rout directions, and low rate of pedestrian accessibility and inadequate pedestrian network coverage. Hence, case study-3 is mostly dependent on private transportation modes, which is not very convincing as environmentally sustainable, though the density and layouts are highly favourable.

Looking at the overall picture of the three Case studies, the attributes of the urban form; Density, Layout, Land Use, Connectivity and Transport infrastructure (Dempsey et al., 2010) determine the inhabitants' perspective on the environmental aspects of neighbourhood sustainability. This detailed evaluation is important in understanding the exact view of the public towards the environmental sustainability of the neighbourhoods.

5.2.2 Social Attentiveness:

Social expectation towards a neighbourhood remains on a well-balanced coexistence of social mix, leading to a sustainable community with social equity (Dempsey et al., 2012; Hamiduddin, 2015). Associated secondary aspects including social capital, social inclusion, safety, and residential stability bind the concept stronger. Assessment is carried out with reference to layouts, land-use, connectivity, and architectural character as socially responsive components of the neighbourhood form (Cullen, 1996; Dempsey et al., 2010; Welches, 2010; City of Pickering, 2011; Teriman, 2012; RTPI, 2015; APA, 2016; Sarachaga, 2018); (Table 5.7).

Table 5.7: Numerical comparison of social sustainability aspect; with reference to corresponding attributes of urban form, derived in the descriptive analysis.
(Refer with Appendix-S)

Sustainabi -lity aspect	**Attribute of urban form**	**Newham Sq. Case study-1**			**Chitra Ln. Case study-2**			**Veluvanarama Rd. Case study-3**		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Social aspect of sustainabil-ity (Social Goals)	Layout	3.33	5.00	4.38	3.83	5.00	**4.81**	3.83	5.00	4.57
	Land Use	2.00	4.00	3.23	4.00	5.00	**4.49**	3.00	5.00	3.83
	Connectivity/ Transport	3.40	5.00	4.29	3.60	5.00	**4.31**	3.60	4.80	4.19
	Architectural Character	3.83	5.00	4.58	4.17	5.00	**4.78**	3.83	5.00	4.60
Mean of Social Sustainability aspect		3.14	4.75	**4.12**	3.90	5.00	**4.60**	3.57	4.95	**4.29**

In a comparison, all three neighbourhoods are expressed as 'good', and rated above 4.00 in the Likert scale. But a detailed analysis on the responses to the questionnaire, it proves that the case neighbourhood-1 is comparatively low successive in providing convenient living and movement within the neighbourhod than the other two. The main concern is the convenience level for elderly people to live and move.

The setting in the case study-1 is recognized as safe, but the neighbourhood space outside the homes is considered too strict in the layouts. At the same time, case study-3 demonstrates the lack of convenient access to public facilities including schools, public transportation, recreational areas, health, and emergency services, whereas case studies-2 and 3 confirm distinction, with case study-2 at a higher rating.

Regarding the land-use distribution, both case studies-1 and 3 express low appeal, rated as 'moderate'. It demonstrates their insufficiency of dedicated facilities such as childcare, community centers, public libraries, skills development facilities in the proximity. Case study-1 is specifically lacking in provision of open spaces. Case study-2 is undoubtedly highly appealing, rated at 4.49, evaluated as 'good' as it provides such facilities in proximity, grounded on intriguing location.

Within the concept of connectivity, the physical facilitation of public transit, non-motorized transportation; walking and cycling are taken into consideration in the assessment. Accordingly, uniqueness is best demonstrated in case study-2. The circumstances in case study-1is evaluated as 'good'. The case study-3 is observed as comparatively least successful in achieving it. The main reason is the distance to the closest public transit stop and the time taken to walk. Second reason is the quality of pedestrian environment up to the transit stop.

Inhabitants' sense on architectural character as a social dynamic is comparative in certain respects. Diversity and variety of housing quality is not accepted as favourable, particularly in Case study-1. Due to it lasting for a very long time without an upgrade, this situation may have occurred. However, residents in some of the units have made their own interior as well as exterior quality uplifting, which were observed as positive modifications in the setting, protecting the striking overall character. Case studies-1, 2 and 3 demonstrate a clearer social acceptance of their architectural character yet show minor modifications for individual identity on facades.

This detailed evaluation on the social attentiveness of the neighbourhoods demonstrates the contribution of attributes of urban form; Layout, Land Use, Connectivity/ Transport infrastructure and Architectural Character (Dempsey et al., 2010; 2011) on the social sustainability of the neighbourhoods. More importantly, it demonstrates that the sustainability is recognized by the inhabitants by the respective attributes of their urban form. They intuitively realize the sustainability based on neighbourhood form that they experience in living.

5.2.3: Economic Viability:

Economic standing of an urban neighbourhood recounts the financing of infra-structure facilities; transport and services concerning the residents, accommodating its resourceful functioning. This aspect is assessed in this study, based on the responsiveness of elements; layout and land-use that led to viable monetary achievement, appropriate with inhabitants' lifestyles (Dempsey et al., 2010; Welches, 2010; City of Pickering, 2011; Teriman,, 2012; RTPI, 2015; APA, 2016; Sarachaga, 2018;); (Table 5.8).

Table 5.8: Numerical comparison of economic sustainability aspect; with reference to corresponding attributes of urban form, derived in the descriptive analysis
(refer with Appendix-S)

Sustainability aspect	**Attribute of urban form**	**Newham Sq. Case-1**			**Chitra Ln. Case-2**			**Veluvanarama Rd. Case-3**		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Economic aspect of sustainability (Living Standards)	Layout	3.75	5.00	4.22	4.00	5.00	4.39	3.75	4.75	4.20
	Land Use	3.33	5.00	4.28	3.33	5.00	4.15	3.00	4.33	3.69
Mean of Economic Sustainability aspect		3.54	5.00	**4.25**	3.67	5.00	**4.27**	3.38	4.54	**3.94**

In layout planning, case study-3 shows less attention to acceptability and convenience of physical connectivity, accessibility to the immediate context, and provision of commercial establishments within the proximity. Case studies-1 and 2 are highly valued in that sense. But in the provision of diversity of housing types and affordability of housing options, case studies-2 and 3, score the highest, as they provide a better variety of options, with flexibility in customization of interior layouts.

Availability of employment opportunities within the neighbourhood is a rare situation in these contexts, but what could be achieved is that to make provisions in proximity, or convenient to access. Overall, case studies-1 and 2 are better facilitated with this respect, and in case study-3 the provisions are not satisfactory.

In the evaluation of economic aspect of sustainability, affordable living, housing options and prices, land value, and close-by facilities, employment, and business activities are assessed. Being an outer city neighbourhood, case study-3 is less advantageous and least successful in sustainability as per the inhabitants' experience. Reasons are clear in the analysis, that some of the attributes of its urban form are less responsive to fundamental requisites of economic viability of the neighbourhood.

5.2.4 Remarks on Comparative Assessment of Sustainability

The main and important intention of the comparative analysis of sustainability assessment on human experience in the research is, to frame the attributes of Urban Form determining the Sustainability of selected neibourhoods as cross contextual urban prototypes in Colombo.

The research on the analysis of urban form identifies the components of urban form in all three neighbourhoods, with reference to their role in resulting sustainable distinctiveness, for its' inhabitants and users to sense them as excellent, good, reasonable, or bad neighborhoods. It facilitates the transfiguration of the structure of urban form; its' physical and non-physical elements, configuration, and composition, into progressive or deleterious features of neighbourhood sustainability (Bertolini, 2005; Hine et al., 2012). It attempts to evoke neighbourhoods as a sensation, for peoples' satisfaction or otherwise (Savasdisara 1988; Lynch, 1960; Gehl, 2010). It shows that the relative desirability demonstrated by inhabitants, indirectly towards the level of sustainability, depends on the differences of the attributes of different urban forms.

5.3 Analysis on attributes of Urban Form determining Sustainability

It is established in the study, that the uniqueness of sustainability of a neighbourhood as sensed by the inhabitants is the judgment on appropriateness of urban form. Its physical and non-physical attributes are the responsible determinant factors in general, which manipulate the resulting appeal (Dempsey et al., 2010; Kotharkar, 2014). This is a remarkable, true to the life finding of the research, in which a clear realization of the link between urban form and specifically the sustainability of neighbourhoods is provoked.

The fact is further elaborated and discussed in detail here, under comparison of sustainability assessment as against Urban Form, followed by Sustainability rating among three case studies. It emphasizes the implication of attributes on relative placement of neighbourhoods in the city. Finally, it raises concluding perspectives on requisites of Exemplary Urban Form for Sustainable Neighbourhoods, remarking on the transfiguration of urban form into Neighbourhood sustainability.

5.3.1 Comparison of Sustainability Assessment as against Urban Form:

In this implementation, it is necessary to understand the relative representation of sustainability appeal enacted by the similar components or attributes of urban form, but in different capacities and aptitudes. Contributory aspects of the attributes of urban form in this rating are concluded as follows.

- Environmental parameters: Physical environment; Physical structure, functional qualities and resource demand resulted by density, layout, land-use, connectivity, and transport infrastructure.
- Social parameters: Social satisfaction with goals, social life, social diversity, social-mix, social equity (inter/intra-generational), security, safety resulted by layout, land-use, connectivity, and transport infrastructure, building typology and architectural character.
- Economic parameters: Affordable living, housing options and prices, land value, close-by facilities and employment, business activities resulted by; layout, land-use.

Findings of research on the above parameters in each case study can be graphically shown in the form of a comparison as follows (see Figure 5.11). The rating on inhabitants' desirability (Y- axis) is shown as against the attributes of form within the sustainability parameters (X- axis).

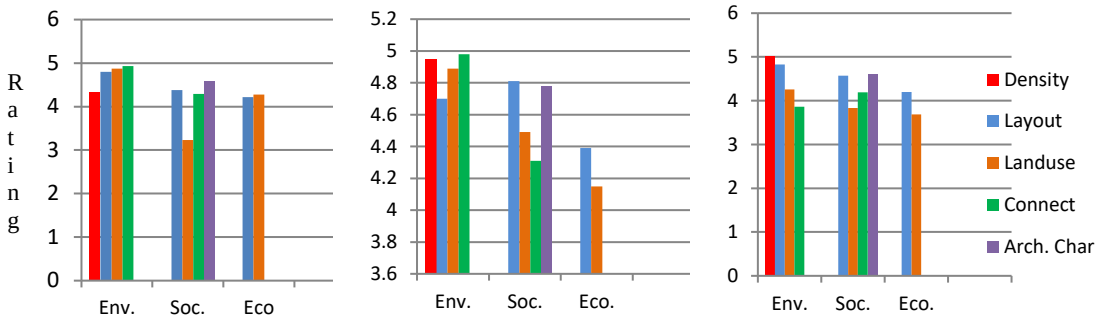


Figure 5.11: Comparison on three neighbourhoods on sustainability assessment, based on the Likert scale (Y-axis), with reference to (attributes of) urban form (X-axis); From Left to Right; Case study-1; Newham Square, Case study-2; Chitra Ln., and Case study -3; Veluwanarama Rd.

Grounded on the urban form, and its attributes, level of appeal in inhabitants' perception indicates strong variations as follows.

- Within the environmental responsiveness, density effects (in red) the human appeal, resulting case study-1 being at the lowest level, and case study-3 at the top. Layouts (in blue) in all cases are almost equally acceptable. Land-use (in brown) is best in practice in both case studies-1 and 2, whereas case study-3 indicates a lesser appeal. Connectivity (in green) is best offered in case studies-2 and 1, lesser in case study-3.
- From the concerns on social attentiveness, layouts (in blue) are equally acceptable in all case neighbourhoods. Achievements in land-use concerns (in brown) are weaker in case study-1 than in case studies-2 and 3. Connectivity (in green) and architectural characters (in purple) are almost equally favourable in all case studies.
- On the economic viability concerns, the layouts (in blue) are highly acceptable in all case neighbourhoods, and case study-3 indicates a lesser appeal in land-use attributes (in brown).

Concurrently, it is identified that the layouts are accepted as favourable in all three sustainability parameters, as they are well planned within the neighbourhood as one urban living entity. Land-use as an attribute is a significant environmental, social as well as an economic concern affecting human appeal. Density is mainly concerned with sufficient housing density appropriate to living population.

Connectivity holds a high level of consideration in both environmental and social parameters, and is indirectly supportive to house and land value, promoting aspects of the economic parameter. Architectural character is also a strong feature in social aspect, where people expect a glimpse of uniqueness, attractiveness, and individuality of their dwelling within the context.

5.3.2 Sustainability rating:

Based on the processed data, it is thought-provoking to launch a recommendation of relative rating on the three neighbourhoods based on the inhabitants' perception as denoted in the analysis of research data. The intention of this exercise is, to comprehend the relative variance of the influence of elements or attiributes of urban form on effective sensation of desirability in varied urbanities. It graphically presents; how the similar attributes of urban form determine varying sustainability characteristics in different physical settings, comparative to each other.

Also it demonstrates the relative sustainability level of each neighbourhood. The most important contemplation is that, these represent the human experience; the inhabitants' judgement on their living environment. It satisfies varying demands of its inhabitants (Lynch, 1960), and offers the zest for life (Gehl, 2010). They are supposed to be reasonable inputs in supporting sustainability principles (Howley, 2009). At the same time, these judgements can be considered as unambiguous and reasonable, in author's deep observations during long diurnal stays in and around the neighbourhoods within the durations of obtaining primary information. Based on the processed data collected in the research, the overall highest rating on the sustainability as assessed by the inhabitants, is determined in case study-2; Chitra lane (in green), second is case study-1; Newham Square (in red) and third is case study-3; Veluwanarama road (in blue).

In the framework of the questionnaire for sustainability assessment, each question aims at a set of determinant attributes of urban form, focusing a sustainability parameter with reference to Appendix-A and briefing on comparison is as follows; (Figure 5.12)

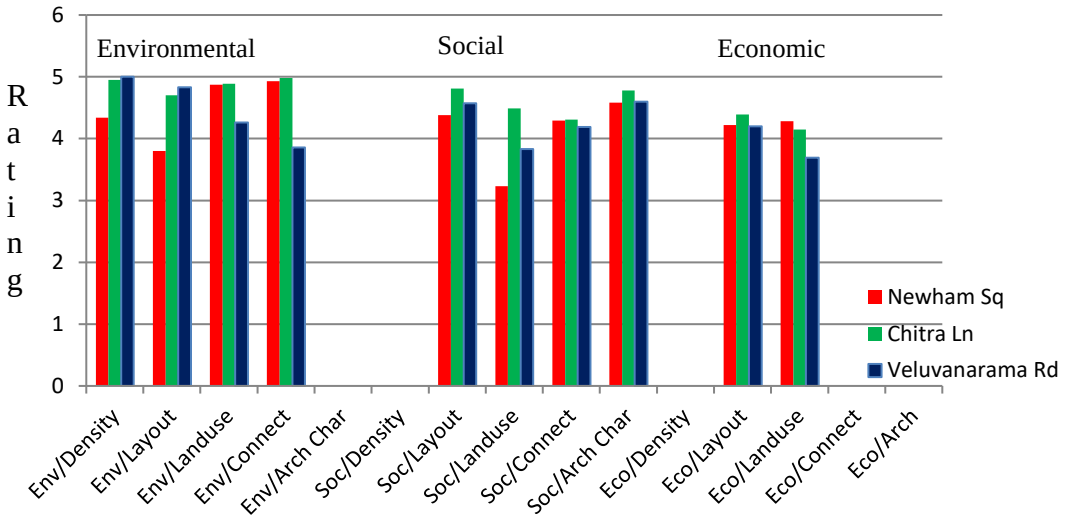
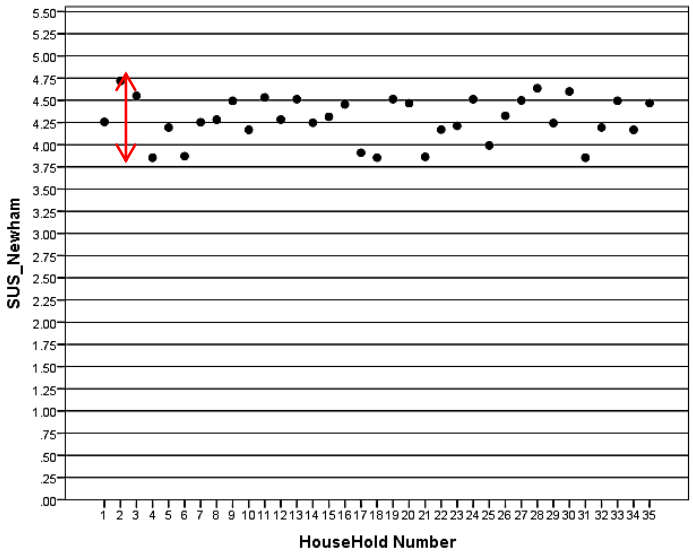


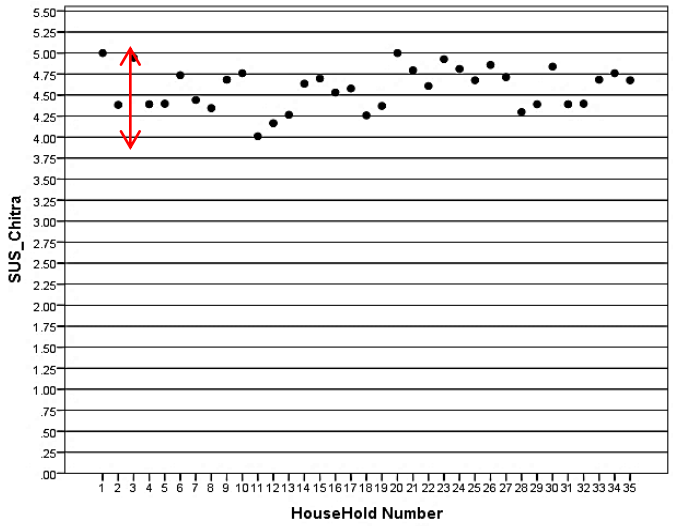
Figure 5.12: Rating on three neighbourhoods on sustainability assessment; Sustainability rating in Y-axis and attribute of form in X-axis:

In a comprehensive analysis performed by using SPSS, the inhabitants' rating of overall sustainably could be numerically verified as presented in figures below; (Figure 5.13, 5.14, 5.15).



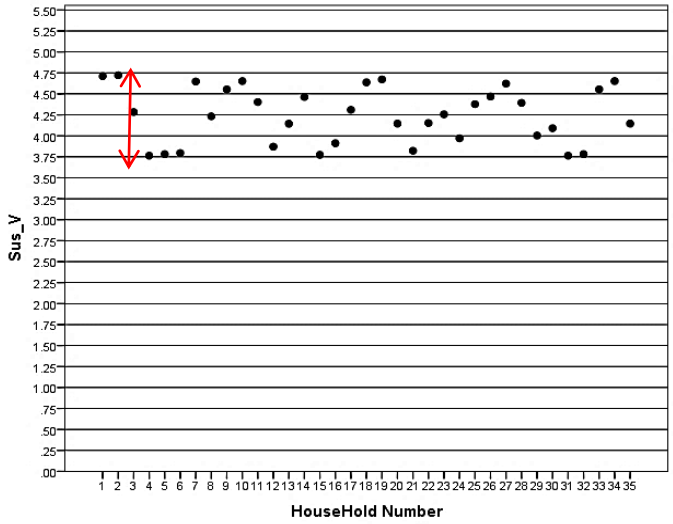
Min: 3.85
Maximum: 4.72
Mean: 4.28

Figure 5.13: Indication of sustainability level in Newham square neighbourhood/Case study-1; varies in between 3.85-4.72 (mean value)



Min: 4.01
Maximum: 5.00
Mean: 4.58

Figure 5.14: Indication of sustainability level in Chitra Lane neighbourhoood/Case study-2; varies in between 4.01-5.00 (mean value)



Min: 3.76
Maximum: 4.72
Mean: 4.24

Figure 5.15: Indication of sustainability level in Veluwanarama Rd neighbourhood/Case study-3; varies in between 3.76-4.72 (mean value)

It demonstrates the range in 'mean' rating of appeal from 1-5 in the 5 level Likert scale for questionnaire in a total 35 numbered households. Accordingly, overall sustainability rating for case study-1 lies in between 3.85-4.72 with a 'mean' 4.28, case study-2 is 4.01-5.00 with a 'mean' 4.58 and case study-3 is 3.76-4.72 with a 'mean' 4.24. The mean numerical figure for overall score of sustainability in each case neighbourhood is as specified in Table 5.9 and 5.10.

Accordingly, it is evident that, in the assessment of overall sustainability, case study-2 is at the highest rating level, case study-1 is found at second level and case study-3 at third level. This could be used to generate a systematized assessment on the exact facets of sustainability that the residents are more conscious about; (refer Appendix H, L, and Q). Considering the analysis on standard deviation, the measure of variability can be disregarded as negligible, and the mean values are considered as mean rating value for samples.

Table 5.9: Numerical comparison on assessment of sustainability aspects of three case neighbourhoods

Sustainability Aspect		**Environmental aspect**	**Social aspect**	**Economic aspect**
	N	**Mean**	**Mean**	**Mean**
Newham Square; Case-1	35	4.4872	4.1179	4.2488
Chitra Ln; Case-2	35	4.8785	4.5988	4.2726
Veluwanarama Rd; Case-3	35	4.4899	4.2986	3.9429

Table 5.10: Overall Sustainability score of three case neighbourhoods

Neighbourhood	**N**	**Overall Minimum**	**Overall Maximum**	**Overall Mean**	**Standard Deviation**
Newham Sq; Case-1	35	3.85	4.72	**4.2846**	0.25052
Chitra Ln; Case-2	35	4.01	5.00	**4.5833**	0.25019
Veluwanarama Rd; Case-3	35	3.76	4.72	**4.2438**	0.33092

The system is used to make an assessment on each neighbourhood, based on inhabitants' experience, in which the elemental framework of urban form is clearly assessed. Remarks on the sustainability distinctiveness as per the judgments by residents are reviewed with reference to the determinant attributes of urban form below; (refer Tables 5.11, 5.12 & 5.13). Residents' judgement on sustainability as against the attributes of urban forms are remarked under each sustainability parameter. Hence, each sustainability aspect is assessed with refernce to attributes of urban form as follows.

Environmental aspect: Density, Land use, Layout, Connectivity/Transport

Social Aspect: Layout, Land-use, Connectivity/Transport, Building Typology/ Architectural Character

Economic Aspect: Layout, Land-use

Table 5.11; Sustainability distinctiveness of case studies with reference to the determinant attribute of urban form within Environmental parameters

Sustainability parameter	**Determinant Attribute of Urban Form**	**Observations on distinctiveness in sustainability** (Note: 'Case' denotes the 'Case study')
Environmental	Density	Conditions are highly desirable in case-3, least in case-1 and in case-2 it is in-between. All three neighbourhoods are rated as 'good'.
	Layout	Internal layouts of neighbourhoods are most desirable in Case-3, least in case-1 and in case-2 it is in-between. Both cases-2 and 3 are rated as 'good' and case-1 is 'moderate'.
	Land-use	Land-use diversity is highly favourable in case-1, in case-2 it is in-between and in case-3 it is least favourable. All are rated as 'good', as they are all connected to diverse land uses within a 1 km. radius.
	Connectivity/ Transport infrastructure	Case-1 and 2 are highly desirable and rated closer to 'very good'. Case-3 has a weak stand and rated in between 'good' and 'moderated'.

Within the Environmental parameters, it is realized that cases-1 and 2 are recognized by the inhabitants, as being more environmentally responsive than the case-3, though its density and layout conditions are highly favourable. Spaciousness of the neighbourhood with more breathing space is favoured against closely packed, dense circumstances. Similar to the density concerns, optimally spacious layouts are preferred where standard amount of floor space is allocated for roads and communal spaces. Land use diversity in and around the nighbourhoods is important in urban settings within cities. This facilitates all day-to-day activities of residents of all age groups.

However, excessively left empty land spaces are not recognized by inhabitants as social spaces. Case study-3 is a reasonable example, that has more open areas comparative to the cases-1 and 2. But, they have not been designed for inhabitants to utilize them. Thus, land use diversity, connectivity and transport infrastructure have become more significant concerns, over the density and layout concerns of urban residents. Public transit-oriented neighbourhoods are better functioning in urban contexts. Proximity to transit stops, with convenient accessibility is indispensable.

Table 5.12; Sustainability distinctiveness of case studies with reference to the determinant attribute of urban form within Social parameters

Sustainability parameter	**Determinant Attribute of Urban Form**	**Observations on distinctiveness in sustainability** (Note: 'Case' denotes the 'Case study')
Social	Layout	In the consideration of social compassion, layout of case-2 is highly desirable, that of case-3 is in between and the case-1 has the least preference. Yet all three cases are rated as 'good'.
	Land-use	Social concerns on land use are optimally appreciated in case-2, and cases-1 and 3 are indicated with lower rating.
	Connectivity/ Transport infrastructure	In terms of social satisfaction on connectivity, case-2 is the most desired, case-1 is in 'between, and Case-3 is least concerned, yet all are rated as 'good'.
	Building typology/ Architectural character	Social concerns related to building types and character are recognized well in case-2, and slightly lower rated in case-3 and case-1is the lowest rated comparatively. Yet all are rated in between 'very good' and 'good'.

Overall, Social parameters are best recognized in case-2, and in cases-1 and 3 they are almost equally rated. In the comparison of urban forms, cases-1 and 3 demonstrate clear differences. Though, case-1 appears to be having the most diverse land-use, it does not have the best social acceptance. Rather, case-2 is recognized the best, with having diverse land-use within the proximity, though not within the neighbourhood.

The determinant attributes need a careful balance in their configuration to portray a dignified character for the facilitation of social goals of living in an urban neighbourhood. Though spacious layouts are preferred by urban residents, a clear limit is appreciated. A standard balance between built and non-built areas is intuitively recognized by inhabitants. Peoples' or social concern is not the highest mix of land uses. They identify the most suitable or appropriate land use mixes that are 'necessary' for their daily life functions. The physical connectivity is a fundamental social requirement in a neighbourhood as an urban living setting. It shows several other concerns focusing the overall quality of expression in access road network. People recognize and appreciate the overall characteristic identity of their neighbourhood, yet a reservation for slight modifications to reach an individual identity is favoured.

Table 5.13; Sustainability distinctiveness of case studies with reference to the determinant attribute of urban form within Economic parameters

Sustainability parameter	**Determinant Attribute of Urban Form**	**Remarks on distinctiveness in sustainability** (Note: 'Case' denotes the 'Case study')
Economic	Layout	Case-2 has the highest preference, and cases-1 and 3 are almost equal and at a slight lower rating than that of case-2. All cases are rated 'good'.
	Land-use	Case-1 is the highest preferrable, case-2 is in between, and both cases are rated 'good'. Case-3 is the least and is at a low rating as 'moderated'.

Economic parameters are responsive to most of the attributes of urban form collectively, out of which layout and land use is primarily important as in a real estate valuation. Thus, the essential land uses in the proximity and resourceful layouts are primarily important in successful neighbourhood planning and design. Convenience of connectivity and balance in house prices and their affordability is an important concern of the residents.

Mixed land use makes urban life convenient and vibrant. It adds value to peoples' urban quality of life at all ages. This makes the neighbourhoods preferable to residents of all age groups. This does not indicate that the attributes other than the layout and land-use of the urban form do not contribute to the economic sustainability of a neighbourhood.

5.3.3 Implication of attributes on relative placement of the neighbourhood

The case neighbourhoods were deliberately selected from three (03) different urban localities; inner city area (concentrated development zone), middle city area (mix development zone) and outer city area (Primary residential zone) within the Colombo Municipality. As per the preliminary and comparative analysis on the assessment of sustainability as against the determinant attributes of urban form, the statistics can be descriptively analyzed and briefed as follows based on relative placement of the neighbourhood; (refer Table 5.15).

Table 5.14: Analysis on implications of attributes on relative placement of the neighbourhood within the city

Case-study Neighbourhood	**Newham Sq. Case study-1**	**Chitra Ln. Case study-2**	**Veluvanarama Rd. Case study-3**
Location with reference to city	Inner city area	Intermediate city area	Outer city area
Development zone	Concentrated development	Mix development	Primary residential
Density	Highly dense, tightly packed, hence human desirability is at a lesser value comparatively.	Highly dense, but not tightly packed, hence human desirability is at a higher level.	Less dense, not very compacted, hence human desirability is at a very high level.
Layout	Internal layout is highly compact, desirability level is low. But social interaction is high. Elderly citizens can move around safely, conveniently.	Compaction is optimized in layouts. Highly dense, spacious. Built space utilization is optimized. Social interaction is higher.	Not compacted, spacious with wide un-built spaces. But low level of social interaction, though more communal spaces are available.
Land-use	Highest land-use diversity. Most preferable. Land use diversity is available within the neighbourhood and within proximity too.	Clear land-use diversity is identified in proximity. Optimally appreciated. Land-use diversity is available in proximity.	Land-use diversity is minimized. Least preferable. Land-use diversity is not available within proximity.
Connectivity and transportation infrastructure	Highly desirable. Well connected to public transit, and pedestrian coverage is high.	Highly desirable. Well connected to public transit, and pedestrian coverage is high.	Least desirable. Not well connected to public transit, and pedestrian coverage is low. Linkages not attractive.
Building type and Architectural Character	Overall character and identity in the neighbourhood are well recognized and appreciated. It has become a striking neighbourhood in the urbanity. Yet reservations for slight modifications to reach and individual identity is favoured	Overall character and identity are well recognized as a contemporary urban neighbourhood. Reservations for modifications in expressing individual identity is yet preferred.	Overall character is maintained as an urban neighbourhood in an outer city area. More provisions are offered in individual identity.

Accordingly, it is necessary to examine the effect of each attribute on the aspects of sustainability of each neighborhood, and their effectiveness on the overall sustainability. For this purpose, the sustainability rating against each attribute is comparatively analyzed with the analysis of frequencies in descriptive statistics. The comparison is numerically tabulated and graphically presented below (Table 5.15, Figure 5.16).

Table 5.15: Effect of attributes on desirability, based on varying city locations; Inner, Intermediate, and outer city limits

Attribute of urban form	**Sustainability aspect**	**Newham Sq. Case study-1** (Inner-city)			**Chitra Ln. Case study-2** (Intermediate city)			**Veluvanarama Rd. Case study-3** (Outer city)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Density	Environmental	4.11	4.78	**4.34**	4.44	5.00	**4.95**	5.00	5.00	**5.00**
Land Use	Environmental	4.86	4.00	4.87	4.50	5.00	4.88	3.75	5.00	4.26
	Social	2.00	4.00	3.23	4.00	5.00	4.49	3.00	5.00	3.83
	Economic	3.33	5.00	4.28	3.33	5.00	4.15	3.00	4.33	3.69
	Average overall	2.44	4.33	**3.58**	3.78	5.00	**4.38**	3.00	4.78	**3.78**
Layout	Environmental	3.20	4.20	3.80	3.80	5.00	4.70	4.60	5.00	4.83
	Social	3.33	5.00	4.38	3.83	5.00	4.81	3.83	5.00	4.57
	Economic	3.75	5.00	4.22	4.00	5.00	4.39	3.75	4.75	4.20
	Average overall	3.43	4.73	**3.88**	3.88	5.00	**4.63**	4.06	4.92	**4.53**
Connectivity	Environmental	4.86	5.00	4.93	4.86	5.00	4.98	3.14	4.43	3.86
	Social	3.40	5.00	4.29	3.60	5.00	4.31	3.60	4.80	4.19
	Average overall	4.13	5.00	**4.61**	3.73	5.00	**4.65**	3.37	4.62	**4.03**
Arch. Character	Social	3.83	5.00	4.58	4.17	5.00	4.78	3.83	5.00	4.60
	Average overall	3.83	5.00	**4.28**	4.17	5.00	**4.58**	3.83	5.00	**4.24**

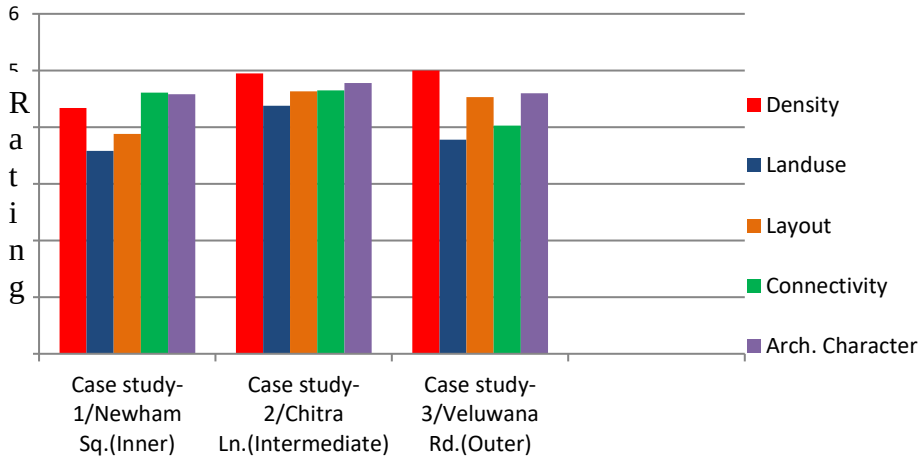


Figure 5.16: Effect of attributes based on relative placement; From left; Inner, Intermediate, and outer city limits; Sustainability rating in X-axis, attributes of form in each case study in Y-axis.

Physically identifiable attributes are briefly assessed in a comparative manner on the subject of study. Each attribute of urban form is identified in a different system of units unique to itself, however, they are presented together in order to recognize the relative disparities irrespective of the measured unit; (Table 5.16). To recognize the relative disparity of sustainability appeal with the attributes of urban form, all figures are concluded in a single graph; (Figure 5.17).

Table 5.16; Comparison on attributes of urban form; numerically analyzed

	Attribute of urban form & unit measured	**Case-1 Newham Sq**	**Case-2 Chitra Ln**	**Case-3 Veluwana Rd**
Density	D1-Population/hectare	600	800	550
	D2-Residencess/hectare	125	200	128
	D3-Built area- %	85	35	38
Land-use	Residential-%	70	35	28
	Commercial-%	14	2	0
	Roads/public-%	14	60	78
	Other-%	2	5	0
Layout	Total Street area –Square meter	14	45	48
	Public streets area- Square meter	8	25	28
	Private streets area- Square meter	6	20	20
Connectivity	Travel distance to bus stop-meters	70-170	300	750-1200
	Travel time to bus stop-minutes	1-2	4	8-15

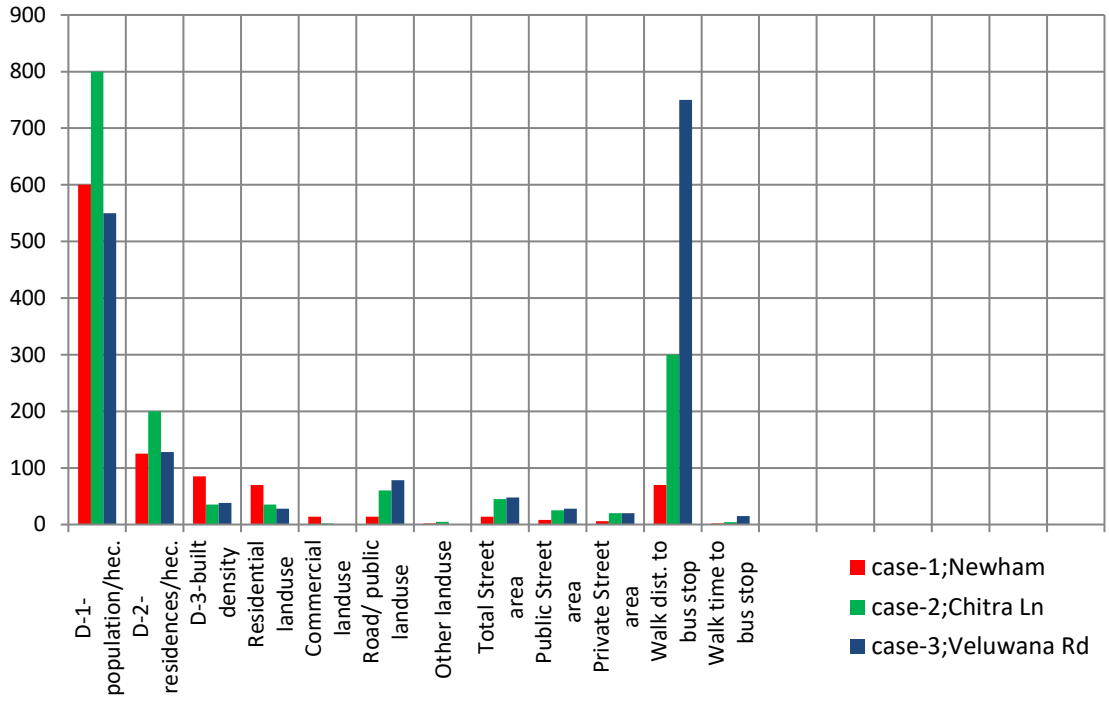


Figure 5.17: Pattern of attributes of urban form in three case neighbourhoods

In the above tabula and graphical presentations, the comparable measures of the attributes are clear. The sustainability score changes over the above measures comparatively of each neighbourhood. Thus, the sustainability score of the case neighbourhoods is evaluated against the attributes identified in respective urban form. The major findings of the research study on Neighbourhood Sustainability are laid out under attributes of Urban Form with the discussion on inferences below.

5.3 4 Major Findings of the Research and Inferences

Conferring to the overall sustainability score originated in data analysis by SPSS, the highest score is obtained by Case study-2; Chitra Lane, second is Case study-1; Newham Square, and third is Case study-3; Veluwanarama road. The pattern or the variation of their attributes are shown in Green, Red and Blue respectively in figure 5.17 above. It indicates that the concerns about density are highly important in the sustainability aspect. Accordingly, case study-3 that has a population density appropriate for the residential density and spacious layouts, is highly appreciated in the sustainability score with reference to density.

The concerns on connectivity such as distance and walking time to the closest public transit and commercial establishments, overrides the high-density factor, in case studies-1 and 2, keeping them high in residents' appeal. Open areas allocated for public use is also recognized as a central concern for urban residents. In this aspect the case study-1 demonstrates a low appeal of inhabitants, though the location in terms of land use and connectivity is appreciated. Diversified land uses within the neighbourhood or in immediate context including commercial uses are primary concerns, so that the case studies-1 and 2 are appealed high. Accordingly, major findings of the research with the revelations on appeal of sustainability under each attribute of form and inferences are discussed in detail below.

5.3.4.1 Density

The analysis of the research reveals that the density figures are different on the urban form depending on the relative placement of urban locality. In the study it was analyzed mainly in three directives; resident (population) density, residential (housing) density and built area density. In the perspective of inhabitants, the inner-city neighbourhoods show up more issues due to high density than in intermediate city neighbourhoods. Outer city neighbourhoods are free of similar issues.

This means at the very first instance, that the human desirability or the appeal on the living setting varies depending on the density factor. Inner city neighbourhoods are highly dense, tightly packed, and human desirability is at a lesser rating comparatively.

Neighbourhoods in intermediate city area are highly dense, but not tightly packed, and human desirability is at a higher level than in inner city areas. Neighbourhoods in outer city zones are less dense, not very compacted, and human desirability is at a very high level. Thus, highly dense, and highly compacted settings are less desirable for living and spaciousness within a neighbourhood to a certain extent is appreciated as sustainable by the inhabitants.

The inference of this finding is that the density and the consequent compactness of a neighbourhood has an impact on the human desirability or the appealing towards it in the real living situation. At the same time, the concentrated living settings result convenient functioning of the neighbourhoods in terms of service provisions and resource efficiency (Jabareen, 2011; UN-Habitat, 2011).

Highly dense neighbourhoods in inner city and intermediate city areas are accepted as preferable and sustainable by the urban residents due to convenience of concentrated services and amenities. For example, the case study-2 with the highest density is rated overall as the most appealed in the research. Hence, the high density is accepted as desirable in urban neighbourhoods, and essentially, the residential density is expected to be optimum, proportionate to the population. Overall, in the concerns of density, people appreciate spaciousness of the neighbourhood, so that the decisions on optimum density appropriate for the area concerned, is a vital decision which depicts their urban living standard. Therefore, in any of these urban settings, the high residential density appropriate with resident population density must be achieved. This holds an important bearing on provision of services and amenities, a proper balance in built and unbuilt areas.

Even in a pandemic situation the concentrated and appropriately dense situations in the neighbourhoods, has made it convenient for the provision of services and commodities. Health and safety precautions and measures are convenient to be supplied adequate, as revealed by post- research discussions carried out with residents, by the author. It is essential to limit the density at appropriate levels with provisions of services and land.

Hence it is argued that a sustainable neighbourhood essentially should have high density of residences, but the compactness must be appropriate with the population density. The provision of services and amenities must be given attention appropriately. These are highly commendable concerns in residential settings, specifically in these urban contexts. Land value and legally allowable floor area ratios are important factors to consider in decision making.

Thus, in a generalization, the requisites recognized in the research for a high rated sustainable neighbourhood can be contended as follows.

- Sufficient residential (housing) density with the resident (population) density appropriate with provisions of services and amenities. This should be predicted for a considerable time span.
- Correct built density; well-balanced built and un-built areas.
- Provision of infrastructure facilities tallying with the resource demand and resource efficiency.
- Well-administered solid waste management system.
- Well-designed storm water management system.

The integration of above requisites in the form of a neighbourhood in design stages ensure the sustainability of such neighbourhood in terms of its density factor. Appropriately supported density as a fundamental attribute of the urban form of any neighbourhood would nurture its sustainability. Thereby, the inhabitants would enjoy the benefits of being in an appealing, efficient, and conveniently functioning living setting.

5.3.4.2 Layout

It is revealed in the analysis that the layout of inner-city neighbourhoods is comparatively less desirable than the intermediate and outer city neighbourhoods. Also, neighbourhoods from intermediate city areas are higher in desirability than in outer city areas. Though with more open and unbuilt areas within the neighbourhood, the outer city neighbourhood became lesser desired.

This means that the spaciousness of the neighbourhood layout is well recognized, experienced, and appreciated by its residents. But excessive undesignated open areas are not considered as acceptable additions to the neighbourhood. The neighbourhood layouts with well designated functional, built, and unbuilt areas are well used and highly appreciated by the urban resident.

The inference of the finding is that well designed, comprehensive neighbourhood layouts are efficient in functioning and high in human desirability. In the study, the intermediate city neighbourhood demonstrated the highest human desirability being a well-designed layout. Appealing street network and layout with a pleasant streetscape, connected to open spaces, with sufficient natural light levels, tree plantation, and wind concerns are sensibly appreciated specifically in case studies-2 and 3. However, mere spacious layouts in case study-3, do not provide socially interactive spaces. The desirable limits are to be met for appealing and sustainable designs. Convenience level for people of all ages, including elderly people to live and move is to be given attention in any urban locality.

Spacious layouts are desired, but especially in inner-city contexts, within concentrated development, it is not practical. But the overall desirability is not much affected by that as it succeeds with several other factors. Specifically, in the case studies from intermediate and inner-city areas, layouts are encouraging more social interactions, though not spacious. With the narrow street setting, they create both socially and visually interactive atmosphere. Thus, tight layouts with narrow, versatile street settings can be sustainable and appealing feature in neighbourhoods in highly urbanized areas.

Hence, in a generalization, the study argues that a sustainable neighbourhood should have the emphasis on its layout with designated functional areas (Engle-Yan, 2005; Rashid, 2017). Those include convenient, safe, and secured walking areas on streets that are well connected, compact, and mixed proximal facilities. It should have a thorough balance in built and un-built areas, providing essential physical and social needs.

Accordingly, in a generalization, the requisites on the urban form for sustainable neighbourhoods can be sorted as follows:

- Space allocations for roads; public/private, enabling cycling, walking.
- Traffic calming precautions on vehicular roads, enabling safe street setting even for small kids.
- Open space provisions in proximity as recreation and play areas, and for social interaction.
- Crime prevention measures, providing safe neighbourhood space.
- Light levels on roads, and road safety during day and night.
- Tree plantation, wind concerns, natural light, and ventilation provisions.
- Convenience for the older community to live and move.
- Convenient access to public facilities; schools and childcare, public transport, commercial establishments, recreation, health, community, emergency services, places of worship.

The importance of integrating above requisites in the form of a neighbourhood has to be concerned at the stages of designating areas for neighbourhoods in urban context. Ensuring sustainability of urban neighbourhood in terms of the layouts are the duties of design professionals.

Appropriately designed layouts as a fundamental attribute of the urban form of any neighbourhood enables fittingness to the existing urban setting. That would encourage the sustainability of any urban neighbourhood. The inhabitants would then enjoy the advantages of living and working in a well-functioning, well connected living setting.

5.3.4.3 Land-use

The analysis revealed that the inner and intermediate city neighbourhoods possess the land use diversity within the neighbourhood or within the close proximity. Neighbourhoods in both placements possess high desirability of their inhabitants. Outer city neighbourhoods are differentiated. They have the least diversity of land uses within the neighbourhood or contains only residential usage as in the selected third case study.

This means the inner and outer city neighbourhoods are effortlessly highly desired by the residents and sustainable in that aspect. Close by commercial facilities are essential expectations of the residents. The outer city neighbourhoods are lacking in that facilitation, and not convenient for the residents.

The inference of this finding is that the neighbourhoods lacking with diverse land use including commercial establishments are not accepted as sustainable by the inhabitants. Diversity in land use is a feature in higher rated residential neighbourhoods. Specifically, when the fact is not possible within the neighbourhood setting, proximal locations are highly important within walking distance. This will make the urban life convenient, by making the setting adaptable to public transit, walking and bicycling.

This is a significant concern in designation of the site for a neighbourhood, especially in primary residential areas. Inner and Intermediate city areas, specifically from concentrated development and mixed development zones in the study, effortlessly fulfill the requirement. But in these locations, the designs must be cautious in the provision of open and recreational spaces for residents in proximity.

Concerns in outer city areas, in primary residential zones, the situation is slightly different, as the land use diversity is minimized. The most critical concern is the availability of commercial establishments and community facilities. If not within the neighbourhood, they are to be available in the proximity, within convenient, walking distances. Pleasing and vibrant street settings are important provisions to be considered to promote walkability and social interaction.

Hence it is argued in the study that a sustainable neigbouhood should have land use diversity that provides several activity options. This is achieved by combining a series of appropriate, well-matching and essential land uses and activities close by, within reasonable distances. Apart from that, it generally states as attempts to generate local employment, enriching a better local economy, but this is not practical within every neighbourhood development, especially in urban contexts.

Thus, the concerns could be within the immediate macro contexts. It encourages walking and cycling, decreases car dependency, diminishes disintegration of landscape and impervious surfaces, and provides public services in proximity and inter-active communities (Dehghanmongabadi, 2014).

In a generalization, the main requisites on the urban form of any neighbourhood confessing sustainability can be identified as follows:

- Functional distribution of land uses within neighbourhood.
- Mix diversity of uses, essentially commercial use, within the immediate context.
- Appropriate movement and interaction pattern within different uses.
- Appropriate distribution of land-use with transportation patterns.
- Existence of impervious surfaces and green areas encouraging walkability.
- Pleasing access streets connecting the setting with the immediate context.

The application of above requisites in the form of a neighbourhood, is fundamentally important for sustainability. This can be achieved within the neighbouhood design or in the close proximity enabling walking. Hence, this has to be considered at the stages of designating areas for residential neiighbourhoods.

Thus, this is a fundamental requirement specifically in planning residential neighbourhoods in primary residential zones. When the neighbourhoods are isolated with only residential usage, they are not convenient for residents, thus creates dependency on vehicles to reach the day-to-day functions. Appropriately supported, matching land uses as a significant attribute of the urban form of any neighbourhood would foster its sustainability.

5.3.4.4 Connectivity, Transport infrastructure

The analysis revealed that connectivity and transportation infrastructure has made inner and outer city neighbourhoods much more convenient and highly desired by the residents. The outer city neighbourhoods are least in desirability in this context, as they are not that well connected with the transportation network. Also, the distance and walking time to closest transportation nodes are lengthier.

This means that the inner and intermediate city neighbourhoods are well connected to the transportation network and conveniently accessible. They are well adapted to the public transportation, as the walking distance and time are within convenient limits.

The inference of this finding is that the neighbourhoods are to be well connected to the transportation network for them to be convenient in functioning. Neighbourhoods in isolation, are low in human desirability. Also, the connections to the closest main roads are to be pleasing and attractive to promote walkability.

Adaptability of the neighbourhood environment towards public transit, adequate street connectivity, convenience levels of rout directions, and convenient and pleasant pedestrian accessibility and adequate pedestrian network coverage are indispensable concerns which enhance the sustenance of a neighbourhood. This fact is primarily important in locating neighbourhoods in different urban localities, and specifically to be given priority in primary residential areas.

Hence it is argued that a sustainable neighbourhood should have a focus on the mobility dimension. Connectivity, linkage, and transportation infrastructure are essential components of a convenient urban living to promote sustainability (Kamble & Bhadure, 2019). Characteristics such as walkable, pedestrian friendly streets, efficient public transportation with interconnected street hierarchy, route directions, appropriate pedestrian coverage and adequate parking are important impacts in this concern.

In a generalization, essential requisites of an urban form of a sustainable neighborhood can be asserted as follows:

- Adaptability to public transit/pedestrians/cyclists.
- Appropriate and adequate street connectivity within the context.
- Convenient rout directions.
- Convenient and pleasant street environment.
- Adequate pedestrian accessibilities and pedestrian network coverage.
- Convenient, systematic, and well-maintained public transport structure.

The integration of above requisites in the form of a neighbourhood has to be concerned at the stages of designating areas for neighbourhoods in urban context. Implementing sustainability of an urban neighbourhood in terms of its connectivity and transport infra structure are fundamental duties of planning professionals. Convenient level of connectivity with appropriate transportation network as a fundamental attribute of the urban form of any neighbourhood enables physical linking to the existing urban setting. That would promote sustainability of any urban neighbourhood for its inhabitants to experience it as a well-functioning, well-connected living setting.

5.3.4.5 Building types and Architectural character

In the analysis it is revealed that the inner, intermediate, and outer city neighbourhoods are almost equally rated and well appreciated by the inhabitants. However, the inner-city neighbourhood does not contain much housing type options, whereas the intermediate and outer city neighbourhoods demonstrates that availability.

This means that the intermediate and outer city neighbiurhoods are better in providing options in housing type, size, and quality. This also means they provide housing affordability options than the inner-city neighbourhood.

The inference of this finding is that in this context, the intermediate and outer city neighbourhoods are sustainable than the inner-city neighbourhoods. Provision of housing options in size, type and quality has made neighbouhoods more versatile in social and economic aspects. The overall character of the neighbourhood is important, but within that, an individual identity of the house is remarked.

There is no vast difference in any urban setting in the study with the residents' appeal on the architectural character, as long as individuality is offered to a certain extent. Collective identity is admired in any neighbourhood, and it has a bearing in sustainability with a glimpse of individuality. This has become a hard achievement in inner city areas but achieved optionally in intermediate and outer city areas to a certain extent.

Hence the argument in the study is that a sustainable neighbourhood should demonstrate a variety of housing options and unique architectural character (Dempsey et al., 2010). They are qualitatively recognized and could only be described, hence not technically measured. However, they perform a special role in dignifying a neighbourhhood as a place with quality, promoting a sense of place for people. Uniqueness of a neighbourhood as the homely setting would make inhabitants attached to the locality. This indirectly makes people love and protect the neighbourly setting, individually and collectively. The overall character of the neighbourhood is the important and remarkable facet, regardless of the minor variations of every façade or interior.

The essential requisites in a generalization can de suggested as follows:

- Provision of diversity and variety of housing type, size, and quality.
- Provision of diversity of affordability.
- Expression of individuality.
- Expression of stronger communal identity.
- Development of sense of place.
- Facilitation of culturally and socially diverse communities.
- Impressing on human experience of a good living.

It can be generalized that the concerns of people on their urban living, have no differences dependent on the relative placements within the city. Every urban neighbourhood is expected to be performed with convenient functioning for a good quality of living. To achieve this specific target, the residents' requirements are to be met with the urban form of the neighbourhood (Howley, 2009; Gehl, 2010). Those are rich and sustainable neighbourhoods.

Yet in our urban housing context, the design of neighbourhoods is not thoroughly concerned specifically with, those aspects. Basically, neighbourhoods in any context are given the same concerns prioritizing the need of quantified urban housing, not the qualitative urban living requirements.

Urban housing and consequential urban neighbourhoods should possess a key responsibility to fulfill the fundamental requirements of a quality urban living. Now it is high time to think of the requisites of an exemplary urban form for quality of urban neighbourhoods, depending on relative placement in the city.

5.3.5 Final Remarks; Transfiguration of Urban Form into Neighbourhood Sustainability:

Sustainability as a central concern in neighbourhood design especially in urban settings within Colombo and its suburbs should be properly identified the concerns of sustainable way of living and quality of urban living. It is globally accepted that the neighbourhood is a key planning unit that possesses a great potential for creating sustainable cities (Al-Hagla, 2008; Choguill, 2008; Tan et al., 2015). Certification systems for neighbourhood developments were lounged to support and formalize the agenda. As exposed in the literature review, several systems were developed and established to inspect the sustainability gauge of neighbourhood development projects (EPA, 2006; Nguyen & Altan, 2011; Berardi, 2013; Sharifi & Murayama, 2015). They are recognized as tools, suitable to evaluate varying contexts. LEED-ND has been used in several countries (Sharifi & Murayama, 2014), focusing on promoting the development of sustainable urban environments.

This research particularly revealed and underlined the measurable standards that is collectively used to identify a development or proposed development as sustainable under the categories of credits in LEED-ND. Accordingly, the selected urban neighbourhoods are evaluated in terms of its environmental and functional superiority, with reference to the physical and non-physical attributes of urban form. The attributes are, density, land use, layout, connectivity, and transportation infrastructure, and building types and architectural character.

The same attributes can be related to the main three categories of credits revealed in the LEED-ND. They are deliberated, focusing on the main concerns of a neighborhood development and are universal concerns.

1. Smart Location and Linkage-‘where to build’:
2. Neighbourhood pattern and design-‘what to build’:
3. Green infrastructure and buildings-‘how to manage environmental impacts’:

Within the research, identification of the sustainability features recognized in the case studies, and relevant deterministic attributes of urban form are indicative with first two categories of credits in LEED-ND, as follows.

1. Smart location and linkage: Land-use, layout, connectivity, and transportation.
2. Neighbourhood pattern and design: Layout, density, building type and architectural character.

Under Green infrastructure of buildings, efficient green practices in design, construction, and maintenance in the long run, focusing to buildings are focused. A Rating System for this has been considered for, by Green Building Council Sri Lanka (GBCSL) founded in 2009. This rating system is specifically for existing buildings. It is a set of performance standards that are used to certify the operations and maintenance of any form of commercial, institutional, and residential buildings of all sizes, both public and private (srilankagbc, 2020). The objective is to promote efficient, healthy, durable, and affordable, environmentally sound practices in existing buildings, and it encourages implementing sustainable practices and reducing the negative environmental impacts of the building over its operational lifespan.

Considering sustainable neighbourhood development, green building and infrastructure is only a part of it. Despite individual building rating, neighbourhood developments are also to be considered with a formal rating system native to Sri Lankan context, for which the research findings will be fundamentally important. Not only in rating the existing developments, but also in proposing new developments, from the initiation, inclusive with the selection of sites and locations, the facts raised are to be strictly considered. They can be considered as recommendations for design neighbourhoods in urban context. Further they could be developed as ‘design guidelines for neighbourhood development’.

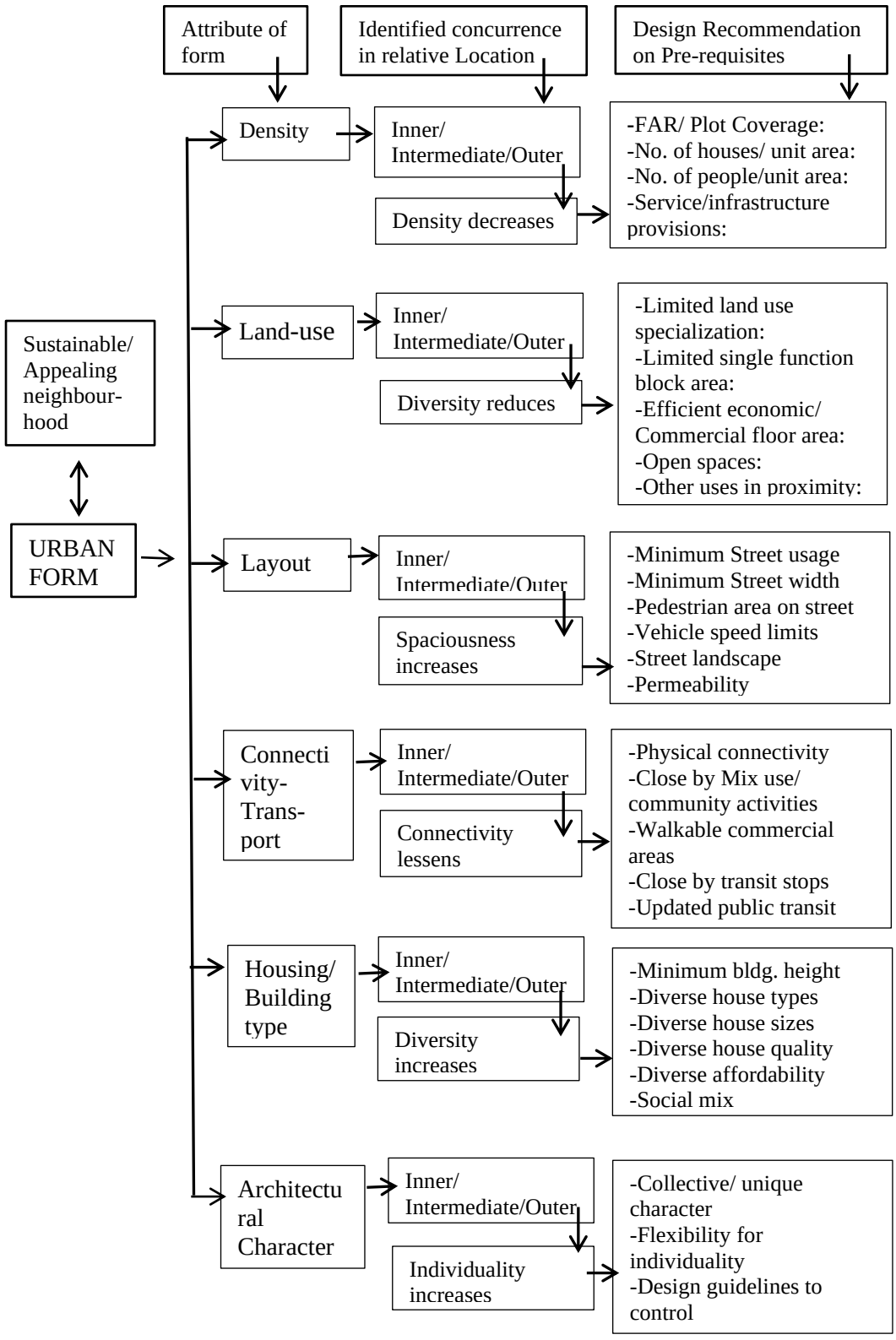


Figure 5.18: Final Remarks on Transfiguration of attributes of Urban Form into Neighbourhood Sustainability

The final remarks of the study are deliberate on the influence of the transfiguration of physical and non-physical attributes of urban form into neighbourhood sustainability. It reiterates the influence of urban form in the concept of sustainability, which has been a long discussion. More importantly, it confirms that each physical and non-physical attribute of urban form has a role to play in creating sustainable neighbourhoods. That differs based on the conditions in the locality in which the development is taken place. In detail, the research demonstrates the commitment of each attribute of urban form in fostering sustainability. It identifies their concurrence with relative location in the city and it discusses recommendations as prerequisites of the urban form for sustainable neighbohoods as final annotations (Figure 5.18).

CHAPTER 6: CONCLUSIONS AND IMPLICATIONS

This chapter, first, provides a summary of the overall research study inclusive of the problem area, objectives, findings, and inferences. The second segment precedes with a discussion on the implications of the research, in terms of its theoretical foundations, focusing into its practical aspects; generalizing and elucidating a broad interpretation of the research, followed by the epilogue in the third segment. Lastly, it recalls the limitations of the research, raising the concerns and recommendations for possibilities of further research extensions. Further predictable studies sprouting out of the findings and remarks highlighted in this research too are suggested.

6.1 Summary of the overall research study

The research problem lies with the urban form and the resulting neighbourhood sustainablity as perceived by the inhabitants. The intention of the study is to formulate the deterministic attributes of urban form for sustainable neighbourhoods. This was split into a sequential set of objectives. The study identifies the attributes of urban form by analyzing three case neighbourhoods. They are three significant planned residential neighbourhoods from varying zones; inner, intermediate, and outer city areas in Colombo Municipal limits. The study examines their respective distinctiveness of sustainability as experienced by their inhabitants. Inhabitants' judgement is considered as a reasonable adjudication on the sustainability.

Overall findings of the research were processed both in a preliminary analysis as well as a comparative analysis. The preliminary analysis, studies, examines, and records mainly on two originations. The first concerns studying, analyzing, and recording the urban form of case neighbourhoods. This was studied with reference to the relative location of the city; inner, intermediate, and outer city areas with the use of secondary data.

The second is revealing the residents' appeal on the three neighbourhoods in terms of its environmental, social, and economic sustainability parameters.

It identified the attributes of urban form in terms of the resulting sustainable character or appeal, under each parameter as sensed by the inhabitants. This was administered by the questionnaire survey and how the inhabitants rated their living setting using the Likert scale. The Likert scale was used to quantify the qualitative personal experience, of the inhabitants in the selected case neighbourhods. The sustainability rating was driven with a technical analysis of primary data, on inhabitants' perspective obtained, where the result was substantiated with reference to the attributes of urban forms.

Following the analysis of urban form, and the primary data on the human appeal towards sustainability, the three neighbourhoods were comparatively analyzed in terms of urban form and sustainability. Further, the implication of those attributes in achieving suitability was comparatively analyzed. This brought the research to an analysis of attributes of urban form that determines sustainability of the respective neighbourhood. It further brings out an insight to a comparison on assessment of sustainability, as against the urban form.

As the final objective, the deterministic attributes of urban form for sustainability were identified as major requisites of 'sustainable urban form'. In concluding major findings of the research, an important inference on the verified clear link of attributes of urban form on the stamped uniqueness of sustainability in neighbourhoods was made in an overview. The inhabitants' experience on the expression of their neighbourhood setting, is the collective contribution of varying attributes of urban form. Same attributes in different urbanities make a clear distinction on their expression with varying configurations, and consequently, make deviances on inhabitants' experience on sustainability. This fact is made clear in the research with a discussion on major findings, meanings, inferences and concluding remarks on sustainability under each attribute. It is graphically shown in the Figure 5.18.

It is proven, that with the changes in urban form along with the specific urban locality, the level or the rating of desirability of inhabitants varies.

It identifies the role that the attributes of urban form play, in the resulting distinctiveness or uniqueness of sustainability, for its' inhabitants and users to rate their living setting at varying rating levels. It reveals the fact that the transformation of urban form; its' physical and non-physical attributes, configuration, and composition, into neighbourhood features, is the challenge that promotes sustainable neighbourhoods for peoples' satisfaction.

Further, it reiterates the internationally acclaimed neighbourhood rating systems, specifically LEED-ND, and tallies with its categories of credits into research outcome. Specifically, the first two main categories of credits; 'Smart location and linkage' (SLL), and 'Neighbourhood Pattern and Design' (NPD) are evaluated under the elements of urban form in achieving sustainability in the following manner.

- Smart location and linkage (SLL): Land-use, layout, connectivity, and transportation.
- Neighbourhood Pattern and Design (NPD): Layout, density, building type and architectural character.

Third category; Green infrastructure and buildings (GIB) is not materially considered in the research particularly, as its focus is on efficient green practices in design, resourceful construction, and maintenance of buildings. This has become an interest and ratifying ratings on building performance standards by the Green Building Council, of Sri Lanka. However, the rating of neighbourhood development has a broader perspective than concentration on rating, and efficiency of individual building units. Alongside this, it is found that neighbourhood developments are to be assessed with a formal rating system inherent to the Sri Lankan urban context.

Findings of this research will be fundamentally important in generating a formalized rating criterion for the existing neighbourhood developments. More importantly, it can be used to form design guidelines to be used in initiating new developments, from the selection of sites and locations.

6.2 Implications of the research; connotations and application in practice

Urban form is identified as the spatial formation or the configuration of physical elements of any urban entity, city, or neighbourhood (Dempsey et al., 2010). This study aims at researching on the urban form of neighbourhoods, recognized as a combination of several attributes such as density, street lay-out, land-use pattern, linkage and connectivity, housing, and other building characteristics (Jenks, 2010; Kotharkar, 2014). These attributes; physical and non-physical, collectively contribute to achieving an identity, or a distinctiveness to the neighbourhood as; sustainable, simply 'great' or otherwise. Concisely, the sustainability of a neighbouhood, perceived by people, is persistently, the physical intervention of its' urban form. Neighbourhoods as the constituents of cities, play a significant role by manifesting the achievement of sustainability, in its physical formation for inhabitants' discernment.

Despite the whims and ways of the academic culture, case-based reasoning was applied in this study, and accepted as a persistent practice of investigation, as specific in social sciences, humanities, and moral thinking (Ruzzene, 2015). The inhabitants' experience interrelates with behavior, and therefore, they are closely related to the physical environment that they live in (Lynch, 1960; Gehl, 2010; Rau & Fahy, 2013). Similarly, scholarly arguments, which conduct careful, rigorous social studies, are helpful for design scholars to imagine on how the built environments shape our society (Freeman, 2001). Ultimately this knowledge can be used when generalized, to succeed in making more livable, sustainable neighbourhoods.

Therefore, theoretically, case studies are considered as past socio-cultural narratives, which encompass prevailing contextualized problems. As such, this research study allows an in-depth analysis of specific urban settings, interpretation, and discussion, resulting in specific recommendations for improving existing conditions. The rationale for selecting the case studies was deliberately cross-contextual in the study.

Resulting analysis of findings allowed a clear comparison of physical structure of the urban form and ensured sustainability appeal for inhabitants. In the final evaluation of the findings of the case studies, a series of recommendations were originated, and

supported by solid evidence. They directly lead the conclusions of the research towards better situations for neighbourhoods with reference to their physical formation, which is the important revelation for implementation.

Accordingly, the study finally validates that the physical manifestation of neighbourhood sustainability is determined by the attributes of urban form. The study finally investigates on the use of those findings to generate fundamentals of an exemplary neighbourhood form, which update policy making in the real physical and social realm of sustainable neighbourhood development. Accordingly, the implications of findings of the research and relevant conclusions are stated below, under each attribute of urban form.

6.2.1 Density

It is depicted in the research that the density measures are critical in any inner-city neighbourhood, in all its facets such as population, residential, and built area. Evidently, that is one of the major drives to push residents away from the city core areas. Neighbourhoods in outer city areas, experience lesser densities, with ample natural light, and ventilation conditions in spaciousness. Intermediate regions of the cities are much denser than outer-city areas, but less dense than inner cities. Higher densities enable infrastructure and provision of services both economic and convenient. People prefer and tend to choose less dense areas as the living atmosphere.

However, the vibrance in urban living relates to a particular level of high density, which adds the vitality, resource efficiency and mixed activities to the setting. Hence, the prerequisite on density differs based on the relative location of the urbanity. Therefore, it is necessary to limit the densification of neighbourhood developments specifically in urban areas closer to city cores.

This density limit varies in the urban areas, from the city centers towards the intermediate and outer areas. These limits can be worked out based on the land areas occupied by the neighbourhood, towards a specific number of housing units per unit

area, in different development zones in the city. The numbers are to be appropriate with the available provision of infrastructure, services, and amenities. This can be an added detailed information for real estate developers, investors and specially designers to adhere onto, other than buildable floor area ratio (FAR) and plot coverage ratios. This will be enabling to achieve the limitations in density within inner and intermediate city areas, and to economize and improve energy efficacy in outer city areas.

6.2.2 Land-use

Diversity in land-use with connecting appropriate functions is a known feature of neighbourhood sustainability. It creates a vibrant urban atmosphere, by reducing travel distance, car dependency, energy usage, and consequently contributing to clean environments. Further, it encourages walkability and results in better level of social interactions of urban vitality.

Corresponding the study, neighbourhoods located in outer city or primary residential areas are generally lack in functions other than residential. The needs of day-today living activities raise the necessity of travelling for considerably long distances, resulting in car dependency. Also, people tend to look for other means to resolve the issues of travelling. Further, the study reveals the importance of the locations of commercial establishments, banking, schools, childcare facilities, community activities, and religious places etc. within the neighbourhood or within the proximity, in walking distance. Residents must fulfill the requirement of living related activities close-by to feel convenience, towards a better quality of life. This is a main fact in designation of sites for, and design of neighbourhoods for long term sustenance.

6.2.3 Layout

Urban neighbourhood layouts are to be permeable. Through traffic is to be avoided for convenience and safety. It influences pedestrian movement and connects different places and spaces with each other (Rashid, 2017). This aspect is fundamental in any of the location of a city or a town, for a secured and a safe neighbourhood. Even within the public, semipublic or private roads, traffic calming precautions are to be

exercised making the neighbourhoods more walkable, versatile, vibrant, and safe; enabling not only kids, but domestic pets also such as dogs and cats to stay and move about within the neighbourhood without fear.

The study reveals that in the outer city or in primary residential areas, the internal roads within neighbourhoods are wider and more spacious, whereas they are narrower in neighbourhoods closer to inner cities. However, both situations may have positive features of attraction for inhabitants. Wider streets in primary residential areas provide sufficient shoulders for pedestrians and cyclists while enabling shady and attractive walking space along with even benches for seating. They can provide roadside parking quite conveniently. Narrow streets in inner city neighbourhods are more socially interactive with better intimacy. Thus, layout is a fundamental attribute in the form that determines the type of permeability, connectivity, and intimacy within the different areas of the neighbourhood. Residents find it convenient and comfortable with well-designed and user-friendly layouts. Therefor the consideration should not only be to provide the highest possible built densities, but also to provide sufficient enough area for streets with concern for openness and landscape.

6.2.4 Connectivity and Transportation infrastructure

It is internationally acclaimed that transit-oriented locations provide a crucial opportunity in addressing affordability (Stewart & Pereboom, 2020). There is no denial that planning on transit must pay attention to automobiles, but certainly this should not marginalize the city dwellers as pedestrians (Dayaratne, 2011).

It is proven in this research that public transit-oriented locations nourished with walkability and land use diversity facilitated with several other activities within the proximity are more desirable for sustainable urban living. Specific to this study, inner city and intermediate city areas offer the aforementioned aspects and are realized as more desirable than that of outer city areas in that sense. The outer city neighbouhoods that are lack in close by public transit options are less desired by inhabitants, though they are richer in density and layout concerns.

Thus, it is the responsibility of the policy makers to fulfill aforementioned requirements before designating sites for residential neighbourhoods. These aspects can be thoroughly evaluated during the stages of preliminary planning clearances on neighbourhood developments. In designing residential neighbourhoods in outer city or primary residential zones, these aspects are to be thoroughly considered. It is to be reiterated that residential activity within any neighbourhood is not sustained without other functions or the land uses in proximity and sufficient connectivity, though the density and layouts are highly appealing.

6.2.5 Housing, Building type and Architectural character

Though the function of residential neighbourhoods is mainly housing, building types may slightly differ in varying urbanities within a city or a town. Standing on the floor area ratio (FAR), or the buildable area ratio, the maximum allowable heights are varied in different urban settings. However, the common fact is that the prioritized function is residential. Whatever other functions may have to be supportive to the urban residential ambience.

Diversity of housing types often increases social inclusion for vulnerable groups. This is an indispensable consideration in uplifting standards of urban living for all in developing sustainable neighbourhoods (Dempsey et al., 2012; Hamiduddin, 2015). The study reveals that particularly in the inner-city neighbourhoods the housing types are strictly limited and tight in both external and internal space planning. Outer city areas are better in providing a diversity of housing types, sizes, and quality.

These facts intuitively induce diversity in affordability in such neighbourhoods. Intermediate city areas are much more compromising in those aspects, providing limited options in housing types and sizes. Diversity in the types of buildings do create versatility, minimizing the monotony within the urban locality. A set of similar buildings would destroy the individuality of houses, which is an important social facet in a sustainable neighbourhood.

Residents prefer having an individual identity on the facades specially to express their sense of belongingness. Provision for that reservation is important as realized in the research. However, strict design guidelines are to be initiated to control the uniqueness of the character in the urban fabric.

It is evident in the study, that the standard living requirements of an urban resident does not bear significant variances depending on the relative placement of the urban locality. What varies is the urban form according to the place which makes it differently appealing for the people in their living setting. However, though the requisites are the same, the way that the designers could achieve sustainability, ought to follow different strategies unique to the locality.

Concisely, achieving sustainability in inner and intermediate city neighbourhoods are crucial in density and layout concerns. They are sustainable in connectivity, transport infrastructure and accessibility to services, amenities, and mixed land uses. Outer city neighbourhoods are to be thoroughly concerned with their connectivity, and transport infrastructure for sustainability. Convenient accessibility to services, amenities, and different land uses, especially close by commercial establishments are fundamental. They are more favourable in density and layout concerns. Building types and architectural characters are to be equally concerned in neighbourhood design in any of the locality for better attraction and to maintain the quality of the urban atmosphere.

The study proposes that, parallel to the application of identified requisites into the physical settings of the neighbourhoods, a standard minimum living quality for urban dwellers could be designated. Similar to the planning and building regulations enforced on habitable interiors of buildings, neighbourhood forms are to be regulated with planning regulations in land allocation and subdivision approvals. Propagation of strict design guidelines for subdivisions and planned neighbourhood developments are to be encouraged, essentially with pre-requisites of urban form for appealing urban neighbourhoods as a national policy whilst discouraging the concept of piecemeal developments within any urban context.

With the knowledge gained in the study, it is suggestive that even the piecemeal residential developments should be designed upon prerequisite conditions. Apart from the planning and building regulations, strict design guidelines are to be initiated as a national policy. For example:

- Constraints on individual parapet walls and fencing, separating the housing from the street, would create an appealing intimate space in between. That would create safer and more secure street space for children and women.
- Reservations on street lines and building lines could be resourcefully used to enhance the quality, safety, and attractiveness of the neighbourhoods.
- Master plans can be worked out for different urban localities to control and regulate the development under the authority of the relevant local government.
- Width of road frontages of individual plots can be formalized, enabling a specific character to be maintained. The provision of services to the properties be made equalized.
- Strict design guidelines for different urbanities in local contexts are to be formulated to enhance and maintain a character unique to the area. This does not mean that the creative façade designs are discouraged. Maintaining a unified quality or the character of the urban locality must be the intension.

By initiating such proposals, all individual houses too could be integrated into a pre-planned urban setting for all residential zones, similar to the planned neighbourhoods.

Development of a country is strongly represented by the raised living standards of the people. Sustainable cities are consequences of sustainable neighbourhoods. Enforcing neighbourhood sustainability is inevitable in creating sustainable cities. This must be taken into consideration by the design and planning related professionals as well as policy making state bodies. Policies in the national context are to be earnestly considerate, both in improving the conditions of current urban living, and in the future neighbourhood development planning proposals in physical development of the built environment.

6.3 Reflections on Current Planning strategies and Recommendations

Based on the research output, it is recommended that considerations be offered with the insights in designing neighbourhoods for sustainable cities. The integration of recommendations into the development process is to be performed strategically. Firstly, by means of appropriately developing regulatory measures and secondly, by the provision of incentives.

With consideration in the Sri Lankan context, the most commonly used strategy is the application of regulations, that is planning and building regulations (CCDP, 2018). There, the preliminary planning clearance is the initial screening of the process, prior to formal approval of the detailed proposal. Neighbourhood design review is considered as one the most effective strategies in other parts of the world, implemented with multidisciplinary involvements considering sustainability. In this situation, the neighbourhood development proposals are to be specifically concerned with the location, in terms of accessibility, connectivity, proximity to commercial establishments and community activities, public transportation, and open spaces.

Open space provision is shown notable consideration in the current planning regulations, and developments are governed with a 10% provision for open spaces from the total development area in subdivisions. The requirement is regulated as the provision of open space within 0.5 kilometers radius either internally within the development or externally, outside. These requirements are to be administered and monitored with precision in the implementation process.

In terms of layout, access roads to residential units are governed with minimum widths and maximum lengths, and maximum number of plots that are accessible. This may incorporate deviations with the number of housing units served, specifically in consideration of the residential developments. The reason being that a single plot can have more than a single household or units. Nonetheless this should be administered by controlling the number of housing units allowable in each plot based on the requirements of accessibility in layout.

The density of residential developments in terms of either population or housing is not specifically governed by the current planning regulations. The building categories in general are specified in terms of height. Maximum number of floors, plot coverage, open spaces are strictly governed by regulations (CCDP, 2018). However, for residential developments, a specific set of concerns on residential density; population and residential unit density may have to be incorporated. Further, this is to be considered with the provision of infrastructure services and community facilities available within the urban setting, or else enhancements necessary with the development area should be regulated.

In terms of public participation, development proposals are exhibited to the public on notice board displays for 30 days, if the authorities perceive that the proposed development causes an adverse outcome. Authority considers the public view, and may direct to alter the development proposal, impose conditions, or restrains in the approval. However, development activities are to be proposed based on the need of the public so as to fulfill the real-life requirement. Therefore, public opinion should be obtained prior to making the decision to initiate the development. This can offer many benefits to the citizens, and it could be integrated into the country's development process resourcefully, as it addresses the real needs and demands of the city.

planned development can be an incentive. The real estate developers can be motivated by the local governments to envisage on comprehensive neighbourhood developments inclusive with the fundamental requirements such as schools, commercial establishments, close by public transits, community facilities, open spaces, and recreational facilities etc. This can be integrated into the development process parallel with other development programs in the country, in the broader context. The system can be linked with the urban sprawl as a solution to the housing problem and land scarcity, and at the same time, achieve the aim of improving the quality of life of the citizen. By inducing this into the process of housing development as a special ground, piecemeal developments can be largely discouraged. Formalization of the physical development of sustainable neighbourhoods in the urban areas can also be expected as an outcome.

6.4 Epilogue

This study develops an integrated approach recognizing the fact that environmental, social, and economic goals in appealing neighbourhoods are often mutually reinforced with the neighbourhood form. The inhabitants' experience impartially adjudicates the circumstances arising in terms of neighbourhood form intuitively. More significantly, the potential contribution or intervention of neighbourhood form in establishing an appealing, sustainable neighbourhood is yet to be discussed and agreed, in order to use it as a tool in the design of new neighbourhoods or in the re-instatement of existing ones as 'great', 'sustainable' or 'appealing' neighbourhoods. Clearly, it constantly faces challenges, and therefore, should be robustly utilized, to withstand upcoming social, environmental, and economic requirements of the neighbourhoods.

Specifically, in this study, it is demonstrated that the convenient location is a fundamental factor of environmental, social, and economic superiority of the neighbourhood. Dedicated facilities for children, youth, and senior citizens, which are in close proximity to the neighbourhood are important and essential inclusions of urban living. Housing and population density should be appropriate for the provision of infrastructure, services, facilities, and amenities. Connectivity, accessibility, and transportation modes are prime concerns of urban residents, owing to the location of the neighbourhood for high rating in sustainability. Diversity in house types, affordability, and quality creates the social mix in neighbourhoods. Further, periodic maintenance and improvements to the quality of houses and other buildings, within strictly designated design guidelines is necessary to avoid deterioration of the collective identity and distinctive character of neighbourhoods.

It is proven in the study, that the attributes of urban form are the determinants that foster sustainability of the neighbourhoods. Hence, the study concludes that the urban form is to be generated with appropriate requisites. They are raised in the conclusion, as suggestive requisites of an exemplary Urban Form for Sustainable Neighbourhoods. They are linked and can be integrated with current planning strategies. They could be resourcefully pre-planned and essentially incorporated in neighbourhood developments appropriately within particular urban settings.

6.5 Recommendations for further research

The study is structured with certain limitations due to the time and resource planning boundaries within the scope as an individual research component, as explained in the introduction. Accordingly, the study concentrates only on environmental, social, and economic sustainability parameters and potentialities, as its focus is on assessing neighbourhood sustainability on inhabitants' experience, with reference to the design of urban form. Findings derived are directly focused an architectural and planning related outcome. This identifies that the policy formulation and state engagement procedures at appropriate governing levels are the keys in implementation. Hence, it is recommended that research on institutional domain, including commitments necessary in policy planning and implementation procedures are to be identified and structured based on planned developments, instead of piecemeal construction. This is an important requirement; in finding the way forward for the deployment of research outcomes.

The selected case studies are limited to the Colombo Municipal Council area and are from three zoning categories regarded as urban prototypes of planned neighbourhoods. It was found in the research that communities acknowledge their living setting specifically based on their lifestyles. Therefore, it is important to understand the human appraisal on the current physical set-up to form a general opinion. In any generalization, studies in the future may investigate conceivable variances and refine the outline to accommodate several other examples as continuations of this experimentation. It could be from various other zoning regions in Colombo and even be extended up to residential neighbourhoods, contiguous to other major urban centers in the island for further refinements, improvements, and more sustainable and appealing future developments. Periodic researches are inevitable, as the prevailing urban form of a neighbourhood is a snapshot at a point in its development process. It may require changes over time to maintain a proper balance with human requirements. Hence, the physical settings are to be evaluated periodically by the authorities, to ensure the quality of life for urban residents in the development process of the country.

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APPENDICES
APPENDIX A
Formatted questionnaire on three sustainability parameters

SUSTAINABILITY ON ENVIRONMENTAL ASPECT							
The level of quality perceived by the resident on the favourability physical environment: Physical structure, functional qualities & resource demand resulted by Density, land use, layout, connectivity, infra-structure, streetscape, and environment related practices							
	Quest	Ranking of the perceived level of indication	**1** Very poor	**2** poor	**3** Moderate	**4** Good	**5** Very Good
Density	1	Are there sufficient dwellings for population living?					
	2	Is there supply of energy and natural resources tally with demand?					
	3	Ecological sustainability; (observation)					
	4	Is the constant development cause any Environmental issues/ or is it manageable?					
	5	Urban water system: Is there adequate availability-for usage?					
	6	Energy usage: Is there adequate availability, for usage?					
	7	Air pollution and noise: How favourable is it in terms of health effects, stress conditions?					
	8	Storm water management; How is the efficiency of disposal system?					
	9	Solid waste management; How is the efficiency of disposal, recycling?					
Layout	10	How do you rate the Street experience?					
	11	How do you rate the Streetscape?					
	12	How are the light levels of streets?					
	13	How is the adequacy of Open space provisions within neighbourhood?					
	14	How do you rate the tree plantation, wind concerns, natural light/ventilation within the neighbourhood?					
Land use	15	Are the movement/ interaction patterns within neighbourhood favorable?					
	16	Is the distribution of land uses and transportation patterns in and around the neighbourhood favourable?					
	17	Functioning of Land uses and Mix diversity; (observation)					
	18	How do you rate on the existence of Impervious ground surfaces within the neighbourhood? (Includes observations)					
Transport/ Connectivity	19	Is your neighbourhood environment adaptable to public transit/pedestrians/bicyclists?					
	20	How do you rate the street safety? (Do you feel it is safe enough for kids & females etc.?)					
	21	Is the street connectivity appropriate and adequate? (Is your neighbourhood well connected with surrounding streets?)					
	22	Convenience levels of Street rout directions?					
	23	How is the convenience level of Street rout directions?					
	24	Rate the levels of Pedestrian Accessibilities?					
	25	Is there adequate Pedestrian net-work coverage connected to main day-to-day activities?					

	SUSTAINABILITY ON SOCIAL ASPECT						
	User perception, satisfaction: Social goals, social life, social diversity, social-mix, social equity (inter/intra-generational), security, safety						
	Quest	Ranking of the perceived level of indication	**1** Very poor	**2** poor	**3** Moderate	**4** Good	**5** Very Good
Lay out	26	Social pattern & behaviour associated with neighbourhood					
	27	Are the Inhabitants' interests represented in their development or ignored?					
	28	Is the older community conveniently to live and move?					
	29	Do you think your Housing /building characteristics collectively contributing to an identity/ a special character?					
	30	How is the availability of easy accesses to schools, public transport, recreational areas, and health, community, & emergency services, places of worship?					
	31	How do you rate the levels of Crime prevention measures, security, road safety, streetlight conditions?					
Land use	32	Are there sufficient dedicated facilities, childcare centers, community centers, public libraries, skills development facilities available? (in proximity)					
Transport/Connectivity	33	Are there sufficient traffic calming precautions available within the neighbourhood?					
	34	Is your Cultural identity expression demonstrated within the neighbourhood?					
	35	Is Non-motorized transport facilitated within the neighbourhood? (Walking, Cycling)					
	36	Is the Planning and engineering standards used, harmonized with your lifestyles?					
	37	How do you rate on Encouragements and supports with public environment and public life of a community!					
Architectural character	38	How do you rate the diversity/variety of housing quality?					
	39	Has a stronger community Identity and sense of place be developed?					
	40	Is it creating Identities for more culturally diverse communities?					
	41	Are the culturally diverse communities facilitated in the neighbouthood?					
	42	How do you generally rate your neighbourhood in your likeliness? (Users perception)					
	43	Is it really offered kind of human experience of a good living?					

	SUSTAINABILITY ON ECONOMIC ASPECT						
	Living Standard, Land Value: Affordable living, housing options, housing prices, Land value, close-by facilities and employment, business						
	Quest	Ranking of the perceived level of indication	**1** Very poor	**2** poor	**3** Moderate	**4** Good	**5** Very Good
	44	How do you rate the diversity (variety) of housing types in your neighbourhood?					
	45	How do you rate the affordability of housing options within the neighbourhood?					
	46	How do you rate house prices within your neighbourhood?					
	47	How do you rate land values in your neighbourhood?					
Land use	48	Are there sufficient commercial establishments available in proximity to your neighbourhood?					
	49	Is the availability of employment opportunities, types, & possibility favorable around the neighbourhood?					
	50	How do you rate standard of your living quality within the neighbourhood?					

APPENDIX B

HOD's letter recommending the public interviews

DEPARTMENT OF ARCHITECTURE

FACULTY OF ARCHITECTURE, UNIVERSITY OF MORATUWA, MORATUWA, SRI LANKA

30th May 2019

TO WHOM IT MAY CONCERN

Reference:

G.W.J.K.K. Wijesundara (NIC 648430361V/ Reg No: 178126U; PhD candidate)

Department of Architecture, University of Moratuwa

Ms. G.W.J.K.K. Wijesundara is currently carrying out a Post Graduate Degree Course in Doctor of Philosophy (PhD) in the Department of Architecture, University of Moratuwa. Her Research Study is based on Colombo and its suburban residential neighbourhoods. Main focus is on following three (03) selected neighbourhood areas as case studies;

1. Newham Square in Kochchikade-North (Ward-19);
2. Chitra Lane neighbourhood in Kirula (Ward-42);
3. Veluwanarama Road neighbourhood in Pamankada-West (Ward-45), Wellawatta;

For this study she needs to visit these neighbourhoods physically and to meet residents. I would be thankful if you could extend your assistance for her to obtain necessary study information for this exercise. Your cooperation in answering her questionnaire is highly appreciated. This information will only be used for her research purposes.

Yours sincerely,

Dr. R.M.K.U. Rajapaksha

Head, Department of Architecture

Dr. R.M.K.U. Rajapaksha
Head / Department of Architecture
Faculty of Architecture
University of Moratuwa
Sri Lanka.

Tel: 0094-11 2650534, 0094-11 2650301, 0094-11 2650671, 0094-11 2650340, Ext: 7104, Fax: 011 2650622

APPENDIX C

Letter from The Chairman, University Ethics Review Committee granting Ethics Approval

University Ethics Review Committee

To : G.W.J.K.K. Wijesundara

From : Chairman, University Ethics Review Committee (UERC)

Subject : Review of Ethics Committee Application A

Title : Attributes of Urban Form Sustainability; Analysis on Colombo Residential Neighbourhoods

Date : 25th February 2020

Dear all,

Decision: Ethics approval is granted

Thank you for submitting revisions to the Ethics Application Form A in relation to the research project referred to above. The project has been reconsidered as complying with the General Guidelines on Ethical Conduct in Human Research of UOM. I am pleased to advise that your project has been granted the ethics approval. Your Ethics Declaration Number (EDN) is **EDN/2020/002.**

The following standard conditions apply to your project:

- This research involves interviews and the researcher is planning to conduct a very long interview with each participant. According to the interview guide provided, it contains about more than 55 questions. This will have an ethical implication as it is too long and it will create an uneasy situation for the subject. Therefore, please reconsider the number of questions that you are planning to ask from the subjects. In interviews, we normally limit the time to 30-45 minutes and ask very focused questions only.

- Limit of Approval. Approval is limited strictly to the research proposal as submitted in your application while taking into account any additional conditions advised by the UERC.

- Variation to Project. Any subsequent variations or modifications you wish to make to your project must be formally notified to the UERC for approval in advance of these modifications being introduced into the project. In order to do this, you are advised to send a revised application.

If the UERC considers that the proposed changes are significant, you may be required to submit a new application form A or B for approval of the revised project.

• Withdrawal of Project. If you decide to discontinue your research before its planned completion, you must advise the UERC and clarify the circumstances.

• Monitoring. All projects are subject to monitoring at any time by the University Ethics Review Committee.

If you have any queries on the information above or require further clarification, please email: ar-fgs@uom.lk or contact me by phone.

On behalf of the University Ethics Review Committee, best wishes with your research!

Kind regards,

Prof. Rangajeewa Ratnayake
Chairman, University Ethics Review Committee
PhD (La Trobe University, Australia)
Head, Department of Town and Country Planning
Faculty of Architecture
University of Moratuwa, Katubedda, Moratuwa, Sri Lanka
T: +94 112 650921 **E:** rangajeewar@gmail.com |rangajeewar@uom.lk

APPENDIX D

INFORMATION SHEET; Ethics Process

Title of the Study:

Attributes of Urban Form fostering Sustainability; Analysis on Colombo Residential Neighbourhoods

This has reference to the attached letter issued by the Head of the Department of Architecture, University of Moratuwa. I would like to invite you to take part in a research study. The research is carrying out with a questionnaire. Please be corporate, take time to understand the questions and give your answer as a rating. You will be convened with Sinhala or Tamil translations if necessary. You can decide whether or not to take part. Your participation and contribution is highly appreciated, without which this study will not be able to pursue.

The Study:

I am G.W.J.K.K.Wijesundara (NIC 648430361V), a chartered architect, currently carrying out a doctoral research in the University of Moratuwa. For this research, it is needed to study how you rate certain aspects in your neighbourhood as its inhabitants/residents.

Scope of participation:

- 35 households from your neighbourhood are randomly selected, and the participants/interviewees are chosen as the head person (adult) of the household.
- Your involvement is to understand the questions and give your rating on each question as indicated. This will take about 30-40 minutes, and your answers will be recorded by the interviewer, on the questionnaire itself.
- Location will be your residence or any place in your neighbourhood convenient to you, and your convenient time will be pre-fixed.
- Your participation is completely voluntary, and you have the right to refuse participation.

Risks or Benefits of participation:

- This information is anonymous, only for the study purpose, so that there is no risk or special benefit to participants.

Confidentiality of information:

- Anonymity and confidentiality of the participants will be protected by the interviewer and the institute. Any personal information of the participants are not recorded or exposed in the study, or in any publication related to the study.
- Consent forms and original recordings will be retained with the interviewer/candidate, and no one has access to data until after degree has been conferred. Transcript of interviews with all identifying information are stated, will be discarded after the submission of research thesis to the institute.

Results of the study:

Final results of the study will be the disseminated in the final research product, including conferences, publications and teaching use.

Contact Personels:

G.W.J.K.K.Wijesundara, Chartered Architect, (PhD Candidate); 071 521 4382
Dr. Upendra Rajapakse, Head of the department of Architecture, University of Moratuwa (Letter attached)
Dr. Gamini Weerasinghe, Principal Advisor, Senior Lecturer, Department of Architecture, University of Moratuwa
Prof.L.S.R. Perera, Specialist Advisor, Associate Professor, Sri Lanka Institute of Information Technology, Malabe

THANK YOU!

APPENDIX E

CONSENT FORM OF PARTICIPANTS; Ethics Process

Title of the Study:

Attributes of Urban Form fostering Sustainability; Analysis on Colombo Residential Neighbourhoods

Consent to take part in research:

- I voluntarily agree to participate in this research study.
- I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences.
- I grant permission to use data from my interview in the research study.
- I am informed the purpose and nature of the study.
- I understand that participation involves indication of my rating on the given questionnaire on my neighbourhood.
- I understand that I will not be benefited directly from participating in this research.
- I agree to my interview being recorded.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report/publication on the results of this research, my identity will remain anonymous.
- I understand that disguised extracts from my interview may be used in the research study. The data from the interview may be used in research report, thesis, conference presentation, published papers etc. with keeping anonymity.
- I understand that the consent forms and original interview records are retained secured and confidential, until the exam board confirms the results of their report/thesis.
- I understand that in a transcript of my interview, all identifying information has been removed.
- I understand that I am free to contact any of the people related to the research; researcher, supervisors, head of the institute, to seek any clarification and information on my interview.

Contact Personels:

G.W.J.K.K.Wijesundara, Chartered Architect, (PhD Candidate); 071 521 4382

Dr.Upendra Rajapakse, Head of the Department of Architecture, University of Moratuwa (Letter attached)

Dr.Gamini Weerasinghe, Principal Supervisor, Senior Lecturer, Department of Architecture, University of Moratuwa

Prof.L.S.R. Perera, Specialist Advisor, Associate Professor, Sri Lanka Institute of Information Technology, Malabe

Signature of research participant, Date

---------- ----------

I believe the participant is giving informed consent to participate in this study.

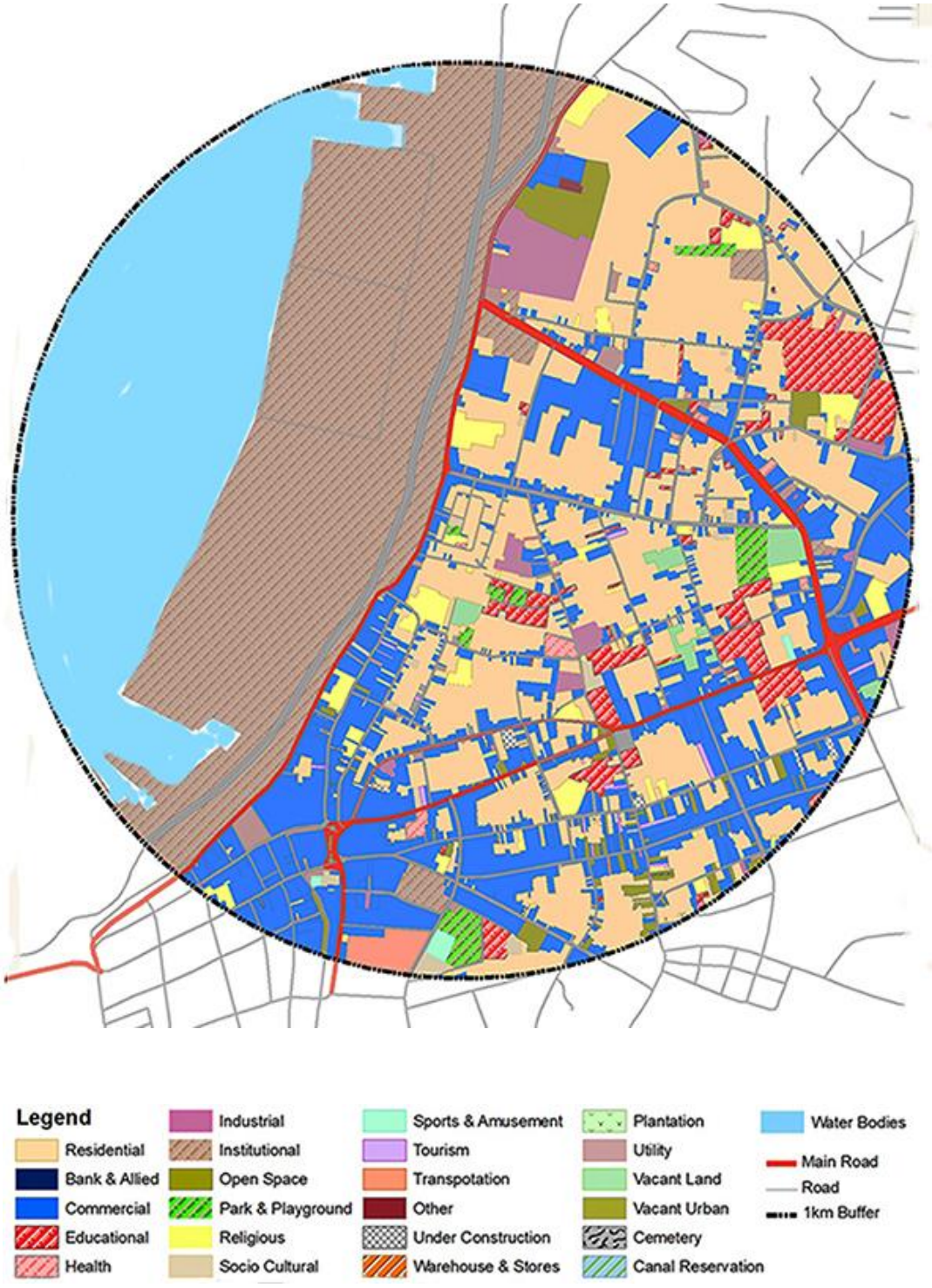
---------- ----------

Signature of researcher, Date

APPENDIX F

Land use Distribution in 1KM radius of Newham Square neighbourhood

Data Source; Department of GIS-UDA, 2015



APPENDIX G

Record of Data on user perception, Case Study-1; Newham Square

Note: Number of questions: 50; Number of residents interviewed: 35; Rating as per the Likert scale: 1-5 (very poor-very good)

HH_NO	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46	Q47	Q48	Q49	Q50
1	5	5	5	4	5	5	4	5	5	4	4	3	3	4	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5	5	5	3	5	4	5	4	3	4	4	5	5	4	4	5	3	3	5	5	4	4
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3	3	5	3	4	5	5	4	5	5	5	4	4	4	3	5	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	4
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APPENDIX H

Descriptive Statistics, Case Study-1; Newham Square

Reliability Analysis

Case Processing Summary

		N	%
Cases	Valid	35	100.0
	Excluded	0	.0
	Total	35	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.872	50

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Q1_Sufficiency of residential density with pop. density	35	3	5	3.71	.622
Q2_Energy & natural resource demands tally with supply	35	4	5	4.74	.443
Q3_Ecological sustainability(observation)	35	3	5	3.51	.658
Q4_Manageability of env. issues in constant development	35	3	5	3.71	.710
Q5_Urban water system; Adequacy of availability for usage	35	5	5	5.00	.000
Q6_Energy usage; Adequacy of availability for usage	35	5	5	5.00	.000
Q7_Air pollution & noice; Health effects, stress conditions	35	2	5	3.40	.976
Q8_Storm water management; disposal	35	5	5	5.00	.000
Q9_Solid waste management; collection, storage, disposal	35	5	5	5.00	.000
Q10_Rate the street experience	35	3	5	4.49	.742
Q11_Rate street scape	35	3	5	4.34	.725
Q12_Light levels of street	35	3	5	4.29	.789
Q13_Adequacy of open space provision	35	2	4	2.91	.562
Q14_Rate tree plantation, wind concerns, natural light/vent.	35	2	4	2.97	.453
Q15_Favourability of movement, Interaction pattern	35	5	5	5.00	.000
Q16_Distribution of land-use & transportation patterns	35	4	5	4.83	.382
Q17_Functioning of land-uses & mix diversity (Obs.)	35	4	5	4.66	.482
Q18_Existance of impervious surfaces	35	5	5	5.00	.000
Q19_Env. adaptable to public transit/pedestrians/bicyclists	35	5	5	5.00	.000
Q120_Rate the street safety	35	4	5	4.66	.482
Q21_Street connectivity is appropriate/adequate	35	5	5	5.00	.000
Q22_Convenience levels of rout directions	35	5	5	5.00	.000
Q23_Rate the street Convenience	35	5	5	5.00	.000
Q24_Rate the level of pedestrian Accessibilities	35	4	5	4.89	.323
Q25_Adequacy of pedestrian network coverage	35	5	5	5.00	.000
Q26_Social pattern & behaviour associated with NH	35	3	5	4.54	.657

Q27_Inhabitants' interests are represented (or ignored) in NH dev.	35	4	5	4.34	.482
Q28_Older community conveniently live & move	35	3	5	3.74	.701
Q29_Housing/Bldg. characters collectively contributing to identity	35	3	5	4.43	.778
Q30_Easy access to schools, pub. transp, Rec., health, comm.,emergency ser.,places of worship	35	3	5	4.66	.684
Q31_Levels of crime prevension measures, road safety, streetlight	35	3	5	4.57	.698
Q32_LANDUSE.SOC.Sufficient dedicated facilities;childcare,comm.centers, pub. library, skills dev. facilities (in prox.)	35	2	4	3.23	.770
Q33_Availability of sufficient traffic calming precautions	35	5	5	5.00	.000
Q34_Cultural identity expression demonstrated?	35	3	5	4.20	.584
Q35_Non-motorized transportation; walking, cycling facilitated?	35	4	5	4.89	.323
Q36_Planning & engineering standards, harmonized with lifestyles?	35	3	5	3.89	.832
Q37_Rate on encouragements & supprts with public env. & public life of community	35	2	5	3.46	.817
Q38_Diversity/variety of housing quality?	35	3	5	3.80	.632
Q39_Stronger community identity & sense of place be developed?	35	4	5	4.74	.443
Q40_Creating identities for more culturally diverse communities?	35	4	5	4.80	.406
Q41_Culturally diverse communities facilitated?	35	4	5	4.83	.382
Q42_Users perception/rate their neighbourhood?	35	4	5	4.69	.471
Q43_Really offered kind of diminished human experience of a good living?	35	4	5	4.60	.497
Q44_Connectivity acceptable & convenient?	35	5	5	5.00	.000
Q45_Diversity of hosing types?	35	3	5	3.51	.658
Q46_Affordability of housing options?	35	3	5	3.51	.658
Q47_House prices?	35	4	5	4.86	.355
Q48_Commercial establishments available in proximity?	35	4	5	4.91	.284
Q49_Availability of employment opportunities, types & possibilities favourable?	35	3	5	4.06	.482
Q50_Rate standard of living quality, buying power, equity?	35	3	5	3.86	.648
Valid N (listwise)	35				

APPENDIX I

Case Study-1; Newham Square.

Descriptive statistics; Average mean value for Environmental, Social, Economic sustainability aspects and overall sustainability aspect

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Environmental Aspect	35	4.27	4.69	4.4872	.09232
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Social Aspect	35	3.14	4.75	4.1179	.47080
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Economic Aspect	35	3.54	5.00	4.2488	.32940
Valid N (listwise)	35				

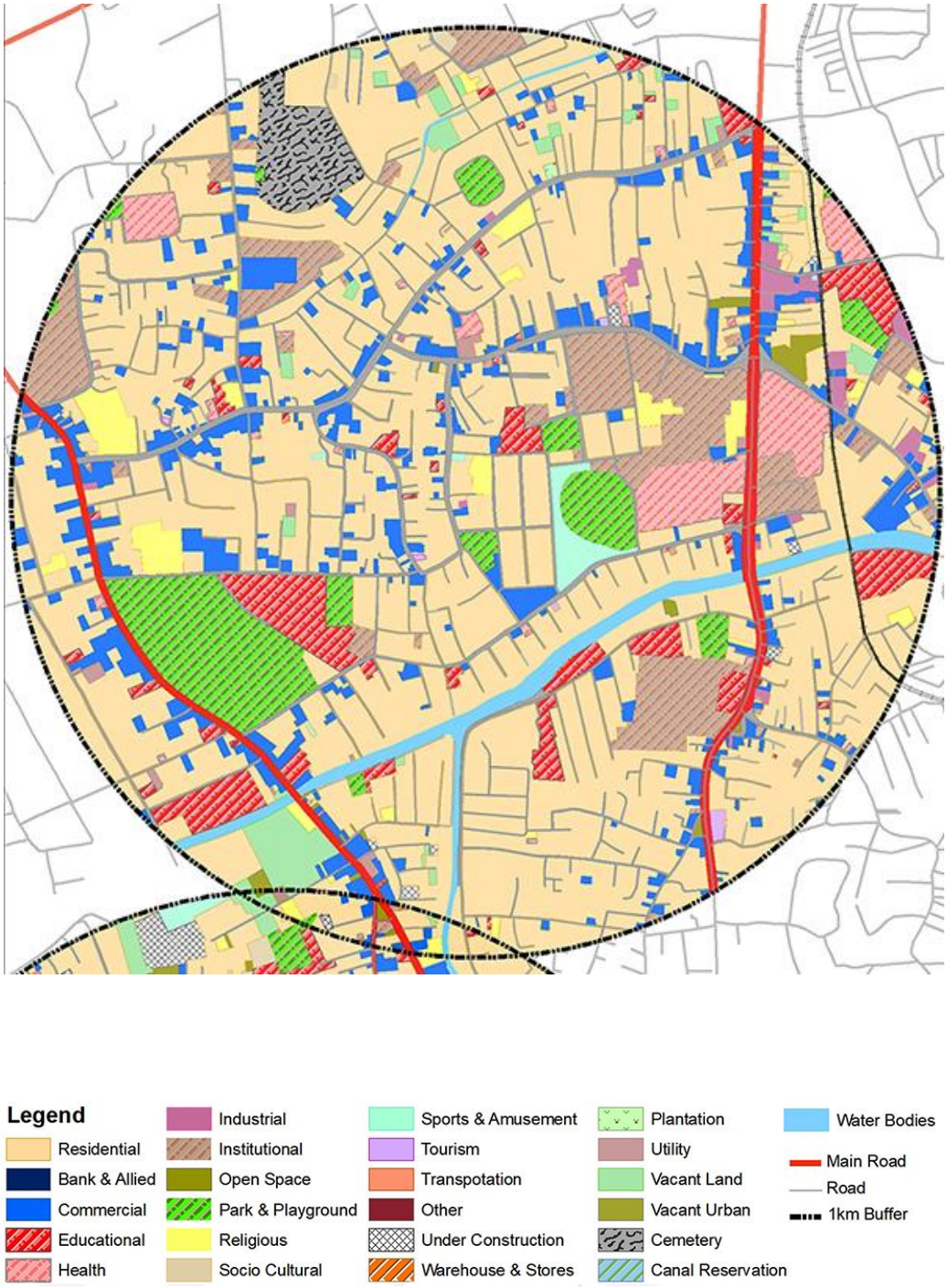
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sustainability; Newham	35	3.85	4.72	4.2846	.25052
Valid N (listwise)	35				

APPENDIX J

Land use Distribution in 1KM radius of Chitra Lane neighbourhood

Data Source; Department of GIS-UDA, 2015



APPENDIX K

Record of Data on user perception, Case Study-2; Chitra Lane

Note: Number of questions: 50; Number of residents interviewed: 35; Rating as per the Likert scale: 1-5 (very poor-very good)

HH_NO	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46	Q47	Q48	Q49	Q50
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
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26	5	4	5	5	4	4	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	5
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28	5	5	5	5	5	5	5	5	5	5	5	5	4	3	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	5	3	4	3	5	5	5	5	4	5	3	3	5	4	3	4
29	4	4	5	5	4	4	5	5	5	5	5	5	3	5	5	4	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	3	4	3	5	5	5	5	5	4	5	5	4	5	3	3	5	5	3	3
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31	5	5	5	5	5	5	5	5	5	5	5	5	4	3	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	5	4	5	4	4	3	5	3	3	3	5	4	5	4	4	5	4	4	5	3	4
32	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	5	3	3	4	5	5	5	5	5	5	5	3	3	5	4	3	4
33	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	4	4	5	5	4	3
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35	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	4	5	4	5	5	5	5	5	5	5	5	4	4	5	5	4	5

APPENDIX L

Descriptive Statistics; Case Study-2; Chitra Lane

Reliability Analysis

Case Processing Summary

		N	%
Cases	Valid	35	100.0
	Excluded	0	.0
	Total	35	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.929	50

.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Q1_Sufficiency of residential density with pop. density	35	4	5	4.91	.284
Q2_Energy & natural resource demands tally with supply	35	4	5	4.89	.323
Q3_Ecological sustainability(observation)	35	5	5	5.00	.000
Q4_Manageability of env. issues in constant development	35	5	5	5.00	.000
Q5_Urban water system; Adequacy of availability for usage	35	3	5	4.83	.453
Q6_Energy usage; Adequacy of availability for usage	35	4	5	4.89	.323
Q7_Air pollution & noise; Health effects, stress conditions	35	5	5	5.00	.000
Q8_Storm water management; disposal	35	5	5	5.00	.000
Q9_Solid waste management; collection, storage, disposal	35	5	5	5.00	.000
Q10_Rate the street experience	35	5	5	5.00	.000
Q11_Rate street scape	35	3	5	4.86	.430
Q12_Light levels of street	35	5	5	5.00	.000
Q13_Adequacy of open space provision	35	3	5	4.60	.651
Q14_Rate tree plantation, wind concerns, natural light/vent.	35	3	5	4.06	.684
Q15_Favourability of movement. Interaction pattern	35	5	5	5.00	.000
Q16_Distribution of land use & transportation patterns	35	4	5	4.86	.355
Q17_Functioning of land uses & mix diversity (Obs.)	35	4	5	4.69	.471
Q18_Existance of impervious surfaces	35	5	5	5.00	.000
Q19_Env. adaptable to public transit/pedestrians/bicyclists	35	5	5	5.00	.000
Q20_Rate the street safety	35	5	5	5.00	.000
Q21_Street connectivity is appropriate/adequate	35	5	5	5.00	.000
Q22_Convenience levels of rout directions	35	5	5	5.00	.000
Q23_Rate the street Convenience	35	5	5	5.00	.000
Q24_Rate the level of pedestrian Accessibilities	35	5	5	5.00	.000
Q25_Adequacy of pedestrian network coverage	35	4	5	4.86	.355
Q26_Social pattern & behaviour associated with NH	35	5	5	5.00	.000

Q27_Inhabitants' interests are represented (or ignored) in NH dev.	35	3	5	4.83	.568
Q28_Older community conveniently live & move	35	3	5	4.66	.639
Q29_Housing/Bldg. characters collectively contributing to identity	35	4	5	4.80	.406
Q30_Easy access to schools, pub. transp, Rec., health, comm.,emergency ser.,places of worship	35	4	5	4.69	.471
Q31_Levels of crime prevention measures, road safety, streetlight	35	4	5	4.91	.284
Q32_Sufficient dedicated facilities;childcare,comm.centers, pub. library, skills dev. facilities (in prox.)	35	4	5	4.49	.507
Q33_Availability of sufficient traffic calming precautions	35	4	5	4.49	.507
Q34_Cultural identity expression demonstrated?	35	3	5	4.06	.684
Q35_Non-motorized transportation; walking, cycling facilitated?	35	5	5	5.00	.000
Q36_Planning & engineering standards, harmonized with lifestyles?	35	3	5	3.86	.692
Q37_Rate on encouragements & supprts with public env. & public life of community	35	3	5	4.17	.664
Q38_Diversity/variety of housing quality?	35	3	5	4.20	.759
Q39_Stronger community identity & sense of place be developed?	35	5	5	5.00	.000
Q40_Creating identities for more culturally diverse communities?	35	4	5	4.89	.323
Q41_Culturally diversed communities facilitated?	35	5	5	5.00	.000
Q42_Users perception/rate their neighbourhood?	35	4	5	4.89	.323
Q43_Really offered kind of diminished human experience of a good living?	35	4	5	4.71	.458
Q44_Connectivity acceptable & convenient?	35	5	5	5.00	.000
Q45_Diversity of hosing types?	35	3	5	3.80	.719
Q46_Affordability of housing options?	35	3	5	3.77	.690
Q47_House prices?	35	5	5	5.00	.000
Q48_Commercial establishments available in proximity?	35	4	5	4.60	.497
Q49_Availability of employment opportunities, types & possibilities favourable?	35	3	5	3.66	.684
Q50_Rate standard of living quality, buying power, equity?	35	3	5	4.20	.759
Valid N (listwise)	35				

APPENDIX M

Case Study-2; Chitra Lane

Descriptive statistics; Average mean value for Environmental, social, Economic sustainability aspects and overall sustainability aspect

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Environmental Aspect	35	4.46	5.00	4.8785	.13389
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Socil Aspect	35	3.90	5.00	4.5988	.32289
Valid N (listwise)	35				

Descriptive Statistics

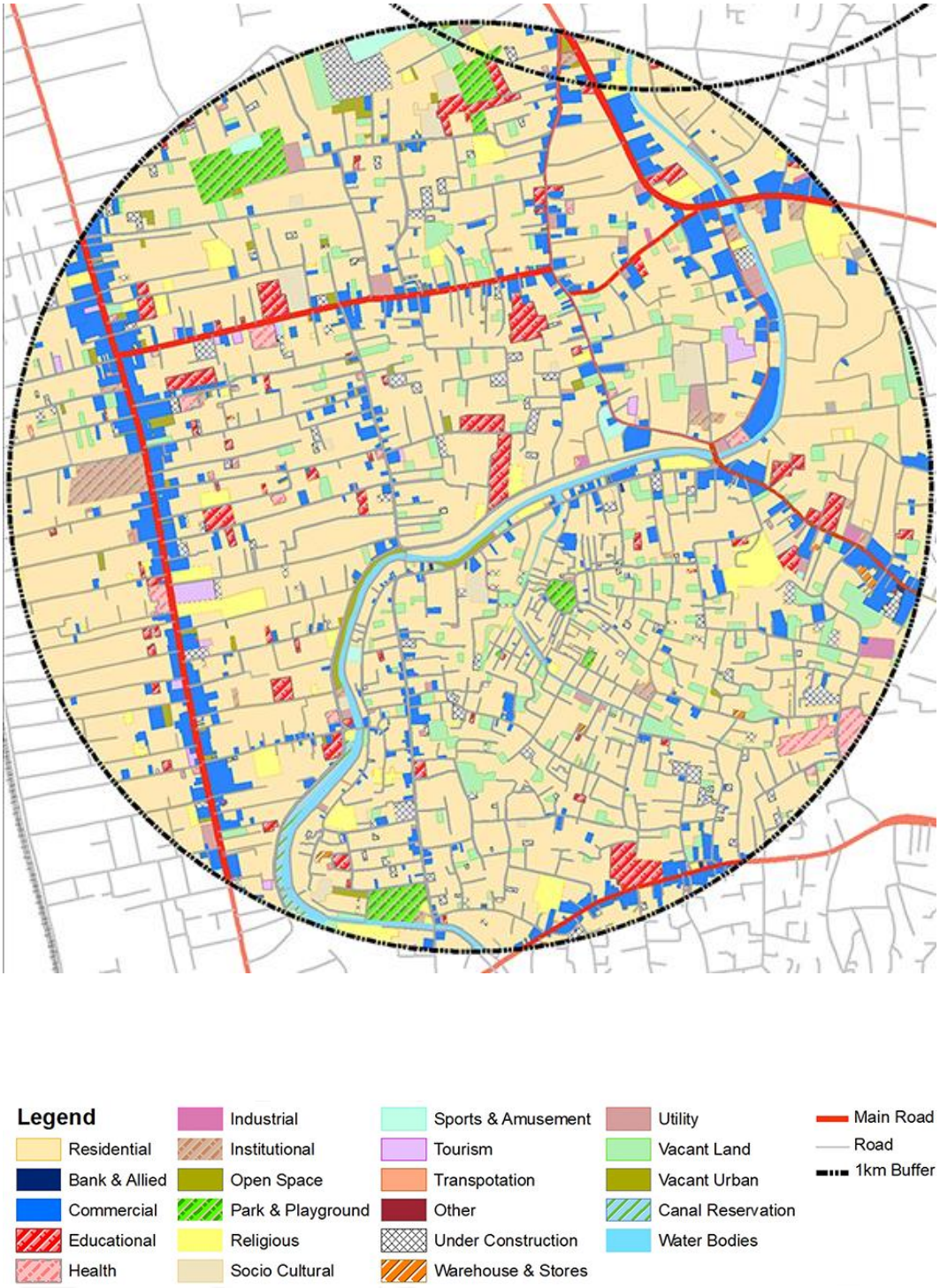
	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Economic Aspect	35	3.67	5.00	4.2726	.42998
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sustainability _Chitra Ln	35	4.01	5.00	4.5833	.25019
Valid N (listwise)	35				

APPENDIX N

Land use Distribution in 1KM radius of Veluwanarama Road neighbourhood
Source; Department of GIS-UDA, 2015



APPENDIX P

Record of Data on user perception, Case Study-3; Veluwanarama Road

Note: Number of questions: 50; Number of residents interviewed: 35; Rating as per the Likert scale: 1-5 (very poor-very good)

HH_NO	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Q31	Q32	Q33	Q34	Q35	Q36	Q37	Q38	Q39	Q40	Q41	Q42	Q43	Q44	Q45	Q46	Q47	Q48	Q49	Q50
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	4	4	4	4	5	5	5	5	5	5	4	5	5	5	4	4	5
2	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	4	4	5	5	5	5	3	5	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	4	4	5
3	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	4	5	4	4	5	4	4	5	5	5	5	3	5	4	5	4	5	4	4	5	5	5	5	5	5	4	4	5	4	3	2	4
4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	4	2	4	4	4	5	2	5	3	5	3	4	3	3	3	3	4	3	4	5	4	3	4	4	4	3	2	4
5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	2	2	4	4	4	4	2	5	3	5	3	4	3	3	3	4	3	4	5	4	3	4	4	4	3	3	4
6	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	2	2	5	4	4	4	2	5	3	5	3	4	3	3	3	4	3	4	5	4	3	4	4	4	3	3	4
7	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	4	5	4	4	5	5	5	5	5	5	5	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5
8	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	3	3	5	5	4	5	3	5	3	5	4	5	4	4	4	5	5	5	5	5	4	4	4	5	5	4	3	5
9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	4	4	5	5	5	5	5	5	4	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5
10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5
11	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	4	5	4	4	5	3	3	5	5	4	5	3	5	4	5	4	4	4	4	4	5	4	5	5	5	4	4	5	5	4	4	5
12	5	5	5	5	5	5	5	5	5	5	5	5	3	5	4	3	3	5	3	5	3	3	4	3	3	5	5	4	5	3	5	3	5	3	5	4	3	3	5	3	4	4	5	3	4	4	4	3	3	4
13	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	3	3	5	5	4	5	3	5	3	5	3	4	4	4	5	5	4	5	5	4	4	4	5	5	4	3	4
14	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	4	5	4	4	5	4	4	5	5	5	5	4	5	4	5	5	5	5	4	5	5	5	5	5	5	4	5	5	5	4	3	4
15	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	3	3	5	3	5	3	3	4	3	3	5	4	4	4	3	5	3	5	3	4	4	3	4	4	3	4	4	4	3	4	4	4	3	2	4
16	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	3	3	5	3	5	3	3	4	3	3	5	4	5	4	3	5	3	5	3	4	4	3	4	4	4	5	5	5	4	3	4	4	4	3	4
17	5	5	5	5	5	5	5	5	5	5	5	5	3	5	4	3	3	5	3	5	3	3	4	3	3	5	5	4	5	3	5	4	5	4	5	5	4	4	5	5	5	5	5	4	4	4	5	5	4	3	5
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20	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	4	5	5	5	4	4	5	4	3	5	5	4	5	3	5	4	5	4	5	3	3	4	5	4	4	5	5	3	4	4	4	3	3	4
21	5	5	5	5	5	5	5	5	5	5	5	5	3	5	4	3	3	5	4	5	3	3	4	4	3	4	4	4	5	3	5	4	5	3	4	4	3	3	4	4	4	4	5	3	4	4	4	3	2	4
22	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	5	4	4	5	4	3	5	5	4	5	4	5	4	5	4	4	4	3	4	5	3	4	5	4	3	4	4	4	3	3	4
23	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	4	5	3	3	4	4	3	5	5	4	5	3	5	3	5	4	5	4	4	4	5	4	5	5	5	4	4	5	5	4	3	5
24	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	4	5	3	3	4	4	3	5	5	4	5	3	5	3	5	3	4	4	3	5	5	4	5	5	4	3	4	4	4	3	3	4
25	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	4	3	5	5	4	5	3	5	4	5	3	4	4	3	5	5	4	5	5	4	3	4	4	4	3	3	4
26	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	4	3	5	5	4	5	3	5	4	5	4	5	4	4	4	5	4	5	5	5	4	4	5	5	4	3	5
27	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	4	4	5	4	3	5	5	5	5	4	5	5	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5
28	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	4	4	5	3	3	5	5	4	5	4	5	4	5	4	5	4	4	4	5	4	5	5	5	4	4	5	5	4	3	5
29	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	5	5	3	3	4	4	3	5	5	5	5	4	5	3	5	4	5	5	4	5	5	4	5	5	4	3	4	4	4	3	3	4
30	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	3	3	5	5	4	5	3	5	3	5	4	4	4	4	4	5	5	5	5	5	4	4	4	4	4	3	4
31	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	4	2	4	4	4	5	2	5	3	5	3	4	3	3	3	4	3	4	5	4	3	4	4	4	3	2	4
32	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	4	3	5	3	5	3	3	4	2	2	4	4	4	4	2	5	3	5	3	4	3	3	3	4	3	4	5	4	3	4	4	4	3	3	4
33	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	4	4	5	5	5	5	5	5	4	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5
34	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	4	4	5	4	4	5	5	5	5	5	5	5	5	4	5	5	4	5	5	5	5	5	5	4	4	5	5	4	3	5
35	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	4	5	5	5	4	4	5	4	3	5	5	4	5	3	5	4	5	4	5	3	3	4	5	4	4	5	5	3	4	4	4	3	3	4

APPENDIX Q

Descriptive Statistics; Case Study-3; Veluwanarama Road

Reliability Analysis

Case Processing Summary

		N	%
Cases	Valid	35	100.0
	Excluded	0	.0
	Total	35	100.0

Reliability Statistics

Cronbach's Alpha	N of Items
.959	50

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Q1_Sufficiency of residential density with pop. density	35	5	5	5.00	.000
Q2_Energy & natural resource demands tally with supply	35	5	5	5.00	.000
Q3_Ecological sustainability(observation)	35	5	5	5.00	.000
Q4_Manageability of env. issues in constant development	35	5	5	5.00	.000
Q5_Urban water system;Adequacy of availability for usage	35	5	5	5.00	.000
Q6_Energy usage; Adequacy of availability for usage	35	5	5	5.00	.000
Q7_Air pollution & noise; Health effects, stress conditions	35	5	5	5.00	.000
Q8_Storm water management; disposal	35	5	5	5.00	.000
Q9_Solid waste management; collection, storage, disposal	35	5	5	5.00	.000
Q10_Rate the street experience	35	5	5	5.00	.000
Q11_Rate street scape	35	5	5	5.00	.000
Q12_Light levels of street	35	5	5	5.00	.000
Q13_Adequacy of open space provision	35	3	5	4.17	.568
Q14_Rate tree plantation, wind concerns, natural light/vent.	35	5	5	5.00	.000
Q15_Favourability of movement,nteraction pattern	35	4	5	4.43	.502
Q16_Distribution of land-use & transportation patterns	35	3	5	4.20	.677
Q17_Functioning of land-uses & mix diversity (Obs.)	35	3	4	3.43	.502
Q18_Existance of impervious surfaces	35	5	5	5.00	.000
Q19_Env. adaptable to public transit/pedestrians/bicyclists	35	3	5	3.77	.770
Q20_Rate the street safety	35	5	5	5.00	.000
Q21_Street connectivity is appropriate/adequate	35	3	4	3.51	.507
Q22_Convenience levels of rout directions	35	3	4	3.51	.507
Q23_Rate the street Convenience	35	4	5	4.51	.507
Q24_Rate the level of pedestrian Accessibilities	35	2	4	3.54	.657
Q25_Adequacy of pedestrian network coverage	35	2	4	3.17	.664
Q26_Social pattern & behaviour associated with NH	35	4	5	4.86	.355

Q27_Inhabitants' interests are represented (or ignored) in NH dev.	35	4	5	4.80	.406
Q28_Older community conveniently live & move	35	4	5	4.40	.497
Q29_Housing/Bldg. characters collectively contributing to identity	35	4	5	4.89	.323
Q30_Easy access to schools, pub. transp, Rec., health, comm.,emergency ser.,places of worship	35	2	5	3.46	.980
Q31_Levels of crime prevension measures, road safety, streetlight	35	5	5	5.00	.000
Q32_Sufficient dedicated facilities; childcare,comm.centers, pub. library, skills dev. facilities (in prox.)	35	3	5	3.83	.822
Q33_Availability of sufficient traffic calming precautions	35	5	5	5.00	.000
Q34_Cultural identity expression demonstrated?	35	3	5	3.80	.632
Q35_Non-motorized transportation; walking, cycling facilitated?	35	4	5	4.54	.505
Q36_Planning & engineering standards, harmonized with lifestyles?	35	3	5	4.06	.765
Q37_Rate on encouragements & supprts with public env. & public life of community	35	3	4	3.57	.502
Q38_Diversity/variety of housing quality?	35	3	5	4.31	.758
Q39_Stronger community identity & sense of place be developed?	35	4	5	4.83	.382
Q40_Creating identities for more culturally diverse communities?	35	3	5	4.26	.817
Q41_Culturally diversed communities facilitated?	35	4	5	4.69	.471
Q42_ers perception/rate their neighbourhood?	35	4	5	4.91	.284
Q43_Really offered kind of diminished human experience of a good living?	35	4	5	4.63	.490
Q44_Connectivity acceptable & convenient?	35	3	4	3.60	.497
Q45_Diversity of hosing types?	35	4	5	4.09	.284
Q46_Affordability of housing options?	35	4	5	4.57	.502
Q47_House prices?	35	4	5	4.54	.505
Q48_Commercial establishments available in proximity?	35	3	4	3.57	.502
Q50_Rate standard of living quality, buying power, equity?	35	4	5	4.49	.507
Valid N (listwise)	35				

APPENDIX R

Case Study-3; Veluwanarama Road

Descriptive statistics; Average mean value for Environmental, social, Economic sustainability aspects and overall sustainability aspect

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus Environmental Aspect	35	4.19	4.79	4.4899	.22377
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus Social Aspect	35	3.40	4.74	4.1057	.43935
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus Economic Aspect	35	3.38	4.54	3.9429	.40676
Valid N (listwise)	35				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Sus_ Veluvanarama Rd	35	3.76	4.72	4.2438	.33092
Valid N (listwise)	35				

APPENDIX S

Comparative Analysis of Sustainability Score**:** Comparison

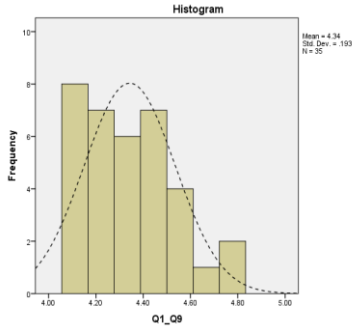
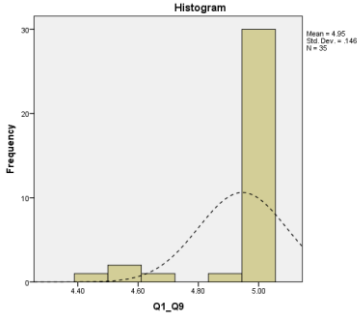
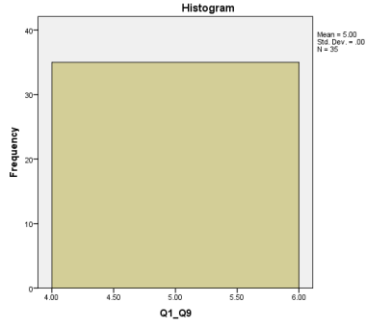
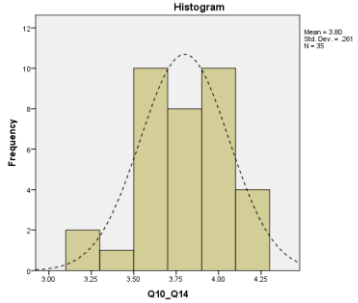
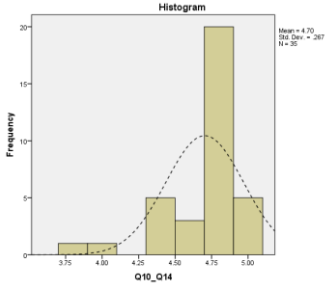
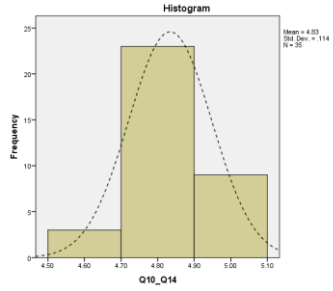
			Newha	Citra	Veluvana
Q.No.	**Question/Variable**	**N**	**Mean**	**Mean**	**Mean**
	Environmental Aspect: (Q1-Q25) **Density: (Q1-Q9)**				
1	Sufficiency of residential density with pop. density	35	3.71	4.91	5.00
2	Energy & natural resource demands tally with supply	35	4.74	4.89	5.00
3	Ecological sustainability(observation)	35	3.51	5.00	5.00
4	Manageability of env. issues in constant development	35	3.71	5.00	5.00
5	Urban water system; Adequacy of availability for usage	35	5.00	4.83	5.00
6	Energy usage; Adequacy of availability for usage	35	5.00	4.89	5.00
7	Air pollution & noise; Health effects, stress conditions	35	3.40	5.00	5.00
8	Storm water management; disposal	35	5.00	5.00	5.00
9	Solid waste management; collection, storage, disposal	35	5.00	5.00	5.00
1-9	**Environmental aspect: Density (Overall)**		**4.3429**	**4.9460**	**5.0000**
	Layout (Q10-Q14)				
10	Rate the street experience	35	4.49	5.00	5.00
11	Rate street scape	35	4.34	4.86	5.00
12	Light levels of street	35	4.29	5.00	5.00
13	Adequacy of open space provision	35	2.91	4.60	4.17
14	Rate tree plantation, wind concerns, natural light/vent.	35	2.97	4.06	5.00
10-14	**Environmental aspect: Layout (Overall)**		**3.8000**	**4.7029**	**4.8343**
	Land use (Q15-Q18)				
15	Favourability of movement. Interaction pattern	35	5.00	5.00	4.43
16	Distribution of land-use & transportation patterns	35	4.83	4.86	4.20
17	Functioning of land-uses & mix diversity (Obs.)	35	4.66	4.69	3.43
18	Existence of impervious surfaces	35	5.00	5.00	5.00
15-18	**Environmental aspect: Land use (Overall)**		**4.8714**	**4.8857**	**4.2643**
	Connectivity (Q19-Q18)				
19	Env. adaptable to public transit/pedestrians/bicyclists	35	5.00	5.00	3.77
20	Rate the street safety	35	4.66	5.00	5.00
21	Street connectivity is appropriate/adequate	35	5.00	5.00	3.51
22	Convenience levels of rout directions	35	5.00	5.00	3.51
23	Rate the street Convenience	35	5.00	5.00	4.51
24	Rate the level of pedestrian Accessibilities	35	4.89	5.00	3.54
25	Adequacy of pedestrian network coverage	35	5.00	4.86	3.17
19-25	**Environmental aspect: Connectivity (Overall)**		**4.9347**	**4.9796**	**3.8612**
	ENVORONMENTAL SUSTAINABILITY ASPECT (Overall)		**4.4872**	**4.8785**	**4.4899**
	Social Aspect: (Q26-Q43) **Layout: (Q26-Q31)**				
26	Social pattern & behaviour associated with NH	35	4.54	5.00	4.86

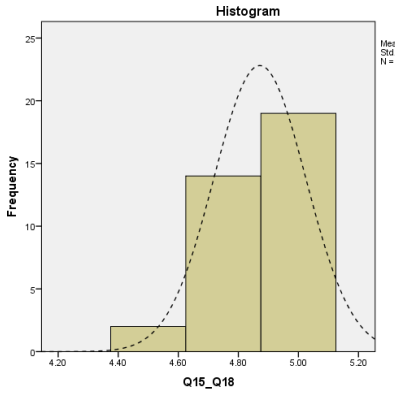
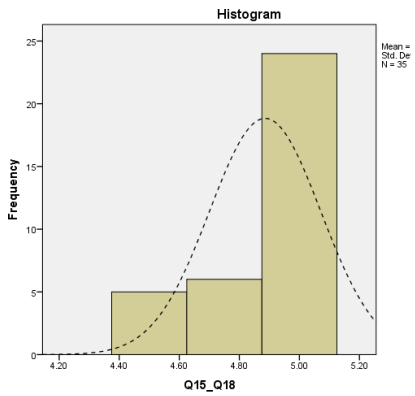
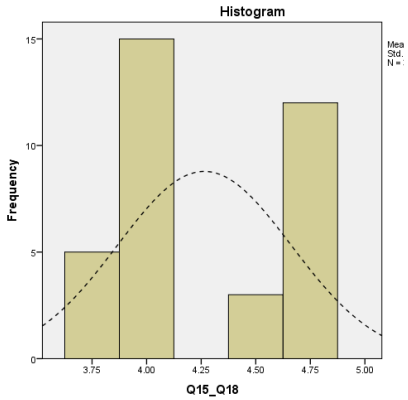
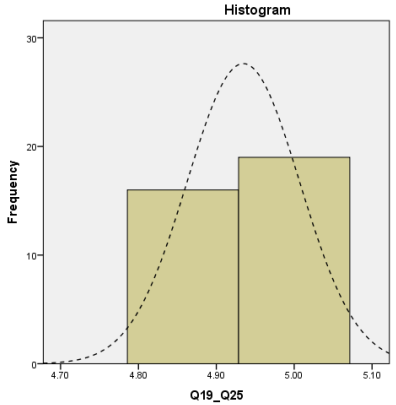
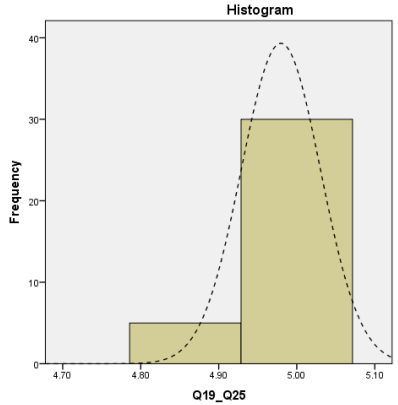
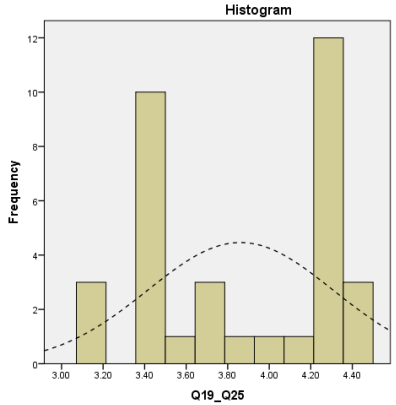
27	Inhabitants' interests are represented (or ignored) in NH dev.	35	4.34	4.83	4.80
28	Older community conveniently live & move	35	3.74	4.66	4.40
28	Housing/Bldg. characters collectively contributing to identity	35	4.43	4.80	4.89
30	Easy access to schools, pub. transport, Recreation, health,	35	4.66	4.69	3.46
31	Levels of crime prevention measures, road safety, street light	35	4.57	4.91	5.00
26-31	**Social aspect: Layout (Overall)**		**4.3810**	**4.8143**	**4.5667**
	Land use (Q32)				
32	Land-use;.Sufficient dedicated facilities; childcare, comty .centers, pub. library, skills dev. facilities (prox.)	35	3.23	4.49	3.83
32	**Social aspect: Land-use (Overall)**		**3.2286**	**4.4857**	**3.8286**
	Connectivity (Q33-Q37)				
33	Availability of sufficient traffic calming precautions	35	5.00	4.49	5.00
34	Cultural identity expression demonstrated?	35	4.20	4.06	3.80
35	Non-motorized transportation: walking, cycling facilitated?	35	4.89	5.00	4.54
36	Planning & engineering standards, harmonized with life	35	3.89	3.86	4.06
37	Rate on encouragements & supports with public environment	35	3.46	4.17	3.57
33-37	**Social aspect: Connectivity (Overall)**		**4.2857**	**4.3143**	**4.1943**
	Architectural Character (Q38-Q43)				
38	Diversity/variety of housing quality?	35	3.80	4.20	4.31
39	Stronger community identity & sense of place be developed?	35	4.74	5.00	4.83
40	Creating identities for more culturally diverse communities?	35	4.80	4.89	4.26
41	Culturally diverse communities facilitated?	35	4.83	5.00	4.69
42	Users perception/rate their neighbourhood?	35	4.69	4.89	4.91
43	Really offered kind of diminished human experience of a good living?	35	4.60	4.71	4.63
38-43	**Social aspect: Architectural Character (Overall)**		**4.5762**	**4.7810**	**4.6048**
	SOCIAL SUSTAINABILITY ASPECT (Overall)		**4.1179**	**4.5988**	**4.2986**
	Economic Aspect (Q44-Q51) **Layout (Q44-Q47)**				
44	Connectivity acceptable & convenient?	35	5.00	5.00	3.60
45	Diversity of hosing types?	35	3.51	3.80	4.09
46	Affordability of housing options?	35	3.51	3.77	4.57
47	House prices?	35	4.86	5.00	4.54
48	Land Value	---	----	---	----
44-47	**Economic aspect: Layout (Mean)**		**4.2214**	**4.3929**	**4.2000**
48	Commercial establishments available in proximity?	35	4.91	4.60	3.57
49	Availability of employment opportunities, types &	35	4.06	3.66	3.00
50	Rate standard of living quality, buying power, equity?	35	3.86	4.20	4.49
48-50	**Economic aspect: Land-use (Mean)**		**4.2762**	**4.1524**	**3.6857**
	ECONOMIC SUSTAINABILITY ASPECT (Overall)		**4.2488**	**4.2726**	**3.9429**
	OVERALL MEAN SUSTAINABILITY INDICATION (Mean)		**4.2846**	**4.5833**	**4.2438**

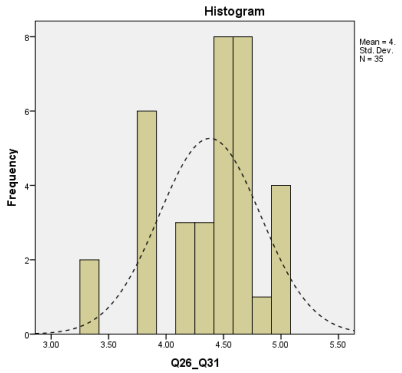
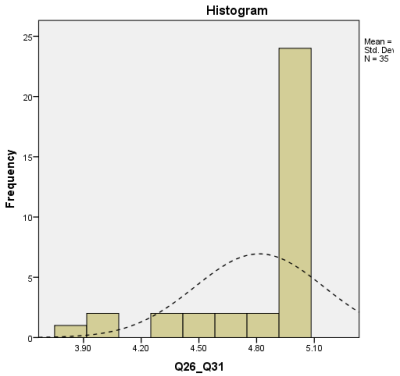
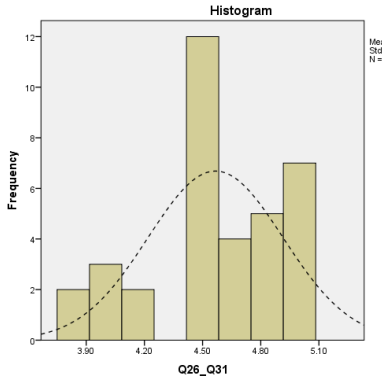
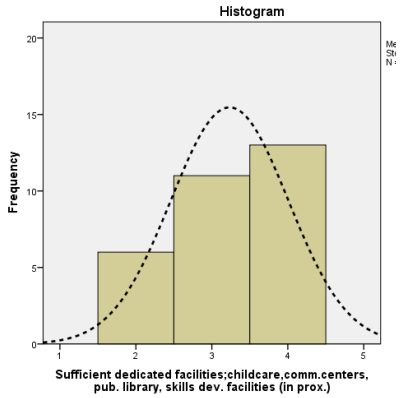
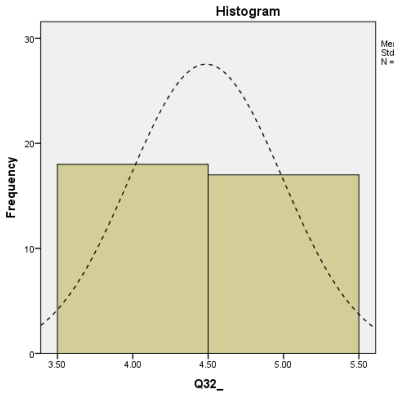
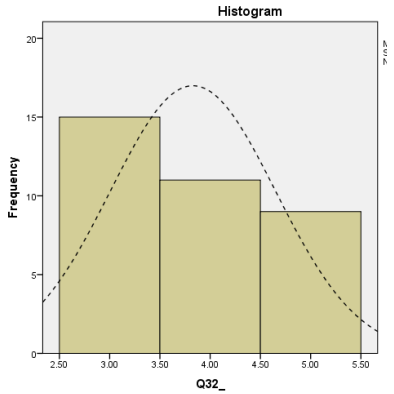
APPENDIX T

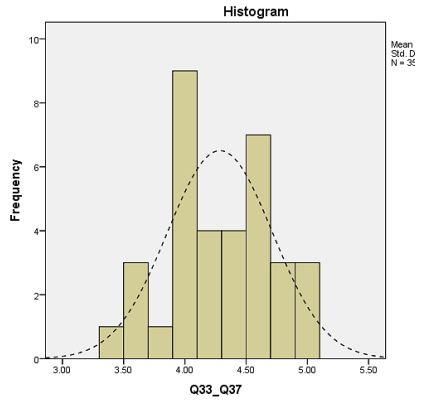
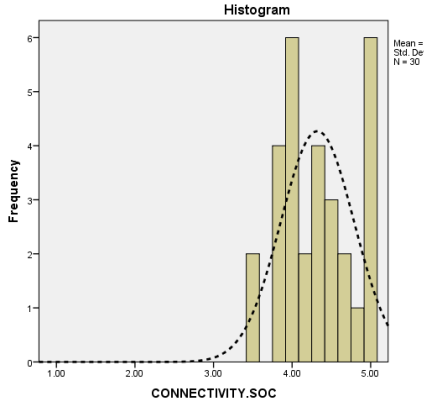
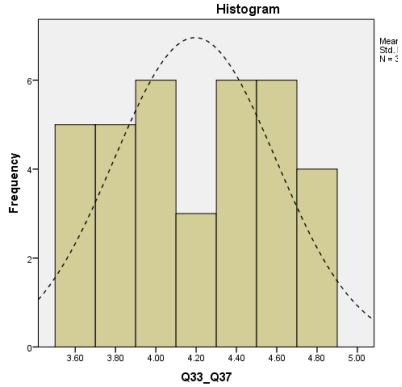
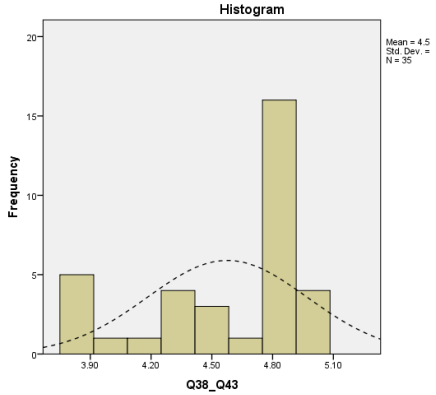
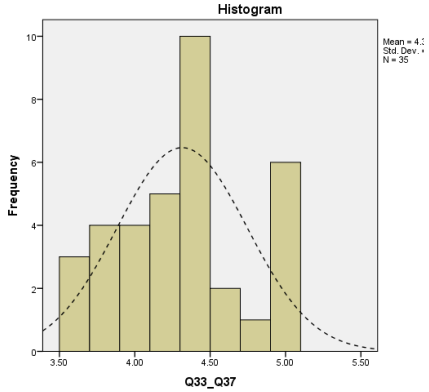
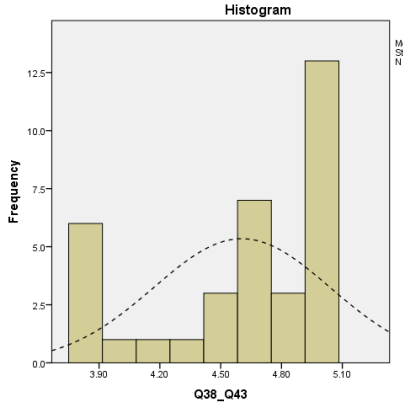
Descriptive analysis of frequencies.

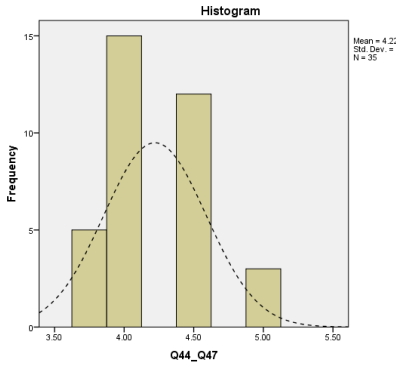
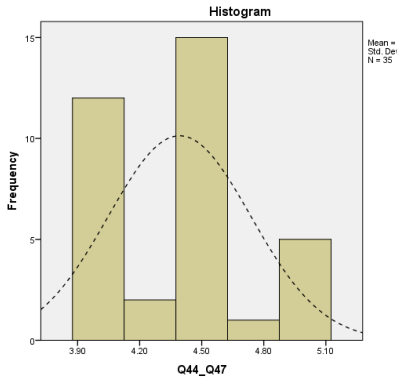
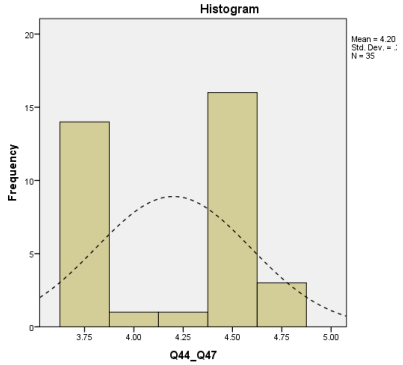
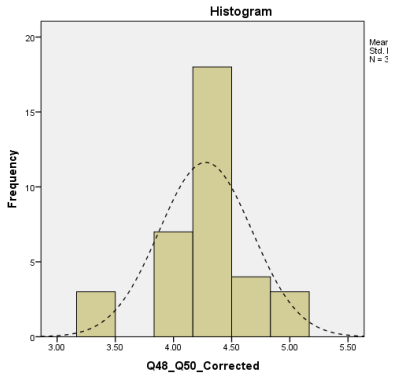
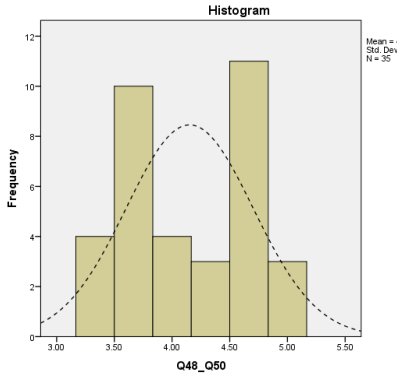
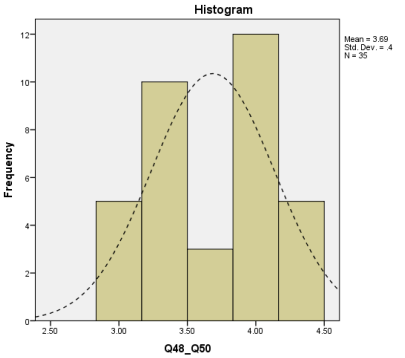
Comparative analysis of Sustainability Assessment against the attributes identified in respective urban form

Environmental Aspect	**Case Study-1; Newham Square**	**Case Study-2: Chitra Ln**	**Case Study-3: Veluvanarama Rd**
Q1-Q9/ Density	 Mean: 4.34 Standard Deviation: 0.193	 Mean: 4.95 Standard Deviation: 0.146	 Mean: 5 Standard Deviation: 0.00
Q10-Q14/ Layout	 Mean: 3.8 Standard Deviation:0.261	 Mean: 4.7 Standard Deviation: 0.267	 Mean: 4.83 Standard Deviation: 0.114

Q15-Q18/ Land Use	 Mean: 4.87 Standard Deviation: 0.153	 Mean: 4.89 Standard Deviation: 0.185	 Mean: 4.26 Standard Deviation: 0.397
Q19-Q25/ Connectivity & Transportation	 Mean: 4.93 Standard Deviation: 0.072	 Mean: 4.98 Standard Deviation: 0.051	 Mean: 3.86 Standard Deviation: 0.447

Social aspect	Case Study-1; Newham Square	Case Study-2: Chitra Ln	Case Study-3: Veluvanarama Rd
Q26-Q31/ Layout	 Mean: 4.38 Standard Deviation: 0.442	 Mean: 4.81 Standard Deviation: 0.335	 Mean: 4.57 Standard Deviation: 0.348
Q32/ Land Use	 Mean: 3.23 Standard Deviation: 0.77	 Mean: 4.49 Standard Deviation: 0.507	 Mean: 3.83 Standard Deviation: 0.822

Q33-Q37/ Connectivity/ Transport	 Mean: 4.29 Standard Deviation: 0.429	 Mean: Standard Deviation:	 Mean: 4.19 Standard Deviation: 0.401
Q38-Q43/ Architectural Character	 Mean: 4.58 Standard Deviation: 0.395	 Mean: 4.31 Standard Deviation: 0.432	 Mean: 4.60 Standard Deviation: 0.436

Economic Aspect	Case Study-1; Newham Square	Case Study-2: Chitra Ln	Case Study-3: Veluvanarama Rd
Q44-Q47/ Layout	 Mean: 4.22 Standard Deviation: 0.368	 Mean: 4.39 Standard Deviation: 0.345	 Mean: 4.20 Standard Deviation: 0.392
Q48-Q50/ Land Use	 Mean: 4.28 Standard Deviation: 0.40	 Mean: 4.15 Standard Deviation: 0.55	 Mean: 3.69 Standard Deviation: 0.45