Density Design and Sustainable Residential Development

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Abstract

Urban growth in the last few decades has led to a number of physical problems. Many factors responsible for this unprecedented growth of urban areas have also contributed to the acute shortage of building space and rise in the price of urban land. Cost of land and infrastructure is increasing continuously. In spite of this, people are generally in favour low density housing with the implicit assumption of its positive effects on the living environment. It is often assumed that high densities are inherently evil and that low densities are inherently good (Forsyth, 2003).

It is, however, quite likely that in spite of high housing densities, living conditions are better than in the low-density areas. The cost of development may also be high for low-density housing. In the older areas of traditional cities, despite high densities, the living environment is often quite good. The effect of high density can be negative and give rise to unpleasant interferences, but it can also be very positive and give rise to social cohesion.

Indeed density plays an important role in shaping cities and how cities function. Research related to density is carried out across a diverse range of disciplines such as urban development, economics, health, psychology, geography, sustainability etc. It is generally assumed that higher density developments are more sustainable. Many planning theories like new urbanism, smart growth and Transit Oriented Development (TOD) have emerged that support higher density housing, particularly in the US, UK, Australia and New Zealand. However, the link between density and aspects of sustainability remains a challenge for planning theory and practice. Therefore, the aim of this paper is to examine the interrelationships between density, design and sustainability.

Keywords: Density, Design, Housing, Sustainable development, Neighbourhood design, Triple bottom line.

1.0 Introduction

Urban growth in the last few decades and the awareness of utilising resources in sustainable way have led to a number of physical, economical and social problems in cities. In spite of triple bottom line problem in cities, people are generally in favour of low density housing with the implicit assumption of its positive effects on the living environment. It is often assumed that high densities are inherently evil and that low densities are inherently good (Forsyth, 2003). A study by Alexander and Tomalty (2002) of British Colombia on issues of development densities suggests that even though many issues of Smart Growth were supported by people but high density was a very controversial issue. Alexander and Tomalty argue that achieving high density is quite controversial because on the one hand it is

supported by environmentalists, transit operators and user-groups, and open space advocates and on the other hand it is opposed by the developers and owners thinking that this will introduce undesirable change such as congestion, crime and reduce percentage of open space in the neighbourhood.

It is generally assumed that high densities are inherently evil and that low densities are good. It is quite likely that living conditions in high-density residential developments are better than in the low-density areas. In the older areas of cities in many countries, despite high densities living environment is often quite good. However, effects of high density could be negative that can give rise to unpleasant interferences, but it can also be very positive leading to social cohesion.

Planning can influence urban development through layout of services and other practices followed in design and subdivision. The economy of planning of housing developments considerably depends on judicious choices of these variables. High densities bring down total cost as well as cost of land per unit. However, design parameters such as plot coverage, height, proportion of area under roads, orientation of layout and buildings, open spaces etc also affect the cost and the environment of residential development, apart from the density effects.

It is often assumed that higher density developments are more sustainable. Many planning theories have emerged like new urbanism, smart growth and Transit Oriented Development (TOD) to support higher density housing, particularly in the US, UK, Australia and New Zealand. However, the link between density and aspects of sustainability remains a challenge for planning theory and practice (Choguill, 2008).

Therefore, the aim of this paper is to examine the inter-relationships between density, design and sustainability.

The first part of the paper will give an overview on density and design and its relationships. Second part of the study outlines sustainability and explains the role of density and design parameters in creating sustainable residential development.

2.0 Density and Design

Both density and design plays very critical role in creating built environment. However, density itself cannot create good or bad environment because density is only a measurement, not an independent factor that could create good or bad urban fabric/built environment (Alexander, 1993; Forsyth, 2003). Indeed, it is design that is responsible for creating good or bad urban fabric. Density is one of many design parameters such as orientation, floor space index, plot coverage, mass, volume etc. Therefore, density alone might not guide the sustainability of residential development. This section gives an overview of density, design and their relationship.

2.1 Density

Concept of the urban density is very old it has been applied ever since the Garden City movement in England and the early modernists movement in Germany (Pont and Haupt, 2007). Density has different implications to professionals in different disciplines such as planners, economists, community organisations, psychologists and ecologists. For example, a psychologist or a sociologist may concentrate on the effects of perceived density on mental

well-being. Density is a term that represents the relationship between a given physical area and the number of people who inhabit or use the area. It is expressed as a ratio of population or number of dwelling units to area (Burton, 2000; Cuthbert, 2006; Forsyth, 2003; Forsyth et al., 2007; Jensen, 1966; Magri, 1994; Montgomery et al., 2003). Population density in a development field might not be a practical measurement because it will be lower with small households such as empty nesters than with large families with several children (Forsyth, 2003). The most widely used method to determine density is dwelling unit (DU) per hectare (Pont and Haupt, 2007). DU sounds much better because it is constant, whereas population is variable based on household size. Gross and net residential density is typically expressed as dwelling units per hectare. Floor area ratio (FAR) is a more precise way of measuring commercial or mixed-use density.

Net residential density includes the area occupied by the housing itself, any services and facilities for its immediate benefit, private gardens, communal gardens, children play areas and incidental open spaces. It includes parking spaces, access roads within the site and half the width of surrounding roads. Small scale facilities such as a local shopping or a community centre may also be included (Burton, 2000; Cuthbert, 2006; Forsyth, 2003; Forsyth et al., 2007; Jensen, 1966; Magri, 1994; Montgomery et al., 2003). Gross residential density (neighbourhood density) includes, in addition to the above, open spaces serving a wider area and other landscaped areas, primary schools, local health centres, distributor roads and transport networks, small scale employment, services and mixed use. It does not normally include large industrial and commercial areas or major roads and transport interchanges ((Burton, 2000; Cuthbert, 2006; Forsyth, 2003; Forsyth et al., 2007; Jensen, 1966; Magri, 1994; Montgomery et al., 2003)). The difference between net density and gross density plays an important role in projecting future land needs. Net density refers to the actual lots used for development after allowance to roads, parklands and other non-development land excluded from calculation. Typically, at least 33% of land is devoted to these uses. A gross residential density of 25 du/ha would be roughly equivalent to a net density of 37.5 du/ha.

Another area of confusion is the issue of crowding, a perception that there are too many people (Churchman, 1999, p.390). Churchman says that ‘density is an objective, quantitative, and neutral term’. It is neutral in the sense that one cannot know immediately whether a given level of density is positive or negative. In housing studies, however, crowding is measured generally as number of people per room, per bedroom, or square foot. Obviously, density and crowding are different and are not even always related. It is possible to achieve very high densities with spacious apartments without crowding, and conversely it is possible a detached farmhouse is crowded in terms of having many people per room.

2.2 Design

Design is often viewed as an activity that translates an idea into a blueprint and vision for urban, rural and regional areas or for different land uses. The important part is the translation of the ideas through design's ability. Design does not have to be new, different or impressive to be successful as long as it is fulfilling a need and is a functional as stated by F.L. Wright ‘form follows function’. Indeed design methods do lead to innovative and interesting places.

Designs not only look at the aesthetic aspects of the built environment, but it is a problem-solving activity. Indeed design is a ‘functionalism’ or 'form follow function’ approach. Jones argues that design is a functionalist approach: “the functionalist approach suggests that if we analyse the problems that the design sets out to address in sufficient details and in scientific

manner, a spatial solution will emerge from this analysis or 'programme". It suggests that design is a linear process, which if carried out with sufficient rigour, will lead to a single, optimum solution" (Jones 2001, p.51). Both design elements and functions have impact on sustainability of built environment. Design has many elements such as plot coverage, floor space index, setbacks, mass, height, orientation, climate consideration etc that helps to create various elements of built environment with same density. Functions of design also play a crucial role in creating an image of the urban fabric such as how the streets are laid out, land is subdivided, and buildings are arranged and detailed, where trees are planted, where the sidewalks lead. Orientation and climate consideration is again very strong elements of design parameters.

2.3 Relationship between density and design

There is a strong relationship between density and design. Density is a measurement but design is a tool, which creates the built environment. Therefore, both density and design play an important role to create desirable and sustainable built environment in various cultural contexts. This section is divided into three parts. A first part argues effect on variations in design and density, second part explains the impact of design parameters and last part describes impact of a layout pattern.

Campoli and MacLean (2007) argue that for many people density is associated with ugliness, congestion and crowding, even if it can be shown that well-designed higher density can achieve well-built environment and could save land, energy, infrastructure cost and the overall cost of the housing development. They argue that people have a problem of distinguishing quantitative and qualitative character of density. Forsyth (2007) argue that higher density has many advantages in terms of efficient use of infrastructure, housing affordability, energy efficiency, vibrant street life that improves social interaction. However, she says that density alone is not sufficient to create a good urban environment, and it requires appropriate design. (Montgomery et al., 2003, p.1) conclude that 'issues relating to urban form and density continue to fuel worldwide debate'.

The effects of variation in the basic relationships between different factors like total living rate, floor space rate, floor space index, plot coverage, communal services index and number of storeys determine the total land requirements for housing. These variables in total determine housing density and plot size.

Nature of grouping of buildings and number of storeys also influence residential densities. These values increase with increasing number of storeys in a continuous row of dwelling or where no additional side open space is allowed. In the case of high-rise apartment, they tend to fall after recording small increase. However, the number of storeys giving maximum density varies with the nature and size of the dwelling units. Floor space index (FSI) values behave similar to that of density. In a continuous row of dwellings, it shows constant increase with the number of storeys. Irrespective of grouping in a row the land coverage reduces at a diminishing rate with increasing number of storeys. Number of dwellings placed in a row influences only the rate at which land coverage diminishes. After certain height high rise development does not become economical if a small number of dwellings are grouped in a row.

Open space per dwelling remains constant for a particular dwelling size and location even with varying number of storeys for a continuous row of dwellings. With other groupings, it uniformly increases and greater rates are achieved in a shorter row than the longer row. In

row type housing open space per dwelling can be determined by multiplying the area of dwelling with the factor for the required for open space. The study concludes that apart from dwelling size, its shape, orientation, and grouping the layout deserves prime consideration in determining densities.

Squares and rectangular blocks are relatively efficient, whereas layouts with irregular and spread out blocks consume relatively more land. Densities vary with the size and number of dwellings in a block, number of blocks forming the pattern, and the spacing between the blocks. Ambrose (2008) says that if layout is design given due respect to solar orientation will allow energy efficient house design because lots are suitable to place a dwelling with good solar access.

Quite often in residential area a block consisting of the single row of dwellings is provided. However, in low-income group housing doubly loaded blocks are also adopted. Relatively higher densities can be achieved with such blocks than blocks with single rows. Higher densities between 68% and 87% of net area densities are possible with doubly loaded blocks as compared to 52% to 78% obtained from single block. Relative increase in density varies between 13% and 57% (Sinha, 1982). However, in most cases about 20% to 25% more densities can be achieved with doubly loaded blocks. If higher floor area ratio is allowed doubly loaded blocks can result in higher densities. This section demonstrates that it is design rather than density that matters in creating better quality of built environments.

Figure 1. Impact of design on built environment
Source: Lincoln Land Policy Institute

Even though high-rise buildings are generally associated with high residential density, there is no basic relationship between the two. For example, the two neighbourhoods depicted in figure 1 have exactly the same density, but look very different at night and day. Although they both have the same density they are not necessarily perceived to be equally dense. What really matters is how the layout is laid out. Layout plays a very important role in creating urban fabric and living environment.

3.0 Density design and sustainable residential development

Sustainability has become a very important element in design of cities as well as residential areas. However, Choguill (2008) argues that even though consideration of sustainability is very important in residential/neighbourhood design, it has received less importance. Jepson (2007) argue that when it comes to practicing sustainable development it remains outside the mainstream. Choguill also argues that old concept of the neighbourhood developed many

decades ago by Howard and Perry address the sustainability issues. Unfortunately these old neighbourhood concepts have been forgotten by planners across the world.

New Urbanism came as new paradigm to address sustainability issues of neighbourhood, cities and regions. New Urbanism movement was launched in the United States and began to unite in the 1970s to 1980s (Deitrick and Ellis, 2004; Grant, 2006; Holcombe, 2004). In 1993 the Congress for New Urbanism (CNU) was established, and in 1996, they adopted the Charter of the New Urbanism a book by Leccese and McCormick that explains the mechanisms of New Urbanism, which has since lead to various task forces studying the re-development and revitalization of regions (Deitrick and Ellis, 2004, p. 427). New Urbanism does not present any new ideas (Hebbert, 2003), many of the fundamental principles can be found in concepts such as City Beautiful, the Garden City and the Compact City approach (Fulton, 1996; Grant, 2006). The reason for New Urbanism being established came about as a response to the problems associated with urban sprawl (Fulton, 1996; Grant, 2006; Holcombe, 2004). Some of the common problems associated with urban sprawl include increasing traffic congestion, loss in sense of community, reduction of open space, vanishing farm land, environmental degradation, social problems associated with isolation and a general dissatisfaction among suburbanites (Fulton, 1996; Grant, 2006; Holcombe, 2004). As Tomalty put it, "new urbanism is a 'back to the future' approach to urban design that attempts to recover the best traditions of city building and export them to the suburbs" (Tomalty, 2000. p. 39).

There are many definitions of sustainability. One definition widely used and accepted is by the World Commission for Environment and Planning (WCEP), which says cities are seen to be sustainable if they meet 'the needs of the present without compromising with the ability of future generations to meet their own needs (World Commission for Environment and Planning, 1987). According to (Newman and Kenworthy, 1989) the concept of sustainability has emerged from a global political process that has tried to bring together, simultaneously, the most needs at present: (1) the need for economic development to overcome poverty; (2) the need for environment protection of air, soil, and biodiversity, upon which we all ultimately depend; and (3) the need for social justice and culture diversity to enable local communities to express their values in solving these issues. To achieve triple bottom line, concept design and density play very important role. Even though there are many definitions of sustainability it is generally agreed the economy, environment and social equity are three prime values of sustainability (Chan and Lee, 2009).

Figure 2: Sustainable Development

It is generally assumed that built form is nothing more than the physical arrangement of various activities, architectural forms to suit land use regulations (Greene 1992). There are various schools of thought: some authors discuss design of urban fabric in physical and environmental terms (Cullen, 1961; Levy, 1999; Lynch, 1960; Trancik, 1986), whereas others argue that creation of urban fabric is the linkage between psychological, sociological and philosophical aspects (Alexander et al., 1987; Rapoport, 1982). Some consider it as interplay between environment and social factors (Barnett, 1982; Lawson, 1980). In spite of great concerns for creating sustainable and lively neighbourhoods, there is not enough comprehensible and consistent terminology in a framework both planners and public can use to communicate ideas about neighbourhood design (Greene, 1992).

Following section will provide the impact of design and density for social, economic and environmental sustainable residential development.

3.1 Social sustainability

Social sustainability is improvement and maintenance of current and future well-being and it reduces social inequality and improves quality of life (Chan and Lee, 2007). Therefore, to achieve the quality of life, there is need for interaction within the community. Chan and Lee (2009) argue that form of development affect the micro climate of areas in terms of temperature, relative humidity, air quality, lighting level and ventilation flow, which affects human comfort. Intensity of interaction is very much related to design elements and layout pattern. For example, residential areas with the row house design and low density tend to reduce the interaction in society, whereas a dwelling unit in U-Shape and medium density increase the interaction. U shape layout increases the interaction because this provides a common entry point for everyone. Common area for passive and active recreation at residential level increases the interaction within the community. Pedestrian oriented neighbourhood provide opportunities for people to interact with society. Design is a key to create sustainable development by improving or enabling social equity, economic vitality and environmental responsibility (Chan and Lee, 2009). In order to ensure social sustainability could be achieved through design and density, number of design considerations has to be taken into account when preparing residential/urban development (refer figure 3).

Figure 3: Design elements to make social sustainable neighbourhood

Therefore, to make residential development socially sustainable these design elements need to be incorporated in neighbourhood design. It is also observed that in low-density suburbs the interaction is less whereas in medium and high density it is more. However, as density does not have a fixed standard and varies from place to place, it needs to be identified in its specific context. Hence, social sustainability is the process that addresses the relationship between society and built environment (design and density) and quality of life in neighbourhood setting.

3.2 Economic sustainability

Design element also impact on economic sustainability. The low cost of infrastructure, low construction cost of residential buildings, maintenance of infrastructure and buildings and permeable design leads to economically viable development. Design that takes care of orientation, ventilation, micro and macroclimate, and materials, generally has lower maintenance and ongoing cost (Chan and Lee, 2008).

Li and Brown (1980) argue that better design, physical condition of the buildings and image of the neighbourhood often lead to an increase in property prices. To obtain such economic gain, development need to consider many aspects of design, and most important element is the layout pattern and spatial distribution of activities and facilities. Density also intends to raise the utilisation of land by providing high quality of high density housing to increase the total revenue (Fishelson and Pines, 1984). Design also has to achieve balance between various land uses to maximise the revenue. Economical sustainability of any residential development is the outcome of intensity of gross and net residential densities and various design elements. Some of the design elements are:

1. Optimisation of natural lighting and ventilation
2. Access to open space and social facilities for all age groups
3. Access to open space and social facilities for all age
4. Efficient use of land & space and mixed use development
5. Adaptability of development to the changing need
6. Green feature related to construction such as installation of energy efficient/water saving devices, use of recyclable and durable construction materials.
7. Provision of accommodation for different income groups
8. Layout pattern
9. Building design in terms of appearance, density, height and mass
10. Convenience efficiency and safety for pedestrian and public transport users.

(Chan and Lee, 2009, pp. 360-361)

Therefore, density and design parameter play a very important role for achieving economically sustainable development.

3.3 Environmentally sustainable design

There is a close relationship between development density, design and environmental quality and it is necessary to decide the form of development carefully (Chan and Lee, 2009). Design parameters affect the environment at both macro and micro level. Intensity of density also plays an important role to make development environmentally sustainable. Increased density and mixed use development means more buildings, shops, homes and local services in close proximity to encourage walking and cycling. It also enables more efficient use of services, resources and more convenience to its citizens. This increase in density means more people

should walk or ride bicycle and thus medium and high density will lead to reduced emissions and pollutions. (Chan and Lee, 2009) argue that design consideration such as quality of life, conservation and preservation, integrated design and provision of welfare facilities should be incorporated to sustain the urban environment. Intensity of density need to be carefully selected because high densities lead to traffic congestion and low density increases the cost of public transport.

Various scholars (Chan and Lee, 2009; Montgomery, 1998; Rowley, 1998) believe that design parameters are key component in creating sustainable development. Some of the design parameters that need to taken into account are presented in figure 4. Design parameter will vary based on the local context.

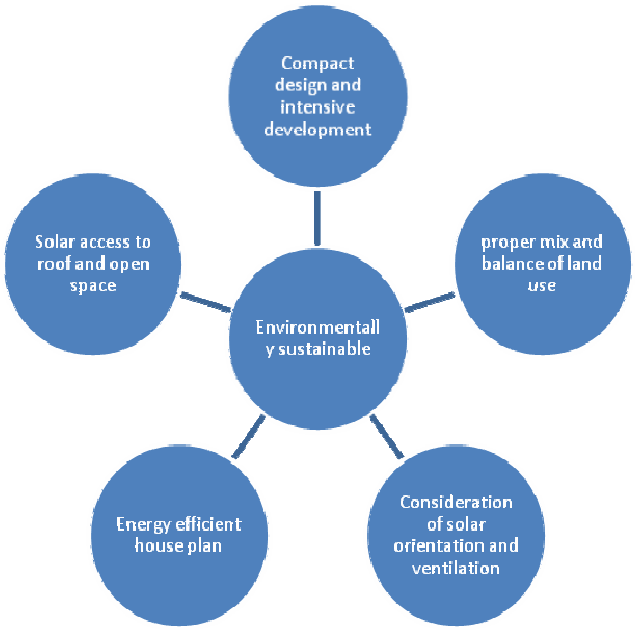

Figure 4: Design elements for environmentally sustainable neighbourhood

Use of New Urbanism theory will be useful to address environmental issues. Sustainability of towns as New Urbanism see it is by way of eco-friendly technologies, energy efficiency, reduction in the use of car and fuel and more local production. It is further enhanced when good design principles are utilised, for example, the positioning of the streets and internal layouts of the dwellings in order to reduce the need for heating and cooling.

Due consideration in layout and house design to solar orientation will harness the warmth of the sun in winter and protect from the hot summer sun. This will lead to sustainability because there will be less requirement for heating and cooling. Well orientated lots will also enable buildings to have potentially greater roof space correctly orientated for solar hot water systems (refer figure 5).

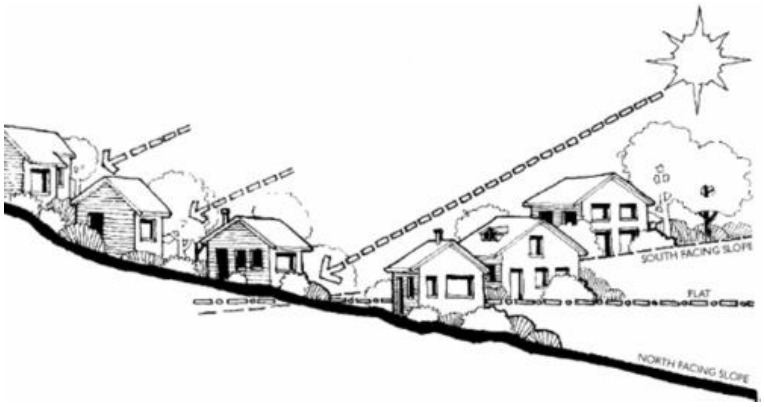

Figure 5. Solar orientation of buildings
Source: Sustainable Energy Development Authority (www.seda.nsw.gov.au)

4. Conclusions

This study has highlighted the importance of density and design considerations in achieving social, economical and environmental sustainability of residential development. It is evident that there is a pressing need to change the way in which we develop our neighbourhood by incorporating density and design parameters. Certainly, density and design parameters have the potential to address triple bottom line principles. In analysing the feasibility of density and design parameters towards providing sustainable solutions for neighbourhood development, we have to reach an agreement with the view put forward by various authors that the potential for sustainable outcomes correlates to the diversity of the urban environment. Greater the diversity of design variables including social, cultural, economic, environmental, transport, housing, land use urban form, the greater the opportunity to manage and balance issues of sustainability.

Undoubtedly, there is a close relationship between design, density and sustainability. However, to provide social, economical and environmentally sustainable residential development the impact of density and design need to be seen for all three sectors as one concept rather than treating design and density individually for social, economic and environment.

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