
Original Article

Influence of urban forms on social sustainability: A case of Guwahati, Assam

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Abstract In the last decade, the rapid growth of cities and exacerbated social problems have led to a great deal of inquiry on the extent to which the physical forms of cities can contribute towards achieving a just and sustainable future. Past investigations in the western context have remained less than satisfactory, further raising concerns about their applicability to the developing world cities which face essentially different urbanisation challenges and socio-cultural shifts. As India prepares itself to become an urban majority by 2050 and gives shape to its futuristic smart cities, there is clearly a pressing need to develop stronger empirical evidence about the influence of urban forms on social sustainability which links to sustainable design, policies and practices. This research therefore, tests the effects of urban forms on six aspects of social sustainability using both, qualitative and quantitative strategies, which are calibrated and validated for Guwahati, the dominant city of Assam in India. The quantitative findings for two urban form types using six case studies show that neighbourhood forms with connected and integrated street network, higher proportion of accessible open recreational spaces, higher mix of uses, higher densities and smaller compact urban blocks display higher levels of social sustainability amongst its residents, after controlling for intervening variables. Qualitative findings for four urban form types using twelve case studies further illuminate this complex relationship at the scale of block-segments. It highlights five key theories: (i) intervening variables, (ii) spatial proximity, (iii) favourable spatiality, (iv) complementing synergies and (v) tipping point.

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Introduction

With a desire to achieve a better environment and quality of life for its residents, the concept of sustainable urban development has revived the interest in the physical forms of cities. As a result, there has been intense debates and inquiry into the extent to which the urban forms and associated human behaviour can contribute towards achieving a just and sustainable future. The outcome of much of this inquiry has been advocacy of compact city as the most common recommended solution to meeting several urban sustainability goals. Despite its perceived benefits, the compact

urban form, in both discourse and practice, has been less than satisfactory, contradictory and complex (Jenks and Burgess, 2000; Williams *et al*, 2000), further raising concerns about its validity and applicability in an essentially different developing world context. Stressed under international sustainability commitments and rapid urban change, the compact-city orthodoxy is being enthusiastically adopted in developing nations like India, without practical strategies for its application and ignoring the potentials of indigenous typologies and practices (see, for example, Parameters for NMSH, 2011 in India). The evidences about the influence of urban forms on



social sustainability are complex and difficult to achieve, and therefore, the link between urban form and social sustainability has been the subject of only a limited number of studies especially in the Indian urban context¹, thus indicating the need for further empirical research that not only informs the design practices but also becomes integral to development policies seen as utmost essential to make the country's urban growth and transition more sustainable and inclusive.

This research tests the influence of urban form components (open spatial-network, land-use, densities, blocks and built-components) on six aspects of social sustainability. To do so, it conducts a critical review of the concept of urban form, sets out its key dimensions and understands their claimed relationship with social sustainability. Building on the comprehensive study of Guwahati, the dominant city of North-East India, six case studies for two urban form typologies at neighbourhood scale and twelve case studies for four urban form typologies at block-segment scale are identified in order to examine both broad-based and detailed urban form variations. Both quantitative and qualitative research methods are adopted to test the associated social sustainability outcomes. The triangulation of outcomes further illuminates this complex relationship between urban form and social sustainability from which the paper draws some key conclusions.

Urban Form: A Critical Review

Compact-city orthodoxy

The interest in urban form-making has, for city designers, always remained a subject for idealistic desire and hope for an optimistic future. Throughout history, various attempts to create the perfect environment for an ideal society – 'utopia' – have been made. From the ancient cosmic ideologies to modern technological exemplars, the notion of an 'ideal' city has remained embedded in urban planning through to the present day, where sustainable forms of cities address urban growth within the ideals of a balanced and sustained environmental, economic or social development. The quest for sustainable form utopias is a powerful but invisible reform movement based on a general agreement that urban forms can improve sustainability; yet there is a disagreement and little hard evidence about the optimal way to modify them to gain sustainability benefits

(Breheeny, 1992). Yet, across the globe, there is a growing awareness of, and concern about, the development of urban form, especially sprawl, which is seen as an outcome of the twentieth-century visions² and a combined effect of growing affluence, changing lifestyles and advance in personal automobile mobility that shaped the dispersed forms of the modern cities (Newman and Kenworthy, 1989). The sprawl has been associated with a variety of negative outcomes leading to further environmental, social and economic impacts such as issues related to health and social fragmentation, increased cost of city services as well as environmental degradation (Bertolini *et al*, 2008). Much research has therefore, been conducted on urban models (New Urbanism, Compact City, Urban Containment, Eco-City and Smart Growth) and their components (high density, mixed uses, sustainable transport, etc.) as design criteria for new forms that promote sustainable development in response to the negative effects of sprawl. The outcome of this has been the advocacy of urban 'compaction'³ and 'intensification' as two of the most-common recommended solutions to meeting several broad goals in areas of energy efficiency, environmental sustainability, as well as health and social outcomes (Dieleman and Wegener, 2004). In the Western context, the compact-city ideology is embodied in planning policies and urban design theories as the twenty-first century utopia for sustainable cities. Such an approach is supported by several sustainable benefits; however, at the same time, there has also been some conflicting arguments and research outcomes regarding the merits of compact cities to which Neuman (2005) refers as 'compact-city paradox' in which lower density areas are associated with higher-levels of liveability, whereas higher densities are seen necessary to meet sustainability goals (Wiersinga, 1997).

The 'compact-city' ideology-turned orthodoxy has been often criticised and debated on empirical grounds and its relevance in different world contexts as evident from the discussions for and against compact-city form (Jenks and Dempsey, 2005; Jenks and Jones, 2010). The major issues with the compact-city orthodoxy are

- i. *Contextuality*: issue of transferability of compact-city model in different cultural and urban contexts with varying patterns of urbanisation and governance as well as different physical, economical, social and demographical characteristics of cities globally (Williams *et al*, 2000).

- ii. *Rigidity*: issue of rigid application of compact-city model as a blueprint rather than being a new approach to achieving sustainable urban development through spatial design.
- iii. *Scale*: issue of spatial scales at which an urban form is measured as it might increase one aspect of sustainability on one scale, while decreasing it on another.
- iv. *Spatiality*: issue of expressing compact forms in formless statistical numbers (Kärrholm, 2011) or concentric circles indicating the need for greater emphasis on the design qualities of sustainable compact urban typologies.

Thus, despite its perceived benefits, the compact urban form, in both discourse and practice, has been less than satisfactory, contradictory and complex (Jenks and Burgess, 2000; Williams et al, 2000), further raising concerns about its validity and applicability in an essentially different developing world context.

In the Indian context, urban form production is becoming synonymous with the process of westernisation and new forms symbolise the achievement of modernity. In the present era of creating 'utopian', world class' or 'global' cities, every international 'ism' is being mirrored as a 'style', while traditional forms and cultural expressions seems to be fighting a losing battle (Doshi, 1997). Stressed under international sustainability commitments and rapid urban changes, the compact-city orthodoxy is also being enthusiastically adopted, without evidence-based and practical strategies for its application (Gopal and Nair, 2014) while ignoring the potentials of indigenous typologies and practices (see for example Parameters for NMSH, 2011 in India). In Indian cities, where compact-city concept has been incorporated, incomplete implementation of policies and proposals has, in some cases, resulted in an inverted⁴ compact city. Perhaps more important is the fact that, given the existing urbanisation trends, it seems clear that 'compaction' of urban areas will remain essential components for Indian cities which will continue to see population growth in the face of limited resources and available land as well as issues related to already high urban densities and integral compact forms.

At the time, when urban policies in many countries have emphasised the compact-city and higher-density urban forms as a means of reaching goals of sustainability (Dieleman and Wegener, 2004), there has been mixed conclusions especially

about its social and community impacts. The evidences about the influence of urban forms on social sustainability are complex and difficult to achieve (Jenks and Jones, 2010), and therefore, the link between urban form and social sustainability has been the subject of only a limited number of studies (Talen, 1999; Bramley et al, 2009). Most research works in this context have been focussed on the comparison of neo-traditional (new urbanism) forms with typical suburban form (Brown and Cropper, 2001; Kim and Kaplan, 2004; Podobnik, 2002; Mason, 2010) or on the differences between the low- and high-density neighbourhoods (Leyden, 2003; Talen, 1999; Yang, 2008) set in the western context. There is also a vast body of literature and empirical evidences on connections between urban form and physical health (Baum and Palmer 2002; Owen et al, 2004), as well as urban form and mental health (Hessler et al, 1971; Handy et al, 2002). However, there is little evidence focussing on the relationship between different components of urban forms and various aspects of social sustainability in a comprehensive manner especially in the Indian urban context⁵, thus indicating the need for further empirical research.

Comprehending urban form

An urban form, in general, is used to describe a city's physical characteristics. Kevin Lynch (1981, p. 47) defines it as "the spatial pattern of the large, inert, permanent physical objects in a city". In reference to Lynch's definition, Jabareen (2006) argues that, the form is a result of aggregations of more or less repetitive elements (generating spatial patterns) that have strong similarities and can be grouped into concepts. Such elements of concepts might be overall shape and size, urban grains, street patterns, urban blocks, aesthetic design, typical spatial configuration, layout and more. They can also be seen as a composite of characteristics related to land-use patterns, transportation systems and design characteristics (Handy, 1996). Dempsey et al (2010), however, assert that the concept of urban form does not merely imply physical features but also encompasses various non-physical aspects and can therefore, be viewed as an integration of urban physical attributes (geometric shape, size, materials, etc.) and contents (uses, activities, impressions, etc). Anderson et al (1996) further identify urban form as 'the spatial pattern of human activities at a certain



point in time'. Such a definition highlights the fact that it may be difficult to conceive of 'space' without human or social content and equally to conceive of human society without a spatial component (Carmona *et al*, 2003, p. 106).

Urban form has remained a subject of continuous debate as to what they may encompass, how they evolve under different contexts and to what extent can they influence sustainability aspects. Yet a wide range of scholars agree that it can influence patterns of human behaviour and social life, and hence, changes in the urban form may be planned integrally with the changes we wish to see in our social environment (Evans, 1998). An urban form can also be viewed from different geographical scales⁶ of regional, country, metropolitan, city or neighbourhood. A number of factors can relate to multiple scales, for example, social cohesion is generally discussed at a national scale, employment at city or district scale, while others such as social interaction and local environmental quality relate to activity and places on a local scale (Bramley and Power, 2009). Urban form is thus, a distinctly complex concept to define and measure since it involves a variety of physical and socio-spatial dimensions across a multitude of scales.

While the urban form of a city can be measured through various aspects, this research identifies the five key elements of urban forms that are theoretically relevant and are claimed to influence various aspects of social sustainability and that for which data measurements would be available. An attempt is made to reach a balance between an exploratory examination of a wide variety of urban form characteristics and a focus on the most relevant and accessible variables. It is important to note that all the variables identified in Table 1 are inter-related, scale specific and context dependent and, therefore, may vary in the way

they are perceived. Detailed descriptions of each of the urban form components and their social sustainability relationship claims have been furnished in Supplementary Material (SM)-1.

Social sustainability

Recent years have seen notable efforts from academicians and practitioners in various sectors to address the often neglected social dimension of sustainability yet, social sustainability is generally seen as 'added-on' to promote the message of other disciplines (i.e. economics, ecology) (McKenzie, 2004) or, in some cases, dismissed altogether. A comprehensive literature review indicates that regardless of its anthropocentric focus and general conformity that social sustainability is significant, the ongoing problems of lack of confirmed definition of the construct, its relation to other variables, and how best to measure it continue to impede the application of the social sustainability (Burton, 2000; Colantonio, 2007). Despite these ambiguities, numerous social aspects or components that constitute the concept of social sustainability have been identified by several authors. For example, Dempsey *et al* (2010) focus on equity and community, while Torjman (2000) suggests poverty reduction, social investment and building of safe and caring communities as three priority directions. Young Foundation (Woodcraft *et al*, 2011) found that social sustainability in built-environment rests on four key aspects amenities and infrastructure, voice and influence, socio and cultural life and, space to grow. Colantonio (2008) puts forward a comprehensive list of key themes for the operationalisation of social sustainability and argues that more intangible and less measurable emerging concepts such as sense of

Table 1: Components of urban form

<i>Components of urban form</i>		
<i>No.</i>	<i>Components</i>	<i>Description</i>
1	Open spatial-network	The network of public open spaces (not just spaces for outdoor sports and recreation but also everyday spaces such as streets, community squares and open markets)
2	Land-use	The total of arrangements, activities and inputs that people undertake in a certain land cover type (different functions of the built environment, mix of uses)
3	Density	The number of people living in a particular area (number of people per hectare)
4	Blocks	The smallest area defined by spatial network (space for buildings surrounded by streets or other open spaces)
5	Built-components	Built components within the urban blocks that form physical containers or 'street-walls' of spatial-network (attributed by orientation, frontage, coverage, enclosure, typology)

place, identity, quality of life and benefits of social networks are gaining importance as opposed to traditional themes, such as equity, poverty reduction and livelihood. And even with the fact that the concept is complex because it includes a multitude of contributory facets, one can identify at least four broadly accepted and overlapping social sustainability dimensions (the 4'S's) within which these social components or aspects can be grouped. Amongst these, social capital and social cohesion relate more directly to the concept as a set of social conditions that 'enable' reaching collective goals while social equity and social inclusion represent actual end-goals. Although there is little information specifically on social sustainability, there exists broader literature on these four dimensions and building on the review of literature so far, it can be argued that: Social Sustainability in built environment is "a combined top-down and bottom-up process for creating urban spatial forms that nurtures the 4'S', social capital, social cohesion, social inclusion and social equity, whilst appreciating people's diverse needs and desires from the places they use" (Hemani and Das, 2015). The four dimensions of social sustainability are vast concepts and include several components amongst them however, six components which were found fundamental and sensitive to (claimed to be influenced by) the built-environment were considered for this research (Table 2).

Research Methodology

Hypothesis

Primary hypothesis

Urban forms (at spatial scales of neighbourhood and block-segment⁷) significantly affect various aspects of Social Sustainability.

Working hypotheses

- Quantitative Study – Spatial Scale of Neighbourhood, broad-based urban form variations

It is assumed that urban forms with higher levels of (1) street connectivity and integration, (2) amount of accessible open recreational spaces, (3) mix of uses, (4) densities, (5) small compact blocks display significantly higher levels of social sustainability amongst its residents, after controlling for intervening variables.

- Qualitative Study – Spatial Scale of Block-Segment, detailed urban form variations

Owing its inductive nature, the qualitative research does not begin with a hypothesis but a set of research questions.

Choice of research methods

With their development and legitimacy, use of both – qualitative and quantitative research methods – has been expanding. Multi-level, multi-method research strategies (Table 3) where "more than one method or worldview is used" (Tashakkori and Teddlie, 2010, p. 11), were employed to inform the research inquiry in order to enhance dimensional insight and illuminate the complexity of the phenomenon under study (Creswell et al, 2003). Such an approach to investigating the effects of urban form on social sustainability offered both, generalisable 'breadth' and context-specific 'depth' (Bamberger, 2000) which were essential in order to adequately understand social design and planning issues as well as establish a firm basis on which to draw policy recommendations.

Social sustainability depends upon the spatial scales at which the urban form has been studied and the relative strength of various forces operating at each scale. The research was therefore conducted at two levels or spatial scales – 'neighbourhood' and 'block-segment'. The quantitative research in form of a questionnaire provided numerical evidence at the neighbourhood scale and allowed for statistical analysis. Qualitative research was included for more in-depth understanding of the complex relationship and study of more detailed urban form variables at the level of a block-segment. Each, quantitative and qualitative research was conducted rigorously, independent and complete in itself. The priority between the two methods was equal and results of the two methods in case of nested case studies were integrated during the interpretation phase (Creswell et al, 2003). Triangulation of outcomes from two different methods strengthened the findings and increased robustness of the results. Collecting different kinds of data by different methods from different sources provided a wider range of coverage that resulted in a fuller picture of social sustainability which would have been difficult to achieve otherwise (Figure 1).

**Table 2:** Components of social sustainability*Components of social sustainability**Social capital/social cohesion***1. Social Interactions/Social Networks (IntNet)***Intensity and type of contacts or exchanges between people*

Significance: Considered integral to people's values and identities as well as to civic society as they influence important aspects of life such as the extent of social support, reciprocal actions and spontaneous cooperation necessary for developing shared identities (Putnam, 1993), feeling of safety and sense of well being (Fischer, 1982; Pierson, 2002)

Relationship: Associated with negative consequences of the sprawling neighbourhoods, characterised by low population density, segregation of land-uses, automobile-dependency, lack of public spaces (Calthorpe, 1993; Leyden, 2003) as opposed to neighbourhoods that have mixed land uses, higher population densities and pedestrian-friendly streets (Jacobs, 1961). Poor social interaction has been associated with very high densities and crowding in an area (Keane, 1991)

2. Trust/Reciprocity (TruRci)*People's general readiness to form associations outside the obligations of family or the compulsion of the state (Fukuyama, 1995) and their continuing relationship of exchange*

Significance: Considered indispensable in mediating the dynamics of social lives, they are central in building cohesive communities as its presence is seen to have a positive impact on collective social actions allowing people to live with and tolerate uncertainty (Putnam, 1993) while its absence is evident in the breakdown of social and institutional relationships

Relationship: Observed to be higher in walkable, mixed-use neighbourhoods as compared to automobile-dependent suburbs (Leyden, 2003). Transit Oriented Developments (TODs) are seen to have a significantly higher levels of trust, reciprocity and connections amongst residents as compared to non-TODs (Kamruzzaman *et al*, 2014)

3. Place Attachment/Pride (AthPri)*Affective bond between people and place or settings (Tuan, 1974) that can take place in two forms: (1) functional (place dependency), and (2) emotional (place identity)*

Significance: Considered as an integral component of people's enjoyment of their built environment (Nash and Christie, 2003), relates to social order, common norms and civic culture in an area (Kearns and Forrest, 2000), and benefits the community, by facilitating involvement in local affairs, as well as individuals, by contributing to their mental health and well-being (Giuliani, 2003)

Relationship: The qualities of housing, property ownership as well as proximity to local landmarks have been associated with greater place attachment (Guest and Lee, 1983). Higher densities (Parkes *et al*, 2002), fear of crime and dissatisfaction with the quality of neighbourhood environment are also seen to reduce attachment (Sampson, 1988) while satisfaction with neighbourhood safety, walkability, streets quality and density of traffic are found to induce the feeling of attachment in a neighbourhood (Oktay *et al*, 2009)

4. Social Participation/Community Engagement (ParEng)*Participation in local celebrations and activities aimed at solving community local issues and improving the well-being of its members*

Significance: Considered crucial to building residents' stock of social capital (Forrest and Kearns, 2001) which result from spontaneous sociability (Fukuyama, 1995) and allowing them to express their shared sense of needs and aspirations and assume responsibilities for general well-being of the local community (Colantonio and Dixon, 2011)

Relationship: Higher densities, mixed land-use neighbourhoods are associated with higher levels of social participation and community engagement as it provides residents greater amount, variety and intensity of activities in which to participate (Talen, 1999)

5. Fear of Crime/Perception of Safety (PerSaf)*Fear of crime and perceived safety among the residents of an area or neighbourhood*

Significance: Considered to have significant consequences affecting quality of life, reducing social activities and increasing distrust amongst the residents. Feeling of safety in a neighbourhood is closely related to other dimensions of community sustainability and their effects on the quality of life (Tennyson-Mason, 2002) and health and wellbeing of individuals (Wilkinson *et al* 1998; Dempsey *et al*, 2011)

Relationship: Maintaining a high level of activity by encouraging higher density, mixed land-use walkable neighbourhoods is argued to reduce opportunities for crime and improve safety in the community. The design of individual buildings such as orientation and active frontages are also associated with the overall safety and vitality of the adjacent public spaces by fostering natural surveillance and reducing opportunities for crime (Jacobs, 1961)

*Social inclusion/social equity***6. Availability and Access to basic services, facilities and amenities:** *The extent to which a neighbourhood provides accessible services, facilities and amenities to all its residents*

Significance and relationship: Described as 'powerful political and policy concerns' (Jenks and Jones, 2010, p. 108), inequalities and exclusion have serious spatial consequences that get manifested into areas of deprivation and poverty, restricting certain segments of the society not only from access to choices and participation but more importantly opportunities to "urban advantage". Increasing inequalities and exclusion are thus, identified as major and structurally threatening costs to the governments. At local scale, they relate to one's everyday experience of the built environment (Dempsey *et al*, 2011) relating to availability and access to basic services (non-negotiable must), facilities (for meeting everyday sustenance and enhancement) and amenities (for fulfilling regular obligation and enjoyment)

**Table 3:** Research design and adoption of quantitative/qualitative research methods

<i>Quantitative and qualitative Research methods</i>	
<i>Quantitative</i>	<i>Qualitative</i>
Scale: neighbourhood (geographically based immediate neighbourhood)	Scale: block-segment (geographically based immediate community – street or commune)
Data collection Primary data collection engaged intensive fieldwork through questionnaire surveys, interviews, observations, mapping, measurement, verification, photo documentation	(purposive sampling) Semi-structured open-ended personal interviews and focussed group interviews, key-informant interviews, life histories, non-participant observation
<i>Social sustainability</i> (random sampling) Self-administered questionnaire surveys consisting of close-ended questions based on 5 point Likert Scale	
<i>Urban form</i> Data for urban forms at different scales collected through field surveys and observation schedules Quantitative data generation involved measuring and analysing urban form through morphological study. A comparative atlas for each case study is created using ‘Base Mapping’ and ‘Overlay mapping’	Qualitative data generation included, urban form observations through schedules, field surveys and participatory mapping
Data analysis Quantitative data (neighbourhood scale) are tested through correlation technique. Relationship between the independent variables of urban form and the dependent variable of social sustainability are tested using multivariate analysis of variance (MANOVA) in SPSS 20	Qualitative data (block-segment scale) are analysed using grounded theory involving (1) Research Questions, (2) Theoretical Sampling and Data Collection; (3) Coding and Categorising; (4) Analysing and Examining Relationships; (5) Authenticating Conclusions; (6) Reflexivity and Theory Development
Method triangulation Qualitative and quantitative outcomes, in case of nested case studies (block-segment case studies nested within neighbourhood level case studies) are triangulated to bring salient points together	

A profile study of Guwahati

Guwahati, the capital city of the Indian State of Assam, is situated at 26°10' North latitude and 92°49' East longitude on the banks of the mighty River Brahmaputra. Positioned on an undulating plain with varying altitudes of 49.5–55.5 m above Mean Sea Level (MSL) in the lower Assam Valley, the city is surrounded by hills on either side of the river and has large areas under water bodies. Guwahati enjoyed an eminent position throughout history due to its geographical location serving not only an important religious centre, but also as a vigorous port of trade and commerce, administrative headquarters and political hub. Its topography also made it ideally suited as a site of war especially during the period between the thirteenth and seventeenth century AD and was completely destroyed during the Burmese War. The city was re-built when Assam came under British occupation beginning a formal planning history of Guwahati whose growth triggered around newly laid transport and communication routes serving the Colonial industries. Following the colonial rule, Guwahati's growth had not been constant and gradual but gathered pace in the

years after India's independence in 1947 and also after 1972, when the state government moved to the Guwahati suburb of Dispur. Since then the city has been growing faster than anticipated, resulting in subsequent change of urban form and continual extension of the administrative boundaries to incorporate growth. The city grew from a town of eight municipal wards within an area 6.4 km² in 1874 into a vast urban agglomeration covering an extended boundary of Guwahati Metropolitan Area (GMA) with 328 km² to accommodate 60 municipal wards. Guwahati today has not only regained its importance as a political and administrative centre but is also a premiere city of the entire North-Eastern region of India in terms of its location, size, population, and transport connectivity, a major centre for industries, education and medical institutions as well as a potential gateway to South-East Asia (Figure 2).

Despite its significance in the current context, intense and accelerated urban development is raising the city's environmental and social vulnerability to an unprecedented extent. Modification to natural land cover within the city, infringement of environmental sensitive areas and uncontrolled urban development, particularly construction

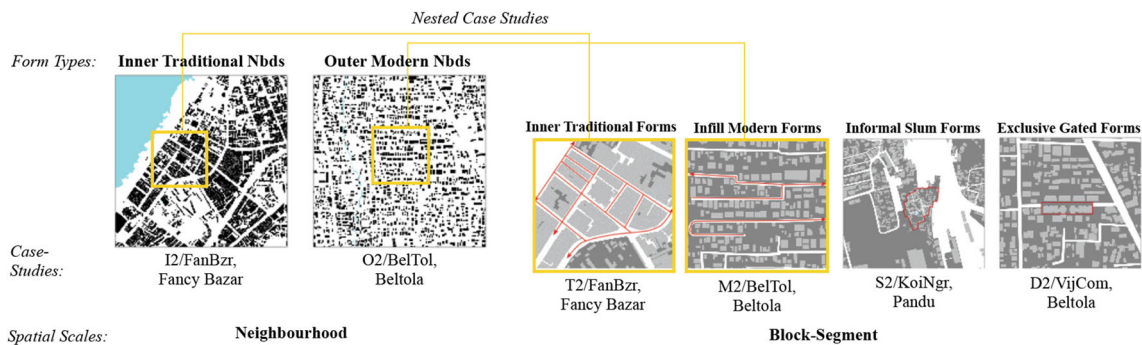
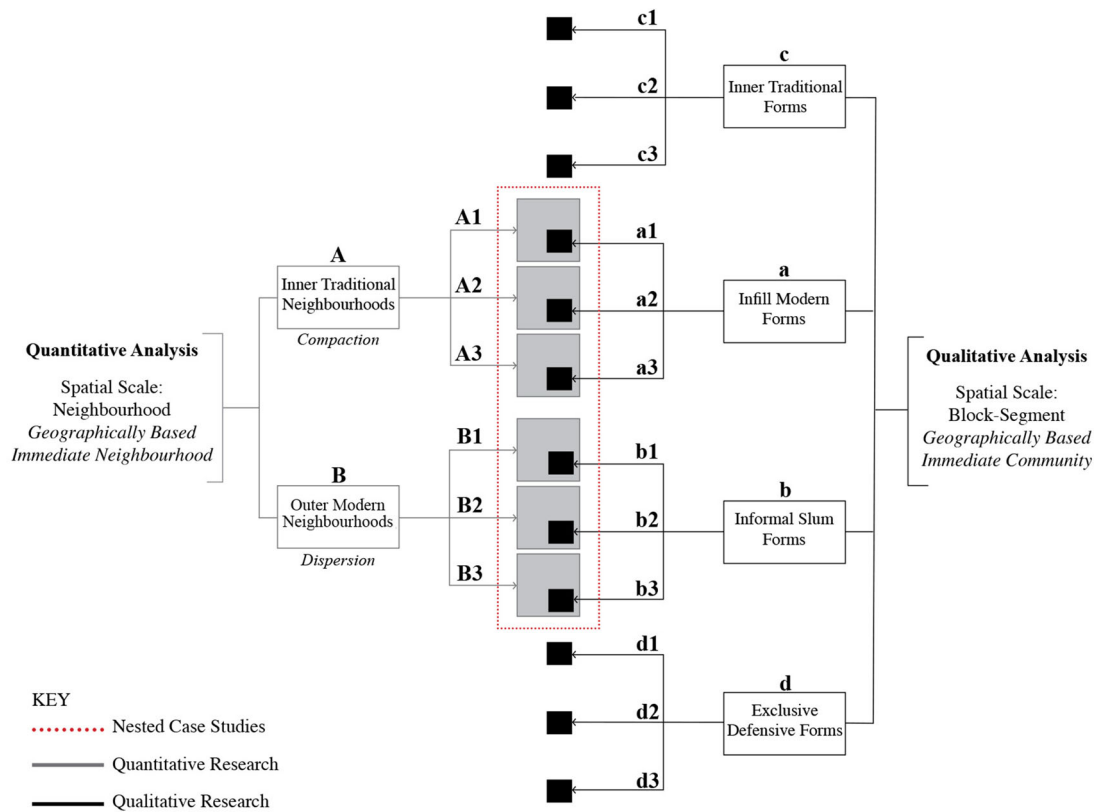


Figure 1: Method triangulation and nested case studies.

activities in low-lying areas, wetlands and steep hill slopes, generally outside the planning control, are seen as some of the major threats to the city, which is located in a high seismic activity zone (V) and prone to both floods and landslides. The analysis of the city in the modern context also highlights the fact that the focus on the overwhelming need for new housing, industry and infrastructure has led to an irreparable break in what should have been a gradual and well-thought evolution and growth of the city. Rushing into the modern age in a few decades had left little time for Guwahati city to restructure its social and physical forms causing some of the fundamental

challenges to sustainable urban development. Guwahati today, represents a composite form developed through ages and shows a spectrum of varied urban typologies and social patterns that developed in response to local combinations of dynamic forces of the past and present hence, no part of it can be seen as a purified form but rather multilayered to some extent, however some distinct typologies emerge. At the scale of neighbourhood, Guwahati can be differentiated by two broad-based urban form variations; “Inner Traditional Neighbourhoods (ITN)” and “Outer Modern Neighbourhoods (OMN)” while at the scale of an urban block the city can be further seen as a

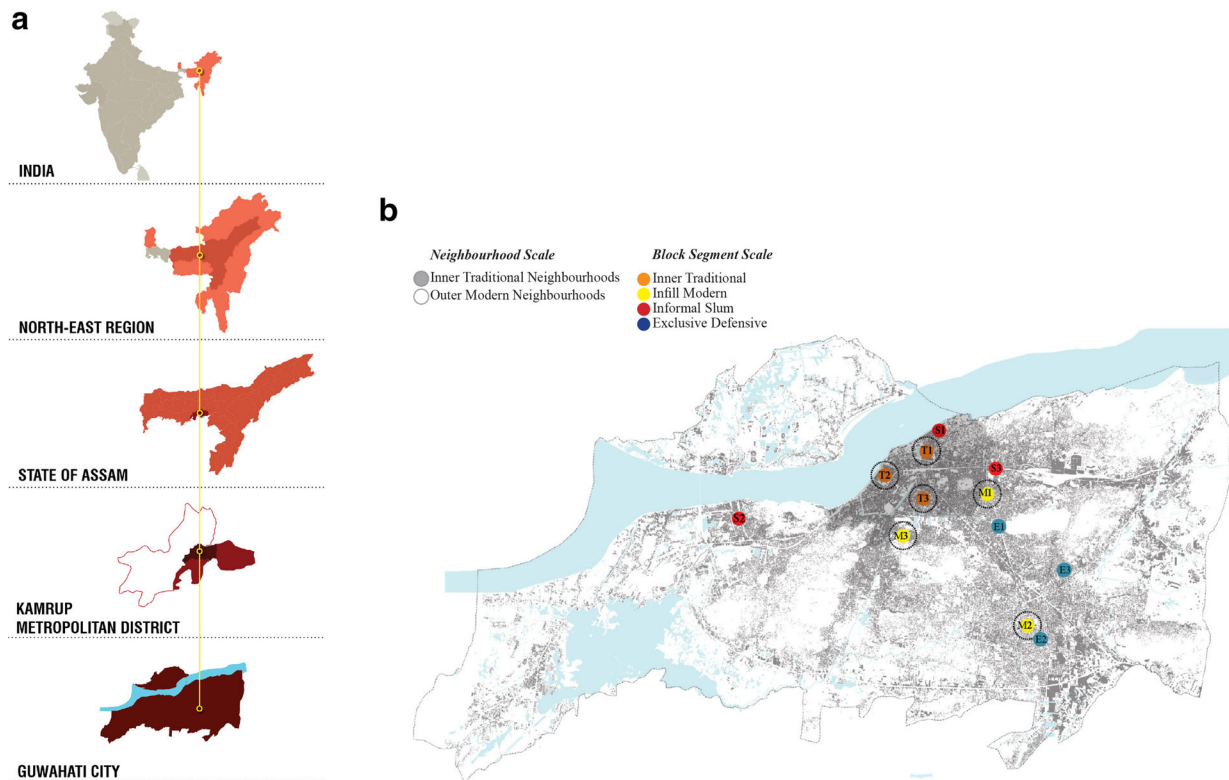


Figure 2: a Positioning Guwahati in the geographical context of India. b Map of Guwahati showing location of case studies.

patchwork of fragmented “Informal Slum (IS)”, “Inner Traditional (IT)”, “Modern Infill (IM)” and “Exclusive Defensive (ED)” forms of which, former two suffer from multiple deprivations while the latter two represent a major share of urban growth. Such a growth does not fit in easily with the city’s efforts to becoming a global player and one of the future smart and most admired state capitals of the twenty-first Century India, thus calling for an acute need to revisit the planning practices adopted in the city. A comprehensive study of morphological evolution and present urban form for Guwahati is available at (to be disclose later) (Table 4).

Quantitative research (neighbourhood scale)

Sampling and data collection



At the scale of neighbourhood, Guwahati can be differentiated by two broad-based urban forms: ‘ITN’ and ‘OMN’ for which three case studies each were identified. Quantitative data for measuring the associated social sustainability outcomes were collected using self-administered close-ended questionnaires based on standard questions used by a variety of major government and non-

government social sustainability surveys (e.g. ONS survey matrix, 2001; Social Capital Assessment Tool (World Bank); Woodcraft *et al*, 2011; Dempsey *et al*, 2011; Jenks and Jones, 2010).

A pilot study was conducted to test the questionnaire for potential misunderstandings or problems and consequently correct possible weaknesses and inadequacies before the actual data collection commenced (Sarantakos, 2005). The questionnaire was pilot-tested with a minimum of 10 respondents in two case-study neighbourhoods (pilot study, $n = 21$) with a total of 31 questions for 7 social sustainability components. However, due to issues associated with resident’s sensitivity with respect to sharing their true views on social diversity of the place they live, the social sustainability component focussing on residents’ perception on ‘Social Mix/Tolerance (towards diversity)’ was eliminated and the research proceeded with a total of 6 components. The original items for some components were also altered to capture concepts arising from the initial survey that were deemed relevant. Finally, while most questions remained as close as possible to their original wording, some changes found necessary for consistency with the larger social sustainability questionnaire were made. The final pool of questions was then



Table 4: Description of urban form types at different spatial scales

<i>Neighbourhood scale</i>		
Urban form type 1	Inner traditional neighbourhoods	Characterised by compaction. Urban form variables typified by higher densities, highly connected and integrated network of streets (permeability and walkability), higher land-use mix and smaller urban blocks
Urban form type 2	Outer modern neighbourhoods	Characterised by dispersion. Urban form variables typified by lower densities, slightly connected and integrated network of streets (lower permeability and automobile dominance), single or lower land-use mix and larger urban blocks
<i>Block-segment scale</i>		
Urban form type 1	Inner 'traditional'	<ol style="list-style-type: none"> 1. T1/UznBzr, Lamb Road Area, Uzanbazar 2. T2/FanBzr, Aloo Patti Area, Fancybazar 3. T3/RehBri, P.P Road Area, Rehabari 
	Located in the historic core Compact, diverse urban structure Often worn-out infrastructure Fine-grain, traditional building typologies	
Urban form type 2	Infill 'modern'	<ol style="list-style-type: none"> 1. I1/ZooRod, Pinaki Path Area, Zoo Road 2. I2/BelTol, Basisthapur By-lanes, Beltola 3. I3/KalPhr, Rehabari Road Area, Kalapahar 
	Located beyond historic core Dispersed, residential urban structure Regular, with modern amenities Coarse grain, modern building typologies	
Urban form type 3	Informal 'slum'	<ol style="list-style-type: none"> 1. S1/AriBst, Aarikati Basti, Jahajghat 2. S2/KoiNgr, Koilash Nagar, Pandu 3. S3/HafNgr, Hafiznagar, Chandmari 
	Pockets, scattered across the city fabric Highly compact, diverse, spontaneous Informal, lacking most basic infrastructure/services Very fine grain, rural resemblance Self-built building typologies	
Urban form type 4	Exclusive 'Defensive'	<ol style="list-style-type: none"> 1. E1/SpnGdn, Spanish Gardens, Zoo Road 2. E2/VijCom, Vijaya Complex, Beltola 3. E3/ProPrk, Protech Park, Hengrabari 
	Located on periphery or within, large developable plots Regular, with privatised amenities/services Desire for exclusiveness, fear of crime, improved QOL Coarse grains, high-rise apartments Large enclaves, restricted access, security	

circulated to a panel of experts from related disciplines in the institute and was also disseminated to a sample of colleagues for feedback on the appropriateness and clarity of items.

The final questionnaire consisted of 28 questions in total including 16 questions based on 5 point Likert Scale and 12 questions of which 8 were controlled variables such as personal, house and neighbourhood profiles and 4 multiple choice questions [SM-2]. The items or measures for the components or aspects of social sustainability used for self-administered questionnaire surveys are listed in Table 5. The questionnaires were handed to neighbourhood leaders, secretaries or influential residents for distribution and were also handed directly to the residents of each

case-study areas. Incomplete questionnaires were followed up at the time of collection of the questionnaire. Prior to the analysis each questionnaire was carefully edited and coded. The total number of 311 responses were collected (ITN = 142 and OMN = 169).

Data analysis and hypothesis testing

- Analysing urban forms

The urban form was measured and analysed using morphological study. The term 'morphology' originally coined by Johann Wolfgang von Goethe (1749–1832) as a branch of biology. In the context of the built environment, it deals with the structure and character of an urban area by examining

Table 5: Items or quantitative measures for social sustainability

Code	Measure
1. Social interaction/social networks (IntNet)	
IntNet1	Number of neighbours interacted with (seen socially, greet or chat)
IntNet2	Frequency of interaction with neighbours
IntNet3	Number of close friends and relatives in the neighbourhood
2. Trust/reciprocity (TruRci)	
TruRci1	Number of neighbours trusted for social support
TruRci2	Frequency of exchanging small favours with neighbours
TruRci3	Neighbourhood as 'a place where neighbours look out for each other'
3. Place attachment/pride (AthPri)	
SatAth1	Residents' views 'likes and dislikes' about the neighbourhood
SatAth2	Neighbourhood as 'a place to live'
SatAth3	Attachment to the neighbourhood
PriPlc4	Pride in the neighbourhood
4. Social participation/community engagement (ParEng)	
ParEng1	Frequency at which local activities, gatherings and celebrations are organised
ParEng2	Frequency of participation in local activities, gatherings and celebrations
ParEng3	Extent to which residents pull together to improve the neighbourhood
ParEng4	Extent to which residents can influence decisions that affect their neighbourhood
5. Fear of crime/perception of safety (PerSaf)	
PcvSaf1	Perceived problems in the neighbourhood
PcvSaf2	Neighbourhood as a 'safe place to live'
6. Basic services and local facilities (availability and accessibility) (LocFac)	
LocFac1	Perceived issues with respect to basic service provision (3 most imp.)
LocFac2	Perceived issues with respect to local facilities/amenities provision (3 most imp.)
LocFac3	Rating for provision of different local facilities and amenities
LocFac4	Rating for physical accessibility to different local facilities and amenities
Controlled variables	
House Profile	
HsPrf1	House ownership
HsPrf2	House type
Neighbourhood stability	
NbStb1	Length of stay
NbStb2	Expected to move in the future
Personal profile	
PerAge	Age in years
PerGen	Gender
PerEdu	Education
PerOcc	Occupation

the patterns and process of its development giving clues about the spatial configurations embedded in social relations. Urban morphology is therefore seen as the study of the city as human habitat (Moudon, 1986). It covers a wide area of spatial research including both qualitative techniques such as the use of the figure-ground or tissue analysis as well as quantitative techniques for capturing the structural properties of urban form.

The tools in the analyses of urban morphology for this research were based on three theories:

- (1) Trellis (system of connections or structure for ordering spaces): showing street network (Rudlin and Falk, 2009; Alexander, 1966; Hillier, 1996).

- (2) Built Form (ground patterns of mass and void, and activity distribution) showing the figure-ground and land-use patterns (Caniggia and Maffei, 1979, Oswald and Baccini, 2003).
- (3) Tissue (spatial anatomy in response to human needs): showing block and component characteristics (Tolentino, 2011; Marshall and Çalişkan, 2011).

A comparative atlas for six case studies at neighbourhood scale covering a geographical area of 1,600 × 1,600 m (800 m r) was first created using (1) 'Base Mapping' – generating base maps for each case-study neighbourhoods in AutoCad using high-resolution satellite imagery. (2) 'Overlay mapping' – creating analysis maps with



different mapping layers or rendering in AutoCad and/or Photoshop softwares allowing for addition or subtraction of layers of information to reveal patterns and relationships that would not otherwise be obvious. Quantitative information or measurements were extracted using area calculations in AutoCad or Measurement Logs in Photoshop software.

The selected urban form components were measured using following methods:

[i] Measuring Open Spatial-Network:

- *Streets*: Syntactic values (for global integration [HH] and local integration [HH]R3 using DepthMap in Space Syntax).
- *Open Spaces*: Syntactic values (for global integration [HH] and local integration [HH]R3 of key access routes to open spaces using Space Syntax analysis) and numerical values for area under open recreational use calculated from open space map using AutoCad.

[ii] Measuring land-use:

- *Land-use Ratio*: Ratio of total residential land-use to all other uses. Numerical values calculated from 'land-use' map using Adobe Photoshop, Measurement Log.
- *Land-use Diversity* (variety and densities of different uses): Scores on the Simpson's Index of diversity [$D = \sum ni (ni - 1) / N (N - 1)$ where N the total of all land uses, ni = the individual land uses] for land-use mix. Numerical values calculated from land-use map using Adobe Photoshop, Measurement Log.

[iii] Measuring density

- *Population Density*: Number of people per hectare. Numerical values for approximate average densities calculated using ward-wise population information (Census 2011).
- *Figure Ground Ratio*: Ratio of total building footprint to total ground coverage. Numerical values calculated from 'figure-ground' map using Adobe Photoshop, Measurement Log.

[iv] Measuring blocks

- *Block Area* (Size of the Blocks): $S \leq 20,000 \text{ m}^2$, $M = 20,001-40,000 \text{ m}^2$; $L = 40,001-$

$60,000$, $XL = 60001-80000$, $XXL \geq 80,000 \text{ m}^2$

- *Compactness Ratio* (Shape of the Blocks): The compactness ratio indicates the geometric properties of the block. Also quoted in Selkirk (1982) as the "circularity ratio" [calculated as $4\pi A/p^2$ where A = area of the block, and p = perimeter of the block].
- Block measures are calculated by assuming street blocks as enclosed entities and obtaining the numerical values for their areas and perimeters using AutoCad software. The size measures are represented in the form of colour-coded block maps.

The comparative atlas and morphological analyses for ITN and OMN are shown in Figure 3. Mean variations and numerical values for the different urban form components are given in Table 6. The mean values for all urban form variables for ITN were found to be higher than the urban form variables for OMN (except for the 'land-use', where lower numerical values indicate higher mix of uses). The mean values for different variables, therefore, confirmed that ITN of Guwahati are characterised by compaction showing higher levels of (i) street connectivity and integration, (ii) amount of accessible open recreational spaces, (iii) mix of uses, (iv) densities and (v) smaller compact blocks than the OMN that are characterised by dispersion.

- *Analysing the effects of broad-based urban form variations on social sustainability*

[i] Reliability and Normality Tests

Cronbach's alpha was used to test the internal consistency or average correlation of items for components with three or more items in survey to gauge their reliability. The values of alpha for all component measures (IntNet, TruRci, AthPri, ParEng) were found to be >0.7 and between 0.8 and 0.9, thus indicating 'good' internal consistency of the items in the scale. A standard single but most important variable employed in various researches [for example, Woodcraft *et al* (2011), Jenks and Jones (2010), Dempsey *et al* (2011)] was used to measure the perceived sense of safety (PcvSaf) in one's own neighbourhood. In case of components (LocFac) with less than three items under survey, Pearson Correlation was used to test the scale reliability. The value r was found greater than 0.5

a

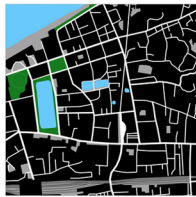



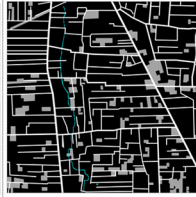
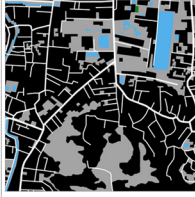










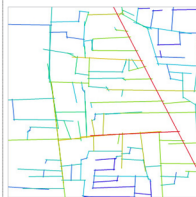


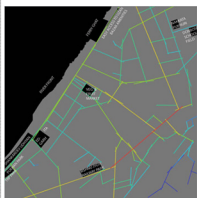
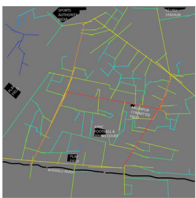
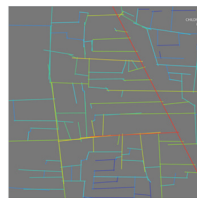
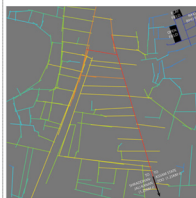

Inner Traditional Neighbourhoods			Outer Modern Neighbourhoods		
I1/UznBzr	I2/FanBzr	I3/RehBri	O1/ZooRod	O2/ BelTol	O3/KalPhr
Open Spatial Network: <i>Trellis of connections</i>					
					
connected regular grid.	connected irregular traditional grid.	hybrid grid, connected primary & disconnected tertiary routes.	hybrid grid, connected primary & disconnected tertiary routes.	hybrid grid, connected primary & disconnected tertiary routes, long blocks & dead-ends.	hybrid disconnected grid, dominated by disconnected dead-end tertiary routes.
Open Spatial Network: <i>Syntactic Values for Intelligibility [HH]/Con</i>					
					
Open Spatial Network: <i>Syntactic Values for Synergy [HH]/[HH]R3</i>					
					
Open Spatial Network: <i>Amount of accessible open recreational spaces</i>					
					
Space Syntax Analysis: The axial lines are represented from red to dark blue, red means the highest value of the parameter while dark blue means the lowest.					

Figure 3: Comparative Atlas **a** Morphological analyses showing open spatial-network for inner traditional neighbourhoods and outer modern neighbourhoods. Comparative Atlas **b**

Morphological analyses showing land-uses, densities, and blocks for inner traditional neighbourhoods and outer modern neighbourhoods.

and between 0.6 and 0.8 indicating ‘strong’ correlation between two variables.

The Normality test was conducted using graphical method (P-P Plots created using SPSS 20 software) which visualised the distribution of a random variable and compare the distribution to a theoretical one using plots [SM-3].

[ii] Hypothesis testing

The hypothesis was tested using Multivariate Analysis of Variance (MANOVA) in SPSS 20 software which allowed determining the effects of one or more independent variables (urban form) on more than one correlated dependent

b

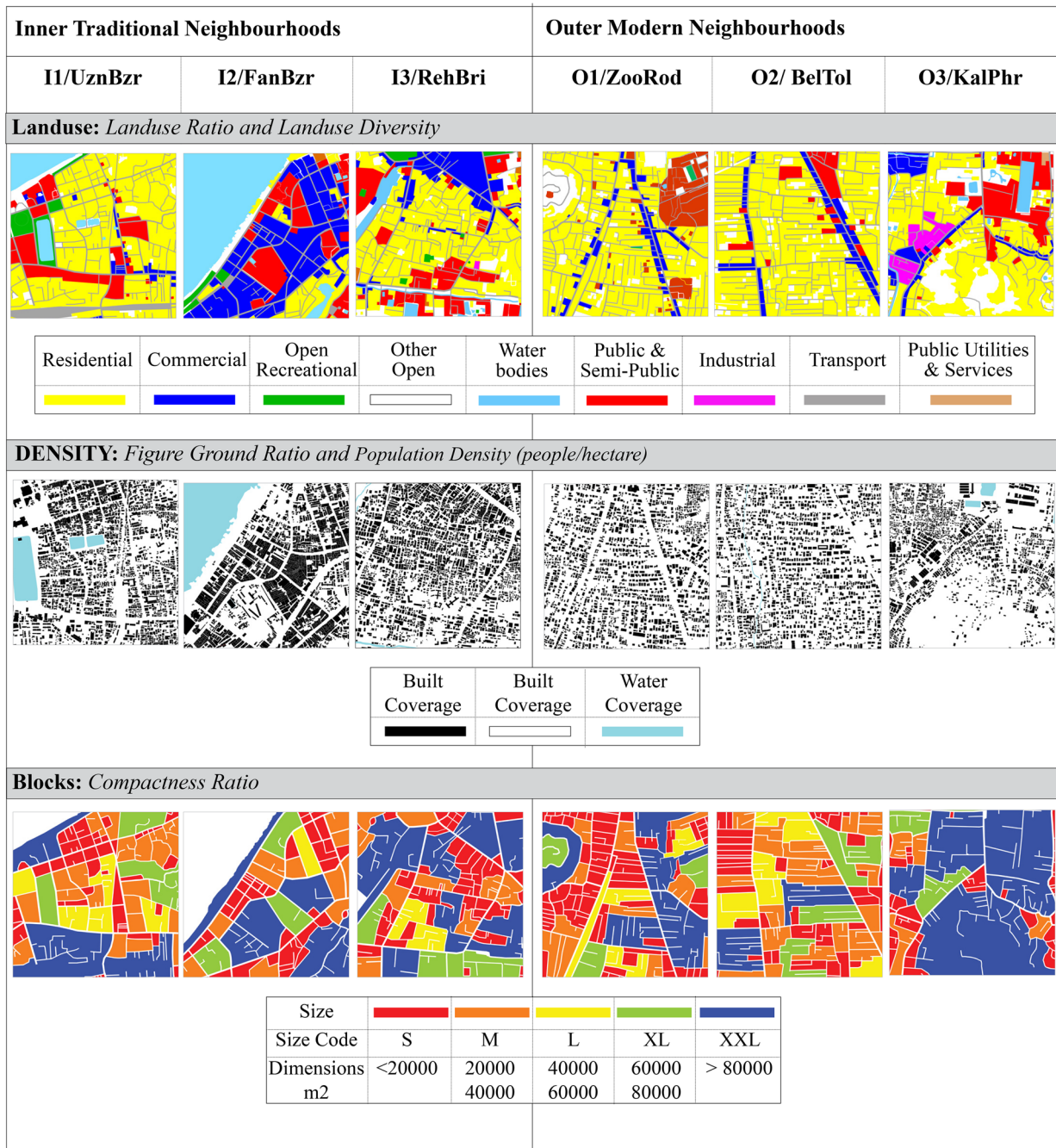


Figure 3: continued

variable (social sustainability). First, multivariate analysis of variance was conducted for two typologies, ITN and OMN. The tests showed that there were significant effects of different form types on all the aspects of social sustainability, and their correlation is positive. Later, the multivariate test was conducted again, but for all the

six case-study areas, and it showed the same results (Table 7).

[iii] Findings

The quantitative testing of the urban form variables (Open-Spatial Network, Land-use, Density,

Table 6: Measured numerical values for different urban form variables

No.	Form typology	Urban form variables														
		Open spatial-network			Open spaces			Land-use			Density			Blocks		
		Street		Intelligibility [HH]/[Con]	Synergy [HH]/[HH]R3		Local integration [HH]R3 for key access routes to ORS		Area for open recreational use		Land use Diversity	Residential land-use ratio	Figure-ground ratio	Population density*	Compactness ratio	
	Spatial scale: immediate neighbourhood	Space syntax [HH]/[Con]	Space syntax	Space syntax	Space syntax (adjusted value, ×/10)	Space syntax (adjusted value, ×/10)	Space syntax (adjusted value, ×/10)	Space syntax (adjusted value, ×/10)	Simpson's index	Residential/other uses (adjusted value, ×/10)	Built/open ratio	People/ha	Selkirk's circulatory ratio			
(A)	Inner traditional neighbourhoods (ITN)															
1	I1/UznBzr	0.510	0.832	0.214	0.257	0.120	0.592	0.119	0.347	0.120	0.592	0.119	0.561			
2	I2/FanBzr	0.291	0.647	0.228	0.082	0.011	0.824	0.179	0.232	0.011	0.824	0.179	0.643			
3	I3/RehBri	0.367	0.792	0.202	0.068	0.078	0.54	0.161	0.257	0.078	0.54	0.161	0.368			
	Mean	0.389	0.757	0.215	0.136	0.070	0.652	0.153	0.279	0.070	0.652	0.153	0.524			
	Median	0.367	0.792	0.214	0.082	0.078	0.592	0.161	0.257	0.078	0.592	0.161	0.561			
	SD	0.111	0.097	0.013	0.105	0.055	0.151	0.031	0.060	0.055	0.151	0.031	0.141			
(B)	Outer modern neighbourhoods (OMN)															
4	O1/ZooRod	0.235	0.650	0.138	0.042	0.128	0.348	0.114	0.368	0.128	0.348	0.114	0.468			
5	O2/BelTol	0.332	0.721	0.179	0.019	0.214	0.337	0.073	0.467	0.214	0.337	0.073	0.407			
6	O3/KalPhr	0.251	0.502	0.043	0.079	0.079	0.296	0.108	0.263	0.079	0.296	0.108	0.324			
	Mean	0.273	0.624	0.120	0.047	0.141	0.327	0.098	0.366	0.141	0.327	0.098	0.400			
	Median	0.251	0.650	0.138	0.042	0.128	0.337	0.108	0.368	0.128	0.337	0.108	0.407			
	SD	0.052	0.112	0.070	0.030	0.068	0.027	0.022	0.102	0.068	0.027	0.022	0.072			

ORS = open recreational spaces.

* Numerical values for approximate average densities calculated using ward-wise population information (Census, 2011).



Blocks) of two form types ‘ITN’ and ‘OMN’ using a total of six case studies showed that urban forms at the spatial scale of neighbourhood significantly affects different aspects of social sustainability (urban form variations for IntNet, TurReci, AthPri, ParEng, LocFac, PcvSaf have significance values less than 0.05), after controlling for intervening variables, and they have a positive correlation, i.e. urban forms with higher values for (1) connected and integrated street network, (2) accessible and amount of open recreational spaces, (3) mix of uses, (4) densities, (5) small compact blocks, display significantly higher levels of social sustainability amongst its residents. The traditional neighbourhood forms of Guwahati (ITN characterised by compaction) are, therefore, more sustainable than the modern neighbourhoods (OMN characterised by dispersion), when different aspects of social sustainability were considered.

The results further showed that neighbourhood stability or length of stay of the residents in a neighbourhood affects outcomes for social interaction/social networks and ‘place attachment/pride’. There also existed correlation between ‘gender’ and ‘fear of crime/perception of safety’

in a neighbourhood, residents ‘education’ and the level of ‘social interaction/social networks’ and ‘social participation/community engagement’ in a neighbourhood as well as resident’s age and ‘place attachment/pride’ (Figure 4).

Qualitative research (block-segment scale)

Qualitative research, described as an inductive process, in which theories or hypotheses, explanations, relationships and conceptualisations are constructed from details provided by the participants, were used to gain further understanding of the influence of urban forms on social sustainability at the scale of block-segment. The aim of the qualitative research was twofold: (1) to provide in-depth understanding of the relationship and (2) to study the effects of more detailed urban form variations on social sustainability which was not possible to assess through the quantitative research conducted at the neighbourhood scale. Qualitative and quantitative researches were thus not seen in contraposition to each other but as means to generate richness of understanding and interpretations.

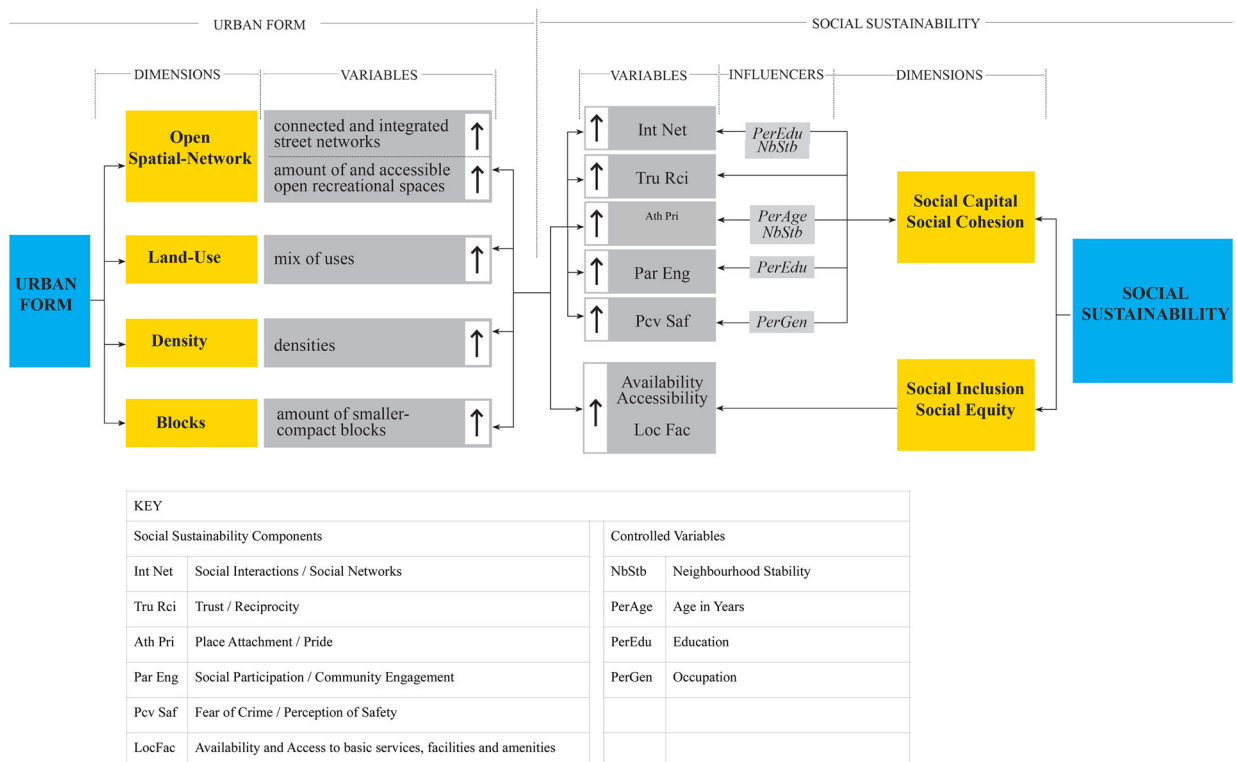


Figure 4: Influence of urban form on social sustainability (quantitative outcomes).

Formulation of research questions

- The key questions for the research using qualitative methods are as follows:

Do urban forms at the scale of block-segment influence social sustainability?

If yes, to what extent and in what ways?

Other questions under investigation are

- a. Which urban forms components, at the level of block-segments, significantly foster social sustainability and, why?
- b. If both, social sustainability and urban forms are dynamic concepts, can we then obtain a socially sustainable equilibrium state for urban communities?

Sampling and data collection

Guwahati at the scale of block-segments can be seen as a patchwork of four distinct urban form typologies: 'Inner Traditional (IT)', 'Infill Modern (IM)', 'Informal Slum (IS)' and 'Exclusive Defensive (ED)' forms for which three case studies each were identified. Qualitative data for measuring the associated social sustainability outcomes for each identified case study were collected primarily using semi-structured in-depth personal interviews. The interviewees were chosen with purposive sampling, followed by snow-ball sampling allowing resources to be concentrated on in-depth interviewing of respondents rather than on screening the entire population to find suitable respondents. In order to avoid biases and skewed opinions, diversification of the sample was ensured by including cases of short-term as well as long-term residents, diverse social backgrounds and age-groups in the final sample. A total of 128 (F = 66, M = 62) interviews were conducted. The size of the sample for each case-study area was determined by redundancy, or when no new information was forthcoming from the residents. A minimum of two focussed-group interviews and focussed-group discussions were conducted for four case studies depending on the residents' willingness and based on field conditions. Recording life histories where possible and non-participant observation also formed important aspects of social sustainability data collection.

The topics covered in the in-depth interview were based on the six aspects of social sustainability identified earlier in the literature review in order to gain a comprehensive understanding of their relation to the urban forms and to reinforce,

contradict or expand on the findings from the quantitative study for the nested case studies. Each personal interview was conducted in quiet settings inside the respondent's residence and lasted over between 30 and 50 min. Prior to the interview, respondents were informed about the purpose of the research, the need to conduct the interview and preserving the confidentiality and anonymity of the information given. All the interviews were transcribed and manually coded. During the interview, along with interview responses, impressions, ideas and thoughts of the interviewer were also noted. Although, only formal interviews are registered here, additional random on-street informal discussions were made during the fieldwork, and notes were taken and evaluated.

Data analysis and theory development

- *Analysing urban forms*

Urban form variables at the scale of the block-segment were measured through observation and field surveys. Information gathered was plotted on the base maps developed from high resolution aerial images (Figure 5). A sample of urban form description is given in SM-4.

- *Analysing the effects of detailed urban form variations on social sustainability*

[i] Coding and categorising

All the raw field notes obtained from observations and interview transcriptions were transformed into well-organised set of notes which were further coded until different re-occurring social sustainability themes seemed to emerge, and their inter-relationship may be established. The coding was done in two phases, initial and focussed (Glaser, 1978). The data in the form of initial coding was further refined and developed into focussed coding to modify and understand the codes in more detail in order to generate patterns or concepts [SM-5].

[ii] Examining relationships and reflectivity

Each major focussed code was examined based on the situations in which they appeared, when they changed and the relationship amongst them. The use of the constant comparative method enabled the analysis to produce not just a description but a model, in which more abstract concepts were related and a social process was explained.



Figure 5: Maps showing case-study areas for four urban form types at the block-segment scale.

The following graphical relationship for the six components of social sustainability can be established (Figure 6). A detailed textual description is given in SM-6.

[iii] Findings

The qualitative outcomes for the influence the urban form variables on different aspects of social sustainability for four form types 'Inner Traditional (IT)', 'Infill Modern (IM)', 'Informal Slum (IS)' and 'Exclusive Defensive (ED)' forms using a total of twelve case studies also showed that urban forms at the spatial scale of block-segments affects all selected aspects of social sustainability. However, intra-form variations highlighted a very high number of intervening variables and the complexity of the relationship (Table 8).

It showed that:

Social sustainability components such as Social Interactions/Social Networks (seen as amount,

intensity and type of contacts or exchanges between people) as well as Trust (general readiness to form associations outside the obligations of family or the compulsion of the state)/Reciprocity (continuing relationship of exchange) were greatly dependant on the strength of local ties,⁸ both strong and weak. Strong ties were generally made up of family, relatives, work mates, close friends living in the neighbourhood or same block-segment while, weak ties consisted of non-intimate, friendly relations between neighbours who knew each other to nod and wave to, or engage in limited conversation with and who were available to call in emergency situations. Social sustainability was found to be higher in case of urban forms where many weak ties were observed amongst its residents along with many or few strong ties. Such weak ties found crucial for fostering social sustainability in any urban form were greatly dependant on the 'intensity and frequency' of spontaneous and organised⁹ sociability which in

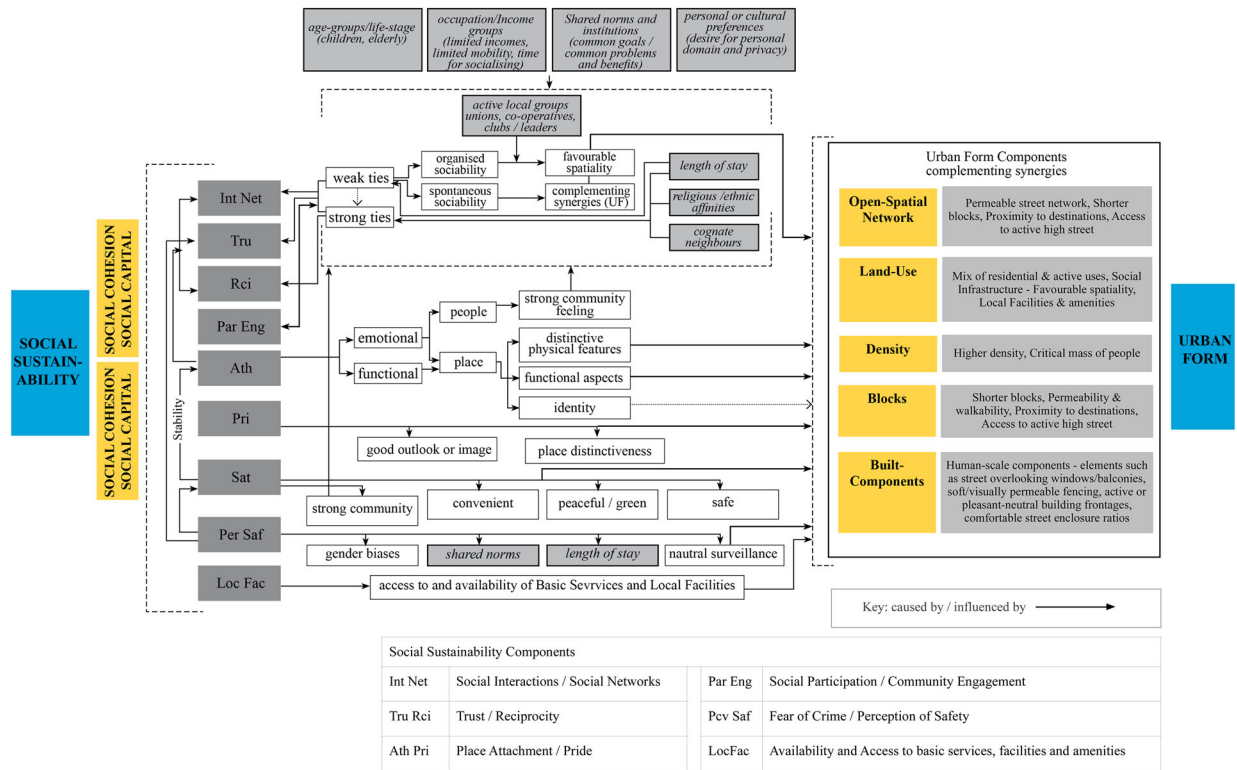


Figure 6: Influence of urban form on social sustainability (qualitative outcomes).

turn influence by the level of ‘favourable spatiality’ i.e. presence of social infrastructure or spaces for social opportunities. However, land-use provision of presence of ‘favourable spatiality’ (presence of local open spaces, play area for children, religious or community centres, local grocery shops, etc.) did not work in isolation, but benefited from or even necessitated the integration of other urban form components such as critical mass of people (density), easy access to these spaces for social opportunities (integrated open-spatial network and smaller urban blocks), and human-scale built components (building orientation, frontage, coverage, enclosure, typology). Hence, a complementing synergy between the different components of urban form was essential to produce a combined positive effect on social sustainability outcome. Participation in community issues, gatherings and social events generated opportunities for organised as well as spontaneous sociability, at the same time, strong and many weak ties also led to greater Social Participation and Community Engagement amongst the neighbours.

Place Attachment seen as an (affective bond between people and place or settings) was both, emotional and functional. Urban form was found

to be a key influencer to the residents’ positive feeling of ‘functional’ attachment to place. Residents with ease of access amenities, local facilities and services felt more attached to their locale than those without. In case of ‘emotional’ attachment to place, residents’ strong feeling of and belonging to the local community was affected by the strength of local ties which were again greatly dependant on the intensity and frequency of spontaneous and organised sociability further influenced by the level of ‘favourable spatiality’ and the ‘complementing synergies’ of different urban form components. Pride in place was highly ‘place-based’ or ‘functional’ i.e. good outlook or image and distinctiveness of their place of residence and thus, greatly influenced by the different urban form components.

Although residents’ perception of safety was greatly affected by external variables such as the length of stay (increase in familiarity and social contacts, confidence in movement in the area), presence of shared norms (social control, self-regulated behaviour and minimised anti-social activity) and gender biases (women feeling more unsafe than men and restrict night-time movement in the area), the level of natural surveillance that



Table 7: Multivariate test of variance – for 2 form types

		UF_TYPE		Mean	SD	N
Descriptive statistics		1		3.37	0.88	142
		2		2.76	0.87	169
IntNet AVG		Total		3.04	0.93	311
		1		3.07	0.82	142
TruRci AVG		2		2.59	0.91	169
		Total		2.81	0.90	311
AthPri AVG		1		3.86	0.67	142
		2		3.53	0.78	169
ParEng AVG		Total		3.68	0.75	311
		1		3.24	0.64	142
LocFac AVG		2		2.89	0.74	169
		Total		3.05	0.72	311
PcvSaf2		1		4.20	0.66	142
		2		3.52	0.76	169
		Total		3.83	0.80	311
		1		3.65	1.17	142
		2		3.24	1.12	169
		Total		3.43	1.16	311

Source	Dependent	Type III	df	Mean	F	Sig.	Partial	Noncent.	Ob.
Tests of between-subjects effects									
NbStb1	AthPri AVG	4.391	1	4.391	10.277	0.001	0.033	10.277	0.892
NbStb2	AthPri AVG	6.687*	1	6.687	15.652	0.000*	0.049	15.652	0.976
PerAge	AthPri AVG	1.595	1	1.595	3.733	0.054	0.012	3.733	0.486
PerGen	PcvSaf2	75.871	1	75.871	72.413	0.000	0.194	72.413	1
PerEdu	IntNet AVG	14.741	1	14.741	22	0.000	0.068	22	0.997
UF type	ParEng AVG	9.841	1	9.841	22.301	0.000	0.069	22.301	0.997
	TruRci AVG	12.347*	1	12.347	18.428	0.000*	0.058	18.428	0.99
	AthPri AVG	11.411	1	11.411	15.41	0.000	0.049	15.41	0.975
	ParEng AVG	3.338	1	3.338	7.814	0.006	0.025	7.814	0.796
	LocFac AVG	4.76	1	4.76	10.787	0.001	0.035	10.787	0.906
	PcvSaf 2	26.115	1	26.115	52.541	0.000	0.149	52.541	1
		6.311	1	6.311	6.023	0.015	0.02	6.023	0.687

Table 7: continued

Multivariate test of variance – for 6 case studies

Descriptive statistics		Case	Mean	SD	N	Descriptive statistics		Case	Mean	SD	N
IntNet AVG	1	1	3.07	0.76	52	TruRci AVG	1	2.79	0.73	52	
	2	2	4.05	0.72	44		2	3.37	0.77	44	
	3	3	3.05	0.79	46		3	3.10	0.86	46	
	4	4	2.95	1.02	57		4	2.78	1.03	57	
	5	5	2.4	0.74	48		5	2.43	0.96	48	
	6	6	2.79	0.77	64		6	2.54	0.71	64	
AthPri AVG	Total	Total	3.03	0.92	311	ParEng AVG	Total	2.81	0.90	311	
	1	1	4.02	0.59	52		1	3.00	0.65	52	
	2	2	3.65	0.78	44		2	3.57	0.55	44	
	3	3	3.86	0.57	46		3	3.17	0.56	46	
	4	4	3.84	0.83	57		4	3.03	0.87	57	
	5	5	3.28	0.79	48		5	2.79	0.72	48	
LocFac AVG	6	6	3.42	0.62	64	6	2.82	0.61	64		
	Total	Total	3.67	0.74	311	PcvSaf2	Total	3.04	0.71	311	
	1	1	4.24	0.67	52		1	3.67	1.11	52	
	2	2	4.44	0.63	44		2	4.09	0.96	44	
	3	3	3.93	0.59	46		3	3.2	1.27	46	
	4	4	3.88	0.72	57		4	3.14	1.24	57	
5	5	3.19	0.75	48	5		3.33	0.95	48		
6	6	3.42	0.66	64	6	3.27	1.11	64			
Total	Total	3.83	0.79	311	Total	3.43	1.15	311			

Tests of between-subjects effects

Source	Dependent variable	Type III sum of squares	df	Mean square	F	Sig.	Partial eta squared	Noncent. parameter	Observed power
NbStb1	IntNet AVG	9.19	1	9.19	15.23	0.000	0.04	15.23	0.97
NbStb2	AthPri AVG	5.59*	1	5.59	13.55	0.000*	0.04	13.55	0.95
PerGen2	PcvSaf2	68.41	1	68.41	66.77	0.000	0.18	66.77	1.00
PerEdu3	ParEng AVG	6.54	1	6.54	15.35	0.000	0.04	15.35	0.97
Case study	IntNet AVG	34.68*	5	6.93	11.49	0.000*	0.16	57.44	1.00
	TruRci AVG	20.32	5	4.06	5.64	0.000	0.08	28.20	0.99
	AthPri AVG	9.28	5	1.85	4.49	0.001	0.07	22.49	0.97
	ParEng AVG	10.93	5	2.18	5.12	0.000	0.07	25.63	0.98
	LocFac AVG	41.85	5	8.37	18.57	0.000	0.23	92.85	1.00
	PcvSaf2	17.37	5	3.47	3.39	0.005	0.05	16.95	0.90

 * Adjusted R².



Table 8: Qualitative research outcome summary

	Inner “Traditional Forms”			Outer “Modern Forms”			Informal “Slum Forms”			Exclusive “Defensive Forms”			Rank	Score	Case Study	Form Type
	T1/ UznBzr	T2/ FanBzr	T3/ RehBri	I1/ ZooRod	I2/ BelTol	I3/ KalPhr	S1/ JahAri	S2/ KolNgr	S3/ HatNgr	E1/ SpnGdn	E2/ VijCom	E3/ ProPrk				
SS													1	21	E3/ ProPrk	4
Int/ Net	HIGH	VERY HIGH	HIGH	VARYING	MEDIUM-LOW	VARYING	VERY HIGH	VERY HIGH	VERY HIGH	HIGH-MEDIUM	VARYING	VERY HIGH - HIGH	2	20.5	T1/ UznBzr	1
													3	20	S1/ AriBst	3
Tru/ Rci	VERY HIGH	VERY HIGH	HIGH	HIGH	MEDIUM-LOW	MEDIUM	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MEDIUM	VERY HIGH - HIGH	4	19	T3/ RehBri	1
													4	19	E1/ SpnGdn	4
Atch	VERY HIGH	VARYING	VERY HIGH - HIGH	VERY HIGH	HIGH-MEDIUM	VERY HIGH - HIGH	VERY HIGH	VERY HIGH - HIGH	HIGH-MEDIUM	HIGH-MEDIUM	VARYING	HIGH	5	17.5	S2/ KolNgr	3
													6	16	S3/ HatNgr	3
Pri	VERY HIGH	VARYING	VERY HIGH - HIGH	VERY HIGH	MEDIUM-INCONCLUSIVE	INCONCLUSIVE	INCONCLUSIVE	INCONCLUSIVE	INCONCLUSIVE	VERY HIGH	MEDIUM-LOW	VERY HIGH	7	15.5	T2/ FanBzr	1
													8	14	I1/ ZooRod	2
Par/ Eng	MEDIUM	VERY HIGH	HIGH	VARYING	LOW-VARYING	VARYING	VERY HIGH	VERY HIGH	VERY HIGH	HIGH	MEDIUM	HIGH	9	10.5	I2/ BelTol	2
													10	9.5	E2/ VijCom	4
Per Saf	VERY HIGH - HIGH	VERY HIGH - HIGH	HIGH-MEDIUM	HIGH	HIGH-MEDIUM	HIGH-MEDIUM	VERY HIGH	MEDIUM	MEDIUM-LOW	VERY HIGH	VERY HIGH	VERY HIGH	11	8	I3/ KalPhr	2

very high = 4	high = 3	medium = 2	low = 1	inconclusive / varying = 0
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reduced the residents fear of crime was influenced by the complementing synergies between different urban form components such as (i) More People (critical mass): Density; (ii) More Activity (day and night-time): Mix of Land-use (active uses such as grocery, newsagents, etc.; active primary street; live-work units; availability and access to local facilities); (iii) More Overlooking (“eyes on streets”): Built-Components (elements such as balconies, windows, fencing, building frontages, building orientation, street lighting); (iv) More Connectivity (access and pedestrian movement): Open-Spatial Network/Urban Blocks (permeable street network, shorter blocks, proximity to destinations, quick and easy access to active primary street).

Finally availability of and access to basic services and local facilities based on the urban form components was found to be the most critical component of social sustainability which not only concerned the issues of inclusion and equity in an urban form but also influenced all the other aspects of social cohesion and social capital. Locational advantage of people’s place of residence in terms of availability of and access to basic services and local facilities was perceived of high importance and therefore influenced residents’ attachment to place (functional dependency) and thus, their length of stay in an area. Length of stay, as a key external variable, in turn, had the potential to influence the level of all other social sustainability components.

The qualitative research also highlighted the fact there existed a very high number of external variables that influenced the strength of ties. Key amongst them were length of stay (duration of stay in ones place of residence) which strongly affected all aspects of social sustainability and spatial proximity’ (based on physical distance) of the residents. In any urban form, the social ties were also found stronger and interactions more frequent amongst residents living in immediate spatial proximity¹⁰ such as same floor, same residential block-component or even adjacent residential plots. Such residents met more frequently, looked out for each other on regular basis, visited socially and organised small gatherings amongst themselves. Other external factors that affected the influence of urban form components on social sustainability outcomes were age-groups and life-stage (children and elderly group of people), occupation and income groups (people with limited income, limited access) showed greater need for local social support and local ties, people with shared norms and institutions (common goals and common problems and benefits), personal or cultural preferences (desire for personal domain and privacy), strong religious and ethnic affinities, amongst neighbours, presence of cognate neighbours and presence of active social groups, local leaders, clubs and co-operatives.

The triangulation of qualitative and quantitative inquiries, therefore, further illuminated this complex relationship – influence of urban forms on social sustainability – based on which five theories can be developed.

- a. **Intervening Variables** (very high number of intervening external variables): Components of social sustainability were dependent on type of social contacts (strong and weak ties) and were greatly influenced by a number of intervening variables such as residents' length of stay, number of cognate neighbours and close friends in the locality, intensity of regional/ethnic affinities. Presence of active local groups, clubs, co-operatives, etc. also played an important role in mobilising community towards achieving positive social aspects.
- b. **Spatial Proximity** (closeness based on physical distance): Although not a sole driver, it was found that spatial proximity had direct proportional effects on the strength of local ties, intensity of interactions and, consequently, on the level of trust and reciprocal relationships, amongst the residents of different urban forms.
- c. **Favourable Spatiality** (spaces for social opportunities): The local ties, interaction and trust were likely to grow in width and depth with the provision of favourable spatiality (everyday spaces for social opportunities; for example: streets, community/faith centres, open recreational spaces, local play areas, local shops). The level of trust, social participation, place attachment, place satisfaction and residents' feeling of safety were also facilitated through 'favourable spatiality' which provided opportunities for random and organised sociability to occur as well as holding celebratory events.
- d. **Complementing Synergies** (integration amongst urban form components required to produce a combined positive effect): Different urban form components were interdependent and benefited from or even necessitated complementing synergies amongst them. Each urban form component required integration of other components to produce a combined positive effect more than the sum of their individual effects on various aspects of social sustainability.
- e. **Tipping Point** (point after which urban form components start to show negative effect): Urban forms constantly evolve, and reach a state of climax where the complementing

synergies between different urban form components are most optimal and its relationship with social sustainability is most balanced. However, since both urban form and social sustainability are dynamic concepts, this state of climax is temporal, and it is possible that the components of urban form traverse a "tipping point" where it crosses a threshold, tips, and bends down steeply to reach the "rupture point". From this point onwards, the components of urban form start to show negative effects. As a result, over-dominant land-use, density and/or activities, whether residential, commercial, retail or office, exhibited greater social problems and were, therefore, found as less sustainable.

Conclusions and Way-Forward

Conclusions: The concept of urban form is important to consider as it encompasses a number of critical issues relevant to sustainability of a city and therefore, can aid urban design and planning processes. This research set out to examine the influence of urban forms on social sustainability. It has traversed and covered ground through detailed review of the literature thus, building blocks for the analysis of the relationship between the two. It explored their meanings, constituent dimensions and methods of measurement. It then conducted empirical tests which were calibrated and validated for Guwahati, the dominant city of North-East region of India using both, qualitative and quantitative research strategies. From the findings of this study, it can be concluded that urban forms at different spatial scales significantly influence social sustainability. This relationship is, however, influenced by a number of external intervening variables, key amongst them being the residents' length of stay. The relationship also flourishes with the presence of 'favourable spatiality' (spaces for social opportunities) and through 'complementing synergies' between the different components of urban form. Despite the fact that urban form components and social sustainability have a 'positive' correlation [i.e. urban forms with higher values for (i) connected and integrated street network, (ii) accessible and amount of open recreational spaces, (iii) mix of uses, (iv) densities, (v) small compact blocks and (vi) human scale built-components display



significantly higher levels of social sustainability amongst its residents than those with lower values], each component has a threshold value after which it begins to show 'negative' effects. It is, however, very difficult to measure or rule down such threshold value for any urban form component due to the presence of various external intervening variables, combined effect of other urban form components and dynamic nature of the society.¹¹

This perhaps leads to another argument that in the absence of a clear theory and an agreed threshold value for urban form components, an evidence-based social sustainability framework for urban forms at different spatial scales, which combines (macro-level variables of) top-down and (micro-level variables of) bottom-up approaches in order to benefit from the strengths of both, may be a necessary intervention for rapidly urbanising and re-structuring Indian cities like Guwahati. Such a framework combining social policies (top-down), social designs (synergic) and social actions (bottom-up) may act as a trellis¹² upon which the social dimension of sustainability grows and evolves (Hemani and Das, 2015) gradually making urban communities more vibrant and their neighbourhoods more thriving places to live.

Notes

- 1 Two key empirical studies in the Indian context at neighbourhood scale are by: 1. National Institute of Urban Affairs (NIUA, 2011) comparing low-, medium- and high-density neighbourhoods and 2. Bahadure and Kotharkar (2012) comparing six neighbourhoods with varying land-use mix.
- 2 20th Century visionaries such as Sir Ebenezer Howard (Garden City, 1902), Le Corbusier (Ville Radieuse; Radiant City, 1927) and Frank Lloyd Wright (Broadacre City, 1952) espoused social and architectural changes and provided a blueprint from which a new society (and/or urban form) was to be constructed (Fishman, 1982).
- 3 Compaction can be described as densification and mixing of land uses so as to intensify the functions of existing urban areas in an effort to conserve the rural hinterland (Gopal and Nair, 2014).
- 4 For example, Delhi Development Authority's initiative to make Delhi a compact city has led to denser peripheries (Kumar, 2000).
- 5 Two key related studies in the Indian context at neighbourhood scale are by National Institute of Urban Affairs (NIUA, 2011) comparing low-, medium- and high-density neighbourhoods as well as by Bahadure and Kotharkar (2012) comparing six neighbourhoods with varying land-use mix. Some comprehensive studies conducted in the western context are Baum and Palmer (2002), Jackson (2003) and Bramley et al. (2009).

6 A scale has been defined as "different level of complexity of the components internally arranged to construct a whole" Caniggia and Maffei, 2001:245.

7 A neighbourhood in physical terms is defined as "key living space through which people get access to material and social resources, across which they pass to reach other opportunities ..." (Meegan and Mitchell, 2001, p. 2172). It is also understood as a social space around one's place of residence (Bruin and Cook, 1997). No set method for defining a neighbourhood and its spatial boundary was obtained from literature review. Government defined administrative boundaries or wards were inappropriate to represent neighbourhoods in reality and study social relationships therefore, for the purpose of this research, heuristic approach was adopted. Geographically based immediate neighbourhoods within accepted walking distance of 10 min or 800 m radius (Ferguson and Woods, 2010; Advani and Tiwari, 2005; UDC, 2000) were demarcated within approximate local area boundaries obtained using information collected from either previous attempt by endogenous or exogenous groups or existing local perceptions.

A block segment represents a section of an urban block comprising of a geographically based immediate community defined within a physical commune, street or gated enclave.

8 The strength of a tie (assumed positive), strong or weak, is a combination of the amount of time, the emotional intensity, the intimacy and reciprocal services which characterises it (Granovetter, 1973, pp. 1360–1380).

9 For organised sociability to occur, especially in the absence of favourable spatiality, social actions such as active leadership, community groups, local institutions were seen necessary to develop social contacts.

10 It is important to note that the spatial proximity based on the physical distance between any two individuals' places of residence is a relative terminology and therefore no fixed measured distance can be taken as a benchmark. It is a concept-constant observed in all different urban form typologies although their shortest or closest physical distance may vary.

11 Forms of cities and their neighbourhoods are therefore not objects frozen in time and space, but rather very much living and evolving. They are constantly in flux with what is spontaneous and planned, natural and imposed, top-down and bottom-up, making them multi-layered. Change, be it growth or decay, a simple redistribution or an alteration, is thus, an in-built mechanism of any system. The consequence of the change depends on the capacity of the urban form, society or individual to adapt or withstand it.

12 The word trellis was coined in the book, the Sustainable Urban Neighbourhood (Rudlin and Falk, 2009, p. 268), which described a master-plan as 'a trellis on which the vine of the city can grow'.

References

- Advani, M. and Tiwari, G. (2005) Evaluation of public transport systems: Case study of Delhi Metro. *Proceeding of START-2005 Conference* held at IIT Kharagpur, India.
- Alexander, C. (1966) A city is not a tree. *Design* 206: 46–55.
- Anderson, W.P., Kanargoglou, P.S. and Miller, E.J. (1996) Urban form, energy and the environment: A review of issues, policy and development. *Urban Studies* 33(1):17–35.



- Bahadure, S. and Kotharkar, R. (2012) Social sustainability and mixed landuse, case study of neighborhoods in Nagpur, India. *Bonfring International Journal of Industrial Engineering and Management Science* 2(4):76–83.
- Bamberger, M. (2000) *Integrating Quantitative and Qualitative Research in Development Projects*. Washington DC: World Bank.
- Baum, F. and Palmer, C. (2002) 'Opportunity structures': Urban landscape, social capital and health promotion in Australia. *Health Promotion International* 17(4): 351.
- Bertolini, L., le Clerq, F. and Straatemeier, T. (2008) Urban transportation planning in transition. *Transport Policy* 15: 69–72.
- Bramley, G. and Power, S. (2009) Urban form and social sustainability: The role of density and housing type. *Environmental Planning B* 36(1): 30–48.
- Breheny, M. (1992) *Sustainable Development and Urban Form*. London: Pion.
- Brown, B.B. and Cropper, V.L. (2001) New urban and standard suburban subdivisions: Evaluating psychological and social goals. *American Planning Association Journal* 67(4): 402–419.
- Bruin, M.J. and Cook, C.C. (1997) Understanding constraints and residential satisfaction among low-income single-parent families' *Environment and Behavior* 29: 532–553.
- Burton, E. (2000) The compact city: Just or just compact? A preliminary analysis. *Urban Studies* 37(11):1969–2001.
- Calthorpe, P. (1993) *The Next American Metropolis: Ecology, Community, and the American Dream*. New York: Princeton Architectural Press.
- Caniggia, G. and Maffei, G.L. (1979) *Architectural Composition and Building Typology: Interpreting Basic Building*. Firenze: Alinea.
- Carmona, M., Heath, T., Oc, T. and Tiesdell, S. (2003) *Public Places Urban Spaces: The Dimensions of Urban Design*. Oxford: Architectural Press.
- Colantonio, A. (2007) *Social Sustainability: Linking Research to Policy and Practice*. Headington: Oxford Brookes University.
- Colantonio, A. (2008) *Traditional and Emerging Prospects in Social Sustainability. Measuring Social Sustainability: Best Practice from Urban Renewal in the EU*. Headington: Oxford Institute for Sustainable Development (OISD), Oxford Brookes University.
- Colantonio, A. and Dixon, T. (2011) *Urban Regeneration & Social Sustainability Best Practice from European Cities*. London: Wiley.
- Creswell, J., Plano, C.V., Gutmann, M. and Hanson, E. (2003) Advanced mixed methods research designs. In: A. Tashakkori and C. Teddlie (eds.) *Handbook of Mixed Methods in Social and Behavioural Research*. Thousand Oaks, CA: Sage, pp. 209–240.
- Dempsey, N., Brown, C., Raman, S., Porta, S., Jenks, M., Jones, C. and Bramley, G. (2010) Elements of urban form. In: M. Jenks and C. Jones (eds.) *Dimensions of the Sustainable City*. London: Springer, pp. 21–52.
- Dempsey, N., Bramley, G., Powers, S. and Brown, C. (2011) The social dimension of sustainable development: Defining urban social sustainability. *Sustainable Development* 19(5): 289–300.
- Dieleman, F. and Wegener, M. (2004) Compact city and urban sprawl. *Built Environment* 30(4): 308–323.
- Doshi, B. (1997) Social institutions and a sense of place. In F. Ameen (ed.) *Contemporary Architecture and City Form: The South Asian Paradigm*. Marg Publications, Mumbai, pp. 13–24.
- Ferguson, N. and Woods, L. (2010) Travel and mobility. In: M. Jenks and C. Jones (eds.) *Dimensions of the Sustainable City*. London: Springer.
- Fischer, C.S. (1982) *To Dwell Among Friends*. Chicago: University of Chicago Press.
- Fishman, R. (1982) *Urban Utopias in the Twentieth Century: Ebenezer Howard, Frank Lloyd Wright, and Le Corbusier*. Cambridge: MIT.
- Forrest, R. and Kearns, A. (2001) Social cohesion, social capital and the neighbourhood. *Urban Studies* 38: 2125–2143.
- Fukuyama, F. (1995) *Trust: The Social Virtues & The Creation of Prosperity*. New York: The Free Press.
- Giuliani, M.V. (2003) Theory of attachment and place attachment. In: M. Bonnes, T. Lee and M. Bonaiuto (eds.) *Psychological Theories for Environmental Issues*. Aldershot: Ashgate, pp. 137–170.
- Glaser, B.G. (1978) *Theoretical Sensitivity*. Mill Valley, CA: The Sociology Press.
- Gopal, A. and Nair, S. (2014) An approach for analyzing prospects of urban compaction in Indian cities. *Journal of Civil Engineering and Environmental Technology* 1(1): 21–25.
- Guest, A.M. and Lee, B.A. (1983) Sentiment and evaluation as ecological variables. *Sociological Perspectives* 26(2): 159–184.
- Handy, S. (1996) Methodologies for exploring the link between urban form and travel behavior. *Transportation Research: Transport and Environment D* 2(2): 151–165.
- Handy, S., Boarnet, M., Ewing, R. and Killingsworth, R. (2002) How the built environment affects physical activity. *American Journal of Preventive Medicine* 23(2S): 64–73.
- Hemani, S. and Das, A.K. (2015) Humanizing Urban Development in India: Call for a more comprehensive approach to Social Sustainability in the urban policy and design context. *International Journal of Urban Sustainable Development*. doi:10.1080/19463138.2015.1074580
- Hessler, R., Kubish, P., New, P., Ellison, D. and Taylor, F. (1971) Demographic context, social interaction, and perceived health status: Excedrin headache #1. *Journal of Health and Social Behavior* 12: 191–199.
- Hillier, B. (1996) *Space is the Machine*. Cambridge: Cambridge University Press.
- Jabareen, Y.R. (2006) Sustainable urban forms: Their typologies, models, and concepts. *Journal of Planning Education and Research* 26(1): 38–52
- Jacobs, J. (1961) *The Death and Life of Great American Cities*. Harmondsworth: Penguin.
- Jenks, M. and Jones, C. (eds.) (2010) *Dimensions of the Sustainable City*. London: Springer.
- Jenks, M. and Burgess, R. (2000) *Compact Cities: Sustainable Urban Forms for Developing Countries*. London: Taylor and Francis.
- Jenks, M. and Dempsey, N. (eds.) (2005) *Future Forms and Design for Sustainable Cities*. Oxford: Architectural Press.
- Kamruzzaman, M., Baker, D., Washington, S. and Turrell, G. (2014) Advance transit oriented development typology: Case study in Brisbane, Australia. *Journal of Transport Geography* 34: 54–70.
- Karrholm, M. (2011) The scaling of sustainable urban form: A case of scale-related issues and sustainable planning in Malmo, Sweden. *European Planning Studies* 19(1): 97–112.
- Keane, C. (1991) Socioenvironmental determinants of community formation. *Environment and Behavior* 23(1): 27–46.
- Kearns, A. and Forrest, R. (2000) Social cohesion and multilevel urban governance. *Urban Studies* 37(5/6): 995–1017.
- Kim, J. and Kaplan, R. (2004) Physical and psychological factors in sense of community: New urbanist Kentlands and nearby Orchard Village. *Environment and Behavior* 36(3): 313–340.
- Kumar, A. (2000) The inverted compact city of Delhi. In: *Compact Cities: Sustainable Urban Forms for Developing Countries*. London: Spon Press, pp.153–166.



- Leyden, K. (2003) Social capital and the built environment: The importance of walkable neighborhoods. *American Journal of Public Health* 93(9): 1546.
- Lynch, K. (1981) *Good City Form*. Cambridge, MA: The MIT Press.
- Marshall, S. and Çalıřkan, O. (2011) A joint framework for urban morphology and design. *Built Environment* 37(4): 409–426.
- Mason, S. (2010) Can community design build trust? A comparative study of design factors in Boise, Idaho neighborhoods. *Cities* 27: 456–465.
- McKenzie, S. (2004) *Social Sustainability: Towards some definitions*. Working Paper Series No. 27. Australia: Hawke Research Institute.
- Meegan, R. and Mitchell, A. (2001) 'It's not community round here, it's neighbourhood': Neighbourhood change and cohesion in urban regeneration policies. *Urban studies* 38(12): 21.
- Moudon, A.V. (1986) *Built for Change: Neighborhood Architecture in San Francisco*. Cambridge, MA: MIT Press.
- Nash, V. and Christie, I. (2003) *Making Sense of Community*. London: Institute for Public Policy Research.
- Newman, P. and Kenworthy, J. (1989) Gasoline consumption and cities: A comparison of U.S. cities with a global survey. *Journal of the American Planning Association* 55(1): 24–37.
- Neuman, M. (2005) The compact city fallacy. *Journal of Planning Education and Research* 25: 11–26.
- NIUA, National Institute of Urban Affairs. (2011) *Sustainable Urban Form for Indian Cities*, Research Study Series No. 112, March.
- NMSH, Ministry of Urban Development Report (2010) *National Mission on Sustainable Habitat*. Government of India.
- Oswald, F. and Baccini, P. (2003) *Netzstadt, Designing the Urban*. Basel: Birkhauser.
- ONS survey matrix (November 2001) Social Analysis and Reporting Division. Office of National Statistics, UK. www.ons.gov.uk/ons/guide.../social-capital-matrix-of-surveys.pdf, accessed 10 May 2012.
- Owen, N., Humpel, N., Leslie, E., Bauman, A. and Sallis, J.F. (2004) Understanding environmental influences on walking: Review and research agenda. *American Journal of Preventive Medicine* 27: 67–76.
- Parkes, A., Kearns, A. and Atkinson, R. (2002) What makes people dissatisfied with their neighbourhoods? *Urban Studies* 39(13): 2413–2438.
- Pierson, J. (2002) *Tackling Social Exclusion*. London: Routledge.
- Podobnik, B. (2002) New Urbanism and the generation of social capital: Evidence from Orenco Station. *National Civic Review* 91: 245–255.
- Putnam, R. (1993) *Making Democracy Work: Civic traditions in modern Italy*. Princeton, NJ: Princeton University Press.
- Rudlin, D. and Falk, N. (2009) *The Sustainable Urban Neighbourhood: Building the 21st Century Home*. London: Routledge.
- Sampson, R.J. (1988) Local friendship ties and community attachment in mass society: A multilevel systemic model. *American Sociological Review* 53(5): 766–779.
- Sarantakos, S. (2005) *Social Research*, 2nd ed. Hampshire: Palgrave Macmillan.
- Selkirk, K.E. (1982) *Pattern and Place: An Introduction to the Mathematics of Geography*. Cambridge: Cambridge University Press.
- Talen, E. (1999) Sense of community and neighbourhood form: An assessment of the social doctrine of new urbanism. *Urban Studies* 36: 1361–1379.
- Tashakkori, A. and Teddlie, C. (eds.) (2010) *Handbook of Mixed Methods in Social and Behavioral Research*. Thousand Oaks: Sage, pp. 297–320.
- Tennyson-Mason, R. (2002) *Tackling the Fear of Crime: Putting the Pieces of the Jigsaw Together*. Leeds: Guidance for Crime and Disorder Reduction Partnerships, Government Office for Yorkshire and the Humber.
- Tolentino, A. (2011) *Suburban Tissue Analysis and Retrofitability: Creating A Catalogue And Scoring System For Potential Retrofit Sites*. Georgia Institute of Technology. http://www.cnu.org/sites/www.cnu.org/files/armantolentino_suburban_tissue_analysis_and_retrofitability_1.pdf, accessed 6 December 2013.
- Tuan, Y.F. (1974) *Topophilia*. Englewood Cliffs, NJ: Prentice-Hall.
- Torjman, S. (2000) *Social Dimension of Sustainable Development*. Paper prepared for the Commissioner of Environment and Sustainable Development at the Office of Auditor General, Caledon Institute of Social Policy, pp. 1–11.
- UDC Urban Design Compendium (2000) English Partnerships and The Housing Corporation, UK.
- Wiersinga, W. (1997) *Compensation as a Strategy for Improving Environmental Quality in Compact Cities*. Amsterdam: Bureau SME.
- Wilkinson, R.G., Kawachi, I. and Kennedy, B.P. (1998) Mortality, the social environment, crime and violence. *Sociology of Health & Illness* 20(5): 578–597.
- Williams, K., Burton, E. and Jenks, M. (2000) *Achieving Sustainable Urban Form*. London: Routledge.
- Woodcraft, S. (2011) *Design for social sustainability: A framework for creating thriving new communities*. Homes and Communities Agency, Young Foundation, pp 1.
- Yang, Y. (2008) A tale of two cities: Physical form and neighborhood satisfaction in metropolitan Portland and Charlotte. *Journal of the American Planning Association* 74(3): 307–323.
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