Disruption, Divergence and Designed Intervention - Making Change Happen
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An Alternative Means to Generate Urban Codes:
An Instrument for Urban Design

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An Alternative Means to Generate Urban Codes: An Instrument for Urban Design

ABSTRACT: This study seeks to develop a methodology to generate urban codes to achieve the desired configuration for neighbourhoods. Urban codes refer to the embedded quality of urban forms which either evolved by itself or is guided by rules & regulations. The novel instrument proposed in this paper brings together city level and local neighbourhood data to aid participatory decision-making in urban design. We utilise an alternative integrated approach to investigate urban forms in a design procedure. Regarding design decision-making, there is a gap between top-down and bottom-up urban design approaches. On the one hand, the top-down urban planning methods define urban forms as a holistic matter which only can be calibrated by urban professionals. Lack of visual information in such approaches causes difficulty for end users to predict urban forms. On the other hand, the bottom-up approaches cannot provide enough information on urban scenarios, where the decisions mostly stay as general assumptions. Therefore, we speculate a middle approach to generate urban forms taking advantages of computational tools to engage stakeholders in complex urban design decision-making processes. This study concludes with a mixed methodology of top-down and bottom-up urban design approaches. We create a method for urban professionals to convey their design ideas on urban forms with visual information in an increased communicative channels for design discussion with stakeholders. At this moment, we are adapting density rules and creating communicative interfaces to generate urban forms by operating density parameters. The methodology can cater any location and can adapt other design rules corresponding to physical parameters of urban forms.

Keywords: Urban forms; parametric urban design; holistic urban planning; a decision-making platform; a knowledge-based system

Introduction

Decades of studies on urban design are looking into the democratic involvement of different stakeholders in a broad variety of collaborative and participatory design decision-making platforms. Traditional urban design techniques can’t offer flexibility to cater the wide range of social issues in the design process (Kiddle, 2011). Methods like design charrettes and planning workshops already have seen their good days in such democratic engagement in design platforms (Batchelor and Lewis, 1985, Steinø et al., 2013, Knevitt and Wates, 1987). However, in spite of having such established methods, there are still differences exist in thinking and communicating language between professionals and laypersons (Friedman, 1973, Forester, 1988). The lack of engaging ways eventually pushes researchers to rethink for a new form of design-decision making platform where non-designers can fully understand the spatial implications of planning and design decisions. Previous collaboration methods have a stance on developing concepts in early design phase which can’t demonstrate engagement with the details of physicality. Relatively detailed architectural models either
physical or virtual can provide further collaboration between the professionals and the non-designer professionals or non-professional stakeholders (Steino et al., 2013). A computational virtual platform can overcome such communicative gap between practitioners and laypersons. An improved visual communication allows stakeholders in immediate and three-dimensional access to the design process (Chen and Schnabel, 2011).

Our research develops a design methodology that includes contextual urban parameters in a generative system. Urban codes are the embedded quality of urban forms which either evolved by itself or are guided by rules and regulations (Marshall, 2012). The study extracts the contents of urban codes as urban parameters for both high and low-density neighbourhoods. Our research considers the regulatory parameters of Tsim Sha Tsui (TST), Hong Kong and Karori, Wellington. The study creates a platform for stakeholders to visualise multiple urban forms by operating density parameters for both high and low-density contexts.

Background: An Algorithmic Urban Modelling

Shifting from top-down modelling to more generative and bottom-up systems has influenced urban designers to address morphogenetic changes in urban design (Ayaroğlu, 2007, Verebes, 2013, Beirão and Duarte, 2005, Beirão et al., 2011). Such systems can function as a creative design assistant during the conceptual stages of architecture & urban design. Traditional urban design and planning methods have limited ability to address multiple urban complex rules and cannot able to provide necessary information to predict the urban forms. City Information Modelling (CIM) can automate design options and generate possible new urban scenarios (Beirão et al., 2012, Stojanovski, 2013, Gil et al., 2011). However, this top-down modelling process cannot visualise urban scenarios in a dialectic way for stakeholders (Kunze et al., 2012). Therefore, this research develops an instrument between top-down and bottom-up design methods to engage stakeholders in urban design process. The research employs CIM and generates interoperable rules for neighbourhoods through mathematical and computational models by analysing and evaluating urban forms and spatial configurations. The research develops a configurational design method which can integrate maximum urban complex rules for building forms. We explore an alternative urban design process; an algorithmic knowledge-based system, in neighbourhood design.

The design strategies for urban design and planning take a lot of information and knowledge into account of the various types of complex urban issues which require visualising in the design process. Urban design is a complex phenomenon which deals with the participation of different conflicting agents. The lack of common language among such
agents raises communication difficulties (Beirão et al., 2011). The addition of parametric design develops an intelligent design system where that design becomes a computer model to understand how the different parts are related. Parametric Design along with BIM modelling system has already pushed architects to go for a new endeavour in building design. Such design method offers distinct advantages for engineering and manufacturing processes (Schnabel, 2007). BIM comprises an integrated system that aims to incorporate all aspects of design from geographical information, to building geometry, to the relationships between components and, to the quantities and detail properties of building components (Montenegro and Duarte, 2009, Guarino, 1998). The ontological description corresponds to city design process demands for creating City Information Modeling. CIM allows a holistic approach to deal urban design on a large scale scenario. However, industrial development in city modelling (Autodesk, McNeel, ESRI, etc.) still not intuitive enough in switching scenarios to be performed well in a design charrette (Kunze et al., 2012).

CIM already extends its boundary by integrating Geographic Information Systems (GIS) as a decision and design support tools. There are already established research which describes urban design method that incorporates the stages of form generation and evaluation of urban models backed by CAD/GIS software platforms (Duarte et al., 2012).

**Test Sites: High & Low-Density Cities**

Density is one of the frequently used words in the field of urban design and planning. It refers to the binary number of inhabitants in the given urbanised area. Jane Jacobs proved that the vitality of cities comes from density & diversity (Jacobs, 2016). There are different models to analyse such density regarding population, dwelling unit, coverage, and land use. Density has perceived as an abstract regulatory mechanism to manage city growth. Apparently, densities correspond to different urban forms, and a particular urban typology can have different densities. However, such numerical value only can be applied to measuring units but aren’t able to define qualitative aspects of urban form.

We choose Tsim Sha Tsui (TST), Hong Kong and Karori, Wellington as investigating sites. They represent two different density situations. Here, we aim to indicate common elements of urban codes and imply them as operable parameters to generate urban forms.
TST area located at the south tip of Kowloon peninsula. This area has developed from a fishing village since the 1840s (Fig.1). There are two reasons lead TST to a crowded urban core zone of Hong Kong. One is the water transportation, and the other is war. Because of the warfare of last century, a large number of population moved to Hong Kong. The special geographical location and history affairs made TST becomes one of the most crowded places in the world.

Figure 1 The urban development of Tsim Sha Tsui

The building forms and functions of TST are complicated because of extreme land-hungry situation. For instance, the Chungking Mansion created a dynamic and chaotic space with homes, small companies, stores, restaurants, as well as underground transfer points. The space users tend to utilise the building space by fully installing multiple functions. Tall buildings are encouraged by the current regulations of Hong Kong. Rules on plot ratio control density by manipulating building height and site coverage (Table 1).

Table 1: A comparison between low and high buildings

<table>
<thead>
<tr>
<th></th>
<th>Site Area</th>
<th>Storey</th>
<th>Each floor area</th>
<th>Height</th>
<th>Plot Ratio</th>
<th>Site Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building A</td>
<td>1,000m²</td>
<td>6</td>
<td>720m²</td>
<td>18m</td>
<td>4.3</td>
<td>72%</td>
</tr>
<tr>
<td>Building B</td>
<td>1,000m²</td>
<td>25</td>
<td>400m²</td>
<td>75m</td>
<td>10</td>
<td>40%</td>
</tr>
</tbody>
</table>

Based on Hong Kong’s existing Building Planning Regulations (BPR), the main parameters include heights, site coverage, plot ratio, open space and lands, as well as projection codes, like eaves, cornices, mouldings, balconies and canopies over streets, and use of verandas or balconies. Each variable has specific requirements for specific sites. The site classification consists of three categories. Table 2 illustrates height regulations for both domestic and non-domestic buildings in Hong Kong.
Table 2: An example of height regulation in Hong Kong-18A, 20&21, BPR

<table>
<thead>
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<th>Height of building in metres</th>
<th>Domestic buildings</th>
<th>Non-domestic buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage site coverage</td>
<td>Plot ratio</td>
</tr>
<tr>
<td></td>
<td>Class A site</td>
<td>Class B site</td>
</tr>
<tr>
<td>Not exceeding 15 m</td>
<td>66.6</td>
<td>75</td>
</tr>
<tr>
<td>Over 15 m but not exceeding 18 m</td>
<td>60</td>
<td>67</td>
</tr>
<tr>
<td>Over 18 m but not exceeding 21 m</td>
<td>56</td>
<td>62</td>
</tr>
<tr>
<td>Over 21 m but not exceeding 24 m</td>
<td>52</td>
<td>58</td>
</tr>
<tr>
<td>Over 55 m but not exceeding 61 m</td>
<td>34</td>
<td>38</td>
</tr>
</tbody>
</table>

Figure 2 Aerial view of Karori Centre (source: www.stuff.co.nz)
The complexity of density stems from the multitude of definitions of the term in different disciplines and contexts (Ng, 2009). In Hong Kong, the value of plot ratio commonly reached 10, while in Australia and New Zealand, plot ratio 3 is already a quite high-density value. Karori is one of the largest neighbourhoods in New Zealand (figure 2). Compared to other suburbs, Karori has good amenity and facilities but fails to integrate the attributes of place-making (Dodge, 2017). Currently, Wellington City Council (WCC) is focussing on Karori to develop a collaborative decision-making instrument which can stimulate interest and participation of the local community in the development of medium-density housing close to town centres. WCC already have proposed new building standards for medium –density housing in Karori (table 3). The draft indicates WCC is looking for a new regulatory system for building construction to transform Karori as a medium density residential area.

Table 3: A Draft of Medium Density Residential Area (MDRA) building standards (Wellington City Council, 2017)

<table>
<thead>
<tr>
<th></th>
<th>Current standards</th>
<th>Proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Height</td>
<td>8m</td>
<td>8m, with scope to build to 10.4m in certain scenarios, e.g., along Karori Road or close to a Town Centre</td>
</tr>
<tr>
<td>Building recession planes</td>
<td>2.5m on the boundary and incline of 45° on all boundaries</td>
<td>2.5m and an incline of 56° or 63°</td>
</tr>
<tr>
<td>Site Coverage</td>
<td>35%</td>
<td>50%</td>
</tr>
<tr>
<td>Front yard</td>
<td>The lessee of 3m or 10m less half the width of the road</td>
<td>3m</td>
</tr>
<tr>
<td>Open space</td>
<td>50m² per unit</td>
<td>20m² per unit</td>
</tr>
<tr>
<td>Vehicle parking</td>
<td>one space per unit</td>
<td>No change</td>
</tr>
</tbody>
</table>
Karori consists of a town centre, community facilities, schools, open spaces, commercial facilities, and multiple public transport lines. Through a field investigation, we have found that the community’s vision includes low-storeyed control, local character maintains, sunlight access, and open space guarantee. According to the Housing Choice and Supply of Karori, WCC, the main regulation parameters of Karori include building storey, height, recession planes, site coverage, open space and setbacks.

Table 4: A regulation parameter comparison between TST and Karori

<table>
<thead>
<tr>
<th>Main Parameters</th>
<th>TST</th>
<th>Karori</th>
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<tr>
<td>Building height</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Building storey</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Open Space</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Plot Ratio</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Eaves</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Cornices</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Mouldings</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Balconies</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Canopies over streets</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Verandas</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Setbacks</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Recession planes</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Site Coverage</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Site Size</td>
<td>●</td>
<td>○</td>
</tr>
</tbody>
</table>

Table 4 presents a regulation parameter comparison between TST and Karori. Through the contrast, we have found that building height, open space, plot ratio, and site coverage are common in both TST and Karori. These are the elements of urban codes to define urban density. We have developed our computational platform on these density parameters.

Research Methodology: A Knowledge-based System

The research methodology comprises four steps. It starts with generating urban rules and ends with an assessment (figure 3). The output of every step feeds into the next step. The first step develops the investigation rules between urban parameters (Schnabel, 2006). The second step transforms those rules into interoperable 3D models. The third step suggests a virtual platform to visualise the urban forms. Finally, the fourth step ensures the engagement of stakeholders in a web-based platform. During the design process, reflections and iterations define the design itself (Chen and Schnabel, 2011). Our proposed methodology gets internal
feedback from the output of the computational simulation and external feedback from stakeholders.

**Generating Urban Rules**

This step establishes the operable relation between different urban parameters. The urban parameters posit an intricate lattice within themselves. At this moment, we are developing the computational rules on density criteria. We are taking the extracted urban parameters from the comparison of TST and Karori (table 4). We also adopt the parameters of plot ratio by employing form-based codes as vertical transects for TST (Schnabel et al., 2017). This step can cater more rules according to the need of the stakeholders’ investigation.

**Modelling and Developing a Platform- An Interface**

This step translates the relationship of urban parameters in a computational platform as programming scripts to generate urban forms. The method is Object Oriented Parametric Modelling (OOPM). The script has written in a programming language like Grasshopper. The script has linked to the test sites by GIS or Open Street Map (OSM) generated vector maps. As we are examining TST and Karori, so we have linked our scripts with the vector map of desired locations of TST & Karori. The script also accommodates the information of the topography. The map is available in online and has sufficient information to meet the requirement for this investigation.
From the beginning, the study is developing communicative Graphical User Interface (GUI). This interface offers a platform to operate and visualise multiple options of urban scenarios which are generated by various inputs. We are using Grasshopper for Rhino to generate real-time urban forms.

![Figure 4 A GUI interface to generate urban forms (developed in Grasshopper 3D for Rhino)](image)

We have developed several interfaces to visualise urban forms in online platforms. Figures 4 & 5 illustrate design platforms for Karori where a change in urban parameters in the interface provides a real-time output in online. Such online platform encourages distant collaboration between stakeholders. The parameters in the interface indicate the density values. The script has designed in such a way that the density indicators regarding plot ratio
can generate new urban scenario for every single input in the sliders. The information on density helps stakeholders to decide which kind of urban forms they want to have for their neighbourhood. Similarly, figure 6 illustrates another platform for TST where the interface provides the information of multiple urban forms regarding plot ratio. Recently we have developed another script to visualise urban forms with the information of construction cost and building energy for Karori mall (figure 7). This platform offers to envision multiple urban forms for Kaori Mall precinct through online collaboration.

Figure 6 A GUI interface to generate building forms by manipulating Plot Ratio for TST and visualise in on-line to get real time feedback.

Figure 7 Visualizing Karori Mall with construction cost per square meter by changing the building width and height. The cost per unit also can be changeable as per the requirement of the stakeholders.


**Discussion**

Software like CityEngine also deals with such procedural modelling but provides a limited interface for editing the regulation parameters without any analysis features (Bum Kim et al., 2011). Similarly, CityCAD does not offer programming interfaces that allow its extension (Gil et al., 2011). In some extent, ArcGIS can work as a data editor and container of physical elements by using point, line, and polygon but demonstrate inaccuracy on the generated data. Compare to all of these tools; our proposed method shows more flexibility to cater multiple urban rules for urban professionals. However, further study requires validating the process in urban design charrettes.

The occupied challenges of digital technologies are as dialectic interfaces. Digital technologies are continually evolving to accommodate dialectic nature with reality which promotes innovative ways to interact with end users. A problematic issue for parametric design approach, in general, is that it never resolves all the parameters which are necessary for design. Urban professionals still need to elaborate most parts of the design in their mind. Another problem of parametric programs that they have been designed and attached with traditional workflow in alignment with process thinking not intuition. Hence, the operators of these systems have to anticipate the project directions beforehand to create geometry and to build the inter-relationships. According to Aish and Woodbury (2005), parametric modelling embraces unnecessary complexity with too much information on items. Additionally, the design decisions are usually made by an algorithmic process, not by the designer (Terzidis, 2006).

**Conclusion**

Urban planning and design always deal with complex issues of urban forms. Throughout decades, urban professionals are working to engage end-users in their design process. But, most often all the participators aren’t able to predict the urban forms as they deal with such complex relation either a top-down process or a bottom-up process. This study bridges the scalability gap between these two design methods. The methodology embraces parametric design tools as well as online communication methods. We propose a robust computational urban design approach which can cater new design rules for different locations. That means, this platform offers urban professionals to create unique design rules between urban parameters and can produce and convey multiple design ideas to their clients. This study presents an interface where numerous urban parameters can be operated. So that, stakeholders
can participate and select which kind of urban forms they want to have for their
neighbourhood. The value of the urban parameters defines the urban regulatory inputs where
a change in one parameter affects the whole urban scenario. The generated outcome can
visualise with relevant urban information to help the stakeholders to decide their desired
urban forms. Bottom line; this study proceeds for further exploration for a participatory
parametric urban design instrument.

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use Regulations into Building Information Models.


Creating Renewable Green Cities

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Gold Coast (QLD) 13-14 November 2017
ABSTRACT: Despite the increasing costs of climate change and the inevitable reduction in natural energy sources such as oil, natural gas, and uranium reserves, most urban areas are planned and designed in a way that indicates that these crises do not exist. Transitioning from a fossil-fuel-consuming city to a renewable city and to renewable city infrastructure requires a novel approach, advanced tools, thorough frames, and a different decision making process. This paper is a guide to this transformation for the cities that are going to be powered by renewable solutions. This paper reviews the priority action areas, such as built environment (e.g., heating and cooling demand), transportation, and green infrastructure, to achieve a renewable/green city concept in a built environment. The literature given on the priority areas highlights the importance of integrating renewable and green solutions in the urban planning process. This review serves as a guide for practitioners, academics, and policymakers in communities and cities worldwide, and informs them about the outcome of their decision making.

Keywords: Urbanization, Renewable Energy, Urban Planning, Built Environment

Introduction

As primary energy consumers, cities and other urban systems represent the largest single source of CO2 emissions (Droege, 2002). Nowadays, almost three quarters of the world’s fossil fuel is consumed in urban areas, as their performance and development require significant amount of energy. The reliance on fossil fuels is also rapidly increasing as they cater 85% of total energy use in commercial and domestic use. Therefore, countries and nations across the world are under great environmental and economic pressure to find alternative sources of energy. Increased rate of CO2 emission, climate change, urban heat island, fossil fuel depletion and environmental degradation caused by the oil and coal consumption, were the main triggers for cities to find alternative energy solutions.

The use of renewable energy is growing nowadays, however the current speed of change is too low to meet and address the global needs in the era of serious environmental crises. Furthermore, introduction of renewable energy sources such as wind and solar energy, requires cities to re-adapt themselves with the new technologies and to be re-engineered in several aspects, particularly in the most energy consumed domains such as built environment and transportation. Urban design principles, planning policies and urban forest strategies play important role in facilitating the transition to a renewable and sustainable city.
Renewable energy sources are more economically viable than conventional power sources, as they provide a cost-effective power supply in diverse locations. Renewables also support the principles of green/smart urbanism and environmentally friendly urban development. Implementing renewable energies in cities and exploring their impacts on the environmental, social, and economic status of urban environments are the best methods to re-evaluate existing planning policies in cities and propose retrofitted planning/design guidelines that can address the regional needs of each neighbourhood on the basis of available resources.

The potential to utilize renewable energies in cities depends on the background characteristics of the cities (e.g., population density, urban form, geographical condition, and energy demand in cold and hot seasons). Therefore, the proposed renewable strategies must be tailored to the context and conditions of each city. For instance, the average urban energy consumption of the building and transport sectors ranges from 500 kWh to nearly 30,000 kWh per capita in cities across the world. The main cause of such difference is different climatic and geographical conditions, which dictate the energy demand in urban areas.

The transformation to a renewable city would not be feasible by simply replacing one form of energy with another; this transformation requires innovative thinking on the overall energy system and the related interactions among different energy sources. This approach includes taking the main end users (e.g., buildings, transport, and industry) into consideration, designing smart integrated urban energy systems that can support different ranges of power produced by solar and wind sources, and studying the urban design and planning policies that define future growth strategies.

Cities, communities, and state governments set, coordinate and implement the policies which are needed to reduce the carbon emission and create a renewable city. However, there are substantial organizational and cultural and behavioural challenges which act against the immediate action and change. This paper reviews the priority action areas to achieve a renewable and green concept in cities, including 1.) Renewable solutions in a built environment (e.g., heating and cooling demand), 2.) Renewable solutions for transportation, and 3.) Green infrastructure. This paper also discusses the incorporation of renewable energy in the design of a smart, sustainable city. This study assists policymakers and state governments in setting renewable solutions for energy and in employing innovative techniques and technologies to tackle the increased energy demand, increased urban air temperature, and depletion of natural energy resources in urban areas.
Built Environment

Buildings account for 40% of the world’s energy consumption and 30% of the annual greenhouse gas emissions (Initiative, 2009). Nowadays, with the rapid population growth and urbanization rate, construction demand is ongoing. The new construction provides a great opportunity to create energy efficient buildings. Techniques and strategies that can be used to reduce the energy consumption in buildings aim to minimize the energy use for heating and cooling and to employ renewable solutions that can address the increasing rate of energy demand.

Modern architecture employs the latest technology to minimize the energy consumption in buildings (e.g., use of insulated windows, modern gas and oil furnaces, and more efficient air conditioners) (Bilgen, Keleș, Kaygusuz, Sari, & Kaygusuz, 2008). Building retrofication saves embodied energy, prevents waste generated from building demolition, and is more cost effective than constructing new buildings. Despite these advantages, the rate at which current buildings are being retrofitted is low. In the United States, the rate for commercial building retrofication is only 2.2% per year. The average energy saving achieved from the retrofication was reported as 11% per building (Olgyay & Seruto, 2010). Retrofication strategies consist of non-invasive measures with short payback periods (heating, cooling, lighting, HVAC system replacements). Studies show that if integrated energy efficiency measures can be used properly, then energy savings can reach 50% (Olgyay & Seruto, 2010). Techniques can range from an upgrade of the building envelop and mechanical systems to alterations in occupant behaviour.

In developed countries, building energy efficiency codes have been established, and ambitious targets have been set to reach low energy rates. However, this may not be the case for many developing countries that suffer from low awareness about energy demand in cities and from miscommunication between national and local governments.

A significant amount of the energy consumption in buildings is contributed by the heating and cooling of buildings and the powering of appliances (Figure 1). Some cities employ decentralized renewable energy production, supplying energy within the immediate surrounding of buildings, and the others use centralized renewable energy production, in which energy is generated elsewhere and then distributed to buildings through energy networks.

Decentralized energy solutions include solar thermal collectors, solar photovoltaic (PV) panels, biomass boilers, and modern cookstoves, which are mainly used in developing countries and powered by bioenergy. Centralized energy solutions include renewable energy applications that produce heat or cold, and they are provided for buildings through district energy networks,
and renewable power, which can be used for cooking, lighting systems and other appliances, and heating or cooling. In addition, renewable energy in buildings can be promoted by incentivizing rooftop solar PV panels and solar water heating systems.

Fig 1: Share of total energy in buildings -Australia-2014 (Tribwell & Lerman, 1996)

For heating space and water, renewable solutions consist of decentralized equipment in buildings and centralized generation. The main technology to achieve this system is the use of solid biofuel-fired boilers (such as wood pallets and chips). However, minimizing the adverse impacts of these boilers on the public health of urban dwellers is important, as such impacts contribute to a high level of air pollution.

Solar thermal systems have been widely used citywide and across different types of neighbourhoods to heat water and interior spaces. According to IRENA, by 2030, more than 3,200 million m² of rooftop space is expected to be used for solar thermal collectors worldwide. Co-generation is another heat reuse technique, but it accounts for only less than 10% of the global power generation, and its usage is reducing worldwide. This technique was first developed to address the large amount of heat that is often lost from power generation and industrial processes.

Another method of providing more cost-effective energy is district heating and cooling networks, which consist of a set of insulated pipes that pump hot or cold water to buildings located in a district, a neighbourhood, or a city. Some of these systems connect only a few buildings, whereas others connect hundreds of buildings throughout a city. Although this method offers several advantages, its usage is limited in cities (only one-tenth of the heating demand). The potential of cities to use this method depends not only on the availability of renewable resources but also on the level of heating density required at the district level. The
majority of Nordic and European countries employ district heating systems through bioenergy. In this heating system, heat is produced in large boilers or heat plants and then transported across cities to households, commercial buildings, and industrial plants. Other renewable energy solutions that have been used for heating purposes include geothermal mainly in Iceland and industrial excess waste heat. The use of geothermal heating systems is rapidly growing in Munich and Paris, and solar collectors are the main renewable heating systems in Denmark.

With rapid global climate change and increased air temperature, the cooling demand is also increasing. Increased urban air temperature is not only limited to tropical or hot climates but has also been reported in temperate climates worldwide. Despite the significant need for cooling, the global market for renewable energy-based cooling is still in its early stage. Nowadays, the majority of cooling energy is provided by air conditioning systems using electricity. While electricity can be generated via renewable systems, cooling energy can also be provided by renewable solutions integrated in the infrastructure of buildings. Some renewable cooling methods include solar cooling systems and desiccant cooling systems (e.g., absorption chillers that use a refrigerant to cool the environment).

An increasing trend is also observed for the use of solar panels installed on rooftops to provide a renewable solution for the cooling demand of households. Cities across the world promote renewable-sourced district cooling using cold water from rivers, lakes, or the sea, waste heat for absorption chillers, and solar energy.

The other major component of energy consumption in buildings is cooking. While traditional settlements mainly cook over an open fire, contemporary urban households mainly cook using solid cooking fuels, which have adverse impacts on human health due to the air pollution they generate. Although urban dwellers have more access to energy sources compared with their rural counterparts, 18% and 70% of city dwellers in developing and least developed countries still use fuelwood and charcoal for cooking (DESA, 2013). Modern cookstoves that use bioenergy or electricity are some of the key solutions that are promoted nowadays. The required electricity for cooling can then be generated by renewable power.

To promote the use of renewable energies in the building sector, energy consumers should be able to generate energy at the same time. Commercial and residential buildings consume the largest amount of energy in cities; however, they are also the most widely available urban resource because they have available space for rooftop solar panels (W. W. Institute, 2016). Several initiatives have been launched to support the energy efficiency of buildings. For instance, the Building Efficiency Accelerator partnership works directly with 23 cities in the
world to set up practical policies and strategies to ameliorate building efficiency (W. W. R. Institute, 2016). According to the International Energy Agency, to achieve the climate change objective of keeping the average global temperature within 2 °C, investment in energy demand in the building sector should increase from 800–100 billion in 2014 to approximately 215 billion USD per year in 2020 (IEA, 2015a).

**Transportation**

According to IRENA’s roadmap, transportation accounts for 25% of the energy use in cities, and this figure could grow to 50% by 2030 (I. a. ICLEI, 2016). If the energy demand for transportation is supported by fossil fuels only, then the outcome would be a significant rise in air and noise pollution in urban areas.

Electric-powered trains, light rail, and metro systems are the main renewable solutions for renewable rail transport. For roads and highways, electric vehicles, liquid and gaseous biofuels, and electrification of vehicles are the main renewable tools for saving energy.

Nowadays, internal combustion engines are also widely used in the transport system. To reduce the carbon footprint of these engines, they can be replaced by biofuels, which are a form of renewable fuel that comes in liquid or gaseous form. First- and second-generation biofuels have been generated. First-generation or conventional biofuels are made from agricultural crops such as corn or sugarcane. Combining liquid biofuels with gasoline, diesel, kerosene, and biogas with natural gas will lead to the generation of 10% energy of the transport system by 2030. However, to achieve this objective, significant market development is required, as investment in liquid biofuel capacity is lacking. Some cities apply first-generation biofuels at the national or regional scales. For instance, the city of Curitiba in Brazil is promoting the use of 100% biodiesel for its regional buses as part of its urban development program.

Second-generation biofuels, which are also known as advanced biofuels, are made from non-edible feedstock (e.g., waste and lignocellulosic material) and have recently started their commercial marketing. Second-generation biofuels have the capacity to reduce the carbon footprint of vehicles by up to 50% to 70% compared with diesel and gasoline fuels. Carbon footprint reduction by conventional biofuels such as ethanol produced from corn or biodiesel generated from palm oil is lower (30% to 50% reduction).

A cleaner alternative to liquid biofuels that can be employed in a range of road/highway transport systems is biomethane. Biomethanes are generated from upgrading biogas and contain more methane. In Sweden, for short distances, biomethane is transported from
production and distributed across sites as compressed natural gas. For longer distances, liquefied gas is preferred. As part of sustainable transportation system strategies in the capital of the country, Stockholm, more than 250 buses are fueled by biogas. In a similar project in Lille, France, the city council employed half of the city’s biowaste to generate biomethane for public buses (ICLEI, 2014b).

Another promising technology in promoting renewable sources for transportation is the introduction of hydrogen to the system. In some countries, hydrogen is generated from excess electricity in urban areas. Hydrogen can either be used in blended format in natural gas grids or stored and used in fuel-cell based vehicles. Few countries promote buses that run on hydrogen.

In addition to hydrogen, electric mobility is another promising method of decreasing air pollution and greenhouse gas emissions. Electric mobility is considered a renewable solution if the power is generated by a renewable energy source. In 2010, 1.3% of the energy demand for transport was supplied by electricity, and this figure is expected to increase and reach 4% by 2030. Sixty percent of the total electricity use in transport will be allocated to public transport (trains, trams, and metro systems), and the remaining 40% will be used in electric vehicles. Currently, electric vehicles have a short average driving distance, and their use is limited to inner urban areas. Electric light rail transit and metro systems are also growing rapidly, particularly in large cities with a high population density.

Cities also play a crucial role in promoting the use of electric vehicles and rails via installation of charging stations infrastructures, city fleet purchasing, procurement schemes, and subsidies for vehicle purchase.

Efforts to reduce energy consumption in the transport sector include technological innovation and modal shift (e.g., more fuel-efficient internal combustion engines, smaller vehicles, zero-emission electric vehicles, and moving toward an electric transport system). Modal shift includes encouraging more sustainable transport modes (e.g., public transport, cycling) and also behavioural change to use less cars and more public transport. Large parts of Copenhagen, Denmark, are no longer accessible to cars. One model predicts that shared autonomous vehicles could reduce the number of cars in use by a factor of 10, but the total motorized distance travelled would increase by 11% (Fagnant & Kockelman, 2014). In Delhi, the government supports carpooling, cycling, and walking, and bans the use of personal vehicles in some parts of the city.

Non-motorized transportation is becoming common in many parts of the world, with 50% in the Asia-Pacific region and Africa and 8% (the least) in North America (Rode et al., 2017).
Urban design policies dictate trip distances and the annual number of the trips per person. In dense mixed-use and compact urban developments, the trips are shorter, and people walk or bike to reach their destinations. The built environment and city infrastructure have to support non-motorized transportation systems. A study of five U.S. cities showed that bike trips increased between 21% and 171% within one year after bicycle lanes were built (Monsere et al., 2014).

**Green Infrastructure**

Infrastructure is a fundamental physical and organizational structure that was built to serve society. Grey infrastructure may provide a certain level of protection against various types of risks, but it also adversely affects the environment of cities in many ways.

By contrast, green infrastructure (GI) provides resilience to climate extremes and supports urban liveability. In green infrastructure, nature plays a role in the augmentation of services and mitigates climate extremes, such as flood, drought, and heat waves. Communities that benefit from GI are more resilient and adaptive to future climatic events. Green infrastructure is incorporated in urban areas from a large to a local scale, such as city parks, street trees, green walls, and green roofs. Green infrastructure is widely used as a passive method to improve the increased air temperature and is a promising strategy in reducing energy consumption.

All types of green infrastructures cool cities and save energy through three processes; shading, evapotranspiration, and alteration of wind pattern (Oke, Crowther, McNaughton, Monteith, & Gardiner, 1989). Shading cools the atmosphere by intercepting solar radiation and by preventing an increase in air or surface temperature. Evapotranspiration refers to the evaporation of water from a plant (Kotzen, 2003). The absorbed solar energy increases latent heat; thus, the leaf and the temperature of its surroundings are cooled (Taha, Akbari, Rosenfeld, & Huang, 1988). However, this condition is not the case for impervious urban surfaces, which immediately retain and absorb solar radiation.

Trees also change wind behaviour. The capability of trees to alter air movement and advection largely depends on the tree type (Bonan, 1997). For example, a deciduous tree can reduce wind speeds by 30% to 40% (Ali-Toudert & Mayer, 2007).

Urban greening is one of the key strategies in saving energy at city scales. Planting only a single tree reduces cooling and heating costs by 7% and 1.3%, respectively (McPherson, Nowak, & Rowntree, 1994). Overall heating and cooling energy use can be reduced by 5% to 10% (US$50 to $90) with a 10% increase in tree canopy coverage. Street trees in Sacramento,
California, contributed to a significant reduction in summertime electricity use by 185 kW/h (5.2%) per household (Donovan & Butry, 2009). In Auburn, Australia, trees decreased summertime energy use by 3.8% compared with houses with no trees, and 1.29 kW h/day reduction in electricity consumption was achieved with a 10% increase in the shade coverage (Pandit & Laband, 2010).

The impact of green roofs on energy consumption was quantified in offices located in four different climate zones (Sailor, Elley, & Gibson, 2012). The reduction in gas consumption in colder climates contributed to the achievement of the maximum level of energy saving. Increasing the leaf area index, shading, and evapotranspiration of vegetation in green roofs played more important roles in energy saving compared with a change in the soil depth of green roofs. A similar finding was reported by a study conducted in Italy that monitored the performance of green roofs in highly insulated buildings. The study showed that shading and evapotranspiration generated by green roofs thermally delay the incoming heat flux into buildings, thereby reducing the building surface temperature (D’orazio, Di Perna, & Di Giuseppe, 2012).

**Conclusion**

Energy is identified as a main crosscutting contributor to the achievement of the environmental, social, and economic development goals of countries. Nowadays, energy demand is growing worldwide with rapid urban development. In contrast to fossil fuel sources, renewable energy sources offer multiple benefits, including increased energy security, sustainable economic growth, and reduced environmental pollution and greenhouse gas emissions. Despite their benefits, renewable solutions account for less than 17% of the total energy demand per person, and this percentage has increased by only 1.5% within 20 years.

This paper conducts a systematic literature review to identify the main actions, drivers, and barriers that have to be addressed to create a renewable city; this review could assist in understanding the diverging paths of renewable energy deployment for different countries. This paper also explores energy saving methods related to built environment, transportation, and green infrastructure. Future works aim to investigate the renewable energy sources in Australian cities and propose a framework to optimize the use of renewables in line with green infrastructure. This literature review highlights the important role of renewable solutions and city infrastructure in addressing global warming and the depletion of natural energy resources.
References:


Solving Urban Challenges with a Serious Global Game

Shahed Khan, Julie Brunner and David Gibson

Abstract
The globalization of world economies and the rapid transfer and sharing of knowledge has created new pressures and challenges for urban designs by juxtaposing global issues alongside local concerns. For example, challenges such as climate change and global warming, poverty and housing affordability, ageing and growing populations and the change that technological advancements bring, demand innovative new designs for urban environs. To prepare the next generation of urban planners, civil engineers, architects and community leaders with authentic experience as members of teams addressing these kinds of complex problems, a new online serious game platform for individual and team-based learning has been developed and piloted at Curtin University in Perth, Australia. This article outlines the domains, online learning features and theoretical foundations of the Curtin Challenge platform and provides initial indications of the analytic potential as well as impacts of the platform on individual, team and organizational learning.

INTRODUCTION

Australian cities face significant built environment challenges. Whilst not all these challenges are new, many have not been so critically experienced in the Australian context previously, or at least not at such scale or complexity (Brunner and Glasson, 2015). Addressing challenges such as climate change and global warming, poverty and housing affordability, ageing and growing populations, global competitiveness and the changes brought about by technological advancements, all require innovative solutions to the design of urban environs (Pinnegar, Marceau, Randolph, 2008; Newton 2008; Brunner and Glasson, 2015).

Brown and Katz (2011) note that the challenges we face today vastly exceed the creative resources that have been brought to bear on them. Underscoring the dire need for innovative thinking in current times, they state, “It is hard to imagine a time when the challenges we faced so vastly exceeded the creative resources we have brought to bear on them” (p.3). This poses a huge and urgent challenge for educators of professions dealing with planning, designing and managing the built environment. How do we prepare future professionals who are not only aware of the reality of the changes occurring around them but also have the courage to experiment, explore and innovate? In short we need to develop learning experiences that build the required professional skills and values into the curriculum, setting them up as graduate attributes.

This paper identifies some of the reasons that tend to discourage future urban designers and planners from fully exploring creative approaches to problem solving that could lead to innovative solutions. It briefly traces issues related to teaching in built environment related disciplines and some collaborative learning and teaching approaches adopted currently to expose students to contextualised real life issues and working environments, such as work integrated learning (WIL) and interdisciplinary learning and teaching. It then reports on efforts being initiated at Curtin University to exploit available technological advances in online education towards this end. Specific reference is made to Challenge, an online platform employing gaming to guide decision making and problem solving for individuals working as part of teams. The paper then draws some conclusions regarding the potential strengths of the Challenge platform to deliver results comparable to collaborative learning and teaching and WIL approaches.
Big Changes Occurring

Profound changes brought on by globalization of world economies and the rapid transfer and sharing of social, technical and economic knowledge has added pressures by juxtaposing global issues alongside local concerns (Brunner and Glasson, 2015). Castells describes transformations brought about by the digital age society as “new forms of spatial arrangements … [emerging] … under the new technological paradigm … [that create] … a new type of space that allows distant synchronous, real-time interaction” (Castells 1989, p.146). He refers to the advent of factors and material arrangements related to the technological infrastructure of information systems, telecommunications and transportation, that enable social practices to occur simultaneously in non-contiguous territories (Castells 2000). These changes, brought about by the drivers of globalisation, need to be understood and given proper expression in the design of the built environment. New ways of production of spaces and flows of information referred to above by Castells (1989; 2000) would cause changes of lifestyle preferences, consumption patterns and dealings within the community. Together, these factors could generate various forms of stresses within the urban fabric that would strain and distort the functions of urban form and the built environment.

Ineffective response to rapidly changing reality

Accelerated and profound changes have occurred in society due to globalisation of the economy and rising awareness of climate change and other political challenges. Adam (2012) notes, however, that the state of the architecture profession and urban development does not show any “seismic change to equal the momentous political and economic shifts that the press reveals daily.” He suggests since the 1990s architectural practice continues to remain dominated by high modernism and glass towers and iconic buildings continue to be constructed (Adam 2012, p.2). Adam notes that contemporary architectural description and theory do not relate to “the way that most people conduct their lives in the modern world – the people that occupy the buildings, the people who commission the architects and urban designers, the people who see the buildings and occupy the new places.” In other words, Adam suggests the buildings and places that the society demands and provides resources for are not adequately reflected in the professional and theoretical discourse of architecture (Adam 2012, p. xvii).

This points to the urgent tasks of monitoring technological advancements and the demands generated by changing political and economic realities as they unfold. The state-of-the-art knowledge needs to be fed back into centres of learning to ensure professionals and future professionals are informed and enabled to play a leadership role in transforming society and culture. The attributes and values that universities aspire to impart to future professionals need to reflect this social and professional responsibility.

Need to encourage cities to exploit innovative sustainable technologies

Newton (2008) notes the urban planning and development paradigms dominating the 20th century have been replaced by concerns for constraints on carbon and resource consumption. There is also a demand for mitigation and adaptation responses to climate change and sea level rise. Newton contends:

to be sustainable, 21st century cities need to be able to appropriate from a pipeline of innovative technologies, products, designs and processes that can be substituted for those currently in operation that are beginning to show signs of failure. (Newton 2008, p.xiii).

Newton (2008) warns that in the case of Australia, multiple threats to sustainability have converged; these include peak oil, climate change, water supply issues and biosecurity issues.
He points to the “increasing public and political recognition that radical changes are required”, maintaining that this, in turn, requires “urban planning and design that creates more resilient cities in the face of new climate-induced vulnerabilities.” (p.3). According to Newton, while the required technology already exists in Australia, the “challenge becomes a matter of how the knowledge that underpins the implementation of these sustainable technologies can be effectively adopted by cities.” (p.3). This again highlights the challenges that exist for educators to prepare future professionals who are ready to create innovative solutions.

Role of educators of built environment professionals in a globalising world

It is clear that urgent change is required in how professionals plan, design and construct solutions. This poses the question then as to how future professionals are to be educated to bring into effect governance structures, democratic consultation mechanisms and policy frameworks that could influence outcomes to create the future the society wants.

Globalisation has transformed the role of educators, especially so in disciplines dealing with urban design. To produce globally employable and job ready graduates, universities have been revising and redefining graduate attributes. Intercultural literacy has been recognised as an important graduate attribute as universities seek to internationalise their curriculum. Intercultural and interdisciplinary approaches to problem solving are needed by professionals aspiring to be the drivers and informed agents of change.

Hill, Walkington and France (2016) observe that graduates of higher education need attributes such as “…skills, knowledge, attitudes and values that are distinguished from the disciplinary expertise associated more traditionally with higher education, but which make a contribution to the profession”. Often these attributes encompass soft skills such as critical decision-making and collaboration. Universities also promote certain values among students such as courage, excellence, integrity and respect. These values together with the knowledge learned and the soft skills developed contribute to the overall success of graduates. Some employers indicate that they are moving away from traditional graduate competencies to those that are more relevant. One employer, for example, has decided to “…focus around resilience, cross cultural competencies, a design mindset and … [a] cognitive mindset.” (Deloitte Australia, 2017) in identifying graduates that have “change-agility, a commitment to diversity of ideas, a culturally inclusive mindset and imagination” are thus more likely to have success beyond 2020 (Deloitte Australia 2017).

Educators need to devise ways to build up the skills, knowledge base and confidence among students to become independent learners with the courage to pursue creative and innovative solutions to current and future problems. The nature of disciplines such as architecture and planning especially need this approach because the problems tend to be unique, require an interdisciplinary approach and involves multiple stakeholders.

The following sections describe Challenge, a digital online learning platform incorporating problem-based and project-based learning while focusing on potential solutions to current real world problems. The Challenge platform supports an ecosystem approach to holistic learning experiences for international problem-solving teams to self-organise, exchange ideas and experience and then to collaboratively resolve complex problems in a game-like environment that supports and encourages people to think outside the box. Data from previous implementations of the challenge platform in other co-curricular domains (leadership, career exploration and solving global challenges) are referred to in outlining the potential for delivering curricular formal learning in fields related to urban design.
Wicked Problems in a Serious Game discourage Innovation

A sentiment widely attributed to Albert Einstein is that we cannot solve our problems with the same thinking we used when we created them”. The thought underscores the need for innovation in solving problems that could only intensify as we continue to do more of the same. For academics, this takes on an added dimension when considering how best to facilitate the production of effective professionals.

We contend that the prevalence of large open-ended problems compounded by poorly understood phenomena such as globalization and climate change seriously discourages innovation in urban design related professions. Rittel and Webber (1973) state, “Planning problems are inherently wicked” (p.136). Among other reasons for being wicked, planning problems tend to be “essentially unique” (p.141) and their solution is a “one-shot operation” with no opportunity to learn by trial-and-error (p.139). They also refer to “discrepancy representing a wicked problem” that makes its resolution largely determined by how one chooses to explain or perceive the problem (p.142). Roberts describes facing wicked problems as being in a situation where it is difficult to both identify the problem and its solution. Roberts further contends that one cannot usefully apply traditional linear methods of problem solving as practiced by planners to deal with wicked problems (Roberts 2000). Brown, Harris and Russell (2010, p.4) further observes that “as wicked problems are part of the society that generates them, any resolution brings with it a call for changes in that society”.

Literature on urbanism and planning theory is full of references to the gap between theory and practice. This gap has often caused tension between what planners should do and what they end up doing. Savini et al (2015) highlight the structural tension in planners’ treatment of organisation and spontaneity. They point out that despite supporting “co-creation” in theory, the field of urban development remains bound by instrumentalism focused on “goal-specific tasks, means, and outcomes”. Planning thus tends to constrain rather than enlarge possibilities for social change. Savini et al (2015) describe planning as “a practice that constantly attempts to exercise a degree of control over a fundamentally complex reality”, while its conceptual tools are “context and time dependent” (p.297).

Roberts (2000) alludes to a wide range of potential drivers that could potentially be creating wicked problems including:

- “the expansion of democracy, market economies, privatization, travel and social exchanges” that tend to highlight differences in values;
- “technological and information revolutions” that dramatically increase the number of “active participants” who seek to engage in problem solving; and
- “organizational decentralization, experimentation, flexibility, and innovation” promoting changing organizational culture within institutions (p.2).

The movement from government to governance over the past few decades spurred by globalization and neo-liberalism has led to the recognition of a wide range of actors and stakeholders (Khan, George and Brunner, 2015). Planning, designing and managing urban areas can thus be seen as a serious game involving many players with stated and unstated objectives. Legitimising the roles of corporate private sector, non-government organisations and local communities means that at any level of decision making, planners, urban designers and city administrators need to engage in a collaborative exercise, or a game with common end goal and rules stemming from commonly shared values with a range of other players such as industry representatives and the community. The complex wicked problems need to be understood within their context where their complexity and uncertainty requires problems to
be resolved consensually through collective knowledge and wisdom and shared risk taking by all stakeholders to justify experimenting in the pursuit of innovative solutions.

The existence of large open-ended problems and the gap between theory and practice in planning create some interesting challenges for built environment educators. How do you teach the discipline and train the professionals when wicked problems do not yield a database of established solutions? Architecture academics face similar pedagogical questions regarding how creativity, design and innovation can be taught. It is contended thus that educators of professions related to planning, designing and managing cities, should prepare students to effectively engage and collaborate with a wide range of actors from within the community and the industry in order to resolve problems contextually.

**Current opportunities and possible resolutions**

Tertiary education providers aim to produce graduates that could lead the profession need to design both content and delivery of learning that is not only relevant to the current reality but also useful in the future. The wide gap between theory and practice in built environment brings into question the relevance of the professional praxis to societal demands, thereby threatening the future relevance of the professions. Meanwhile, the advent of the digital age has ushered in phenomenal technological advances, replacing processes associated with gradual and continuous improvement by ‘digital disruption’. This new reality of digital disruption has brought forth major changes in the way things are done as “digital technologies and business models affect the value proposition of existing goods and services” (http://searchcio.techtarget.com).

Leaders in tertiary education provision realise the gravity of the situation and the relevance of digital disruption to the education sector. The Deputy Vice Chancellor Academic of Curtin University, Jill Downie, speaking to Universities Australia in 2017 states: “Digital disruption in all sectors of the economy and the globalization of higher education represents an opportunity for creative response by universities – or else a threat for those who cannot adapt.” Curtin University has long been engaged in online delivery of units that it also offers internally in face-to-face format as part of Open Universities Australia (OUA), a consortium of six Australian universities, and also on its own. In the context of designing built environment, Curtin offers online courses in urban and regional planning, construction management and architecture through OUA.

On another front, Curtin’s strategic objectives have included widespread adoption of WIL through active linkages with industry, internationalisation of curricula, promotion of international student exchange and promotion of interdisciplinary approaches to education. The School of Built Environment has actively sought to incorporate the university’s strategy. It has effectively involved the industry to offer courses with practical orientation and responsiveness to the employers’ needs, organised international fieldwork as part of international study tours and taken up interdisciplinary approaches to learning. While the results from such initiatives have been very encouraging based on student experience and academics’ satisfaction, these initiatives are becoming increasingly difficult to add on to normal delivery of courses.

WIL seeks to take advantage of the workplace environment that is conducive to learning through experience and observation and the availability of mentors to guide students in developing practical skills and building confidence in applying those skills. However, this may not always be the case. For example, while studying the prospects of incorporating WIL into the urban planning course, Khan and Brunner (2010) observe where the workplace was
stressful, as was reported by PIA’s 2004 National Survey, the advantage could turn into disadvantage. They warned that stressful conditions at workplace due to shortage of planners could see best practice replaced by adhocism instead, causing disillusionment to students (Khan and Brunner 2010).

Collaborative learning and teaching initiatives that take students out into the community to experience real world contexts yields many benefits, but can create many logistical issues and resource implications. These relate to scheduling and organising site visits and meetings, attending to safety and security concerns of students, forward planning to build community components into unit outlines, juggling timetable schedules to match university requirements and community availability and accommodating last moment change requests by external parties (Khan 2008; Khan 2006; Bajracharya and Khan 2003).

International study tours with built in fieldwork offer a great means of concentrated learning and understanding similar problems in an intercultural context, heightening students’ ability to shed their own cultural bias while analysing problems and their solutions from a value neutral perspective. They are an effective means of improving cultural literacy, an essential requirement of job readiness for globalising job markets (Khan and Khan 2009; Khan 2009). However, they are expensive to afford, share many of the logistical issues of collaborative learning and are not suited to all students.

In this situation where academics have a track record of taking up such rewarding initiatives but may be reluctant to engage in such activities, discouraged by the logistical, administrative and resource demands, the Curtin Challenge platform is emerging as a viable alternative medium or platform to capture the benefits without being faced with the resource implications.

**Curtin Challenge**

Curtin Challenge is game-based online learning platform that supports team solving large open-ended urban design challenges. In doing so, it facilitates the making of higher education agile and innovative with an aim to create employable graduates who are entrepreneurial and self-sufficient. Challenge represents a creative response to at least three forms of digital disruption in higher education.

- Students’ expectation of personalisation in their learning experience.
- Phenomenal increase in numbers of people requiring higher education, outstripping the capacity of existing structures and requiring large scale delivery of education.
- Employers moving away from traditional graduate competencies favouring candidates that can think for themselves, use technology to creatively solve problems, work with others to get things done, communicate effectively, and empathise with and meet the needs of others (Billett, 2014).

For urban planning and architecture schools, Challenge is especially relevant as global and virtual work teams now dominate the professional landscape (Neeley, 2015; Shaffer et al. 2012). The demand for a globally employable workforce is increasing, as there is a great scope for technology transfer and technological collaboration across nations. The nature and form of built environments that house communities along with their culture are influenced by architects, planners and urban designers. These professionals need to be trained in soft skills, social/interpersonal skills, intercultural literacy and value-neutral analysis. The Challenge platform allows students exposure to such work cultures.
There are thus several needs for challenge-based learning visible on today’s horizon. Students need and demand engaging, flexible and interactive learning experiences. Higher education needs to be able to help massive numbers of diverse, globally dispersed students who could be working part-time or full-time; caring for children and parents, managing a career; and balancing many life and work pressures while studying. In the current milieu, the challenge for universities lies in their ability to integrate both formal and informal learning experiences and collaborating with businesses and industry in creating a new vision of graduate employability.

**The challenge based learning solution**

The Challenge platform integrates ‘gamified’ learning into quality curricular and co-curricula activities provided by the university to strengthen graduate employability and global leadership capabilities of students. The platform helps the university to deliver personalized learning and assessment on a large scale. Research on challenge-based learning is beginning to illustrate its positive impacts such as increased engagement, increased time spent working on tasks, increased creative application of technology, and increased satisfaction with learning (Johnson, Adams, & Apple, 2010; Roselli & Brophy, 2006).

Challenge provides individuals and teams the opportunity to take up self-paced learning by going through a series of problem solving exercises to reach a certain result. Challenge-based learning thus offers a call to action that inherently requires learners to make something happen through deliberative decision making, which supports learning-by-doing and the application of knowledge to real world problems. Participants on the Curtin Challenge platform can self-organize into teams based on common interests and learning objectives. They can research relevant topics related to their selected challenge, brainstorm strategies and solutions that are both credible and realistic in light of time and resources. Through decision-making based on their research, participants can then define and develop solutions that address their challenge in ways both they and others can see and measure.

Challenge allows the team members to be rewarded through a competitive reward process (Gibson, Irving, & Scott, 2017). For example, an industry partner such as a local business or cultural organization might offer a prize for a solution needed to address a specific issue especially where the problem and its solution are poorly understood. Challenge-based learning can thus be seen as a way to incentivize crowd-sourced ideation and solutions. In challenge based higher education professional training, also allows the assessment of individual participants and the team to be made part of formal learning that can, in turn, be made more authentic by reference to the real-world context (Gibson, 2005).

Challenge based learning encourages teams to compete with each other for high scoring solutions through a system of recognition and rewards. In the process, their actions, communications and products are saved as potential evidence of learning and performance (Gibson, Irving, & Seifert, 2017). The evidence of learning can be scored by self, peers and experts as well as by automated and semi-automated mechanisms as found in adaptive testing and adaptive curriculum (Gibson & Jakl, 2013; Scandura, 2007). In this way, the authentic and natural activity of collaborative problem solving can become part of formative and summative feedback practices needed in professional training.

The Challenge, set up as an online platform, allows participants based at remote locations to come together to share their culturally influenced perspectives on a common problem as they seek to understand its various dimensions. Challenge based learning could thus stimulate students’ curiosity and desire to learn by engaging in solving open-ended problems as members of a self-organizing and self-directing international team (Harris & Nolte, 2007).
Processes of learning that involve knowledge, expertise and interpersonal differences strengthen empathy and cultural responsiveness, which is central to the professional practice of user-centred and universal design, and these processes also build understanding across cultural divides (Ladson-Billings, 1995).

Some of the problems with implementing a challenge-based curriculum include authoring new learning cases for the platform, the problem (for some instructors) of allowing students freedom of choice in problem selection, creation of methods, decision-making concerning priorities and criteria of success, trials and pilots of solutions, and self-evaluation as well as peer and team evaluation of solutions. Each of these areas of instruction require a sophisticated understanding of cognition as a distributed, emergent phenomenon rather than a feature of intelligence evidenced by reasonable retrieval and use of information on a test. Thus, the platform is not a panacea for instruction but is instead a delivery system for a more learner-centred pedagogy. Much research remains to be done on these core issues of design, delivery and assessment, for which fine grained data collected in server logs provides ample data (Griffin & Care, 2015; Quellmalz et al., 2012), but requires substantial analytics to mine for insights into learning and teaching.

Case example at Curtin University

Challenge is an initiative that is aligned to Curtin University’s Digital Strategy and builds on Curtin’s existing extensive suites of online program delivery. After piloting and proving the challenge-based learning system in the co-curricula space, Curtin University has now set out to move Challenge into formal learning, to engage students and build graduate employability and life skills, preparing them for the jobs of the future.

Currently the university has deployed and researched three Challenges: Leadership, Careers and English Language Proficiency. Each Challenge comprises 12 to 14 modules, each taking about an hour to complete with the flexibility of stopping and starting at any time. Since its inception in 2014, students have completed over 186,000 activities; 10,000 modules have been completed in Careers and nearly 22,000 modules in Leadership. The cost of delivering these learning experiences to students is minimal and amounts to ‘pennies per student.’ Curtin is currently setting up another two Challenges, Global Perspectives and Sustainability, bringing the total to five (Figure 1).
The roadmap of the Curtin Challenge platform includes features that support individual and team based learning in a serious game context. These features include:

- Self-organizing teams
- Self-determined paths of action
- Transparent milestones for checking progress
- Self and peer scoring of outputs and artefacts
- Expert scoring for awards and recognition
- Openness to external mentors and advisors helping solve problems
- Automated feedback on progress
- 24-7 access
- Support tools for chatting, co-production and automated messaging
- Administrative dashboard for research data and monitoring

Challenge captures the decision-making, collaborative actions and products of both individuals and teams of learners. It promotes active engagement to enable deeper learning, evidence of which is captured through a complex analytics engine. Challenge has the capability, for example, to identify who does the work on a team, thereby promoting individual responsibility. The platform engages students in peer feedback, helping them to develop critical thinking and reflection skills, while they solve a variety of open-ended challenges or problems inviting innovation, creativity and entrepreneurship.

At an operational level, Challenge has so far focused on delivering learning modules that facilitate effective self-directed digital learning for individual learners. These modules that are readily personalized by each individual are delivered at very low cost compared to face-to-face workshops providing equivalent results. They also allow a much larger scale of delivery than could be offered at a time in a face-to-face teaching mode. With the experience of
running Challenge for individual participants, Curtin is now developing team based learning modules.

With established online program delivery in disciplines dealing with built environment and fully online Award courses available in disciplines such as Urban and Regional Planning, Architecture, Project Management and Construction Management Interior Architecture, Curtin University is now considering the development of team based challenge learning modules in urban design, planning and architecture.

### Challenge for Creativity

During design research stages at Curtin University, the network analysis (Dirk Ifenthaler, Pirnay-Dummer, & Seel, 2010; D. Shaffer et al., 2009) of Challenge projects is already providing some useful preliminary observations into participants’ engagement patterns with online learning and approaches to problem solving. Much of the early findings serve to highlight areas of further focused enquiry rather than providing useful insight at this stage. Even so, extensive observation, monitoring and documentation are being carried out to ensure there is sufficient basis for critical research in future.

A case in point is the finding related to the aggregated spread of all unique pathways charted by participants in designing their response to given problems. In one particular study of a project comprising five modules, a detailed network analysis graph showed that only a very small sample of the possible pathways was discovered and utilized by over 3500 students in over 14,000 interactions with the designed space. It was found that only 608 unique pathways were traversed out of a possible 254 million (refer Figure 2). This could potentially suggest a tendency among participants engaged in team decision making to stick to familiar approaches and techniques rather than stretch their horizons through creative exploration. If substantiated by further research, such findings could usher in substantial research interest among educators and industry.

![Figure 2: Network Graph of Five Modules of a Challenge](image)

These initial observations provide sufficient motivation for Challenge to be deliberately designed such that participating teams are provided incentives to strive to chart out wider swathes of exploration. It is contended that a gaming environment could allow framing problems in a way that rewards thinking outside the box, thereby promoting an aspiration among participant students for creativity. The simulated settings allow experimenting and risk
taking, helping students to develop skills through reiteration, and thereby developing confidence, attitude and the courage to innovate.

**Discipline Specific Learning and Teaching within Challenge Structure**

Seeking to incorporate challenge-based digital ‘gamified’ learning into curricular activity is a significant strategic move being undertaken by Curtin University. This requires designing challenge-based digital learning experiences for particular disciplines or professional fields, considering pedagogical nuances while delivering a richer learning experience to participants who set out to gain specific learning outcomes. The learning experiences created should be relevant to the context within which participants are expected to perform both as students and graduates/professionals.

Designing challenge-based learning for a particular discipline or professional field is a collaborative team-based effort that includes people knowledgeable in that field combined with several other domain specialists: people skilled in dramatic narrative, mechanics of game-like interactions and rewards, digital-media artists and communicators, and people who can use computational science tools for algorithms and visualizations (Gibson, Aldrich, & Prensky, 2007). The mission of such a team when creating challenge-based learning experiences is to create a digital learning space where trans media engagement (Passalacqua & Pianzola, 2011) and multi-disciplinary thinking can evolve through a highly participatory experience shared by those who take up the challenge.

An innovative type of digital teaching structure has emerged via collaboration among people knowledgeable in the field or subject matter experts (SME) working with learning-experience designers and technical teams. These new structures of teaching and learning are being created in response to the myriad changes taking place in higher education today (Grummon, 2010). In this situation, instructors – academics and/or SME - have a special role in constructing a challenge. They embed into the problem space the key ideas, essential questions, resources, and evaluation criteria needed by participating teams for self-guidance toward the desired end goals. In the challenge-based learning framework, instructors are course designers who put in most of their time and effort in up front and then take a backseat during the implementation or running of the program as participating individuals and teams learn, work, communicate, negotiate, collaborate, create, and submit artefacts. In this model, the bulk of the input from SME authors is also gathered during the design phase and is embedded into the digital experience designed for participants through public scoring rubrics, artefact descriptions for final submission, and scaffolding activities that the team members can choose to experience or ignore.

The successful collaboration between SME, learning-experience designers and technical teams has provided the confidence to seek to harness Challenge based learning to create a wide range of pedagogical experiences including those that best suit specific groupings of related disciplines, such as those related to the built environment. They could be further fine tuned to align with pedagogical nuances of individual disciplines such as urban design, urban planning and architecture. For example, a challenge might be constructed as a simulation of typical professional group problem-solving processes in urban design, bringing attendant benefits of a simulation, one of which is referred to as ‘time dilation’ for its ability to speed up or slow down the natural speed of processes. This allows, for example, the capability of trying out numerous alternative solutions that would be impossible in the real world. A process that could take years can be sped up to take place in a matter of minutes or hours. Conversely, a process that happens very quickly can be slowed down and examined in slow motion. Since repetition is a critical part of learning, the experience of many cycles and trials through time dilation can speed up the process of developing expertise (Ifenthaler & Landriscina, 2014; Mislevy, 2011).
Project-based or problem-based learning studios that are commonly used in teaching urban design, architecture and planning units encourage students to work toward designing a solution to a problem through iterative processes of generation and processing of information for decision making and evaluation of the outcome. These studios can be made more dynamic and versatile by setting them up on a challenge based learning framework, especially simulating situations requiring development of plans and designs dealing with complexity and multiple stakeholders. Challenge could incorporate numerous reiterative decision making cycles built in at various stages of the project, allowing stakeholders to verify and ratify decisions before moving on to the next level of problem solving and decision making. It could thus provide participants the luxury of making and learning from mistakes including those resulting from technical shortcomings or misreading of stakeholders’ needs, aspirations and priorities.

The use of the Challenge platform for teams of urban design, architecture and planning students could also serve to highlight the tyranny of incremental decision-making where small individual decisions made independently of each other, or at various stages, can produce unintended outcomes of extremes. By generating scenarios based on multiplication of various dimensions of small impacts of isolated decisions made by individuals across various stages of negotiated decision making, Challenge could require individual participants and the team to realise the cumulative impacts each decision could lead to and work out ways to avoid unacceptable outcomes by changing priorities and/or finding room for compromise. The Challenge platform can facilitate the illustration of principles and objectives of strategic planning that sets out long term planning vision for our community into the future and the need for short-term and medium term initiatives that need to be in place to get us there. In the process, it can reinforce strategic planning’s basic decision making cycle that features monitoring and review of outcomes and realignment or resetting of directions. Records of all communications between team members and products or outputs by each member are easily accessible and printable as reports. This feature aligns well with the focus on documentation of decision-making and the justification of those decisions as required in any governance structure to demonstrate accountability and transparency.

By enabling students to interact with counterparts located overseas, Challenge can simulate global workplace conditions we seek to prepare our students for. Working in teams with diversity of perspectives due to personality types, disciplines, organisational cultures and socio-cultural norms. The Curtin Challenge in particular is conceived as an ecosystem of learning experiences for international problem-solving teams in order to develop global work skills (e.g. leadership, cultural responsiveness, collaborative problem solving experience, and high performance computing and communication technology skills) embedded within professional degree programs.

The Challenge format also has the flexibility to allow other SMEs (community members, industry representatives or participants from governance structures concerned with resolution of the problem) to be invited to become involved if called on by a group that is undertaking the challenge. This empowers the team to further customise their approach to resolve the problem that they set out to do.

**Conclusion**

At Curtin University, Challenge represents a positive exploitation of the digital disruption in higher education and the challenges brought about by globalisation.

Changes to the built environment are happening albeit not keeping pace with changing societal demands, bringing into question the role of related professions. Rapid advances in
teaching technology, meanwhile, offer the opportunity for educators to seek ways to effectively educate relevant professionals for the future. Challenge presents an opportunity to deliver learning and teaching that is truly engaging and has far lower logistic issues and resource demands than some of the teaching approaches currently employed to provide meaningful student experience, such as WIL, international field work and collaborative teaching in community settings.

Challenge is well suited to disciplines related to the designing of the built environment. The iterative approach to problem resolution in urban design in a platform such as Challenge would facilitate trial and error. It would encourage students to engage in decision-making in a safe environment where courage to think outside of the box is encouraged and the effort rewarded. Rather than being overly concerned whether decisions made look good and bad, students could seek to tackle wicked problems contextually in close consultation with a range of stakeholders. The open-ended nature of outcomes at the end of each stage allows endless possibilities of decision making to solve a problem. The iterative nature of the Challenge based modules resembles the process of planning and design making and allows participating teams to reconsider and reflect upon undesired outcomes. Engaging in such activity can only enhance a student’s learning and promote self-efficacy. According to Pijanowski (2009), constructive failure provides the ability to understand and learn from failed attempts at learning or attempting a task. A strength of Challenge is its capacity to record and document all communications that transpire among participants in the course of solving a problem. This function could be used to train students to document decisions and decision making along with their justification, as required in the profession to ensure transparency and accountability.

A major strength of Challenge is its ability to provide network analysis that could help to improve the design and the impact of the challenges. Findings from the network analysis of earlier projects undertaken at Curtin University underscore the need for deliberate effort to encourage participants to creatively explore innovative approaches by thinking outside the box. It is contended that while Challenge provides a powerful framework for exploring open-ended solutions at each stage of problem-solving, opening up practically endless possibilities for arriving at varied solutions to a problem to best respond to a given context, there still remains the need for focused development of certain skills and values of students, particularly those inspiring innovation and building the courage to explore!

References


Avoiding the Massing Muddle: Towards Better Infill Housing in Queensland

ABSTRACT: In 2017, Australian state governments are re-examining issues of housing density, diversity and affordability in our middle-ring suburbs (‘the missing middle’) through revision of housing design guidelines and through design ideas competitions. This paper compares the suitability of the draft Queensland Housing Code 2016 (QHC) and NSW’s draft Medium Density Design Guide 2016 (MDDG) for the design of new townhouses and terraces in Queensland. The study models the permitted outcomes of these regulations and reveals dramatic differences in maximum building massing permitted by the codes and the consequent provision of open outdoor space.

The second part of the study examines the broader urban outcome that would result from application of these housing models across a suburban neighbourhood. This comparison focuses on the Woodridge site in central Logan City that formed the basis of the recent Queensland ‘Density and Diversity Done Well’ (DDDW) design competition. Maximum redevelopment of the site permitted under QHC and MDDG regulations are further compared with the author’s ‘Back Yards Not Car’s (BYNC) entry in this competition.

Discussion of these housing models addresses key issues identified in the ‘missing middle’ debate: density, diversity and affordability in redevelopment strategies for middle ring suburbs. Impacts on energy, environment and ecology are also discussed within the context of current pressing climate change challenges. The paper concludes that the QHC is significantly inferior to the MDDG in these terms and advocates more radical strategies, such as BYNC, to reduce the detrimental impact of cars.

Keywords: suburban redevelopment; terrace housing; the missing middle; Queensland Housing Code; Medium Density Design Guide; Density and Diversity Done Well competition.

Introduction
This paper attempts to critically contribute to the current urban housing conundrum described as ‘the missing middle’ through analysis of recently proposed housing design guidelines and the author’s own design proposition.

One basic interpretation of the missing middle refers simply to gap in the range of residential density, as a result of the widening disparity between the increasingly high density of inner urban precincts and the traditional very low density of the surrounding suburbs in most Australian cities, including greater Brisbane. Planned urban consolidation underway in most capital cities is delivering high- and high-medium density redevelopment zones in urban centres and along transport corridors, but is actively resisted by residents in established low-density suburbs. Lower scale, but more wide-spread increases in housing density in the many reasonably serviced middle ring suburbs is seen to have the potential to produce a significant (but currently missing) middle option that could accommodate more population growth within
the zone of desirable commuting distances. Although not politically easy, an incremental infill strategy that allowed doubling or trebling of dwelling numbers across these suburbs would produce a valuable intermediate housing choice between the current extremes of inner urban density and peri-urban sprawl.

A second aspect of the missing middle arises from the polarisation of housing options that are currently available. Recent urban redevelopment activity has increased supply of small studio, one- and two-bedroom apartments and provides a marked alternative to the traditionally large three- and four-bedroom detached houses that are still being developed on peripheral green field sites. Market analysts have identified an unmet demand for smaller attached freehold houses with private gardens or courtyards in the middle ring suburbs.

The current small apartment/big house dichotomy is sometimes characterised in popular media as an economic impasse between rent-payers and home-owners, as a geographic divide between inner urban hipsters and suburban traditionalists or as generational conflict between aspirational millennials locked out of the market by baby boomers enjoying unearned privilege. The current record disproportion of house price to earnings in east coast cities underpins the seriousness of the need for more affordable housing options.

Early twentieth century planning idealised the garden suburb as the melding of the best of city and country. Today, treed and leafy suburbs remain highly prized in the property market. The recent loss of the backyard garden reported by Hall (2010), and others, is viewed by many with nostalgia and regret as a loss of shared memories and common values. To many, residential densification is invidiously and inextricably associated with the hardening of the city, the replacement of familiar old buildings, gardens, lawns and trees with the concrete of apartment blocks and the bitumen of car parks. The challenge for planners and architects is to confront this model and demonstrate how residential density, trees and gardens can coexist in a contemporary variant of the garden suburb.

Architects’ moral responsibilities in the face of climate change are clear: to develop building types that are energy efficient, climatically responsive and resource-frugal, not just through bespoke projects, but through broadly replicable demonstration projects and public advocacy. Urban planners should seek to minimise transport and servicing energy use through compact, walkable, well-serviced and equitable neighbourhoods. As we head into an
unprecedented history of more extreme weather, all urban designers need to work to ensure our cities are resilient to heatwaves, droughts, storms and floods.

The progressive hardening of our cities produces urban heat island (UHI) effects that exacerbate heat wave impacts, producing spikes in mortality rates and exposing extreme energy vulnerability. Evidence that urban tree cover combats UHI through shading, evaporation and transpiration underpins recent endeavours to increase urban tree cover (Amati et al, 2017; Brown et al, 2010; CRC for Water Sensitive Cities, 2016; 202020 Vision, 2014). Municipal street tree planting, aligned with water sensitive design initiatives provides some remediation within the public realm, but is significantly overwhelmed in most cites by the rapid loss of previously permeable garden or landscape space on private land. The scale of urban hardening is immediately apparent in any time sequence of aerial city imagery, but has not yet been the focus of a strategic policy response.

This paper is premised on the belief that creative design is capable of synthesising a resolution of the apparently intractable dichotomies between development and environment; density and liveability; accessibility and affordability; profitability and sustainability. It investigates whether the current market demand for ‘missing middle’ housing’ can be met through the provision of smaller, more flexible, climatically sensitive, individually titled houses with private garden space in well-connected, breezy and well-treed suburbs, that can contribute to reduction of greenhouse gas emissions and help to ameliorate urban warming.

The study employs simple comparative analyses of the land area designated for buildings, vehicles and open space to evaluate current policy proposals, and to demonstrate the principles underpinning the author’s alternative design proposal.

**Method**

This analysis examines two equivalent sets of housing design regulations released for public comment in 2016. The Queensland government released the draft Queensland Housing Code in September 2016, one month before New South Wales’s draft Medium Density Design Guide (MDDG). Although the MDDG is a more wide-ranging document, the current study focuses specifically on those sections that apply to individually titled, small-lot Class 1 buildings - attached townhouses or terraces. In addition to these two policy documents, the study is extended to discuss the author’s entry in the Density and Diversity Done Well
competition recently conducted in Queensland (Skinner, 2017). The DDDW competition by the Queensland Government Department of Infrastructure, Local Government and Planning and the UDIAQ expressly sought creative design responses to the missing middle dilemma and all entries, including the authors ‘Back Yards Not Cars’ (BYNC) entry were published online in September 2017 (Queensland, 2017).

The study is in three parts:

Part A examines the impact of the QHC and MDDG requirements on the design of an individual house. This comparative study investigates the maximum permissible development on a range of common lot sizes under the two different guidelines.

Part B looks at the application of these two guidelines to small-lot housing redevelopment of a low-density suburb. This study uses a common site to illustrate the impacts of the QHC and MDDG rules and also the BYNC proposal. The site is the theoretical DDDW competition setting, a simplified depiction of real residential block in Woodridge.

Part C is a discussion of these analyses in terms of sustainability and the missing middle. Analysis throughout generally focuses on three interrelated aspects of the design of small lot housing: the extent of building massing as it supports indoor living functions; the area of roads, lanes, driveways, garages and parking bays primarily designated for motor vehicles; and thirdly, but most importantly, the remaining outdoor space available for outdoor living, the environment and ecology. These three factors are calculated and modelled at the scale of the individual house lot and the suburban block, to demonstrate urban impact.

Part A. Application of the draft QHC and MDDG regulations for small-lot housing

This initial analysis examines the draft QHC alongside its NSW counterpart, the draft MDDG. Analysis of these two regulations is modelled on the range of preferred lot sizes advocated in Queensland’s Reconfiguring a Lot Code (RLC). Lots studied have frontages ranging from 5m to 20m in 2.5m increments, with plot depths of 25m and 32m. The narrowest 5m and 7.5m wide lots are of particular interest in this study as they support higher residential densities through incremental subdivision of standard lot sizes in Queensland that traditionally have frontages slightly over 10, 15 or 20m in width derived from imperial units of measurement. Although the MDDG does not permit terrace houses on lots smaller than 200m² or narrower
than 6m in NSW, these lots are permissible in Queensland. For comparative purposes this study hypothetically extrapolates the NSW guidelines onto smaller lots down to 125m$^2$ in area and 5m wide as permitted by the QHC. The MDDG’s height restriction of 9m can allow three storey houses in many situations, however the comparative study is limited to the two-storey houses, permissible under QHC regulations.

Modelling of the maximum permissible building envelope for each lot results from the application of Site Cover (SC) and Floor Site Ratio (FSR) constraints where applicable and incorporation of required minimum front, rear and side boundary setbacks, maximum boundary wall lengths, and minimum recreational and landscaped area provision. Planning provisions that focus on issues of visual character or compositional aesthetics and are intended to introduce formal variety or spatial variation have not been included in this analysis which is limited to the more quantifiable parameters of the codes.

Although the draft Queensland Housing Code purports to introduce ‘up-to-date siting and design rules that reflect emerging best practice for dwelling house development’ there is little apparent attempt to benchmark the Code to equivalent interstate standards like the concurrent draft NSW Medium Density Design Guide. The illustrated case studies in Fig. 1 demonstrate quite significant differences in desired outcomes in response to similar small lot constraints.

Fig 1. Comparable terrace house propositions - Draft QHC 2016 and Draft MDDG 2016.

Comparative modelling of the application of these two different regulations is shown in Fig. 2. It should be noted that the darker blue plan diagrams represents the hypothetical extrapolation of MDDG rules to lots narrower than 6m and smaller that 200m$^2$ that are currently permitted by QHC but not by MDDG. Although rear lane access is required for lots narrower than 7.5m,
for graphic simplicity the massing analysis has not been reconfigured to incorporate this detail. The issue of rear lane access will be studied in detail in subsequent studies in Part B.

Fig 2. Comparable building footprint on lots from 125 to 600m² (QHC maroon; MDDG blue)

Fig 2 shows that on equally sized sites, the building envelopes permitted by QHC are significantly greater than those of the MDDG and leave commensurately less outdoor space. The key difference between the two regulations is that the MDDG invokes a Floor Site Ratio (FSR) that limits Gross Floor Area (GFA) as a proportion of Site Area to 0.80 for lots less than 300m², increasing to 0.75 and 0.70 over 500m². The application of FSR links the maximum size of each house to the size of its site in NSW so that only small houses can be built on small lots, and larger houses require larger sites. Without any FSR constraint, the allowable QHC building envelope is generally limited only by site cover allowance and boundary setbacks resulting in house envelopes that are up to twice the size of their MDDG counterparts producing FSRs that range from 1.3 to 1.5.

The second key difference between the Queensland and NSW regulations is the permissible rear boundary setback to the upper storey of a two-storey house. In the MDDG regulations this is limited to a minimum of 10m, but can be as little as 3.5m in QHC (although screening is required if less than 9m from a neighbouring window). When combined with the
MDDG FSR restrictions, this results in the preservation of significantly larger backyard space, sometimes more than four times greater than that resulting from application of QHC rules.

Fig 3. Perspective study of permissible QHC and MDDG building massing and shadows

A third substantial constraint unique to the MDDG is requirement for the provision of deep-soil Landscaped Space varying from 20% to 35% of the site area. In addition to these required landscaped area provisions the MDDG requires the planting of a medium-sized tree in every back yard and in all front yards deeper than 3m. By contrast, there is no requirement for provision of landscaped open space or for tree planting in QHC provisions. Both MDDG and QHC regulations require a minimum 16m² of Private Open Space for every house although QHC reduces this to 12 m² in lots less than 200m². Compared to the MDDG requirements the QHC Private Open Space regulations are very minimal, accepting a 2.5m wide roofed balcony enclosed on three sides as sufficient private open space for the smallest houses.

Fig 4. Sectional view of permissible building volumes and building-to-building separation

While there are obvious functional and recreational advantages of the larger landscaped MDDG backyards for residents, the breathing space they provide between buildings provides even greater environmental benefits to each house, its immediate neighbour and to the precinct as a whole. The combination of MDDG rear boundary setbacks ensures a minimum 20m separation between the upper floors of MDDG houses compared to only 7m between
QHC houses (illustrated in Fig. 4) or a minimum separation of only 9m separation between unscreened windows.

Most typically, these upper rooms will be bedrooms, and with terrace houses built to side boundaries, these closely interfacing windows are likely to provide the only opportunity for light and ventilation. Installing screens, drawing curtains or closing these windows to gain visual and acoustic privacy significantly limits opportunities for passive climate control by controlled solar gain and cross-ventilation. By comparison, the significantly deeper yards and compulsory tree planting in the MDDG back yard zone greatly improves privacy between houses, allowing greater responsive environmental control through access to sun and breezes. When combined with the much shallower floor plans and possibly taller sectional configurations resulting from the FSR constraints, it is clear that there is much greater opportunity for passive climate control under MDDG, and conversely a greater need for air-conditioning and energy consumption to deliver thermal comfort in the QHC house.

A final comparison between the two codes is that the MDDG mandates solar orientation and natural cross-ventilation requirements. The focus of the solar access provision in the southern state is to ensure that living rooms and private open space are oriented between northeast and northwest to admit winter solar access. Requirement for northern solar orientation is even more desirable in the warmer climate of Queensland. In addition to allowing winter solar gain, a direct north-south orientation enables absolute exclusion of all unwanted summer sun, and protects houses from the direct impacts of the afternoon summer sun. Despite significantly greater need for good solar orientation and ventilation in Queensland’s climate, the QHC is mute on this important issue, and permits the construction of houses with the worst possible direct east-west orientation.

Modelling shows the MDDG produces smaller houses with larger yards while comparable QHC requirements permit, and effectively encourage, much larger houses with little open space. The magnitude of the difference between these two different regulations is perhaps most starkly illustrated in Table1 that charts the maximum building area and resulting minimum backyard areas under the policy regimes being investigated. For context, minimum unit sizes from the NSW Apartment Design Guidelines and the median Queensland ‘new house’ and ‘all new dwellings’ sizes are also shown in this chart.
Table 1. Comparison of permissible GFA, and backyard area by lot size (+ apartment size)

In the context of the ‘missing middle’ discussion, it is salutary to note that allowable houses on the smallest (125m$^2$) site permitted by the QHC are already well above the median size for all new Queensland dwellings, and houses equivalent to the median new house can be built on sites as small as 188m$^2$ in Queensland, but would require a 320m$^2$ site in NSW. At the upper extreme of this analysis, regulations permit a 450m$^2$ house on a 640m$^2$ site in NSW, while the same site in Queensland could house an enormous dwelling of twice the size.

**Part B Modelling the broader urban impact of QHC, MDDG and BYNC designs**

To date the study has focussed on lot-by-lot and building-by-building comparison of the application of the two proposed regulatory codes. Part B of this study models the impacts of these codes at the scale of a typical suburban block, and extrapolates these outcomes to the broader city. The recent Density and Diversity Done Well competition by the Queensland Government Department of Infrastructure, Local Government and Planning provides a topical framework to investigate the broader implications of the small lot housing issue. The competition also invited new designs for medium density apartment buildings, but the
majority of the 100 published entries focussed on the issue of small-lot housing to three storeys in height that coincides with the focus of this paper.

The site for the competition is a slightly abstracted version of the suburban neighbourhood centred on Baleri, Jean, Toolooma and Albert Streets in the central Logan City suburb of Woodridge. The neighbourhood has all of the best physical characteristics of the intelligently laid-out Housing Commission suburbs of the immediate post-war era. Small roundabouts at intersections calm through traffic and local parks dot the suburb. The street grid is aligned close to north with the long residential streets running east/west. This underpinning strategy gives the perfect sub-tropical solar orientation to every lot, a simple and obvious strategy seemingly lost to subsequent generations of Queensland planners.

Today the site is a neighbourhood of relatively modest low-set brick or weatherboard cottages occupying building lots approximately 600m$^2$ to 750m$^2$ with large existing backyard trees. In September 2017, median house values in Woodridge were just below $300,000 with median apartment values close to $200,000. The neighbourhood rates a ‘very walkable’ Walk Score of 73. The block is within a fifteen-minute walk to Woodridge railway station, the Logan Central Shopping Centre and access to three cross-city bus routes. At 12 km from the Brisbane CBD, Woodridge may not strictly qualify as a middle-ring suburb, but the current 48 minute rail commute to Brisbane CBD, is to be supplemented in 2018 by a one hour rail and light rail commute to the Gold Coast, while proximity to M1, M2 and M3 motorways also provides a high level of connectivity to the South-East Queensland road network with associated retail, commercial and industrial opportunities.

B1. Existing conditions on the DDDW base site

The competition site is an ideal test for the objectives of the missing middle design competition. Currently there are twenty detached houses on lots that average 666m$^2$ with frontages between 18.2m and 20.7m. Twelve of the lots front north and south onto the principal residential streets, but the four corner lots and four additional lots are aligned east/west with principal frontages to the minor streets (Fig 5). Current site density is 15 dwellings /hectare, with a net residential density (measured to the centre line of surrounding roads) of 10.8 dw/ha. Currently there is undercover parking for 26 cars on site although the large open yards can accommodate many more on-site vehicles. Because of the frequency of driveway crossovers only 26 cars can be parked on the street.
B2. QHC redevelopment of the DDDW site.

Maximum redevelopment of the block under QHC regulations is facilitated through introduction of a shared lane to provide rear access to lots from 5.0m to 6.6m in wide (Fig 6).

For simplicity, the lane is shown symmetrically straddling the rear lot boundaries requiring amalgamation and reconfiguration of boundaries for all lots. A less generic layout could offset
the access lane to one side or other of the rear boundary requiring only eight of the lots to be amalgamated for immediate redevelopment. As the QHC has no requirement regarding solar orientation, the eight existing blocks aligned east/west have been expediently subdivided retaining their existing orientation. As a result 24 blocks, more than one third of the total, are left with highly undesirable western orientation. The maximum yield achievable in this arrangement is 64 separately titled sites from 155 m² to 225 m², averaging 185 m².

Two storey attached houses built within boundary setback, site cover and built-to-boundary wall constraints yield floor areas from 196 to 308m², with an average GFA of 240 m² and a resulting average open space of 42 m². All houses have two on-site car parking spaces with an additional 40 on-street visitor parks (0.63 cars/dwelling). The following yield table (Table 2) gives averages based on the site area of separately titled residential lots, omitting the common 1, 511 m² rear lane. Vehicle calculations are for garage areas that are also included within overall building cover.

Table 2. Maximum QHC Yield: Characteristics of House Types

<table>
<thead>
<tr>
<th>HOUSE TYPE</th>
<th>Site Area (m²)</th>
<th>Building Cover (m²)</th>
<th>Open Area (m²)</th>
<th>Vehicle Area (m²)</th>
<th>Lower Floor (m²)</th>
<th>Balc (m²)</th>
<th>Upper Floor (m²)</th>
<th>GFA (m²)</th>
<th>Floor /Site Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. NS Narrow</td>
<td>16</td>
<td>173</td>
<td>138</td>
<td>35</td>
<td>39</td>
<td>23</td>
<td>99</td>
<td>5</td>
<td>1.35</td>
</tr>
<tr>
<td>b. NS Wide</td>
<td>24</td>
<td>214</td>
<td>160</td>
<td>54</td>
<td>38</td>
<td>18</td>
<td>121</td>
<td>9</td>
<td>1.26</td>
</tr>
<tr>
<td>c. EW Lots</td>
<td>20</td>
<td>155</td>
<td>124</td>
<td>31</td>
<td>36</td>
<td>23</td>
<td>88</td>
<td>9</td>
<td>1.26</td>
</tr>
<tr>
<td>d. Long Cnr</td>
<td>2</td>
<td>225</td>
<td>173</td>
<td>54</td>
<td>38</td>
<td>17</td>
<td>135</td>
<td>0</td>
<td>1.36</td>
</tr>
<tr>
<td>e. Short Cnr</td>
<td>2</td>
<td>183</td>
<td>136</td>
<td>47</td>
<td>39</td>
<td>21</td>
<td>97</td>
<td>10</td>
<td>1.17</td>
</tr>
<tr>
<td>AGGREGATE</td>
<td>64</td>
<td>11,824</td>
<td>9,146</td>
<td>2,678</td>
<td>2,434</td>
<td>23</td>
<td>6,712</td>
<td>496</td>
<td>1.15</td>
</tr>
<tr>
<td>Av. House Lot</td>
<td>1</td>
<td>185</td>
<td>143</td>
<td>42</td>
<td>38</td>
<td>21</td>
<td>105</td>
<td>8</td>
<td>1.30</td>
</tr>
</tbody>
</table>

Within the overall redevelopment block this scheme delivers a net residential density of 48 dwellings/hectare. (Table 3) Site coverage within the redevelopment block is: buildings 69%, vehicle access lane 11% and private open space 20%. However if we include the 27% of the built area allocated to internal garages, the total ground floor area allocated to vehicles is 30% and the habitable ground floor of houses is reduced to 56%. The broader impacts of these guidelines can be recalculated for the net urban area measured to centrelines of surrounding roads. The resulting net residential density of 35 dwellings/hectare is comprised of buildings
49%, cars 23%, and open space 28%. Separately identifying the garage areas within houses we could alternately recalculate the site area devoted to housing and cars as equal at 36% each.

Table 3. Maximum QHC Yield: Land use on private and public land and at net urban scale

<table>
<thead>
<tr>
<th>SITE COVER</th>
<th>Areas at Roof Plan</th>
<th>Land Area (m²)</th>
<th>Building Area (m²) (%)</th>
<th>Vehicle Area (m²) (%)</th>
<th>Open Space (m²) (%)</th>
<th>Residential Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIVATE LAND</td>
<td>House Lots + Lane</td>
<td>13,335</td>
<td>9,146 69%</td>
<td>1,511 11%</td>
<td>2,678 20%</td>
<td>48 dw/ha (Site)</td>
</tr>
<tr>
<td>PUBLIC LAND</td>
<td>Roadway + Footpath</td>
<td>5,167</td>
<td>2,786 54%</td>
<td>2,381 46%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URBAN BLOCK</td>
<td>to Road Centrelines</td>
<td>18,502</td>
<td>9,146 49%</td>
<td>4,297 23%</td>
<td>5,059 27%</td>
<td>35 dw/ha Net</td>
</tr>
</tbody>
</table>

B3. MDDG redevelopment of the DDDW competition site.
As the MDDG requirements mandate good solar access the original lots that were aligned east/west have been amalgamated and reconfigured so all new lots run north/south. Living room and principal outdoor spaces thus face the street for northern lots and face into the backyard for southern lots (Fig 7).

Fig 7. Maximum MDDG redevelopment of DDDW site – 56 terrace houses on av. 215m² lots

Rear lane car access is required as all lots are less than 7.5m wide. For simplicity the lane is shown centred on the original rear fence line but could be offset to one side or other, reducing the necessity to amalgamate all lots in the initial property realignment. The site plan also illustrates narrow cross-block pathways resulting from subdivision of the wider lots. The layout provides one on-site car park per dwelling, as per MDDG documentation, but lot width
could accept a second garage space if needed. This layout also incorporates 44 on-street visitor parks (0.79/dwelling).

Table 4. Maximum MDDG Yield: Characteristics of House Types

<table>
<thead>
<tr>
<th>HOUSE TYPE</th>
<th>Site Area (m²)</th>
<th>Building Cover (m²) %</th>
<th>Open Area (m²) (%)</th>
<th>Vehicle Area (m²) (%)</th>
<th>Lower Floor (m²)</th>
<th>Balc (m²)</th>
<th>Upper Floor (m²)</th>
<th>GFA (m²)</th>
<th>Floor /Site Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>f. Corner lot</td>
<td>4 267</td>
<td>149 56%</td>
<td>118 44%</td>
<td>21 8%</td>
<td>107 22</td>
<td>107</td>
<td>214</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>g. NS Typical</td>
<td>52 214</td>
<td>126 59%</td>
<td>88 41%</td>
<td>21 10%</td>
<td>86 18</td>
<td>86</td>
<td>172</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>AGGREGATE</td>
<td>56 12,196</td>
<td>5,924 49%</td>
<td>5,048 41%</td>
<td>1,176 10%</td>
<td>4,900 1,024</td>
<td>4,900</td>
<td>9,800</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>AVERAGE</td>
<td>1 218</td>
<td>106 49%</td>
<td>90 41%</td>
<td>21 10%</td>
<td>87 18</td>
<td>87</td>
<td>174</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>

MDDG minimum lot requirements (200m² and 6m width) result in a yield of 56 new houses (Table 4) on average 218m² lots; 33 m² larger than QHC. The application of FSR rules results in smaller houses (174m² GFA vs 240m²) but significantly greater open space (90m² vs 42m²). The fundamental difference between the large house/ small garden model promoted by QHC and the relatively smaller house/ larger garden model of the MDDG flows through to the land use breakdown at the urban scale (Table 5).

Table 5. Maximum MDDG Yield: Land use on private and public land and at net urban scale

<table>
<thead>
<tr>
<th>SITE COVER</th>
<th>Areas at Roof Plan</th>
<th>Land Area (m²)</th>
<th>Housing Area (m²) (%)</th>
<th>Vehicle Area (m²) (%)</th>
<th>Open Space (m²) (%)</th>
<th>Residential Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIVATE LAND</td>
<td>House Lots + Lanes</td>
<td>13,335</td>
<td>5,924 44%</td>
<td>2,244 17%</td>
<td>5,167 39%</td>
<td>42 dw/ha (Site)</td>
</tr>
<tr>
<td>PUBLIC LAND</td>
<td>Roadway + Footpath</td>
<td>5,167</td>
<td>2,786 54%</td>
<td>2,381 46%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URBAN BLOCK</td>
<td>to Road Centrelines</td>
<td>18,502</td>
<td>5,924 32%</td>
<td>5,030 27%</td>
<td>7,548 41%</td>
<td>30 dw/ha Net</td>
</tr>
</tbody>
</table>

B4. Back Yards Not Cars, s design submission for the DDDW design competition

There were 100 conforming entries for the DDDW competition submissions, from which the judges selected nine winning proposals with a further eleven schemes commended or mentioned. The author’s entry ‘Back Yards Not Cars’ (Skinner, 2017) was not awarded but is represented here to illustrate an alternate land use strategy. The design proposal incorporates a range of design innovations including a novel prefabricated timber construction system designed to reduce multi-storey construction costs, a flexible and adaptable internal planning strategy, and a strong passive climate design response (Fig 8). Of particular is the site planning strategy designed to allow simple, quick and affordable incremental development on a site-by-site basis, while maximising the landscape area and retaining existing tree cover.
Earlier analyses highlight the interdependence of site areas designated for house, vehicles and open space. The author’s design seeks to reduce the proportion of the site devoted to cars, in order to free more of land for residential and environmental purposes. It aims to achieve this outcome by co-locating all required off-street parking within shared car park structures located within the residential block. Fig 8 shows a single storey parking structure on the side street initially providing secure parking for 14 new houses. Fig 9 illustrates a maximum yield of 57 houses in the block enabled by a two-storey parking station accommodating 58 cars.
The BYNC model incorporates lots between 5.02m and 6.17m wide derived from simple subdivision of existing lots into three or four new terrace house lots (Table 6). As with the MDDG proposal all east/west lots are reconfigured to run north/south and all living rooms and principal outdoor spaces face north for optimal solar design. Consolidation of all required parking in an efficient multi-storey structure liberates open space in the block and eliminates the need for site amalgamations to create access lanes. The current back yard zone can be largely retained as landscape space preserving the majority of the established tree canopy.

Table 6. Proposed BYNC Redevelopment: Characteristics of House Types

<table>
<thead>
<tr>
<th>HOUSE TYPE</th>
<th>No</th>
<th>Site Area (m²)</th>
<th>Building Cover (m²) %</th>
<th>Open Area (m²) (%)</th>
<th>Vehicle Area (m²) %</th>
<th>Lower Floor (m²)</th>
<th>Balc (m²)</th>
<th>Upper Floors (m²)</th>
<th>GFA (m²)</th>
<th>Floor/Site Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>h. Corner Lot</td>
<td>3</td>
<td>253</td>
<td>96 38%</td>
<td>157</td>
<td>63%</td>
<td>76</td>
<td>20</td>
<td>114</td>
<td>190</td>
<td>0.75</td>
</tr>
<tr>
<td>f. NS Narrow</td>
<td>30</td>
<td>187</td>
<td>93 50%</td>
<td>94</td>
<td>50%</td>
<td>74</td>
<td>19</td>
<td>111</td>
<td>185</td>
<td>0.99</td>
</tr>
<tr>
<td>g. NS Wide</td>
<td>24</td>
<td>233</td>
<td>108 46%</td>
<td>125</td>
<td>54%</td>
<td>85</td>
<td>23</td>
<td>127</td>
<td>212</td>
<td>0.91</td>
</tr>
<tr>
<td>AGG HOUSES</td>
<td></td>
<td>11,961</td>
<td>5,670 47%</td>
<td>6,291</td>
<td>53%</td>
<td>4,488</td>
<td>1,182</td>
<td>6,720</td>
<td>11,208</td>
<td>0.94</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>1</td>
<td>210</td>
<td>99 47%</td>
<td>110</td>
<td>53%</td>
<td>79</td>
<td>21</td>
<td>118</td>
<td>197</td>
<td>0.94</td>
</tr>
<tr>
<td>h. Carpark</td>
<td></td>
<td>1,374</td>
<td>1,091 79%</td>
<td>283</td>
<td>21%</td>
<td>1,124</td>
<td>1,091</td>
<td>2,182</td>
<td>1.59</td>
<td></td>
</tr>
</tbody>
</table>

The BYNC House model is a taller house comprised of two generous floors to the north, and three more compact storeys to the south (Fig 10). This enables greater average habitable floor area (197m²) within a smaller building footprint (99m²) further increasing the area of landscaped open space (110m²) to 53% of the site area.

Fig 10. Section of BYNC house, 2 storeys to north, 3 stories to south (Skinner, 2017)

Table 7 demonstrates the urban implications of this mode of development if carried across the whole block. It should be noted that one of the strongest arguments for this
approach is that wholesale redevelopment is not necessarily required as individual sites can be redeveloped one by one, once an initial common parking structure is established.

Table 7. Proposed NYBC Yield: Land use on private and public land and at net urban scale

<table>
<thead>
<tr>
<th>SITE COVER</th>
<th>Areas at Roof Plan</th>
<th>Land Area (m²)</th>
<th>House Area (m²)</th>
<th>Vehicle Area (m²)</th>
<th>Open Space (m²)</th>
<th>Residential Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIVATE LAND</td>
<td>House Lots + Carpark</td>
<td>13,335</td>
<td>5,670</td>
<td>1,091</td>
<td>6,574</td>
<td>43 dw/ha (Site)</td>
</tr>
<tr>
<td>PUBLIC LAND</td>
<td>Roadway + Footpath</td>
<td>5,167</td>
<td>2,786</td>
<td>2,381</td>
<td>2,381</td>
<td>46%</td>
</tr>
<tr>
<td>URBAN BLOCK</td>
<td>to Road Centrelines</td>
<td>18,502</td>
<td>5,670</td>
<td>3,877</td>
<td>8,955</td>
<td>31 dw/ha ()Net</td>
</tr>
</tbody>
</table>

**Part C. Discussion**

**Affordability**

It is important for urban strategies to seek to increase the residential density to improve walkability and to increase yield to improve affordability. The three strategies examined increase net density significantly from the initial 10.8 dwellings/hectare to 35, 30 and 31dw/ha respectively. In these arrangements original house lots now yield 3.2, 2.8 and 2.9 new dwelling site, reducing the land component of new house prices.

The resulting houses vary significantly with QHC houses characterised by the largest floor areas (av 240m²) on the smallest lots (av 185 m²) but little outdoor open space (42m²), compared to MDDG houses (174 m² GFA, 218m² lots, 90m² OS) and BYNC (197m² GFA, 210m² lots, 110m² OS) The minimal open space provision of the QHC has a clear impact on the amenity of residents, giving only limited access to external recreational space and poor internal room amenity and environmental control. The QHC houses are significantly larger, with a proportionally greater construction cost.

In the current condition of the missing middle, provision of smaller, more affordable houses should be prioritised. It should be noted that the QHC houses, at 240m², is equivalent to the current median new house size in the state, while the BYNC house is 81% and MDDG 73% of this size. It is not possible to predict an optimal house size or price point that would satisfy the missing middle market, but the two and a half storey BYNC house as illustrated is capable of accommodating a wide range of household configurations or can be delivered as a much more compact two storey house to further economise.
Incremental development

A key factor addressing affordability is the development model required. Because the QHC and MDDG models are both based on rear access lanes, requiring at least 50% of the lots to be reconfigured to deliver significant early infrastructure. This effectively requires the same model of large scale land acquisition and amalgamation used to accrue apartment development sites. This is a slow and risky process, with significant holding costs, and would rule small-scale developers out of the process.

By contrast, the BYNC proposal offers an opportunity for genuinely incremental development that could be undertaken by much smaller builder/developers. Following purchase of one of the original lots to establish a common carpark, an initial developer could provide sufficient off-street parking to permit redevelopment of any four of the current large lots to 14 new houses. Once this redevelopment mechanism is in place, it provides an easy framework for existing landowners to undertake small scale developments yielding 3 or 4 new houses to replace each existing house, subject to purchase of the required number of parking spaces. The initial investment in the common parking station could be undertaken by a private entrepreneur, or could be provided as catalyst infrastructure by state or local government with costs recouped through subsequent value capture.

Diversity

None of the schemes studied involve garages areas facing the street and associated loss of ground floor, publically accessible space. Pedestrian and cyclist safety and amenity is improved by the absence of driveways across footpaths and front yards, and on-street visitor parking is maximised by the reduction of driveway crossovers. All schemes offer potential for universal access for diverse residential or entrepreneurial uses of the ground floor. The BYNC offers the largest and sunniest yard spaces for adult, child or pet recreation and gardening or other productive outdoor pursuits.

Urban Ecology

Peter Myers (2000) identifies the great amenity of the middle ring suburbs in Australian cities provided by the established landscape of backyard trees. In the Woodridge site almost all existing trees within nine metres of the rear boundary would need to be removed to allow construction of rear lanes and associated car parks. Every tree on the block would need to be
removed to enable the sprawling QHC redevelopment, and the larger MDDG courtyards may allow some retention of tree cover. The BYNC model preserves a back yard planting zone about 24 m wide, supplemented by contiguous front yard and footpath zones at least 9.5m wide. As a landscape strategy applied across a suburb these long parallel green zones have the potential to provide link wildlife corridors as well as providing a structure for more ambitious green infrastructure such as stormwater detention through water sensitive design (CRC Water Sensitive Design, 2016).

**Environmental Impacts**

Environmentally, a smaller house should use fewer resources in construction and require less energy to run and maintain. For the individual house the larger open spaces around houses enable application of passive design strategies for cross ventilation and solar design. The MDDG and BYNC proposals that strongly prioritise northern orientation for principal rooms and outdoor spaces contribute superior passive performance in the subtropics and tropics. At the scale of the neighbourhood, the urban tree cover has a significant cooling effect on the microclimate. The BYNC option that allows retention of substantial existing trees offers immediate benefits, without requiring the growing time of new tree planting.

**Future Vehicles**

The BYNC proposal aims to maximise indoor and outdoor spaces for living by dramatically reducing the area of the city primarily dedicated to car movement and parking. The BYNC scheme requires only 21% of the ground surface to be dedicated to roads and parking, while MDDG requires 27% and the QHC 36%. The land area devoted to vehicles could be seen as a lost opportunity to improve yield, affordability, functional diversity and environmental and ecological sustainability. It can also be seen as an unwise long-term commitment to a transport technology already undergoing major change. Provision of a well designed community car park can accommodate current levels of car ownership in the short term while offering greater potential to rapidly adapt to electric, automated, shared and on-demand vehicles. In the current era of rapid technological change it seems unwise to allow the current car ownership model to dictate the design of houses and gardens into the future.

**Social Impact**

The BYNC model not only produces walkable densities it produces walkable lifestyles. Without rear lanes all neighbours come and go on the shaded streets, and regularly converge
on the parking station as an important part of daily life. As illustrated, the BYNC model is depicted as a relatively prosaic functional utility, but it could equally be conceived as the vital social hub of the neighbourhood.

**Conclusion.**

There are currently conflicting messages coming from the Queensland Government with regard to the strategies to deliver the ‘missing middle’ housing options. The QHC represents a particularly muddled response to the current situations as it appears deliberately designed to perpetuate massive overbuilding of new houses at the expense of open space, landscaping, the environment and ecology. The disproportionately massive houses it permits are a very poor design response for small lots and appear antithetical to the argument for affordable ‘missing middle’ housing options.

As a comprehensive set of design guidelines the MDDG is vastly superior to the QHC. Inclusion of FSR constraints, requirements for significant landscaped area and tree planting, solar orientation and cross-ventilation, and greater back-to-back separation will safeguard a high level of amenity for residents and neighbours alike. The Queensland government would be well advised to base any new housing code on the NSW model. However, the MDDG prohibition of lot areas less than 200m² in area or 6m in width is more difficult to endorse when seen within the long history of smaller, perfectly habitable terrace houses in Australia and abroad, and the current imperative to pursue affordability. The Queensland acceptance of 5m wide, 125m² lots appears perfectly reasonable particularly in the context of contemporary experimentation with tiny-houses and micro-apartments.

The BYNC model represents an attempt to advance beyond the MDDG model through fundamental reconsideration of the negative impacts of vehicles on the planning of our cities. The proposal questions why the car network needs to access every lot, why motor vehicles need to be garaged within our expensive houses, at the expense of habitable indoor and outdoor space. Efficient centralised parking stations can reduce the overall space devoted to cars in the city and positively enhance private and public amenity. Secure community parking stations respond to forecasts of shared or on-demand, self-driving electric vehicles and allow rapid adoption of new technology without impacting residential space.
Importantly, removal of vehicular driveways, laneways and carports from the residential allotment immediately simplifies and stimulates opportunities for wide-scale, incremental redevelopment. This transformation is not dependent on amalgamation of multiple lots or creation of large contiguous land holdings. Empowering each individual property owner to simply subdivide their own land to yield three or four new houses per lot, at the time of their choosing, without requiring the approval of neighbours, would unleash a powerful mechanism to rapidly and affordably increase density and diversity in our existing low-density mid-range suburbs.

References:


Urban Climate Adaptation through Design and Planning: 
A New Zealand Perspective

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10th International Urban Design Conference 2017  
Gold Coast (QLD) 13-14 November 2017
Urban Climate Adaptation through Design and Planning: A New Zealand Perspective

ABSTRACT: Urbanization is one of the twenty-first century’s most transformative trends, and increasing urban population along with the impacts of climate change provide new challenges and new opportunities. However, there are significant differences in the way countries are perceiving the phenomenon of climate change and implementing adaptation strategies to improve urban climate. This paper reports on a study carried out in New Zealand and aimed at identifying how the country is implementing adaptation strategies through urban design and planning to improve urban climate in the face of climate change. Semi-structured interviews were conducted with New Zealand scholars studying urban climate related issues, urban design and planning practitioners, and governance. The study was designed to provide a wide range of perceptions rather than a set number of interviews in specific cities. The semi-structured interviews focused upon awareness of the need for climate change adaptation, existing urban climate phenomena because of design decisions, existing design strategies to improve climate adaptation, communication of climate change issues, existing policy instruments and implementation of initiatives. The paper discusses the perceptions of interviewees regarding awareness and urgency of action; the role of citizens, governance, and urban designers and planners in the urban climate adaptation agenda; and the role of dramatic events such as the Christchurch earthquakes on acknowledging the need for appropriate design and planning. Results indicate that the geographical condition of New Zealand and its consequent maritime climate means that climate change – particularly effects related to city design – are not seen as a major issue. However, the recent Christchurch earthquakes have sped up the processes of change, making citizens and governance more aware of consequences of inappropriate design and planning.

Keywords: Urban design, urban planning, climate change, adaptation, New Zealand

Introduction

Urbanization is a twenty-first century transformative trend, and increasing urban population along with climate change provide new challenges and opportunities (Henstra, 2012; Howden-Chapman et al., 2010; Prasad et al., 2009). There are, however, significant differences in the way countries are perceiving and responding to the climate change phenomenon. This study is part of a worldwide research on urban adaptation and similar studies are being conducted in the Netherlands, Bulgaria, South Korea, China, Kenya, and other countries.

A main climate change challenge in New Zealand is sea level rise (RSNZ, 2016), and some important documents have been produced regarding its impact on the built environment (NIWA et al., 2012), the development of National Climate Change Adaptation
Plans (Tait and Ungaro, 2017), and relationships between climate change and human health (Howden-Chapman et al., 2010). Recent earthquakes were also a powerful demonstration of disruption consequences and potential climate change effects. The Christchurch earthquakes, for instance, sped up landscape change processes expected to happen over 100 years (Hughes et al., 2015).

While conversations and documents exist, there is little information about local citizens, urban planners and designers, urban climate experts and politicians’ awareness of urban climate phenomenon and to what extent measures to adapt are effective. The objective of this study is, therefore, to investigate the state of the art of urban climate adaptation awareness and response in New Zealand based on three questions: (1) What is the current situation of urban climate adaptation in New Zealand?; (2) What are the current issues related to climate change awareness and communication amongst the groups?; (3) What instruments are used by government to adapt, and how are they implemented?

The study is centred in three main topics: climate change, urban heat islands (UHI) and wind, and urban climate adaptation, and discussions about climate change mitigation and greenhouse gases (GHG) reduction to meet specific targets are beyond the scope of this work. While similar studies have been undertaken in other places (Bulkeley, 2010; Moser and Ekstrom, 2010; Theoharides et al., 2009; Tompkins et al., 2009; Colson et al., 2012), this work helps to understand the New Zealand current reality.

Climate change makes urban residents vulnerable to floods, landslides, and extreme weather events (Henstra, 2012; Wamsler et al., 2013). Reduced access to freshwater, frequent hot days and nights, fewer cold days and nights, heavy precipitation, drought, intense tropical cyclones, and high sea levels (UN-Habitat, 2011) are also foreseen. Climate change effects are driven by GHG generated by a wide variety of human activities (UN-Habitat, 2012), the heat generated by these activities is known as anthropogenic heat (AH).

UHI happen where urban centres are substantially warmer than less or non-urbanised surroundings (Lenzholzer and Brown, 2013) resulting in adverse human health, economic and environmental impacts. UHI intensity is affected by urban design and fabric, types of surfaces within the city, and sky view factor. Climate change is expected to increase UHI occurrence and higher temperatures are expected to impact cities (Corburn, 2009).

“Responding to climate change is about adjusting to risks, either in reaction to or in anticipation of changes arising from changing weather and climate” (Adger et al., 2013, p. 1 The ‘groups’ mentioned throughout this article refer to these four groups.
Urban planning can improve regional and urban resilience, but its efficiency relies on understanding place-based vulnerability (UN-Habitat, 2015). Climate adaptation, however, tends to get extra attention following extreme weather events rather than gradual changes in average climate conditions (Füssel, 2007), which are happening almost in every location.

Planning for urban climate adaptation focus on reducing potential disruption and exploring opportunities (Henstra, 2012; Smith and Levermore, 2008; Wamsler et al., 2013). The success of these endeavours involves broad measures and diverse stakeholders, including the groups considered in this study.

**Methodology**

As a part of a larger study, this investigation was based on pre-made interview questions, used for all participating countries. Semi-structured interviews (n=10) were conducted with New Zealand scholars studying urban climate, urban planners and designers, and government employees working on urban responses to climate change. New Zealand is a small country and it soon became clear that there was no need to limit interviewees per city, as most interviewees demonstrated knowledge and experience in various locations. Therefore, the study was designed to provide a wide range of perceptions rather than a set number of interviews in specific cities.

Semi-structured interviews discussed awareness of the need for climate change adaptation, existing urban climate phenomena, existing climate adaptation measures, climate change communication, policy instruments, and implementation of initiatives.

**The case of New Zealand**

As a case study, New Zealand provided powerful insights into adaptation following disruption, in this case, following earthquakes. Christchurch, in particular, is a city undergoing rapid urban change, relevant for research into adaptation to climate (Tavares, Swaffield and Stewart, in press). The Christchurch events influenced more than only Christchurch, making New Zealanders aware of the consequences of intense disruption, while generating more pressing issues and placing climate change as a lower priority.

New Zealand is in a temperate climate zone between 35°S and 46°S latitude and has a temperate maritime climate (Mullan, Tait and Thompson, 2012). The ocean plays a key role in the local climate as there are no major land masses between the South Island and Antarctica, and the climate is influenced by circulation patterns in the Southwest Pacific.
(Huisman, 2014). The three key factors determining New Zealand’s climate are prevailing winds, surrounding oceans, and the country’s mountain ranges.

Climate change impacts in New Zealand are set to increase over time. According to the Royal Society of New Zealand (RSNZ, 2016), the country is sensitive to climate change because of its population location, freshwater availability and economic basis. The main population centres are located on coastal areas – exposed to rising sea levels, strong storms, and coastal erosion – and in major rivers floodplains – vulnerable to increasing extreme rainfall, floods, and erosion. New Zealand’s economy is dependent on primary industries linked to freshwater availability, which associated with urban expansion and increasing droughts is of real concern. Moreover, changing ocean temperature and currents constitute a challenge for fishing, aquaculture, and marine recreational and iconic wildlife. Finally, New Zealand has important international trading links, and climate change-related impacts on other countries are likely to affect the country’s trades.

All points above mentioned are important, but unrelated to urban climate, which so far has not been acknowledged as a concern.

Data collection and analysis

Potential interviewees were contacted through email. In total, 38 emails were sent and 10 positive responses were received. For the ones who agreed to participate a phone or Skype interview was arranged. Interviews were recorded and transcribed, and interviewees were anonymised and assigned a code (Table 1). All interviewees had at least four years of experience in their fields of work.

<table>
<thead>
<tr>
<th>Code</th>
<th>Role</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Urban designer</td>
<td>Auckland</td>
</tr>
<tr>
<td>P2</td>
<td>Urban climate expert</td>
<td>Christchurch</td>
</tr>
<tr>
<td>P3</td>
<td>Urban designer</td>
<td>Auckland</td>
</tr>
<tr>
<td>P4</td>
<td>Urban researcher</td>
<td>Wellington</td>
</tr>
<tr>
<td>G1</td>
<td>Government</td>
<td>Christchurch</td>
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<td>G2</td>
<td>Government</td>
<td>Nelson</td>
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<tr>
<td>G3</td>
<td>Government</td>
<td>New Plymouth</td>
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<tr>
<td>A1</td>
<td>Academic</td>
<td>Christchurch</td>
</tr>
<tr>
<td>A2</td>
<td>Academic</td>
<td>Auckland</td>
</tr>
<tr>
<td>A3</td>
<td>Academic</td>
<td>Palmerston North</td>
</tr>
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</table>

Table 1: Interviewees, their roles and location
The interview guide was divided into four categories: awareness, communication, instruments and implementation, also used to present the results. Data analysis was based upon interviews’ transcripts. Questions based on the Likert scale (awareness) were analysed using Excel and converted into graphs for visual representation. Open-ended questions were summarised and tabled according to main identified topics. Results are presented next, following the questionnaire structure.

Results

Awareness

Q1. What is the sense of urgency to adapt the urban environment to climate change amongst the groups in the future in your city?

Urban climate experts were considered the most aware group regarding urgency for climate change adaptation, followed by urban planners and designers, politicians and lastly citizens (Figure 1).

Urban designers and planners are seen as being aware, but their actions do not lead to changes (P1, A2). While efficient measures depend upon political persuasion, climate change is important and 'politically correct', so politicians use it to attract funding, but not act on it (A2). Their actions tend to focus on short-term issues (P1) within their mandates (A2), and at the local government level (G2). Due to New Zealand’s geographical position, citizens are concerned with earthquakes and wind, and do not connect worsening wind conditions to climate change (P4, A2).
Q2. In case the sense of urgency is low, what is needed to make those groups feel more urgent about adapting the urban environment?

The work done by local and central government should be promoted. There is a need to "change conversation parameters around the broader range of affects and impacts of climate change on the urban environment", beyond the sea level rise topic (P3). Awareness of the need to change behaviour is also fundamental, and behaviour only changes when the situation gets critical (A2). This was mentioned by other four interviewees who believed citizens only change their minds when their properties are affected (G3), or a disaster occurs (P4, P1). Some councils tried to include sea level rise information on property documents, but faced resistance due to potential impacts on property values (P4, G3).

Awareness-raising campaigns can be useful (G3), and politicians need to focus their priority (P2), as they must provide financial support to local governments to implement adaptation measures (A1). Urban planners and designers still follow planning rules and are not strategic (A2), they need to monitor, understand and plan for change (G1). For urban climate experts the main challenge is to connect with people in simple terms and to lead by example (A2).

Q3. How aware are the groups of the following two urban climate phenomena?

Urban heat island (UHI)

Responses show UHI is not a well-known phenomenon. No group has been indicated as very aware (urban climate experts were not included in this question) (Figure 2).

Figure 2: Awareness of UHI

UHI is not seen as an issue in New Zealand due to low density cities, wind and maritime climate (P1, P3, A1). Climate change tends to be viewed in a rural context in relation to impacts
on land use and productivity, not as an urban problem (G2). Some New Zealanders think climate change means their city will be warmer and therefore, as an interviewee pointed out: "If you said to somebody, we're going to develop a heat island, everyone would go 'yay'" (P4).

While citizens are unaware of UHI (G2, A2), it is difficult to grasp what politicians know as public communication is written for them (A2). Urban planners and designers are aware but not concerned due to prevailing urban morphologies and local maritime climate (G1).

Wind discomfort

Wind discomfort awareness is significantly higher than UHI. Interviewees responses show that all groups are aware of this phenomenon, while most interviewees (at least seven) believe all groups are aware or very aware (Figure 3)

Figure 3: Awareness of wind discomfort

Although all groups are aware of the problem and tend to consider these local conditions when designing residential buildings (P1, G1), they tend to take it as local weather conditions and do not relate the issue to climate change (A2), but as something to adapt to or move elsewhere (A2, A3, P4). The only exception was an interviewee who pointed out that there is awareness of wind damage and climate change is increasing the problem (G3). Urban planners and designers are considered very aware of city layout in relation to cold winds, and the need for sunny and sheltered places (G1, A1, P3, P4).
Q4. In case awareness is low, what is needed to increase the awareness of two urban climate phenomena mentioned in question 3?

General education (P2, G3, G2), and discussion on how tall buildings locally contribute to wind problems (P3). Citizens need more information through local media on how the issues will affect them (A1). Politicians’ priority is based on economy, hence the need to understand relationships between successful precincts and pleasant outdoor climate (P2). Local and central government should provide information for citizens to learn about climate change. Urban planners and designers require confidence for addressing issues (G1). Although they are aware, there is no strategy to work towards solving the issue (P3). They need guidance and reliable data to prompt action (A1).

Q5. How aware are the groups of following four urban climate adaptation measures?

City design

Awareness of the role of city design was considered low for citizens, as six interviewees pointed out that their view is neutral or lower. All other groups are considered more aware being urban planners and designers and urban climate experts aware or very aware (Figure 4).

![Figure 4: Awareness of city design](image)

All groups are aware of building orientation to address sun and wind (A1), and that they could do more to prevent flooding in low-lying areas (P4). However, citizens are unaware of solar orientation in public spaces, although they make choices based on sun availability (A2). Politicians understand the issue but do not turn into practical applications. They need to enforce appropriate practices through planning instruments, so developers should address it (G2). Urban Planners and designers are aware, but there is no evidence of it in their
designs. May happen overseas, but not in New Zealand (A3). Urban climate experts discuss issues but not their designs or implementation (A2).

_Urban vegetation_

Even more than city design, the groups were considered to be aware of the vegetation’s role on urban climate adaptation. Seven out of 10 interviewees pointed out that citizens, politicians and urban climate experts are aware or very aware of the vegetation impact on urban climate (Figure 5).

![Figure 5: Awareness of urban vegetation](image)

In the Christchurch rebuild, there is a belief that if the gardens are not kept, the city may become warmer (A1). Citizens of Christchurch were also mentioned as being aware due to the city’s reputation as a Garden City (Wilson, 2013). This was the strongest view received through community engagement for the new city plan. During the earthquakes, parks provided a kind of sanctuary, but awareness is still stronger due to visual amenity and comfort, rather than linkages with climate change (G1, G3). Politicians are aware due to the popularity of the urban garden and green belt ideas, so councils encourage it (P4).

_Use of materials_

Seven out of 10 interviewees considered that citizens and politicians are neutral or unaware of the potential use of specific types of materials to improve urban climate. The most aware group was considered to be urban designers and planners (seven) followed by urban climate experts (Figure 6).
Citizens are more concerned with aesthetics (A1) and are influenced by materials cost and short-term thinking (P1, A2). Politicians have knowledge of ways of creating energy efficiency (A1), but do not apply it (A2). Urban planners and designers are aware regarding public spaces (G3), and that making existing cities sustainable is more efficient than building new ones, but keep doing the same things because changing is risky (A2). Despite that, transport seems to be a more advanced field than other urban design aspects. Planners and designers are looking at environmental-friendly road materials, because of the relationships between heat, roads and buildings (P4).

**Anthropogenic heat (AH)**

AH was considered a complex concept and nine out of 10 interviewees said citizens are neutral or lower, followed by politician (seven) and urban planners and designers (six). The only group most interviewees (seven) believe to be aware of AH was urban climate experts (Figure 7).
Citizens are aware of pollution, but New Zealand has a very car-reliant culture (P1). Politicians are aware but do not promote policy to improve it (P1). Urban planners and designers try to promote public transport and cycling infrastructure (P1), but are uninformed when designing so their designs fail (A1). Urban climate experts are very knowledgeable but are not being heard (P1).

**Q6. In case awareness is low, what is needed to increase the awareness of four urban climate adaptation measures mentioned in question 5?**

Local government should lead by example and provide demonstration projects (G3, A3). An increased media exposure would be beneficial to improve citizens’ awareness, as the only current media coverage is related to retreat from the sea (A1). Education through campaign strategies, from the local designers and businesses to their clients and population (G3) and about how these issues fit together, rather than thinking about them in isolation (P3) would also be beneficial.

Amongst politicians, commercial interests tend to dominate (P2), and climate change is a difficult message to get across, but if framed from the cost saving or resilience perspective, it may be effective (G3). Stronger urban climate adaptation policies are needed, and they must be brought into building codes and statutory documents. Local government is likely to initiate change as long as there is community support (A3). Tertiary education needs to embrace it, so the new urban planners and designers are informed (A3).

**Communication**

**Q1. Which roles do the groups have in the process of planning, designing and implementing urban climate adaptation measures?; and Q2. What are the relationships between these actors in the communication strategies?**

Citizens influence politicians and if mobilised, elected representatives would respond (P1, P2, P4, G1, G2, G3). Politicians represent the public view and should encourage community to think about climate change (P1, G3). At both local and national government, progress is limited if politicians do not communicate that there is a problem (P2). The relationship between citizens and urban designers and planners happens through community consultation processes (P1, G1, G2), and citizens trust these professionals to make the right decisions and promote best practice ideas (P2, G3).
Urban planners and designers should facilitate ideas and guide citizens and politicians towards right decisions (P1). Urban climate experts must communicate potential impacts (G2), provide evidence of urban climate issues and help offer solutions (P2, G3). They should also communicate urban climate change science and the effectiveness of measures being adopted (P3). Natural disasters are driving research into urban planning and design to focus on understanding these issues and bringing it into the government agenda (G1). Urban climate experts can bridge the gap between citizens and politicians (P1, P2) and should work with urban planners and designers to inform all other groups (P2).

Q3. What is the role of communication to support the planning, design and implementation of adaptation measures?

Education is important, if citizens were aware of simple adaptation measures they could take, they would act. But this should not only be individual's responsibility, as adaptation issues require system-wide approach (P4). Best practices should be promoted through TV and social media, but the message must be clear and not use jargon (A2). Most councils have only one person working with urban climate, who is likely too busy to be efficient. It should be a prominent work area, especially in local governments (P1).

Q4. Are there formal guidelines or policies driving the use of communication in the planning, design and implementation of adaptation measures? If yes, can you please name them?

Some interviewees believed there are no guidelines around sustainability and climate change communication, and that there is a need for an overarching strategy dedicated to it (P3, G3). However, some guidelines were also mentioned. The Report of the Parliamentary Commissioner for the Environment, for example, provides broad instruction to engage with communities about climate change (G2), and consultative procedures in the Local Government Act, sets out principles under which councils must undertake consultation (A1).

Q5. What are the strengths and weaknesses of the communication process?

Strengths: Christchurch was cited as an example of relationships between council, designers, developers, and users, as they are "building a program that goes from the design of a building to the occupant and how they behave, [which] is an extraordinary service for New Zealand" (G1). There is also an initiative to encourage people coming into the
Christchurch CBD to think about transport, and the city has an urban design panel which provides review of large scale projects (G1).

**Weaknesses:** New Zealand’s self-image as a green country enforces the perception that issues are not significant and so communication between groups is often limited (P1, P2). When principles are applied, it happens with council's discretion, but it should be applicable to all council's activities. Finally, most RMA provisions reduce the ability for public participation (A1).

**Q6. Is there a need to improve the communication process? If yes, how to improve?**

Climate change needs more exposure and prominence in the design process. It should be a concern from beginning, rather than an afterthought. Could use comparisons between well-designed and poorly-designed areas for driving attention to design (P1).

**Instruments**

**Q1. Are there legally binding instruments used to implement urban climate adaptation measures? If yes, please explain how they work?**

The Building Code has requirements such as floor heights for the event of flood (G2, G3, P3), and addresses building safety, sanitation and functionality (G1). The City Transition Plan addresses expectations and restrictions around land use (G1), and the New Zealand Coastal Policy Statement addresses planning for 1 in 100 year coastal flood events, and offers prescriptive requirements (G2, G3, P3). The RMA requires local governments to consider climate change effects in their planning and decision-making process, however, local governments must interpret the requirements and apply them locally (G3, A1, P3).

**Q2. What are the strengths and weaknesses of the legally binding instruments used?**

**Strength:** Allows for the ongoing land use change in areas expected to be impacted by climate change (G1).

**Weaknesses:** Existing laws are not being enforced (A2), and even when strategies are legally binding, they are often vague (P4). The Building Code acts as a bottom line, but it should state best practice to set higher performance goals concerning resilience to earthquakes and climate change (G1). The RMA requirements focus on issues related to sea level rise, but it does not allow for considering climate change mitigation. It is not possible
to "take into consideration or include any provisions in plans about avoiding GHG emissions" due to potential impact on dairy industry (A1).

**Q3. Are there chances missed when using the legally binding mentioned instruments?**
The lack of compulsory requirements was the main missed opportunity raised by interviewees. Although documents exist, they fail to be effective (P1). The RMA sets out requirements but does not identify how to implement them at the local level (G1). The variations between local instruments makes it confusing, and there is a missing opportunity to have a national set of standards (G2). Information about risk of sea-level rise on property information is a legal document, but does not require action (P4). The government can also issue national environmental standards and policy statements, but have not put one out on climate change. When they exist, they are guidance only (A1).

**Q4. Are there other policy instruments used to implement urban climate adaptation measures? If yes, please explain how they work?**
New Zealand Coastal Policy Statement requires planning for sea level rise and councils are expected to address the issue, but politicians avoid engaging (A1). There is also the Urban Design Protocol (MfE, 2005), which lists seven principles that urban designers should follow, and there is the New Zealand Green Building Council commercial and residential rating tools (G2, G3). Christchurch has management plans, and guides about water sensitive urban design, storm water, and flooding, and over 180 commercial buildings in the Christchurch CBD are being monitored and assessed (G1).

**Q5. What are the strengths and weaknesses of the other policy instruments used?**
**Strengths:** Incorporation of climate change considerations in infrastructure investment planning is starting to happen (P3).
**Weaknesses:** The existing documents are broad (G2) and there is scientific debate about the evidence of sea level rise predictions (A1).

**Q6. Are there chances missed when using other policy instruments?**
New buildings in Christchurch are an opportunity to build as promised. Buzzwords such as sustainability have been used, but it would be interesting to see it been applied (P1).
Implementation

**Q1. Which concrete urban climate adaptation measures are currently implementing or have been implemented in your city?**

Councils are using materials that hold less heat, such as permeable paving, and alternative approaches to stormwater (P1). Detailed maps look at the extent of future sea level rise and vulnerable areas. Christchurch City Council (CCC) has undertaken revegetation and restoration of sand dunes along the coast, wetland rehabilitation and establishment of new ones, including providing reserve areas for flood events (G1), and provisions of coastal habitats for species adaptation to climate change (G2).

Development in low lying or beachfront areas at risk of flooding have been restricted, plans for natural barriers were implemented (A1), and managed retreat is starting to be considered (G3, P3). Wellington incorporates wind reduction in urban design, and is increasing surfaces’ permeability through water sensitive urban design and planting native vegetation (P4).

**Q2. What are the strengths and weaknesses of these mentioned urban climate measures?**

**Strengths:** Concrete measures have been undertaken and there has been a move from debating whether climate change was occurring to looking at responses (P4, G1). Christchurch is part of the 100 Resilient Cities Program, which requires measurements of carbon footprint, goals and targets, and reports on mitigation and adaptation to climate change responses. There are also partnerships looking at climate change impacts on health (G1).

**Weaknesses:** Sea level rise takes all attention, but is countered by vertical land movement in New Zealand, particularly in earthquake-prone areas. "Measuring sea level rise in the New Zealand context is tricky because the dominant feature is more the rate of land uplifting or lowering", and it can challenge the need to make decisions about sea level rise due to climate change (A1).

**Q3. Are there conflicts between aesthetics and these mentioned urban climate adaptation measures?**

Conflicts identified by interviewees regard specific outcomes that clients want (P1), as sustainable design is not considered 'cool' enough (A2), but others said there is no conflict, as the ‘aesthetics of sustainability’ has become trendy (P3). Existing conflicts were also
identified regarding whether there is a business case for climate adaptation measures, as sometimes it is seen as luxury (G3). In this context, positive outcomes were achieved from restoring or creating artificial dunes promoting a natural character (A1). There is also acceptance of solar panels, however there would probably be opposition to extensive solar farms as they may interfere with the overall city atmosphere (G2).

**Q4. Are there conflicts between urban functions and these mentioned urban climate adaptation measures?**

Conflicts pointed out by interviewees regard the easiness of applying these measures in comprehensive redevelopment or in new developments. However, change should be also happening in dense and well-established areas (P3). Other conflicts regard the use of new materials requiring complex techniques for implementation (P1), green roofs use and their potential loadings and costs, associated to existing ground space in New Zealand, as opposed to Europe (A2). There have been initiatives to increase bicycle lanes by removing car parking along roads, which generated differing views within community (G3).

**Q5. Are there chances missed when implementing these mentioned urban climate adaptation measures?**

Urban climate adaptation needs to be included in financial planning, and if citizens push for adaptation measures it may force government budgets to incorporate it (P4). But citizens want to buy properties right beside the sea and in flood plains and councils do not want to fight. People still want to live by the sea and they do not expect the sea level will rise or that New Zealand should do anything or agree to reduce GHG (A3). Statutory and enforceable policies are needed to deal with this situation (P1).

In summary, results of this study show that awareness exist but urban climate adaptation is not a priority. Communication is successful through community engagement and consultation, but there is a need for more campaigns and education. Instruments exist, but they are not statutory, and there is a need for more extensive and clearer regulation. Overall, measures in response to climate adaptation were implemented, but they are largely related to coastal areas and do not directly relate to urban climate adaptation. The only exception is Wellington and its endeavours to minimise wind tunnels.
**Discussion and conclusion**

This study aimed at investigating how New Zealand is responding to climate change through planning and design, particularly concerning urban climate. While the small number of interviewees is a limitation of this project, it generated new information and useful insights into the research questions.

Urban climate conditions are not seen as a problem in New Zealand and therefore they are not made priority. This has been highlighted by the apparent lack of urban climate experts in the country. The local temperate maritime climate conditions, in a country where urban settlements are largely low density mean UHI is not major issue. The main problem identified was the discomfort generated by the wind, but this is not seen as something that can be changed or is related to climate change. However, it is likely that in the future damage caused by climate can be frequent and intense.

The challenges identified by the RSNZ (2016) as the main threats to New Zealand largely relate to water, which is understandable considering the geographical condition of the country. In this context, urban climate has not been identified as a major concern, being this a gap mentioned as a pressing issue, as climate change will affect cities where most population live (Adger *et al.*, 2013).

Because urban climate is not priority, existing policies are not regulatory, meaning it lacks enforcement of measures to be adopted in city design. Moreover, there seems to be a need for disruption to happen before action is taken, and due to the earthquakes, Christchurch, in many cases, has been mentioned as an example, including citizens expectation of seeing it as a world-class example of a prosperous economy operating under a low carbon environment.

Finally, there is space for the Christchurch example to be extended and to focus and promote better and resilient cities through design and regulatory planning. In the case of climate change, as in many others, "prevention is better than cure" (G1), as we are likely to experience changes greater than we can adapt to.

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Using Climatic Maps to Assess the Development of Shenzhen International Low-carbon Eco-city

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Using Climatic Maps to Assess the Development of Shenzhen International Low-carbon Eco-city

ABSTRACT: In order to achieve the goal of sustainable development, Shenzhen is considering building an international low-carbon eco-city in the Pingdi area, in which the climatic issue has to be taken into account. A key step is to use urban climatic analysis maps to aid planners in focusing on urban thermal comfort and energy saving when planning the design of Shenzhen International Low-carbon Eco-city (SILE). Climatic analysis maps can demonstrate the area’s thermal characteristics, which will also be included into the planning process. It is believed that urban climatic maps are feasible tools to make a correct decision corresponding to current micro climatic situations. In this study, climatic analysis maps synthesized urban morphology, geographic topology and wind condition within the urban canopy layer that are made to present thermal effects of the present SILE. An environmental response to various urban morphologies based on wind and thermal loads was explored in climatic environmental evaluation in order to decrease anthropogenic heat release and air ventilation at the pedestrian level. It was expected that, through this study, the designing process could be monitored somehow to achieve the goal of ecological development.

Keywords: Climatic map; Evaluation; Planning recommendation; Shenzhen low-carbon eco-city

1 Introduction

1.1 Shenzhen International Low-carbon Eco-city

Shenzhen International Low-carbon Eco-city (SILE) is a redeveloping program of the Pingdi District, which aims at introducing low-carbon concepts and ecologically developing technologies adopted when re-forging the Pingdi District to attract worldwide manufacturers of low-carbon products. In response to energy crisis and global warming, Chinese urbanization has to proceed along a sustainable path where low-carbon and ecological issues are crucial. Therefore, the Shenzhen City Council has decided to reshape the Pingdi District as a low-carbon ecological developing model for the whole country. The SILE project aims to integrate low-carbon emission industrial enterprises with low-carbon living and supporting services. After it’s established, the SILE will be a research center for talented people working on low-carbon issues and a community to support sustainable life styles.

The SILE is located on the border of the cities of Shenzhen and Huizhou. At present, the Area is 53.4 square kilometers, with a population of 250,000, scattered in nine administration
districts of thirteen blocks. The SILE site is currently underdeveloped with only a few furniture manufacturing plants and low-density residential buildings. The northern part of the site is screened by a large range of hills, while the southern part is rimmed by the Longgang River. And the Dingshan River and Huangsha River run across the whole site from north to south. The site is obviously characterized by a rather favorable natural landscape. In addition to its geographic topography, the site is also located in the axis running northeast from Shenzhen to Huizhou, which is expected to be an economic belt from Hong Kong and Shenzhen to the middle northeastern part of Guangdong Province. The whole SILE area is shown in Figure 1.

Figure 1: The SILE site (the satellite images were obtained from Google satellite maps)

In order to achieve a low-carbon development, an urban morphology in compliance with the physical environment and energy-saving purposes is needed in which the micro-scale climate in the area has been taken into account. Over the last 40 years, urban climatic map (UCMap) studies have sprung up at the planning stage of a city’s development (Baumüller, 2006). It is necessary for the SILE project to use UCMap to provide feasible guidelines in
creating an environmental-friendly and well-off social circumstance for the low-carbon, ecologically-sound and sustainable development. Therefore, in this study, UCMaps were made for the SILE considering parameters such as urban land use, building volume, ground coverage, nature landscape, and opening status, along with thermal loads and dynamic potential in terms of winds. Furthermore, suggestions for realizing low-carbon and ecological development were given to the SILE planning with respect to urban climatic issues. Eventually, the study can serve as a reference to urban designers and planners during decision-making in order to achieve the project’s low-carbon development.

1.2 UCMap studies

The speeding-up urbanization is gradually changing the urban physical environment, especially the urban canopy layer. In this layer, as a result of the large amount of buildings, the climatic conditions are very different from the rural and wilderness areas, which are largely related to the community health within the urban context. Buildings in cities are mostly constructed with manmade materials that have a higher thermal capacity and can store a lot of heat during the daytime. But, at night, the stored heat cannot be released because buildings block the urban skyline, causing the elevation of urban temperature. There is then a need to connect urban climatology with morphology, in which an UCMap methodology is proposed to aid urban designers and planners via translating the climatic knowledge into planning languages (Baumüller & Reuter, 1999). The UCMap is a tool to present climatic phenomena in two-dimension maps. Prof. Knoch first proposed it for planning purpose of fitting micro-scale climatic changing issues (Knoch, 1963). Nowadays, more than fifteen countries have implemented UCMaps in the planning practice in response to climatic changes, such as air pollution caused by weak wind conditions and the heat island effect (Ren, Ng & Katzschner, 2011).

Many UCMap studies have focused on low and medium density cities in Europe, South American countries or Japan until Prof Ng conducted UCMap studies in Hong Kong (Ng, 2009a). The Hong Kong works linked urban climatic conditions with urban morphology and planning parameters, which did not just rely on land use information as typical low and medium city studies does. For all the UCMap studies, a typical map structure contains a series
of basic input layers derived from climatic elements, geographic terrain information and planning parameters and two outcomes, that is, climatic analysis maps and recommendation with planning instructions. A difference between the Hong Kong UCMap studies and others is that more detailed building information, such as building volume and ground coverage, has been taken into account. Moreover, the Hong Kong UCMaps consist of thermal comfort, which is more closely related to the dynamic potential and thermal load of a built environment. Typically, urban area gains more heat than it loses, resulting in the heat island. With tall buildings and high-roughness grounds, wind flows through an urban area more slowly, weakening the effects of air ventilation and heat island mitigation. Therefore, the Hong Kong UCMap study synthesized topography, wind condition, land use and detailed urban morphology factors, and translated them into eight PET categories to draw up the climatic maps. As Shenzhen’s situation is similar to that of Hong Kong, UCMaps for the SILE will adopt the Hong Kong UCMap study method in accordance with the particular local circumstances.

2 Material and method

The foundation of urban environmental climate map compilation is data collection and arrangement. The detailed data plays a decisive role in the preparation of the results. Data collection includes three aspects: land use data, topographic data and building information data. The data of land use and building information in Shenzhen(2009) are selected in this paper. Topographic data is from geospatial data cloud(http://www.gscloud.cn/). The 3 dimensional spatial information of SILE site(Figure 2) is drawn by using all above datas.

Figure 2: 3 dimensional spatial information of SILE site
Evaluation of UCMaps is mainly based on GIS platform. Calculated the weight of each influence factor in each cell (100m*100m), then superimposed the influence factors to get the thermal load and Dynamic potential analyses. The method of compiling UCmaps is shown in Figure 3.

Figure 3: The working process of the UC-AnMap of SILE site

3 Climatic analysis map

A purpose of this study is to constitute UCMaps for the SILE project through identifying climatic problems and giving planning guidelines in terms of thermal sensitive issues. Moreover, the study result is expected to provide planning criteria corresponding to climatic changes in terms of urban settings. As wind and heat island play a key role in urban thermal problems, and were mostly concerned in the Hong Kong UCMAP studies, the thermal load and potential dynamic of the UCMAP were particularly analyzed in the SILE UCMAP studies. In this study, values were given to compile maps which had been calibrated based on field measurement.

3.1. Thermal load analysis maps

Thermal is an important issue impacting urban heat island that is essential to the thermal comfort. In thermal load analyses, many factors are correlated including geographic terrain,
greenery, land-use and building density. In this study, the factors affecting thermal load were identified using Physiological Equivalent Temperature (PET), a thermal index describing thermal comfort, as a reference. The Hong Kong UCMaps study found that 1 UCMap class difference equals 1°C of PET value (Ng, 2009a). In this study, UCMaps were made based on the SILE site’s current situations to provide recommendations for the planning process.

Corresponding to thermal load, different PETs were calibrated and classified in accordance with the above factors. In terms of building volume, the Sky Visible Factor (SVF) was used, where six values referring to PET were given to present building volume’s contribution to urban thermal load. In terms of geographic altitude, research found that, when the height increases 100m, the temperature drops by 0.6°C (Oke, 1981). Therefore, four values were given based on altitude variations, including -3 (>400), -2 (200-400), -1(50-200) and 0 (0-50).

In terms of green coverage, previous studies showed that, compared with non-green-covered areas, a 100m² green covered area with water-bodies can reduce the ambient temperature by 1°C. Then two values were given to greenery in reference to PET, which were, respectively, -1 for green covered areas and 0 for non-green-covered areas.
In total, regarding geographic and planning parameters, three factors, namely building volume, altitude, and greenery, were addressed and synthesized to draw the thermal load analysis map as shown in Figure 4. It can be seen that, with a large value of altitude and greenery, a small thermal load value is present, indicating the benefit of reducing thermal load, whereas the building volume is the opposite. This implies that larger developed areas will add more thermal loads, except when bigger green coverage exists or in a higher-altitude place. According to analysis on the UCMaps of thermal load of SILE, a value from -1 to 5 can be seen as suggesting that the present developed area contributes too much to thermal load and that more attention has to be paid to this during the planning process.

3.2. Dynamic potential analyses

In addition to thermal load, dynamic potential regarding wind and air pollution is another key issue needed to be addressed in UCMaps study. As ground coverage, nature landscape, and opening situation are known to interfere with wind performance (Ng, 2009b), the study then took ground covering percentage, landscape feature, and opening factors into account when making dynamic potential analysis maps. In terms of ground coverage, three values from -2 to 0 were given to identify three different ground covering percentages that were 0-30, 30-50, >50. In terms of nature landscape, two categories are usually made: grass area and the rest. Therefore, two values that refer to PET were given to nature landscape, where -1 is for grass area and 0 for the others. In terms of opening factors, three aspects had to be taken into account, namely, water body, public open spaces like squares and parks, and earth slope status. Three values that also refer to PET were given to water body based on the distance of an area from a water body, where -2 is for 0-70m, -1 for 70-140m, and 0 for >140. Similar to nature landscape, two values referring to PET were given to the public space status based on whether it is open, where -1 is for the open space and 0 for a non-open one. Also two values were given to the earth slope status regarding whether a slope would influence wind flow, where -1 is for an area influenced by wind flow due to proximity to a slope, whereas 0 for the opposite. These three factors can comprehensively illustrate of the impact of opening status on wind performance, as shown in Figure 5.
In total, UCMaps of dynamic potential analysis were formulated based on ground covering percentage, nature landscape, and opening status, as shown in Figure 6. The map shows that dynamic potential area for wind flow has less ground coverage, more nature landscape and plenty of opening spaces. A map designed for dynamic potential analysis using six values referring to PET from -5 to 0 is present to identify wind flowing possibility in the current SILE site. The smaller the number is, the larger dynamic potential it has, with -5 being the best dynamic potential and 0 the worst. Therefore, it can be seen that regions with more grass and opening spaces and less ground areas are better for wind flowing.
4 Climatic recommendation maps

In order to use UCMap analysis results to give recommendations to the design of SILE planning in terms of micro-climatic issues, an overall climatic analysis map was developed based on thermal load and dynamic potential analysis maps. Furthermore, suggestions for the SILE planning were given to assist urban planners and designers during decision-making, taking into account climatic issues on a micro scale during the planning process.

4.1 Climatic analysis map for SILE

In order to formulate climatic analysis map for the SILE project, a map structure proven feasible in the Hong Kong UCMap study was applied. A grid calculation was made to define the area’s climatic changing situations by using thermal load and dynamic potential parameters, which also contributed to the formulation of a climatic analysis map defined as ten plus thermal load value times 100, plus ten plus dynamic potential value. After calculation, forty-six numbers were obtained, which could be classified into eight categories if the nine thermal load values and six dynamic potential values were divided into three interconnected classes. Based on these eight categories, climatic analysis map for the SILE could be illustrated to show climatic conditions around spatial distribution, as can be seen in Figure 5.
Figure 7 presents climatic distribution of SILE corresponding to thermal load and dynamic potential for wind flowing aspects while considering factors such as building volume, geographic altitude, nature landscape, ground and grass covering, and opening status. Category 1 stands for the best areas and 8 for the worst ones in terms of thermal comfort in a micro-scale urban climatic environment. From the map, it can be seen that the developed areas fall in categories 8 to 6, and un-developed areas with surrounding hills, rivers and green parks fall in categories 1 to 4.

4.2 Suggestions for SILE planning

To apply the SILE UCMap to the planning process, eight present categories with different colours in the map had to be transformed into climatic classes. As these categories were formulated by PET value variations combining climatic elements, geographic terrain and greenery information, and planning parameter considerations, they were transformed into eight climatic classes indicating impacts on thermal comfort from moderate to very strong extents. Specifically, class 1 stands for moderately negative thermal load and good dynamic potential, 2 for slightly negative thermal load and good dynamic potential, 3 for low thermal load and some dynamic potential, 4 for some thermal load and some dynamic potential, 5 for
moderately high thermal load and low dynamic potential, 7 for high thermal load and low dynamic potential, and 8 for very high thermal load and low dynamic potential, which is the same as the Hong Kong UCMaps. According to the climatic classification, Class 3 is relative to 28 of the PET value, indicating a thermally comfortable limitation, while classes above have better thermal comfort performance and those below have worse performance.

Regarding the climatic classes, five climatic areas can be recommended. Area one corresponds to Class 1 & 2, indicating somewhere with highly favorable climatic feature; area two to Class 3 & 4, showing a moderate climatic value potential; areas three, four, and five to Class 5, 6, 7 and 8, respectively, referring to climatic areas with different degrees of sensitivity. Corresponding to five climatic recommendation areas, five approaches of improvement have been proposed that should be adopted in the SILE planning process. They are: climatic protection approach, protection and renovating approach, renovating approach, suggested renovating approach, and mandatory renovating approach. According to five approaches, the areas surrounding the present developed areas should be protected as along with several open pitches inside them. In Figure 6, it is worth noting that the three corridors along the rivers belong to Classes 1-3, which also need to be protected. Moreover, other corridors formed along the main transportation roads belong to Classes 5-6, as shown in Figure 5.

**5 Conclusion**

In order to provide thermal comfort and reduce climatic and environmental changes for the SILE, this paper studied UCMaps using methodologies derived from the Hong Kong UCMap studies. Corresponding to climatic and geographic information and planning parameters, the SILE UCMaps were made using building volume, geographic altitude, green coverage, ground and grass coverage, water body, nature landscape, and open space factors, in conjunction with thermal load and dynamic potential aspects. Based on the analyses of UCMaps, five climatic recommendation areas were identified and approaches of improvement were given accordingly. Eventually, guidelines to urban planning of the SILE have been promoted in terms of micro-climatic issues via applying these approaches to different recommendation areas. Although the UCMap study for the SILE can provide suggestions for
urban planners and designers in response to micro-climatic changes, the class-defining criterion in regard to various factors needs to be refined based on different situations, where methods of the Hong Kong UCMap studies should be verified, which will be studied in detail in future works.

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References


Planning as an Entrepreneurial Method: 
A Comparative Study on Superblocks in Contemporary China and Colonial Australia

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ABSTRACT: This paper examines the characteristics of planning as an entrepreneurial method and its corresponding effects on urban form as a subsequent evolutionary pattern. Largely stemming from a monopoly on land ownership and principles of economic pursuit, planning as an entrepreneurial method has the following features: it is (1) driven by economic benefits; (2) led by a dominant authority; and (3) performed as a large-scale development. As a consequence of the features, planning as an entrepreneurial method has had a huge influence on urban form in contemporary China and colonial Melbourne. By comparing the corresponding effects of a monopoly on land ownership and principles of economic pursuit on superblocks in two cities in two different periods - contemporary Shenzhen and colonial Melbourne - the hidden complexity behind urban form will be unveiled. The authors argue that an informed understanding of superblocks in contemporary Chinese cities and colonial Australian cities cannot neglect the roles of planning as an entrepreneurial method in reforming urban form and in constructing the built environment. Furthermore, urban life that has been shaped, inspired, or implied by urban blocks will also be analysed. It is our hope that the findings of this study will not only lay a foundation for researching cities with different cultural and political backgrounds planned using a superblock pattern, but also contribute to revising the future planning of superblocks for new urban areas and the reconstruction of existing urban areas in contemporary cities.

Keywords: Urban planning; Superblock; Contemporary Shenzhen; Colonial Melbourne; Entrepreneurial method

Introduction

There is a famous Chinese saying that “urban planning is the continuation and concretisation of national economic planning” (Tang, 2000). Because the transitional economy in China has been characterised by its dynamism, Chinese cities, which have primarily served as political and administrative centres throughout the Socialist period of China, became centres of economy when the government’s attention changed to economic efficiency (Fei, 1986).

The institutional innovation of land systems has created a new planning method with entrepreneurial characteristics that has strongly accelerated economic growth and urban development in China. This planning as an entrepreneurial method has played a role in
directing urban development in contemporary China. “Planning” in this paper not only indicates spatial planning, but also includes socio-economic planning. Largely stemming from a monopoly on land ownership and principles of economic pursuit, planning as an entrepreneurial method has the following features: it is (1) driven by economic benefits; (2) led by a dominant authority; and (3) performed as a large-scale development. However, rapid urban development inevitably triggers many severe urban problems. As urban blocks are fundamental elements in the whole planning process, the issue of urban blocks, especially superblocks, is a severe problem in China.

**What is planning as an entrepreneurial method?**

Firstly, we need to understand the entrepreneurial method. Due to a state monopoly on land ownership and principles of economic pursuit, urban planning in contemporary China has been treated as an “entrepreneurial method”. As a result, urban form in contemporary China has been drastically changed and constantly remodelled. This change has not only had a profound impact on the micro-structure of urban space and urban layout, but also affected the macro-structure of the urban planning mechanism. Macrosopes should thus be applied when considering analytical land ownership and thinking based on economic principles. In short, due to a monopoly on land ownership and principles of economic pursuit, it can be concluded that planning as an entrepreneurial method in contemporary China is: (1) driven by economic benefits; (2) led by a dominant authority; and (3) performed as a large-scale development.

1) *Driven by economic benefits*

In the early 1980s, urban development in China was modified from a tool of political propaganda to a tool for promoting economic benefits. In terms of the urban planning method, economic efficiency and economic benefits are often treated as priorities in regional development (Zhai and Ng, 2009, Chen et al., 2010). In order to provide sufficient financial support for urban development, the current land leasing system was introduced by the central government in 1988. This land reform generated great land
revenue for local governments to improve their infrastructure and competitiveness (Zhao, 2014). With ongoing urban land reform that allows land financialisation and rent capitalisation based on property-led development, urban form began to differentiate, causing a huge urban reconstruction. Therefore, land is not only a resource of cities, but also their capital and assets. Objectively speaking, the legacy of a monopoly on land ownership from socialist China has provided an important environment for rapid urban development and a social economy in contemporary China.

2) Led by a dominant authority

In the early 1980s, soon after the implementation of reform and opening-up policy, urban planning in China was a top-down model launched and led by the government, and was also called “urban development from above”. Urban development is normally a long process, but urban development in contemporary China tends to take place relatively quickly because there is only one predominant and powerful authority. Consequently, governmental willing is adulterated in urban form. There is a serious gap in the opinion of the general public and the government because the general public does not take part in any judgement when it came to urban planning (Qiu, 2002). In short, planning is an intentional process driven by the government.

3) Performed as a large-scale development

“Large-scale” development started as the “grand urban planning of the metropolises”, occurring in most metropolitan cities and provincial capital cities in China, and quickly spreading to a large number of middle-sized and small-sized cities. The number of proposals for “creating a cosmopolitan city” (Yulin, 2015) rose to 182 in 2003, while the number was 78 in 1998. In order to attract more investment, some politicians suggested creating a city two to four times larger than its current population and industrial planning size. Along with proposals for “creating a cosmopolitan city”, there was a rapid emergence of urban superblocks, vehicle-scaled avenues, big interchanges, large lawns and huge squares. When it expressed in terms of urban form, it could be
said that the city continued to expand outwards like a pie. In short, large-scale development consists of uncontrolled urban spreading (Qiu, 2010).

Thus, it can be seen that urban planning in contemporary China is an entrepreneurial method possessing the three features mentioned above. Similar to China, the planning method in the colonial period of Australia was also an “entrepreneurial method” with the same features. Because the United Kingdom intended to expand its markets and political power through the colonisation of new territories, Australia would become a significant destination for immigration. However, civil settlements were not allowed to commence before the Australian colonial governments generally prepared town planning during the eighteenth and nineteenth centuries. As a result, the majority of colonial cities were located and laid out by colonial governments, and unplanned or private settlements were relatively rare. Once Australia had been declared open for settlement by the British, Australian colonial governments were encouraged to grant or sell land plots to migrants. As scholars claimed, land settlement in Australia generally followed the same process: land was first claimed by the Crown and surveyed by the colonial authorities, and then granted, sold or leased to settlers (Siksna, 2006).

To conclude, because colonial cities were new creations from the era of colonialism and merchant capitalism (Proudfoot, 1996, Statham, 1990), the planning method in colonial Australia was not only a means of land financialisation via property-led development, but also a method of urban replication on a large scale. The three features of the entrepreneurial method, “driven by economic benefits”, “led by a dominant authority” and “performed as a large-scale development”, were also displayed and implemented in colonial planning. Thus, two typical cities from different locations and time periods - contemporary Shenzhen and colonial Melbourne – are selected as case studies.

**What has given rise to planning as an entrepreneurial method?**

A monopoly on land ownership and principles of economic pursuit can lead to planning as an entrepreneurial method.
Land is a fundamental building block of urban development. The form of a city’s urban development is greatly influenced by its land ownership and land development, which in turn are influenced by its socio-economic and political structures (Yeh and Wu, 1996). In short, land ownership plays a core supporting role in urbanisation. Due to the special political system and historical background of China, land in China is publicly owned. Similar to China, land in colonial Australia was at first all state-owned as a result of British colonisation.

Economic pursuit in contemporary China started with the revision of the Constitution in 1988. Since then, land has become a sought-after production factor, as it has obtained a market price, and can be sold, rented, or mortgaged. As local governments are responsible for their own expenditure on infrastructure and public services, the sale of land-use rights enabled local governments to gain more funding. It is clear that land revenue has gradually become the easiest and fastest way to increase local GDP and raise government revenue in China (Ding, 2007). In other words, because of principles of economic pursuit, land financing has become an essential source of government revenue for both ongoing public service provision and future investment in infrastructure (Lin, 2007, Peterson, 2006).

Economic pursuit in colonial Australia started with British colonisation. British settlers occupied aboriginal land for a very low price or even for free. The land was then claimed by the Crown, which had a monopoly on ownership. Later, land was granted, sold or leased to settlers after land surveying had been completed by the colonial authorities. Subsequently, land value was dramatically increased by the provision of infrastructure and public services by the colonial authorities, who intended to create more legal taxpayers with urban assets using a method of land selling. The essence of colonisation was to build a model of land financing as “land acquisition - supplying infrastructure - land re-selling”.

Land financing is, in essence, a source of financing based on property-led development. The typical process of land financing is that local authorities use land as a hostage in order to obtain land revenue from the primary land market. Such a process
successfully formed a huge stock of assets and capital as startup funding for urbanisation in contemporary China and colonial Australia. Land and real estate cannot automatically generate wealth, but possession of land or real estate is a means of sharing land value. Thus, the pursuit of land revenue during the urbanisation process can be explained as an entrepreneurial method, caused by a monopoly on land ownership and principles of economic pursuit.

**Contemporary Shenzhen**

Shenzhen City, situated in the coastal area of south-east China, is one of the five global cities in China, along with Beijing, Hong Kong, Shanghai, and Guangzhou (Chubarov and Brooker, 2013). Having been transformed from a tiny rural town into a giant modernised metropolis, Shenzhen is one of the earliest and most successful test sites of urbanisation, having experienced astounding growth as a result of the reforming of the urban economy and having attracted investment through the application of the entrepreneurial planning method. The specificity of Shenzhen’s urban development over the first 20 years offers a way of viewing this iterative and heuristic process of planning as an entrepreneurial method (Ng and Tang, 2004).

Shenzhen City was first designated and benefited from the implementation of several important government policies concerning its economic development in the 1980s by the Chinese Central Government as the first step towards the opening policy to resolve socioeconomic issues in an era of rapid urbanisation (Chen et al., 2014). Before 1979, the area of the city proper covered only three square kilometres, with a population of 23,000 inhabitants and a building floor area of 290,000 square metres (Sun, 1991). As a result of a scarcity of almost all facilities, Shenzhen City needed significant physical urban construction. Following the application of the entrepreneurial method, Shenzhen City grew to cover 327.5 square kilometres (49 km by 7 km). Furthermore, Shenzhen’s population increased by 23 times, its GDP by 724 times, its fixed capital investment by 488 times, the gross output value of its industry by 3,014 times, and imports and exports by 3,918 times from 1980 to 2001 (Ng and Tang, 2004).
Shenzhen is also the place where the first land auction took place in China in 1987. Driven by economic benefits, the fundamental purpose of establishing Shenzhen City was to attract investment in a major way by stipulating a special preferential policy. Indeed, the linear grid plan of Shenzhen is designed based on the entrepreneurial method in its organisation of the flow of capital. With maximum utilisation of land as a hostage to attract investment in order to create a booming GDP and to build urban infrastructure, Shenzhen City continued to experience a high rate of economic growth in the 1990s.

The characteristics of “driven by economic benefits”, “led by a dominant authority” and “performed as a large-scale development” have also appeared in Shenzhen. Superblocks in Shenzhen are valued for their efficiency when it comes to planning and land transaction. The Shenzhen Urban Planning and Land Administration Bureau was formed in 1989, combining planning, land administration, and housing development and management functions under the same roof. At the same time, the amount of land allocated for various uses increased dramatically, reflecting the large-scale development inherent in the entrepreneurial method. For example, 145,000 square metres of land was developed by Shenzhen Industrial Development Company as one piece in the 1980s, and allocated land for residential use increased from 22.4 to 35.5 square kilometres between 1996 and 2000 (Ng and Tang, 2004).

To conclude, urban planning in contemporary Shenzhen can be regarded as according to the entrepreneurial method because its essence is land financialisation. It has generally taken place based on the following process:

1. The government proposes the range and index of land sales.
2. The spatial information (topography, urban blocks, buildings) and social information (population structure) of the site are removed.
3. Planning bureaus propose entrepreneurial planning and land division for the site.
4. The government has a monopoly in selling land lots to land developers, and land developers have a monopoly in building and selling housing property to local residents.
5. As a result of the provision of infrastructure and public services, the housing property of local residents appreciates in value, meaning land value increases too.

**Colonial Melbourne**

On the southern edge of the Australian continent, Melbourne was initially established as a straggling colonial outpost. A change happened on March 1837 on this piece of land that the site of Melbourne was confirmed and a land sale was announced by the colonial governor. Then, a predominant standardised rectilinear grid street pattern ignoring the existing private and official huts was aligned along the river by Robert Hoddle, who was put in charge of the land survey (Melbourne, 1987). However, because it was “driven by economic benefits”, colonial planning consisted of little more than a two-dimensional survey of streets and the reservation of strategic allotments for land sales in the early colonial period.

In terms of being “led by a dominant authority”, the first land sales took place in 1837, after the land survey. One hundred half-acre lots (around 2,000 square metres each lot) were auctioned by the colonial government, earning it a total of 3,842 pounds. By November 1837, the sale of 195 allotments had brought in 11,500 pounds. Because surrounding areas were converted from rural land to suburban land, the land value appreciated, as owners of allotments were automatically entitled to use the infrastructure and public services provided by the colonial government. For example, three lots bought for 136 pounds by Charles Ebden were sold for over 10,000 pounds in September 1839, and Fawkner sold a lot originally worth 32 pounds for 6,000 pounds in 1840. Thus, the process of colonial planning in Australia can be described as consisting of land first being claimed by the Crown, then surveyed by the colonial authorities, and then granted, sold or leased to settlers (Siksna, 2006).

This early colonial planning in Melbourne not only raised government revenue as a result of an increasing number of allotments being put up for sale, but also bought opportunities and order to the colony. Indeed, the population grew from 600 in 1841 to
20,500 in 1850 (Tout-Smith, 2008). Particularly interesting is the rapid urban development that occurred in the early 1850s as a result of the gold rush and being “driven by economic benefits”. Rapid urban development in Melbourne could be described as being “performed as a large-scale development”. By the mid-1850s, Melbourne became the largest city in Australia and remained so for the next 40 years (Barrett, 1979).

As shown above, planning in colonial Melbourne can be regarded as according to the entrepreneurial method, as it was a gradually strengthened land financialisation. It generally took place based on the following process:

1. The colonial authorities confirmed the site, proclaimed the town, declared ownership, and surveyed the land.
2. The spatial information (topography, existing huts) of the site was ignored and removed.
3. The colonial authorities implemented the entrepreneurial planning method (standardised grid street pattern) and announced a land sale.
4. The colonial authorities had a monopoly in selling land lots to settlers.
5. By providing infrastructure and public services, land value appreciated, meaning land tax also increased.
Superblocks in Shenzhen vs. superblocks in Melbourne

Table 1 Comparisons of contemporary Shenzhen and colonial Melbourne

<table>
<thead>
<tr>
<th>Origin of the metropolises</th>
<th>Shenzhen</th>
<th>Melbourne</th>
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<tbody>
<tr>
<td>Founding year</td>
<td>1980</td>
<td>1837</td>
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<td>Ideology</td>
<td>Economic settlement</td>
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<td>Entrepreneurial method</td>
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<tr>
<td>Characteristics</td>
<td>(1) Driven by economic benefits; (2) Led by a dominant authority; (3) Performed as a large-scale development.</td>
<td>(1) Driven by economic benefits; (2) Led by a dominant authority; (3) Performed as a large-scale development.</td>
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<tr>
<td>Superblocks</td>
<td>Gated communities</td>
<td>Open communities</td>
</tr>
<tr>
<td>Initial block size</td>
<td>A one-square-kilometre superblock system</td>
<td>231 metres×231 metres</td>
</tr>
</tbody>
</table>

Urban Blocks are unavoidable components of the physical structure of urban form in the whole planning process, and those in Australia and China are no exception. Colonial city centres (today’s CBDs) in Australia and newly-built urban districts in Chinese cities are broadly similar to rectilinear superblocks. Thus, superblock size/dimension, superblock form, and newly planned streets/alleys in Australia and China will now be compared.

Previous research (Maitland, 1984, Maitland, 1985, Panerai et al., 1980, Tonuma, 1981) on urban blocks has classified block size as either small (under 10,000 square metres), medium (10,000-20,000 square metres) or large (over 20,000 square metres). Since the length and depth of large blocks often exceeds 200 metres, they normally have adequate space to allow outward frontage to the street and inward frontage to internal malls. However, in “minimal urban structure” theory (Maitland, 1984), there are three types of spacing for urban blocks: spacing of 60-70 metres, spacing of 100 metres, and spacing of 200 metres. Maitland pointed out that 200 metre urban spacing is used for primary pedestrian routes, meaning large blocks with 200 metre spacing are generally considered as very coast meshed and inconvenient for pedestrians.

Urban planning in contemporary Shenzhen, as summarised in the book of Great Leap Forward, is based on several elements: linear infrastructure, zone, and blocks
(Koolhaas et al., 2001). Because the entrepreneurial planning method in contemporary Shenzhen consists of large-scale land parcelling created by linear infrastructure based on land use, superblocks in Shenzhen are simply the colour patches of functional blocks mainly based on benefits and efficiency. For example, Figure 1 shows the masterplan of Shenzhen Bay proposed in March 2014. In this proposal, the average superblock is around 320 metres×370 metres, and the largest superblock is 430 metres×560 metres.

![Figure 1 Masterplan of Shenzhen Bay](image)

Different from superblocks in colonial Melbourne, superblocks in Shenzhen are mostly gated communities. The ideology of the gated superblocks was initially adopted from the self-sufficient working unit (Danwei) in socialist China. A one-square-kilometre superblock system was employed by the local planning authorities in the establishment of Shenzhen (Shane, 2014). Following marketisation, the original residents either moved to better places or were laid-off. Thus, the state-owned company has continuously sold its peripheral land to private land developers to re-build commercial stores, apartments and offices over the years. However, the inner parts of
Shenzhen’s superblocks have become lacking in value as a result of not having direct street access. Under this situation, new roads have been planned as back streets linking the back entrances of plots to become secondary circulation channels for business operations. Superblocks in Shenzhen are thus subdivided into a relatively smaller scale through these newly-planned back streets, though they remain superblocks. A study has shown that the average block size in Shenzhen during its 1990-2014 built area was 35,100 square metres, compared to the 61,700 square metres of the pre-1990 city area (Angel et al., 2016). This illustrates that both ones are large blocks according to previous research on urban blocks (over 20,000 square metres), although superblocks in Shenzhen have been gradually splitting as a result of supplementary planning of back streets, as Figure 2 shows. However, since the back streets are state owned, they are neither well-invested in nor well-developed, although it could be assumed that they would have a large circulating flow and high potential when it comes to commercial value. Nevertheless, the reality of back streets is associated with crowding and unsanitary scenes.

Figure 2 Addition of circulation mesh in Shenzhen 1980s-2010s (Song, 2017)

The initial planning of colonial Melbourne could typify Australian colonial planning, because all urban blocks were divided by the predominant standardised rectilinear grid street pattern. As a result, all urban blocks, with small houses dotted throughout, were standardised at the same size and scale. Since surveyor Hoddle's 1837 street grid made no provision for lanes or alleys, the initial size of the superblock in Melbourne was 231 metres×231 metres.
It was inevitable that allotments being designated for land sales and the occurrence of much speculative property-buying in colonial Melbourne would trigger subdivision of superblocks (Doyle, 2012). By the 1850s, lanes and back alleys had quickly proliferated Melbourne’s superblocks, breaking them into two equal pieces. Thus, the size of the superblock in Melbourne was revised to 126 metres×231 metres. Lanes and back alleys not only promoted the subdivision of superblocks by providing access to new back lots, but also helped to maintain the distinct half-superblock when superblocks were subdivided or amalgamated.

Figure 3 Addition of circulation mesh in Melbourne 1837-1997 (Siksna, 1998)

Melbourne’s superblocks were standardised and unified with the same block size in initial planning. During 200 years of development, Melbourne’s coarse initial superblocks were reduced to a finer circulation mesh by the addition of streets, lanes, alleys and arcades. Urban forms have revised towards a similar pattern of land subdividing and circulation mesh over time. That is to say, superblocks have been
subdivided into orderly patterns of smaller fractional blocks. Furthermore, superblocks in Melbourne have become more adaptable and come to better meet both the past and present requirements of urban planning. A study has found that retail cores in the Melbourne city centre have pedestrian networks with an average spacing of 50 metres to 70 metres (Siksna, 1998). Particularly interesting is that many locally favoured restaurants, cafes and night-life venues are located in the new streets, lanes, alleys, and arcades in Melbourne (As Figure 4 shows).

Figure 4 Street view of the additional lanes and alleys (Hardware Ln) in Melbourne

Discussion

By studying superblocks in contemporary Shenzhen and colonial Melbourne, a clear conclusion can be made that superblocks tend to appear in cities that adopt planning as an entrepreneurial method. With this entrepreneurial method, urban development
possesses the features of being “driven by economic benefits”, “led by a dominant authority” and “performed as a large-scale development”. As a consequence, planning as an entrepreneurial method has a huge influence on urban form, especially in the creation of superblocks.

Initial superblocks in contemporary China and colonial Australia were much larger than 20,000 square metres. However, they have since been considerably adjusted by the addition of extra streets, lanes and alleys to create smaller blocks and a finer circulation mesh. Melbourne’s superblocks of over 20,000 square metres, for example, have been broken down into smaller blocks or sub-blocks ranging between 3,600 and 20,000 square metres, a more acceptable size for general urban functioning. By contrast, superblocks in Shenzhen are still too large, with the average block size of 35,100 square metres in Shenzhen’s built area between 1990 and 2014. One thing should be mentioned that although superblocks in Shenzhen have been gradually split into smaller sub-blocks as a result of additional planning of back streets, most residential sub-blocks are gated communities, which is considered as a major difference between two cities in splitting superblocks.

There has been a clear trend in favour of large-scale blocks being broken down into smaller blocks and sub-blocks in the evolution of superblocks. It has also been illustrated that small-scale blocks work better than large-scale blocks because a finer circulation mesh is created. A circulation mesh with street spacing of around 110 metres and urban blocks of between 3,600 to 20,000 square metres can constitute an optimum urban network for both pedestrian and vehicular movement (Siksna, 1998).

**Conclusion**

This study revealed the features of planning as an entrepreneurial method, and its crucial and predictable effects on the subsequent evolutionary patterns of superblocks. The main finding of this study contributes to its comparative nature. The authors argue that an informed understanding of superblocks cannot neglect the role of planning as an entrepreneurial method in reforming urban form and in constructing the built
environment. This study could be a forerunner in urban research covering similar or different superblocks in different cities, especially cities with different cultural and political backgrounds planned using a superblock pattern.

Another related finding of this study would be the simulation of future planning/evolution on superblocks in contemporary cities. It is my considered expectation that if certain block sizes and forms have functioned well and produced positive effects in the past, they will work similarly well in other cases with similar backgrounds and conditions, such as in colonial Australian cities, contemporary Chinese cities and in other cities that use planning as an entrepreneurial method worldwide. The recognition of optimum block sizes and forms is recommended to be used as a model for the planning of new urban areas, as well as for reconstructing existing urban areas.

Bibliography


1 ABSTRACT

“Why as a competent Architect/Planner would you involve local residents in the planning and design, let alone the building, of a future project?” A question often heard and referenced in contemporary texts. The answer may seem obvious to some but is commonly misunderstood or neglected.

A glib answer is “well if people are involved then they will respect the outcome more and look after it”. But there are so many unknowns in this... What constitutes being Involved?

The work we have been doing over the last 20+ years has used a methodology wherein people who are directly impacted by the development become “partners in development” but in addition many stakeholders are embraced in order to contribute to the development process ensuring a broad portfolio of ideas, needs, feedback and opportunities are considered. Of particular importance in this is the Communication Loop that is developed and managed with all contributors and stakeholders. This methodology is termed as a “Multi-faceted Approach to the Project Development Process” or in other places as “Human Centred Design” or as a “Participatory Involvement Approach”. It is also similar to a project development process described as “Integral Development”.

“The word “Integral” means comprehensive, inclusive, non-marginalizing, embracing, integral approaches to any field attempt to be exactly that to include as many perspectives, styles and methodologies as possible within a coherent view of the topic. In a certain sense integral approaches are meta-paradigms or ways to draw together an already existing number of separate paradigms into an inter related network of approaches that are mutually enriching” – Ken Wilber.

A Multi-Faceted Approach is described in this paper outlining its relevance to all projects no matter who the client might be and where the project might be located, using a recent project in Doomadgee North Queensland as a case study, outlining the process and challenges experienced during the project development process.

1 Marcus Miessen -
2 Ken Wilber -
2 INTRODUCTION

The main title of the paper “Disruption as a Methodology not a Consequence” refers to two scenarios. Firstly, the often experienced “Consequence” of projects being disrupted or stalled by protests, objections, rallies, demonstrations and sometimes legal challenges; often arising from perceived and/or actual lack of consultation, negotiation or communication. Secondly the value in devising a project development methodology and framework that incorporates a comprehensive engagement strategy to embrace those who are; directly and indirectly impacted by a proposed project, as well as those involved in the funding, management and approval of a project.

Jane Jacobs states interalia:

“Cities have the capability of providing something for everybody, only because, and only when, they are created by everybody.” – Jane Jacobs, The Death and Life of Great American Cities

The implications of such a statement [and many like it advocating Human Centred Design, Participatory Design and Integrated Design] are far reaching especially if this resonates as a fundamental requirement of one’s project delivery methodology – as is the case with our firm PM+D Architects Geoff Barker - about which this paper explores.

Conversely Marcus Miessen has stated that “Why as a competent Architect/Planner would you involve local residents in the planning and design, let alone the building, of a future project? The answer may seem obvious to some, but the practice is commonly avoided, misunderstood or neglected. A simple linear or cyclical view of a project’s development is common and generally accepted:

Community and other interests can be engaged as partners right through this life cycle.
The steps of this process are not being contested here apart from suggesting that many of the considerations and tasks that make up the scope of these stages take place concurrently, especially in the early stages. It is suggested from experience that it is in the detail of what takes place within each “stage” of the Cycle and how its “Context”, and external factors, might impact on those stages, and any proposed step from one stage to the next, that is of interest and importance.

3 RESEARCH

The first essential step in any project development process is a period of research and investigations during which the objectives, setting and potential of a project to deliver desired outcomes and outputs are assessed and how these might be achieved. The first part of this research period is to compile a comprehensive portfolio of information and ensure there is an understanding of the Context within which the project is located.

The Project Context

Every Project has a broad multifaceted context within which it is located. The Context can be portrayed as nine key areas of investigation, research, consultation, consideration, negotiation and resolution, as shown below:

While they are shown as discrete areas, in reality it is more complex and they in fact overlap and are intertwined, often presenting conflicting material with which to be dealt.

The above diagram represents the starting point for working on a “Multi-faceted Project Development Process” [MFPDP] where people and the context within which the project is located are the “givens” with existing locality features, socio-cultural and physical connections,

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6 Further details pertaining to this Diagram and the Areas are contained in a separate Paper: Barker. G, 2009, Considering the Complexities of a Project’s Context
and its form and structure providing the setting for a development process to be determined that will be implemented by a team that not only delivers a project that meets basic needs but also potentially satisfies additional community benefits. It should be noted that while the framework is the same no matter where and what the project might be, the detailed project development process and its participants need to be tailored to suit each project.

The focus of the Research step can be seen as reconciling the ideas, requirements, opportunities and constraints identified within the project brief with the actual needs and requirements of people and interests, as well as determining what the project might deliver and how it needs to meet specific outcomes and objectives – in the case to be considered in this paper the users [the people who will live in the houses] and their needs. [Noting especially that external interests expect value for money and practical results, not fanciful excesses.]

4 PLANNING – THE PROJECT TEAM

The Context is a complex array of consideration areas not all of which are the province of the architectural professional, and depending upon the scale and complexity of a project, this work cannot generally be performed by a single person but will require contributions from a vast array of people and interests; especially if the project has been established, or has the potential, to achieve a range of disparate objectives.

There will of course be professional consultants from various disciplines being engaged, depending upon the type, size and complexity of the project, but there are many “interests” [stakeholders] who hold information, skills, knowledge and authority [concerning formal decisions] that will arise during any project delivery process who, experience suggests, also need to have input. In the early stages of a project this conventionally will involve the client and funding agency, and potentially end users, who need to be encouraged to contribute to the gathering of information and material relevant to the project’s advancement. How all this is made to come together is a challenge but an Architect with a broad skill base is seen as an ideal facilitator, ensuring the contributions of a diverse range of expertise and interests are engaged to deliver a comprehensive portfolio of information appropriate to the planning and other steps in the process of delivering a successful project.

There are two extreme views about the roles of the community and other interests and how they should or could perform in such teams in the delivery of projects into the community, and there are proponents of both extreme views:

1. The first extreme is discussed by Markus Miessen who encourages designers to be adventurous and challenge CURRENT PRAXIS and use their creative expertise to deliver innovations and challenge rule makers and inspire directions for the future. The designer is dominant, has the experience, knows best and with good research can deliver a physical environment that not only suits people but can achieve a myriad of other objectives. In his book The Nightmare of Participation “ he advocates designers become crossbench practitioners, ‘uninvited outsiders’ who actively seek out conflict...” (Wired Website Review) and not be like politicians and bureaucrats hiding behind the mediocrity that inevitably comes from the public running the show. In other words zero Community Input.
2. The second centres around the people in the community, knowing what works for them, needing to be engaged as the leaders in a project to ensure it meets their needs. Community determine and manage the project.

In between these two extremes there is a continuum of positions as to who, how many and how the “community” might be involved. The MFPDP used by PM+D Architects Within this continuum involving government agencies, approval agencies, funding providers and other interests, is seen as fundamental to getting the most out of projects. This is not an abrogation of responsibility by the professional specialist but recognition that the team needs to work WITH regulators, regulations, controls, laws and bureaucratic processes; without limiting what negotiations might take place to advance the project. How this “involvement” is established and managed is an important consideration and decision. The opportunities and benefits of working collaboratively with all interests are significant but to ensure potential is delivered from the opportunities there are 5 important principles that underlay a workable collaborative structure:

1. Develop and share knowledge and understanding about the project context its location and the project’s formal requirements – constraints and opportunities
2. Question and interrogate project and its potential
3. Maintain open and honest dealings – which can lead to trust and a higher level of relationships
4. Listen to take notice and implement appropriately, respect cultural parameters and maintain effective communication channels – not just meetings or public notices
5. Regularly review and assess progress with all collaborators and act to make change where necessary

In other places similar principles underpin what is known as Integral Development or Integrated Development:

"The word integral means comprehensive, inclusive, non-marginalizing, encompassing. Integral approaches to any field attempt to be exactly that: to include as many perspectives, styles, and methodologies as possible within a coherent view of the topic. In a certain sense, integral approaches are “meta-paradigms,” or ways to draw together an already existing number of separate paradigms into an interrelated network of approaches that are mutually enriching”

~ Ken Wilber

Such Principles underpinned the formation of the collaborative working relationship with Doomadgee Aboriginal Shire Council [DASC] with whom we worked on a 3 year housing program funded by the Federal Government [National Partnership Agreement on Indigenous Housing - NPARIH] through the Queensland Department of Housing [QDoH] and Building and Asset Services [BAS] and importantly included Century Mines as a private commercial entity committed to supporting the training of local residents in key trade areas [utilising an Indigenous Training organisation to manage the training component]. All key contributors played essential parts in seeing the project through to completion, achieving; the planning and design of a range of houses, the construction of a Subdivision, the construction of 20 Houses, the employment of in excess of 30 people at a rate of around 30% of the total labour force, utilising local businesses
as suppliers and trades, and the training of 12 men [3 of whom have graduated as tradesmen - 2 carpenters and 1 plumber].

5 PLANNING - SETTING PRIORITIES

There are many questions that need to be asked and answered, relating to the priorities to be given to certain aspects of the project, before any decision is made on what form of program might be implemented, especially for projects involving the delivery of housing and infrastructure into remote and regional areas:

- Is equity important?
- Is safety important?
- Is environment important?
- Is heritage protection important?
- Is Employment and workforce development important?
- Is quality important?
- Is local business involvement important?
- Is sustainability important?
- Is appropriateness for location important?
- Are capital costs and/ or whole of life costs important?
- Are client objectives important? (Government policy)
- Are user’s needs important/ the people important?
- Is flexibility important?
- Is time important?
- Is local capacity important?
- Is ongoing management important?
- Is compliance with legislation, standards, codes and guidelines important?
- Are risks important?
- Is more housing important?

Obviously in order to answer these questions a deal of information and understanding of each area is required. These are typically covered during early engagement interactions with Client, Users, Funders and approval agencies. In addition, there is the potential to include a broader range of objectives specifically attuned to the context of the project and beyond the formal requirements of a Brief. For example, it might include:

- Socio-Cultural outcomes
- Employment and Workforce development [including Training]
- Support for local economy
- Achieve Broad community acceptance
- Buildability – locally relevant construction method and materials
- Sensitive to Heritage
- Include challenges to exceed common contracting standards – SUCH AS
  - Safety
  - Environment
o Timeliness
o Quality – minimising defects at source AND
o Innovation

• Include challenges to consider long term outcomes not just short term – so consider
  o Sustainability – robust, energy efficient, water efficient and efficient waste management
  o Maintainability
  o Management efficiencies
  o Whole of life evaluations

• Agree a price and share Risks

Such issues, questions and opportunities formed part of the early negotiations with the interests engaged on the Doomadgee project development process and were ultimately included in designs, drawings and support documentation submitted to agencies for consideration and approval.

6 CASE STUDY - DOOMADGEE HOUSING PROJECT

DASC were adamant that they wanted a Housing Project where they could not only build their houses but also plan and design how they might be developed. Conditional approval of such a program was eventually given with a range of conditions and guidelines to be satisfied. From the beginning the agencies were invited as collaborators on the project as it was a first new attempt to support a community organisation to plan, design and build their own houses.

From the early research and investigations, and discussions with the key agencies, around their requirements, a detailed Project Proposal was put to QDoH for consideration and approval, including compliance with; funding arrangements, design standards, materials and scope turnout.

The design of the houses started with interviews and meetings at the Council Level followed by household visits with residents and housing management personnel. These visits investigated what residents believed worked and didn’t work in a range of existing house types and sizes, covering; materials, health hardware, room dimensions, house layout appropriate to cultural requirements, fitout, accessibility, energy usage, water usage, function status, repairs and maintenance regime and occupancy arrangements for single and multi-generational families.

From the interviews an iterative process of design was carried out over three-month period incorporating appropriate QDoH design guideline requirements, and requests for variation where the guidelines were unable to accommodate the local needs or considered too restrictive.

4 designs were eventually submitted for approval. 2 Bedroom dwelling, 3-bedroom dwelling with adaptable Bathroom and second toilet and shower, 4-bedroom dwelling with adaptable bathroom and second toilet and shower and a duplex made up of 2x2 bedroom dwellings.
The design incorporates a toilet that is directly accessible from the covered and screened “Patio”. This was a particular requirement of the Community that was debated at length with the DoH and finally agreed to on the basis of cultural parameters rather than blindly accepting a design guideline. It is noted that the toilet is screened from distant view although it is directly outside a regularly used external living space.

The 3 Bedroom dwelling incorporates two showers [one over a bath, that was specifically requested by women for bathing children] and two toilets. The provision of this high standard of functional amenity was specifically requested to accommodate the cultural parameters that impact on the living patterns of residents.

The living spaces are the same for each house type but in the latest iteration of the houses the 4 Bedroom house has had a small modification gleaned from feedback and requests from existing and prospective residents.

A concrete path encircles the house under the eaves and end awnings, so enabling people to move from one area to another around the outside of the house without venturing across the garden or rough surfaces. This is considered a Universal Design feature that will also benefit external movement during the Wet Season without needing to venture into the rain.

Some of the criteria prioritised in the development of these designs includes the following:
1. Keep the floor footprint similar amongst the four different house types so that the trainees can become experienced in the set out. Each of the House types has the same width and similar functional layout so that all materials, structural elements [such as trusses and roof], Windows and Doors, and fitout elements become standard.
2. Utilise a limited suite of windows and doors to maximise standard componentry
3. All doors to be 920mm wide to effect universal accessibility
4. Utilise factory made joinery in flat packs that can be assembled on site
5. Universal access on approach, entry and within the residence to meet minimum standard of accessibility.
6. One bathroom fully accessible with secondary facilities adaptable, depending upon size of the house.
7. Large bedrooms to accommodate desired family structures and arrangements
8. Low maintenance materials, fixtures, fittings and finishes so the dwellings are easily and effectively maintained at a local level
9. Steel trusses to be standardised so that they can be made on site by skilled local Welder
10. Robust and strong materials to withstand high winds
11. Fire safety an important factor so there is at least one fire escape through a main window at the sleeping end of the house.
12. Heavily insulated roof and ceiling to effect a higher level of comfort than in existing dwellings.
13. Wide insulated eaves to protect the walls of the house from excessive sun exposure
14. Awnings to ends of dwelling to afford additional shade
15. More than one external living space to accommodate different living and use patterns at different times of the day and year.
16. Hot water service to deliver hot water on demand and all year round required a Heat Pump unit

The compilation of these priorities was effected with the support and high level contribution of Council, Community and external stakeholders.

2 Bedroom Duplex Pair showing gap in dividing wall between Breezeways.
The duplex caused considerable angst as it was designed to provide a flexible arrangement where two related families could have separate residences with separate legal occupancy but with a connected veranda. If there were two unrelated families, then the connection could be closed off with a fire rated wall. Only one of this type has been built at this stage.

The program has now entered its 4th round and some minor changes to the designs have been made to accommodate feedback from residents, QDoH/BAS, as well as local housing management staff.

But of significance is that the community has built their own dwellings over a 3-year period using local labour, to a higher rate than previous external contractors, trained 3 men who are now qualified tradesmen and completed the dwellings to designs that they developed.

This particular example has a step at the front main veranda so limiting accessibility. Provision is made within the Housing Management Office to request for the addition of a small ramp to facilitate access if and when required.

Collaboration incorporating consultation and cooperation take many forms. In this case the uncertainty and debate around the community building their own houses as well as some debate over the appropriateness of some of the design guidelines compared to the needs and requirements of local residents were able to be handled in a professional and logical way because there were strong relationships with the local Councillors and community who took the responsibility to argue their case combined with the early buy-in by the agencies involved. This produced workable outcomes, was valuable and saved an enormous amount of wasted time, effort and dollars.

In the case of this Doomadgee project the community involvement has produced outcomes particularly attuned to the needs of people while still achieving the objectives of the program and fitting within the parameters prescribed by the Brief. Such a result would not have been possible without the direct involvement of the agencies as collaborators and the Council and local community people as PARTNERS IN THE PROJECT rather than being MERELY RECIPIENTS of it!
7 OUTCOMES AND BENEFITS

So, what are some of the outcomes and benefits enjoyed by this and many other projects.

- Appropriate physical Housing and Infrastructure is delivered on time and within Budget
- Employment and training is delivered as requested
- Potential for enhancing the local community in terms of real socio-economic and environmental benefits
- Positive impact on local community from workers and team being integrated into it and vice versa.
- Familiarity of people with the project and its delivery such that when the project is completed there will be a wide range of local people with knowledge that can contribute to the ongoing management and maintenance of the facility [making Handover manuals more relevant when there are workers involved who were engaged on the project].
- Quick responses to issues that impact on the community
- Improved understanding locally of the construction process
- Positive feedback at the end of a project leaving people comfortable with what happened and the results.
- And people become your advocates

While a post occupancy evaluation has not as yet been carried out we look forward to performing that assessment and deriving “lessons Learned” so that future programs might benefit from this special project.

8 CONCLUSION

A well planned and well implemented engagement process enables a wide range of benefits to flow for all involved. However, there are conditions:

1. Integrity of the process
2. Skills and experience of the team conducting the process
3. Recognising that the construction phase requires as much support as the planning and design phase.
4. The commitment of the builders to continue the levels of involvement established earlier in the project
5. Relationships require time, energy and commitment to be maintained at a high level

In terms of determining how a broad measure of success might be assessed it is common for a simple Dollar Cost to be correlated with physical deliverables [number of houses and extent of Infrastructure] but to pick up a broader range of benefits and outcomes it might be worth considering measuring the cost of NOT including certain outcomes/objectives – the “Opportunity Costs” – rather than merely focusing on risks and short-term interests.

The words of Marcus Miessen ring true to some extent when we consider how poorly community engagement and consultative design have been managed in past projects delivered into Aboriginal communities in which we have been working with the local people as partners in development. However, our firm advocates that skilled Architects are the right people to work
collaboratively with community as partners in development and equally have the skills to work with like-minded and motivated people in the delivery of multifaceted successful projects into communities, ensuring there is innovation and disruption, as a methodology, incorporated into a project scope. This then has the potential to deliver a broad range of outcomes and benefits that accrue to the users and community and NOT be an example of a project where the participants hide behind bureaucracy as a justification of mediocrity.

Geoff Barker – PM+D Architects P/L

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Attachment “A”

A list of some of the relevant *sub-areas* within each of the Context Areas is listed below:

<table>
<thead>
<tr>
<th>No</th>
<th>Context Area</th>
<th>Sub Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>Conditions, Remoteness, Reputation</td>
</tr>
<tr>
<td>1</td>
<td>Physical</td>
<td>Local and Surrounding Buildings, Engineering Services, Infrastructure</td>
</tr>
<tr>
<td>2</td>
<td>Political</td>
<td>Imperatives, Policies, Programs, Regulations and Processes of three levels of Government, Land Tenure.</td>
</tr>
<tr>
<td>3</td>
<td>Economic</td>
<td>Circumstances [how much In/Out], Ownership, Resources, Funding, Budget, Businesses, Jobs and Employment,</td>
</tr>
<tr>
<td>4</td>
<td>Cultural</td>
<td>Sacred Sites, Cultural Practices, Priorities, Beliefs, Organisation, Belonging, Stories, Sites of Significance, Demographics</td>
</tr>
<tr>
<td>5</td>
<td>Environmental</td>
<td>Natural Fauna and Flora, Climate, Soils, Resources, topography,</td>
</tr>
<tr>
<td>6</td>
<td>Management</td>
<td>Brief governing the project scope, Governance, Finances, Structure, Resources, Programs</td>
</tr>
<tr>
<td>7</td>
<td>Social</td>
<td>Demographics, Health, Education and Recreation Support Services, Facilities and Networks for both sexes - Children, Youth, Adolescents, Seniors, Aged, Infirm, Disabled - Professional Support</td>
</tr>
<tr>
<td>8</td>
<td>Historical</td>
<td>Heritage of Place - Natural, Physical, Human – Chronology of place, Recognition, Respect, previous Studies, Reports, Research, Projects that might inform background to new project</td>
</tr>
<tr>
<td>9</td>
<td>Aesthetic</td>
<td>What suits location, Form, Structure, Colour, Texture, Sound, Feeling,</td>
</tr>
</tbody>
</table>
‘Smart’ design interventions – A way to achieve better urban design outcome for Indian cities

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‘Smart’ design interventions – A way to achieve better urban design outcome for Indian cities

ABSTRACT: Town and urban planning in India have its roots from Mohenjo-Daro and Harappan Valley ancient civilizations, with Fatehpur Sikri and Shahjahanabad being earliest examples of planned cities. Post-independence, cities like Chandigarh, Ahmedabad, and Bhubaneshwar were planned as new state capitals. Despite these precedents, urban design in modern India is more an afterthought than a conscious decision for a functional and aesthetic outcome. In this context, the paper analyses one of India’s recent ambitions - to transform one hundred cities across the nation into smart cities by retrofitting existing urban centers across the country, within the next two decades. India’s Smart Cities Mission (SCM) launched in 2015 intends to provide an enforceable mandate to redevelop its existing cities and free them from the shackles of chronic infrastructure deficiencies along with social, environmental and governance issues. The mission document clearly identifies the need for individual city governments to choose a specific area based and pan-city developments, based on self-analysis, consultant recommendations, and public participation. The focus of this paper is therefore to understand the proposals put forth by the first twenty cities selected under SCM and analyze in detail on the importance of urban design related ‘smart’ interventions proposed by various cities, on their journey to become a smart city.

Keywords:
Smart cities mission, India, urban design, city planning

1.0 Introduction:

Though delving into the matter of urban growth projections is a highly clichéd starting point for most contemporary urban studies, it is a stark reality that most cities attract population and grow exponentially over time, as historically well-documented. Yet, as a global community we are still grappling with several concepts that offer to lead us towards a perfect “Utopian City” from the present dystopia, leaving behind several failed cities in terms of planning and infrastructure, lack of social cohesion, achieving a balance with the environment and nature and finally an unfulfilled promise on improved quality of life (a very abstract term). On the other hand, human fascination for science fiction, automation, robotics and other machine-based technology have moved on to proliferate. The exponential growth of smartphone technology and cloud computing, now accessible at a more personal level, has contributed to the sustenance of this technological fascination for humans (Townsend, 2014). Following from
This technological reliance, the current fad is to move away from ‘dumb’ cities and make them ‘smart’, which could facilitate connection and seamless flow between all facets of our lives. Glasmeier & Christopherson (2015) comment on this notion as an evolution from the long-held desire for urban technological utopias and to live in the perfectly competitive city. Smart Cities are recipients of this technology and its applications, for fostering meaningful urban transformation.

Though smart cities movement has gained momentum in many countries across the world, as Parnreiter et al. (2013) points out that studies on urban transformation have been primarily focussing on the ‘big three’ cities of London, New York, and Tokyo. However, studies on South and South-East Asia region along with Latin American and African cities are limited and do not explore the relationship between globalization and its imprints on the respective cities, in-depth. Their study based on Mexico and Johannesburg as samples of Global South emphasized on how the global dynamics driven by the corporate geographies have been having a huge impact on the restructuring of the built environment that has in turn led to a transformation in their local real estate market dynamics.

Given this imbalance in development, Zegras et al., (2015) highlight this issue of how technological innovation developed for prosperous developed countries are light years ahead of the urban population residing in most other countries of the world. They cite the example of non-availability of a transit map in Dhaka, the capital city of Bangladesh, to emphasize this situation. Therefore, this warrants the need for meaningful work in the global south that do not necessarily share similar characteristics to the cities in the global north. Supporting this view is Harris (2015), who notes that this ‘smart city’ proposals in India have not elicited the same kind of response from urban studies practitioners as with studies on North American, European and other East Asian smart cities. There are very few studies that have addressed this critical gap in the literature on the urban design of global south’s smart cities, especially in India. This has resulted in shortcomings in both empirical evidence and from a theoretical perspective, that is required for understanding the phenomenon in these cities.

In this context, this study aims to understand the proposals put forth by the first twenty cities selected under Smart Cities Mission (SCM) of India and analyze in detail on the importance of urban design related ‘smart’ interventions proposed by various cities, on their journey to become a smart city. The key objectives are to i) understand the importance of smart cities mission (SCM) proposal in relation to the urban development standing of Indian cities, ii) to
analyse the proposals submitted by the first twenty Indian cities under SCM and finally iii) to understand the extent of urban design interventions proposed in the submissions. The need for placemaking even in a technology-centric city is discussed to demonstrate its relevance in smart cities. The paper then presents the need for urban design interventions in smart cities, followed by a brief introduction on urban challenges in Indian cities that establishes the premises for the need for urban renewal and a broad outline of the SCM. The proposals by the first twenty cities selected under the mission are studied in detail to infer the results that are further analyzed.

2.0 Sense of place in place of senses:

Batty (1997) predicted two decades ago that by the year 2050 that everything around us will contain some form of computerization and will lead to a ‘Computable City’. Batty’s prognostics has almost come to the realization as places and spaces are increasingly being linked through mobile communications. However the basic need of humans is to belong somewhere and ‘there is no reason to believe that this need will disappear as a result of increased electronic connectivity’ (Mitchell, 1999, p. 73), thereby driving the point that urban design and placemaking will always be relevant even if technological innovation is moving towards the forefront of city planning. Kourtit et al., (2012) expresses how contemporary cities are contradicting this approach by moving away from creating the feeling of ‘sense of place’ towards being ‘place of senses’, facilitated by smart cities. As Hudson-Smith (2014; pg. 123) indicates ‘Smart city is one of a smart citizen and smart design whereby the environment senses, streams and adapts to the data’. The smog of digital data that is being generated by a city is growing multi-fold every day and given that the data is tagged with the location, it could soon be possible to retrieve a real-time view of the city by analyzing the data. The data thus deduced could be highly beneficial for urban designers and planners to plan, predict and propose appropriate design interventions.

More and more cities around the globe have shifted their focus on delivering smart city proposals and moved away from achieving sustainability goals. However, a section of academics claims that these two are interconnected as smart cities share several common principles with sustainable cities (Albino, Berardi, & Dangelico, 2015). As evident, though we can draw parallels between these two city planning goals, there have been not many attempts to identify the crucial differences between these two paradigms. Ahvenniemi et al., (2017) tries to address this lacuna by comparing the city assessment frameworks for both concepts. Sustainability assessment frameworks place more emphasis on measuring environmental
sustainability, which smart city frameworks lack, as they focus more on the social and economic outcomes. The authors observe the gap in smart city frameworks and recommend devising a combined framework that not just concentrates on analyzing the impact of smart solutions but one that would measure the eventual goals of social, economic and environmental sustainability. An urban design framework or a guideline document that could combine both smart and sustainable goals could be the right answer for addressing these shortcomings.

The Urban design framework is a widely adopted strategy by several countries as a means of achieving effective city planning and design outcomes. According to Cowan (2002, p. 12), an Urban design framework is “a document describing and illustrating how planning and design policies and principles should be implemented in an area where there is need to control, guide and promote change”. They are also called by other names such as urban design strategy, planning and urban design framework and area development framework. Urban design, in developed countries, is extensively used for creating a good urban design and is highly relevant in the context of city building, image, and identity. Australia has a nationwide Urban design protocol that is an outcome of collaboration between industry, government, and community. The protocol sets out its ambition as to create livable and sustainable spaces with excellence in urban design (Australian Government, 2011). Similarly, New Zealand has a similar protocol for its cities which cites the 7Cs – Content, Character, Choice, Connection, Creativity, Custodianship and Collaboration, for a good urban outcome (Ministry for the Environment, 2005). Likewise in the United Kingdom, the Commission for Architecture & Built Environment (CABE) prepared a Councillors Guide to Urban Design document (CABE, 2003) as a guide for understanding the fundamental qualities of successful urban places. Though these practices are widely adopted by the developed countries, evolving an urban design framework for smart cities that are based on the premises of sustainability, facilitated by technology, can be a development tool for countries like India, where such practices do not exist.

3.0 Challenges and Constraints in Urban India

The World Urbanisation prospects document by UN states that clear majority of the megacities and large cities are in the global South. The Indian cities of Ahmedabad, Bengaluru, Chennai, and Hyderabad, with a current population of 5-10 million are expected to become megacities by 2030, increasing India’s tally of megacities to seven from the current number three (United Nations, 2014). Likewise, India comes second only to China in terms of large-scale urbanization, with 127 million urban population added in the period between 2000-2014. However, India’s per capita spending on infrastructure is just $17 while China during the same
period had spent $116 per capita (Dobbs & Sankhe, 2010). While most studies estimate current India’s urbanized areas as under 35%, the World Bank reckons that at least 50% of India’s landmass is already urbanized. Given that India’s urban areas classification widely varies from most countries and is considered more stringent, redrawing municipal boundaries along the redefined edges of the larger metropolises is a highly delayed process in Indian cities. However, in recent years India’s policymakers seem to have realized the potential of urbanization on the economic development and urban regeneration (Tewari & Godfrey, 2016). The Indian Government in the last few years has launched a slew of initiatives to promote livability in Indian cities including the 100 Smart Cities Mission, Clean India Mission (Swachh Bharat Abhiyan), 500 Cities Fund, Heritage Cities and other urban-centric infrastructure programs. This large-scale urban intervention is both appropriate and timely, considering the state of stalemate in urban policy decision making in the last several decades.

Batra (2009) reveals that post gaining independence from the colonial powers, India’s urban agenda can be generally divided into three phases- the initial three five-year plans primarily focussed on housing provision, clearing slums and overall rehabilitation. The master plan approach adopted by policymakers resulted in low-density settlements built at huge costs. The following three plans, viz., fourth, fifth and sixth five-year plans took a transitionary stance of redevelopment and up gradation of slums, balancing regional development and small to mid-sized towns along with containing the expansion of metropolitan cities. The subsequent 7th to 11th five-year plans reflected the policy stance of economic liberalization that was instrumental in linking urban growth and its economic development with that of employment opportunities. This was also the time when urban local bodies (ULB) were given more authority and therefore increased accountability that was instrumental in moving towards a market-based financing regime. Despite putting in place a structured planning at the central government level, urban development was slow paced and mired with issues that have left most Indian cities facing several inadequacies even to the current day, some of which is well highlighted by World Economic Forum’s report (Fig. 1).
There are various gaps in achieving sustainable urban development in India. When it comes to urban infrastructure development schemes, such as Jawaharlal Nehru National Urban Renewal Mission (JNNURM), has resulted in non-achievement of key agendas (Kundu, 2014). Lack of devolution of power to the local government, ambiguous regulatory system, and regulation is viewed as a limitation rather than a developmental tool. JNNURM’s lack of achievement as an effective city building program is owing to restricted decision making at the local government level. Additionally, most master plan developments are non-inclusive that rely predominantly on external consulting agencies without ownership by the political powers. Similarly, other issues include lack of integration of utilities like trunk infrastructure and knowledge sharing between different government departments. It is a common sight in most Indian cities to find electrical/ telephone line laying works being carried out on a recently laid new road, leaving behind semi-damaged roads that would be fixed only before the following elections. Given that a holistic approach to planning policy and implementation has been lacking for decades, most cities have also missed out on achieving acceptable urban design outcomes.
4.0 Urban planning and design in Indian Cities:

Town and urban planning in India have its roots from Mohenjo-Daro and Harappa civilization, with Fatehpur Sikri and Shahjahanabad being early examples of planned cities during the Mughal rule (Ansari, 2009). Post-independence, cities like Chandigarh, Ahmedabad, and Bhubaneshwar were planned as new state capitals. Barring these few cases, urban design in Indian cities is more of an afterthought than a conscious decision for a functional and aesthetic outcome. In a telling review of the state of aesthetics in urban spaces, Gupta (2014) criticises that aesthetics in the public realm is the last concern in Indian town planning and sense of design and aesthetics is often limited to just new buildings, that is in turn influenced by individual property developers. Likewise, architect Das (2015) argues that urban planning and design in India is not given due relevance by India’s policymakers, as the core of city building. He insists that people and community should have planning and design as a right. Whilst design suffers, planning is also hampered due to several issues like lack of coordination, vision for long-term growth, policy deadlock and administrative inefficiencies.

While most Indian cities are overcrowded, the land use policies, restrict high-density built-up floor space in the central areas of the cities, becoming a contributing factor for urban sprawl. A common characteristic is the low density in cities regulated by floor space index (FSI) or floor area ratios (FAR) which place a high restriction on the maximum built-up area per plot. FSI’s in Indian cities are generally regarded as very low compared to most economically successful cities in the world. Additional regulations like maximum height specification, plot-coverage restrictions, compulsory setbacks and parking requirements render an overall restrictive approach to urban planning. This place a huge strain on real estate pricing within prime areas of the city thereby pushing market prices. Mumbai stands as an example for this case and is consistently named as one of the most expensive real estate destinations in the world. The lack of affordable low-income housing results in growing slums as real estate prices is high. The lower income and middle income households who wish to own dwellings are pushed further and further away to the periphery of the city, which is devoid of basic urban infrastructure, deficiencies in water supply, sewerage and sanitation, lack of solid waste management facilities and very poor transport connectivity (Tewari & Godfrey, 2016). Policy issues related to one aspect have a compounding effect and impacts several other elements of city planning.
Pethe et al., (2014) states that long-term planning is generally enacted through Master Plans that prescribes the land use of current and envisaged future boundaries of a city. However, city planning in India has traditionally dealt with issues in isolation than a cohesive whole structure, with parts complementing the whole and with each other. Various urban development schemes both at Central and the state level were developed without a long-term vision, that would set the guidelines for the projects. Marudachalam & Jothilakshmy (2010) highlights that the current planning rules are simply two-dimensional zoning plans and needs to move towards performance-based guidelines. They advise that development plans should include – details on public spaces between buildings, integration of a new neighborhood to its urban context, indicate movement pattern, locate street furniture, landscape, lighting etc., and control relationship between built form and public realm. In India’s context, the smart cities mission cannot be implemented without appropriate legislative measures at the city level, that could yield long-term strategic results towards good urban design.

5.0 Smart Cities Mission:

In spite of the rich civilization and history, the inefficiency of the governance systems has led to defalcations in the infrastructure and amenities, thereby indirectly bolstering social inequity which has, in turn, resulted in the impairment of urban India (Nandi & Gamkhar, 2013). In this context, Hoelscher (2016) calls India’s attempt to transform from a rural to urban-based society as one of the most challenging demographic shift ever in human history. He presents an interesting argument on the agenda and policy behind the Smart Cities Mission. The Smart Cities Mission and 500 cities proposals, aim to build upon works carried out under other schemes like Jawaharlal Nehru Urban Renewable Mission (JnNURM), initiated in 2005. Despite the decade-old presence of the JnNURM programme, there has been no comprehensive evaluation of its achievements or its impacts. However, there have been several cases reflecting the lack in implementation capacities at the local government level. Therefore, at this crucial juncture, it will be very expensive for India to continue the journey of unplanned, uncontrolled sprawled urban growth model, not just economically but even socially and environmentally.

Chandrasekar et al., (2016) in their study state that India had followed on the footpaths of China in announcing the smart cities mission. However, China had initiated its move towards informatization from early 2000 and invested heavily in its urban infrastructure, thereby paving for the current smart cities plan to be set up in 317 cities. India, on the other hand, had not done any groundwork before launching the same mission. Bhattacharya et al., (2015) support the
Smart Cities Mission can be used as an opportunity to achieve larger goals that form part of the national development agenda, by addressing various urban challenges. Some of the key areas identified for achieving this include

- Establishing an efficient urban management system – to address the absence of a panoptic monitoring and evaluation platform that tracks changes at the city level, utilizes analytical platforms and measure the performance of projects.
- Capacity building of Urban Institutions and Local Governments - to meet the increasingly high demand of technology-based domain requirements with a specific requirement to city building applications. There is high potential for ULBs, through adequate training to step-up it’s technology and skill set
- Achieving Decentralisation – by creating citizen engagement platforms for city-level projects implementation, by not only using technology but to make institution level changes about decision making.
- Minimising conflicts in urban environment – by establishing essential linkages between different project stages to prevent ad-hoc decision making, that leads to conflicts in urban spaces. A comprehensive decision -support platform could allow cities to be dealt as a system of systems.
- Creating enabling conditions for inclusive and equitable urbanization – by addressing differences in income, opportunity, and quality of life by increasing access to infrastructure, facilities, and information.

Although the original intent publicised in 2014 for smart cities was to build 100 new Greenfield cities, the further announcement of smart cities mission outlined the plan for upgrading existing cities to smart ones. The initial argument was centered on building new cities to cater to the growing population and increased migration to urban areas from rural centers. However, addressing the shortcomings of existing cities is the right priority before building new ones. Therefore, identifying the cities for the implementation stage was a crucial step.

6.0 The city challenge:
First time in the history of city building in India, the smart cities selection process adopted a nationwide ‘city challenge’ that was both impartial and transparent. The Ministry of Urban Development (MoUD) in 2015 invited the state governments, to submit an expression of interest on cities that they propose to develop as smart cities. Further to submission by the 29 Indian states, a total of 98 smart cities were finalized (refer Fig. 2). The state of Uttar Pradesh did not shortlist one city from its allocated number of 13 cities, while Jammu and Kashmir state
did not submit its proposal on time. The next stage involved city challenge wherein the 98 cities submitted detailed smart cities proposal reports that led to the selection of the first set of 20 cities for implementation. The cities had submitted proposals on two levels of development namely, i) area based development – proposal for urban redevelopment with smart city features within an identified city region, ii) pan-city development – smart city proposal for the entire city (Smart Cities Mission, 2017). While the area based development included several elements in terms of urban regeneration and smart city elements, the pan-city development included only one or two proposals.

![Location of 98 smart cities](image)

**Fig. 2: Location of 98 smart cities**

*Source: MoUD (2015)*

### 6.0 Key findings from India’s Smart Cities Mission Document:

Content analysis is a method of qualitative analysis that is defined as “a set of methods for analyzing the symbolic content of any (written) communication. The basic idea is to reduce the total content of a communication to a set of categories that represent some characteristic of research interest”. Although the content analysis is primarily used to analyze the content of novels, newspapers and other forms of media to evaluate the message conveyed, in a planning context, it is also used for evaluating contents of planning codes, zoning codes and other policy
documents (Singleton & Straits, 1999). Therefore, this method was chosen as appropriate for understanding the proposals submitted by different cities.

The study involved analyzing the proposals submitted by the twenty cities that won the city challenge competition (refer Fig. 3). The proposals were analyzed by two segments, area-based development, and pan-city development proposals. The smart city challenge document submitted by the cities followed the format issued by the Ministry of Urban Development. The document contains five sections namely city profile, area-based proposal, pan-city proposal, implementation plan and financial plan. The document was submitted with a set of annexures including conceptual drawings detailing out the various smart city features proposed along with self-assessment forms. The proposal has been prepared with the help of consultants shortlisted by the Ministry and involved citizen engagement facilitated by the respective city level local bodies. The area-based development is the key proposal in the document in which an identified area within a city region was proposed to be developed into a ‘smart area’. Under this head, the proposal outlines the smart characteristics proposed that relate to the urban form. The content analysis was primarily focussed on this section. The pan-city proposal was principally one proposal that was intended for application throughout the city and this segment was also analyzed for its content to get a picture of the various proposals submitted.

![Fig. 3: 20 cities that won the first level city challenge](source: MoUD (2015))
The analysis of the document revealed that the cities had proposed a wide and varied range of proposals that sometimes used different terminologies for communicating the same design intent. For instance, some cities specify cycle sharing facilities while some others specified it as including non-motorised transport feature. Therefore, to arrive at a common platform for comparison, similar features were combined. The Area-based proposal analysis (refer Fig. 4) revealed that many the cities had proposed to improve the public realm of the area by improving public open space provision and use. The next most highly specified proposal was encouraging walkability by improving pedestrian facilities with the proposed area. In many proposals, this was also clubbed with including provisions for a non-motorised form of transport like cycling, providing cycle sharing facilities and e-rickshaws.

![Proposals under Area-based Development submitted by 20 cities](image)

**Fig. 4: Proposals under Area-based development submitted by 20 cities**

It is evident from Fig. 5 that most major percentage of the proposal was related to improving the urban realm with a special focus on open space, walkability, and connectivity. There were very few proposals that spelled out using technology in the smart area development whereas in the pan-city proposal (Fig. 5) use of smart technology is highly intended through smart transit systems, centralized command center and e-governance platforms to name a few.

The other most common proposals included transit-oriented developments (TOD), encouraging mixed-use and density and improving economic activity through tourism and heritage preservation. It is evident from Fig.4 that most major percentage of the proposal was related to
improving the urban realm with a special focus on open space, walkability, and connectivity. There were very few proposals that spelled out using technology in the smart area development whereas in the pan-city proposal (Fig. 5) use of smart technology is highly intended through smart transit systems, centralized command center and e-governance platforms to name a few.

![Proposals under Pan city Development submitted by 20 cities](image)

Fig. 5: Proposals under Pan city development submitted by 20 cities

The Smart Cities Mission and Guideline document produced by the Government of India (Ministry of Urban Development, 2015) clearly adopts a realistic perspective of the smart cities expectations of the participating cities. Instead of aspiring to impersonate the smart city attributes from global cities, the guidelines set down the framework for urban planning development that could use some aspects of ‘smartness’. From the findings of the literature review and the preliminary analysis of the area based smart city proposals of the twenty Indian cities, it is evident that most cities are trying to improve their public realm by improving the open space, green belts, promote mixed use and TOD and encourage walkability and cycling through design. This is in addition to improving the physical infrastructure of the identified area. However, there is a lack of urban design guidelines in achieving these goals. Though it is true that urban design is placed centric, it cannot be denied that an absence of guidelines or a framework could lead to haphazard solutions that do not meet the future requirement of the city and the community at large. Therefore, the study reveals the need to establish an urban design framework that could guide the works undertaken by the smart cities mission.
7.0 Conclusion

Given the near permanency of huge policy decisions on the urban landscape, India’s policymakers have the huge opportunity to make the right decisions in the next 5-15 years, that would benefit the cities for many decades, if not for centuries to come. Global evidence suggests that poor planning that leads to urban sprawl, which is, in turn, increases vehicle-dependency, thereby leading to huge economic, environmental and social costs. Contrastingly, compactly designed, well connected and co-ordinated cities can be productive, resilient, cleaner and safer. Achieving an urban design framework that includes smart city features inherently will be an inevitable step for Indian cities to move forward. The development of this innovative framework will make a real contribution not only to India’s cities but also would serve as a reference document to several cities in the global south.

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Executive summary

If a proposed subdivision of land is consistent with State and local planning strategies and policies, the only controlling consideration is the availability and provision of the necessary infrastructure.

The agency in Western Australia (WA) responsible for approving the subdivision of land is the Western Australian Planning Commission (WAPC). The WAPC has the responsibility of ensuring that all new subdivisional lots are provided with the infrastructure required for them to function effectively within the urban fabric.

Most subdivisional infrastructure is essentially local and is expected to be provided individually by each subdividing landowner within its own subdivision area. However some major infrastructure required at a district or regional level by reason of its reach and expense is ordinarily funded on a shared basis (shared infrastructure, or common infrastructure).

Local governments (LGs) are usually given responsibility for ensuring the provision and funding of shared infrastructure through the subdivision process, the LG being nominated as the supervising agency for the clearing of relevant subdivision conditions. Since the 1960s LGs in WA have adopted two different systems to ensure that subdividers’ contributions to shared infrastructure are made on an equitable and timely basis. A common problem has arisen in both of the systems adopted by LGs, due in each case to:

(a) Pressure by subdividers on the WAPC to approve subdivision prematurely before arrangements for the provision of shared infrastructure are in place; and

(b) Inability of LGs to manage the often very difficult processes of:

- Identification of infrastructure to be provided on a shared basis;

- Settling on accurate costings so as to be able to provide subdividers with accurate estimates of shared infrastructure cost contributions before subdivisional lots have been created and sold, after which time additional costs cannot be passed on to the lot purchasers.

The system LGs used from the mid-1960s to the mid-1990s for sharing of common infrastructure costs, and the replacement system in use from the mid-1990s to the present, have both been
handicapped by a lack of understanding, or an unwillingness to accept, that the establishment of reliable estimates of common infrastructure cost contributions cannot be achieved as quickly as the plans for new subdivisions can be prepared. Subdividers who complete their subdivisions before shared infrastructure costs have been incurred or reliably estimated take a significant risk that their assumed profits from lot sales will be significantly reduced when the full cost of shared infrastructure has been ascertained and contribution obligations have been satisfied.

THE REQUIREMENT OF INFRASTRUCTURE TO SERVICE SUBDIVISION

1 In established urban areas, new or upgraded infrastructure will be required from time to time. Funding for that infrastructure is considered to be the responsibility of government at one or more of the three levels of government:

- Federal Government;
- State Government; or
- Local Government.

2 In development areas evolving from rural to urban use, infrastructure is expected to be funded by one or more of the three levels of government, but additionally there is a significant demand on the developer whose subdivision or development project is imposing the urban structure and the demand for new or extended infrastructure.

Infrastructure demands on developers

3 A developer imposing urban use on a development area may be a major developer of a mining resource; a developer of a major industrial enterprise such as an oil refinery or a natural gas processing plant; or a developer of a major commercial project, such as a strategic regional centre. Developments such as that proceed with their own special funding rules, often after extensive negotiations between the developer and the relevant State and local government agencies. This paper is not concerned with development funding of that kind.

Subdivision funding

4 The developer funding this paper is concerned with is that of the subdivisional developer, whose subdivisional infrastructure falls more or less into two categories:

1) **Shared infrastructure**: The term ‘shared infrastructure’ is used in this paper to refer to major infrastructure required to connect a new subdivision to the regional infrastructure services including:

- The regional road network; and
• Sewerage, drainage, water supply headworks; and
• The power and telecommunications services of the region; and
• Infrastructure to provide regional, recreational and community services; and
• Land for State schools.

In most cases, the benefit of this infrastructure is shared by a number of subdividing developers, who also share in the funding burden.

(2) **Local infrastructure**: The term ‘local infrastructure’ is used in this paper to refer to the infrastructure required to create and service the lots in an individual subdivision, including local roads, local public open space (POS), and reticulation of and connection of subdivisional lots to, the sewerage, drainage, water supply, power and telecommunications services.

**Responsible agency**

5 The WAPC as the agency regulating land subdivision in WA, has the responsibility of ensuring that new lots will not be created and sold to the public unless they are provided with all services which have come to be regarded as essential for urban living. The obligation to fund and provide the subdivisional infrastructure is imposed on the subdivision developer through conditions of subdivision approval. Compliance with the conditions is the price the subdividing developer pays for the approval. The High Court in a WA appeal (**Lloyd v Robinson** (1962) 107 CLR 142) at p.154 stated -

‘... If the [subdivision approval agency] has performed its statutory duty by giving approval to the subdivision subject only to conditions imposed in good faith and not with a view of achieving ends or objects extraneous to the purposes for which the discretion exists, the inescapable effect of the Act is that the landowner must decide for himself whether the right to subdivide will be bought too dearly at the price of complying with the conditions.’

6 There is a limit on the type of conditions that can be validly imposed, expressed in the three principles for validity of conditions identified in the leading case **Newbury District Council v Secretary for the Environment** [1981] AC 578, namely:

(a) A condition must be imposed for a *bona fide* planning purpose;

(b) There must be a connection (nexus) between the development and the condition; and

(c) The condition must be reasonable in the sense derived from the case **Associated Provincial Picture Houses Ltd v Wednesbury Corporation** [1948] 1 KB 223, namely the condition must be within the spectrum of conditions that a planning decision-maker might reasonably impose.
It is the business of the subdivision developer to ensure that the cost of shared and local infrastructure can be met, and the subdivisional lots can be sold, at a level which enables the subdivider to make an acceptable profit. Payment of the shared and local infrastructure costs is entirely a matter between the developer and the lot purchaser, though it is after all the lot purchaser who funds all the shared and local infrastructure required for the individual subdivision. The subdivision developer is merely a conduit passing the costs from the infrastructure provider to the lot purchaser.

The subdivision developer finances the provision of the subdivisional infrastructure, but passes on the whole cost to lot purchasers, who also pay the developer’s profit margin. Although this paper will observe the convenient fiction that it is the subdivision developer who funds the provision of subdivisional infrastructure, it is of course the lot purchaser. In a very real way, the process which has escalated in the last four decades, where government agencies increasingly pass off the cost of regional and other major infrastructure to developers, is a significant cause of the increasing cost of housing, and the tendency to price first home buyers out of the market.

Local infrastructure funding is always treated as the responsibility of the subdivision developer. There is no argument about that and it will no longer be a concern of this paper.

Shared infrastructure funding

Although individual subdividers from time to time mount appeals against conditions relating to the type and level of local infrastructure required in conditions of subdivision approval, the more serious problems regarding infrastructure funding in WA arise in regard to the funding of shared infrastructure. The very broad principle is that the cost of shared infrastructure should be contributed on an equitable basis, partly by new residents through the conduit of developers, and partly by existing residents through LG rates, in each case the contribution to cost being proportional to the contribution of the existing residents and the new residents respectively, to the need for the infrastructure and facilities to be funded.

Contribution to new infrastructure through rates

The contribution by existing residents to new infrastructure through LG rates is a simple and familiar notion. In the Local Government Act 1995 (WA) (LG Act), a LG is given the power to impose a specified area rate\(^2\) within a portion of its district for the purpose of meeting the cost of the provision by the LG of a specific work, service or facility if the LG considers the ratepayers or residents within that area have benefited from or will benefit from, or have access to or will have access to, or have contributed or will contribute to the need for, that work, service or facility\(^3\). A specified area rate would provide the opportunity for a LG to distribute some of the cost of new shared infrastructure to existing residents, though there is a problem for LGs in that a specified area rate presently can only be imposed year by year, and there is a tendency for ratepayers subjected to a specified area rate to elect Councillors who pledge to oppose future impositions of the rate. Commonly the burden

\(^2\) LG Act s.6.37 provides for Specified Area Rates.

\(^3\) LG Act s.6.37.
will then fall on the LG’s ratepayers generally by inclusion of the existing resident portion in the annual budget for the municipal fund.

Though the use of LG rates to cover infrastructure costs is a simple and familiar notion, the difficulty with the notion is in establishing the apportionment of the burden between the existing and new residents, i.e. between rates and Development Contribution Plans. That difficulty is a significant contributor to the current problems of Development Contribution Plans (DCPs) which are at the heart of the issue this paper addresses.

I will come back to DCPs after explaining the methods that can be used for managing contributions to shared infrastructure costs.

Two methods for shared infrastructure cost contributions

There are two methods for collecting shared infrastructure cost contributions from developers, being the Old Method which has been abandoned through disuse, and the Current Method. It will be seen that they function in essentially the same way, but there is a widespread misconception that the current method involves much less delay.

The Old Method

The original or Old Method current from the latter 1960s to the mid-1990s involved the use of single purpose Development Schemes. A Development Scheme:

- Identified the Scheme Area;
- Identified the precise nature and scope of the shared infrastructure works to be carried out to effect the subdivisional development of the Scheme Area, referred to as ‘the Scheme Works’;
- Established with some degree of certainty the costs of the Scheme Works, referred to as ‘the Scheme Costs’; and
- Established the basis for contribution by individual owners to Scheme Costs, referred to as ‘the Scheme Cost Contribution’.

The validity of such a Development Scheme was unsuccessfully challenged in the WA Supreme Court in *Costa & Anor v Shire of Swan* primarily on the basis that the Scheme amounted to a taxing measure without direct statutory authority to impose a tax. The Court did not accept that argument and it was never raised subsequently. Development Schemes continued to be used successfully for another decade and a half. They had the great advantage that they provided certainty to participating owners as to their level of shared cost contribution, because the Scheme wouldn’t be approved by the Minister and published in the Gazette (the processes that gave the Scheme the same force as if enacted in the parent Act) until the Scheme Works had been settled and the Scheme Costs ascertained. But it

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4 The writer presented a paper on that method of infrastructure cost sharing to the International Bar Association’s ‘Infrastructure 96’ Asia Pacific Conference in Auckland in 1996. The paper ‘A Flexible Instrument for Infrastructure Cost Sharing: The Western Australian Solution’, can be provided to any interested enquirer.

was the requirement for that certainty that led to the unpopularity and subsequent decline of Development Schemes, because the achievement of that certainty took time, and sometimes much time, and developers weren’t prepared to wait that long. They wanted to be able to subdivide as soon as they could connect their land to sewerage, water supply and drainage services, and as soon as they prepared a Structure Plan demonstrating the intended subdivision pattern and service connections.

**The Current Method**

17 The Current Method was thought to overcome the delay problem. There are essentially two parts to the Current Method, namely:

(a) The developer prepares a Structure Plan demonstrating how the urban structures are proposed to be established in the developer’s subdivisional area. The Structure Plan must be acceptable to and approved by the WAPC; and

(b) The responsible LG prepares a Development Contribution Plan (DCP) which does the same work as was previously done in a Development Scheme by:

- Identifying the shared infrastructure works required in the Development Area; and
- Establishing with some degree of certainty the Shared Infrastructure Costs; and
- Establishing the basis for owners contributing to the Shared Infrastructure Costs.

18 This new or Current Method appears to overcome the problem of Development Schemes, which was the sometimes long delay in identifying the Scheme Works, establishing the Scheme Costs, and establishing the basis for contributions to the Scheme Costs.

19 But the advantage of the Current Method is illusory, because it may take years, and perhaps many years, for those issues to be resolved for any particular Development Area by the completion and inclusion of a DCP in the local planning scheme of the responsible LG.

20 There is a serious problem due to the fact that developers and the WAPC choose not to recognise that there is a necessary delay between the stages of:

(a) A Structure Plan being prepared for a Development Area; and

(b) The time when it can reasonably be expected that a DCP will be prepared and included in the LPS.

Developers commonly don’t wait for completion of a DCP, and the WAPC commonly is prepared to give premature approval to a subdivision, subject to a condition of subdivision approval requiring the developer to enter into an agreement with the LG to pay the Shared Infrastructure Contribution when the DCP has been finalised.
The fact is that there may be a gap of years between the date when a subdivision can be approved based on an approved Structure Plan, and the date of finalisation of a DCP and its inclusion in the local planning scheme. The delay between subdivision approval and the completion of the DCP can be as much as 10 or 11 years. The developer under the agreement with the LG will pay an Initial Cost Contribution based on a rough guess by the LG as to what the Shared Infrastructure Costs might ultimately be, and covenant to pay an Additional Cost Contribution when the DCP had been finalised. Of course the developer will often have completed the subdivision and sold all lots well before the DCP is finalised, and before it was ascertained that the Additional Cost Contribution may be more than double the Initial Cost Contribution based on the LG’s best guess a decade previously.

The developer in such a case would have sold its subdivisional lots within months of the final subdivision approval, and in fact many lots may have been pre-sold even before endorsement of the WAPC’s approval on a Deposited Plan for the subdivision. Even if the completion of the DCP had only taken two years, it is likely the developer would have had no opportunity to pass on the Additional Cost Contribution to lot purchasers. The difference between two years and 10 or 11 years is for that reason irrelevant.

The problem

The problem has two facets, namely:

(a) The processes for:

- Identifying the precise nature and scope of the shared infrastructure works; and
- Establishing with some precision the estimated shared infrastructure costs; and
- Establishing the cost contributions by individual owners,

are difficult and complex, and in some difficult Development Areas the process will necessarily take a great deal of time.

(b) The second facet of the problem is that developers and the WAPC are not prepared to acknowledge that the DCP processes necessarily take time, and in some cases will take a considerable amount of time.

As a consequence, subdivisions are frequently approved prematurely, and developers and LGs must deal with a bad situation as best they can.

State Planning Policy 3.6 – Development Contributions for Infrastructure

The WAPC on 20 November 2009 published its State Planning Policy 3.6 – Development Contributions for Infrastructure (SPP 3.6). There is an explanation of the principles associated with the preparation and application of DCPs as the WAPC perceives them, in
the INTRODUCTION AND BACKGROUND in Part 2 of SPP 3.6. A careful reading of the following extract from SPP 3.6 should disclose to a perceptive reader the fact that the work expected of a DCP is likely to be complex, difficult, and time-consuming. At p.4690, it is stated -

‘The policy has taken into account the recommendations of the Public Accounts Committee—Inquiry into Developer Contributions for Costs Associated with Land Development (2004). The inquiry, among other things, recommended that local governments should have the capacity to recoup infrastructure costs and that this should be by way of provisions in local planning schemes. Under this policy, local government planning schemes will set out the system of charging through development contribution plans. This provides an equitable system for planning and charging development contributions across defined areas, and provides certainty to developers, infrastructure providers and the community about the charges which apply and how the funds will be spent.

The key principle is that the ‘beneficiary’ pays. Sometimes benefits will be largely confined to the residents of a new development. Sometimes, the benefits will accrue to both existing and new residents. Consistent with this principle, developers will only fund the infrastructure and facilities which are reasonable and necessary for the development and to the extent that the infrastructure and facilities are necessary to service the development. Development contribution plans will, therefore, need to identify growth trends based on service catchment areas, translate these trends into the infrastructure and facilities necessary to meet these increasing needs within the catchment, and allocate the costs of meeting these needs to existing residents and new residents proportional to their contribution to the need for the infrastructure and facilities. This will ensure fairness and equity. It will mean that existing residents through councils and new residents (through developers) will share the burden of the cost of the additional infrastructure and facilities proportional to their need.

A fundamental prerequisite of these plans is that local governments will need to plan ahead. The development contribution plan must have a strategic basis and be linked to the local planning strategy and strategic infrastructure plan and program which identify the infrastructure and facilities required over the next 5-10 years and the cost and revenue sources for the provision of the infrastructure. In this way, those contributing towards the development contribution plan will be assured that the funds will contribute to the local government’s longer term planning and programming of infrastructure in an integrated and coordinated way. ...’

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The complex prescription for Development Contribution Plans

26 It can be seen from the above passage that the WAPC contemplates that the preparation of a DCP by an LG involves a process which has the following potential complications:

(a) **Developers should only be required to fund the infrastructure and facilities which are reasonable and necessary for their developments, and to the extent that the infrastructure and facilities are necessary to service the development.** There can be no doubt that the identification of infrastructure and facilities which are reasonable and necessary for any particular subdivisonal development, and determining the extent that the infrastructure and facilities are necessary to service the development, will commonly involve difficult decisions for the LG to make.

(b) **The need for a DCP to identify growth trends based on service catchment areas.** The identification of growth trends based on service catchment areas is likely to be a complex and demanding task.

(c) **Translating the growth trends into infrastructure and facilities necessary to meet the increasing needs within the catchment** is likely to be a further difficult problem for the LG.

(d) **The next requirement of the policy is for the LG to allocate the costs of meeting the increasing needs within the catchment which must be apportioned between new residents and existing residents proportional to their contribution to the need for the infrastructure and facilities.** Again that is likely to be a complex and demanding issue for the LG.

(e) **The above extract further emphasises the need for LGs to plan ahead.** In real life, a LG commonly will only become aware of a proposed subdivision shortly before, or even after, an application for approval of the subdivision is lodged with the WAPC. In those circumstances it is fanciful to expect that the local government will have had an opportunity to plan ahead for the preparation of a DCP.

(f) **The extract quoted above also emphasises the fact that a DCP must have a strategic basis and be linked to the local planning strategy and strategic infrastructure plan and program which identify the infrastructure and facilities required over the next 5 to 10 years and the cost and revenue sources for the provision of the infrastructure.** Again that is clearly a demanding and time-consuming process for the LG to undertake. To expect that it will be undertaken before the WAPC deals with premature subdivision applications is fanciful, and for the LG to complete the whole process after subdivision application and before endorsement of WAPC approval on a Plan of Survey for the subdivision is an unrealistic expectation in most cases.

27 It is clear from the passage quoted above from SPP 3.6 that the requirements for a LG to responsibly prepare a DCP are such that the process is likely to take a considerable amount
of time, and possibly many years. Since LGs commonly become aware of a proposed subdivision only shortly before, or soon after the application for approval of the subdivision is lodged with the WAPC, it is likely that the preparation of a DCP will follow a considerable time, and quite possibly many years, after the date of the subdivision final approval.

That then identifies the problem with the current method used for apportioning shared infrastructure costs between contributing developers, and collecting contributions from them. The method is commonly associated with the requirement imposed by the WAPC at the time of approving a subdivision, that the subdivider enter into an agreement with the responsible LG for a contribution to shared infrastructure costs to be paid when the LG has finalised its infrastructure cost sharing arrangement, which involves the completion of a DCP, and its incorporation in the LG’s local planning scheme.

This paper elaborates the problem in the WA experience of infrastructure cost sharing arrangements for developers essentially as follows:

1. The Current Method for calculating and collecting developer contributions to shared infrastructure costs is necessarily a time-consuming process. The preparation and inclusion in a local planning scheme of a Development Contribution Plan necessarily takes a considerable amount of time.

2. Notwithstanding the time required for the putting in place of a DCP, subdividers commonly seek subdivision approval as soon as they are in a position to prepare a Structure Plan which elaborates a potential subdivision pattern within the Development Area containing the subdivider’s land.

3. The WAPC is commonly prepared to give premature approval of such subdivisions, relying on a condition of subdivision approval requiring the subdividing developer to enter into an agreement with the LG to pay an appropriate contribution to Shared Infrastructure Costs when the development contribution arrangement (ie. the DCP) has been finalised and included in the LG’s local planning scheme.

4. In such cases there will be a delay between the date of subdivision approval and the date when the LG is able to incorporate a DCP in its local planning scheme. The delay is commonly years, and may be as long as 10 or more years. The WAPC incidentally often exacerbates the problem by the lengthy period of time it takes to satisfy itself as to the appropriateness of a DCP which the LG proposes to include in its scheme.

5. The complaint which developers make about the delay in the finalisation of a DCP is that they are deprived of the opportunity to pass on their shared infrastructure cost contribution under the DCP to the purchasers of subdivisional lots. However that opportunity would be lost even if a DCP was finalised within a year or two after the subdivision approval, as competent subdividers endeavour to sell their subdivisional
lots before or at least within a very short time after the WAPC endorses its approval on a plan of survey for the subdivision.

**Conclusion**

30 The problem with the Current Method of dealing with contributions to shared infrastructure are the same as the problems which brought Development Schemes into disfavour. The difference is that Development Schemes allowed little potential for dispute between the LG and the subdividing owner as to the level of contribution to shared infrastructure costs, whereas the Current Method is almost calculated to cause disputes, and commonly does cause disputes and legal actions. The Current Method further commonly results in the ratepayers of the LG having to bear costs which ought to have been borne initially by the developer of the subdivision, but ordinarily would have been passed on to the purchasers of the subdivisional lots.

Denis McLeod
November 2017
1. Introduction

Western Sydney forms half of the County of Cumberland, defined by a river system, an ocean and the Blue Mountains. It remained isolated from the heart of Sydney due to the city’s centre being formed at the extreme eastern edge of the county and due to the rivers being too shallow for the first fleet to birth at the heart of the region.

2. Barrier to Western Sydney’s Early Development

The ships of the first fleet attempted to sail up the Parramatta River however their keels hit the bed of the river. As a consequence, the first fleet remained at Port Jackson whilst the fleet’s long boats rowed up the three main rivers to establish farms to grow food for the settlers at Sydney cove.
3. Keeping the Colony Fed

The colony’s first farm was established at Parramatta by James Ruse, a convict farmer. By 1828, there were more people living in the river town settlements providing food for the colony which was settled around Sydney Cove.

4. Exporting Agricultural Produce

Sydney’s west therefore played a key role in keeping the new colony fed and financially viable as agricultural produce was exported such as wool from the sheep industry, founded by Captain John Macarthur of the Royal Navy at Camden Park in South West Sydney.

Sydney’s First Railway 1855

This export of agricultural produce prompted the first rail network in 1855 between Parramatta and Sydney to feed the colony and for export from the wharves at Sydney Cove. The rail systems were, for many years, generally not for passengers.
5. Overcrowding of Inner Sydney

Sydney’s population grew around Sydney’s waterfronts where shipping and the export trade, together with warehouses and workers housing predominated. The rail network was extended for passenger use and opened up a number of suburbs at the periphery of the early settlements.

6. The Tram Network

The tram network was commissioned in 1861 and was horse drawn. The next stage was steam trams introduced in 1879 and converted to below surface, cable drawn tram cars in 1886.

Electric power was introduced in 1890 and refined in 1900 to form a comprehensive network within a broad radius of 20kms from Sydney City Centre.
7. The 1909 Royal Commission

The 1909 Royal Commission into the improvement of the City of Sydney and its suburbs, made two significant recommendations:

- To open up Garden Suburbs so as to deconcentrate populations and enable the working class to live like the middle/upper classes and:

- Electrify the rail network to provide an underground loop in the central area. This would allow people to commute from the Garden Suburbs to work rather than having to walk. Progress was slow on these fronts due to the 1914-18 World War and the economic depression of the 1920s-30s.
8. The 1948 County of Cumberland Plan

Western Sydney

In 1947, everything west of Parramatta was considered “rural” and constituted 10% of Sydney’s total population.

The County Plan

It was the first strategy for Sydney, the 1948 County of Cumberland Plan which set the future shape of Sydney, based on the 1944 London Plan, and adopting its “green belt” concept to avoid urban sprawl into the rural lands which made up the bulk of Western Sydney.

This was a good plan but for the wrong city. London at the time and before the war was declining in population, making the ‘green belt’ a valid concept for a no-growth situation.
The District Format

The County Plan divided the Sydney region into “districts” each with a “district” centre as well as “satellite” centres within the greenbelt in the event that additional towns were required beyond the greenbelt. These were at Penrith, St Marys, Blacktown, Riverstone, Windsor, Richmond, Pitt Town, Liverpool, Camden and Campbelltown.

Slum Clearance

The County Plan nominated many of Sydney’s traditional inner suburbs as slums and recommended demolition. Redevelopment was inspired by le Corbusier’s 1925 Voisin Plan for Paris. Luckily, the inner suburbs were saved particularly by European immigrants who considered these as perfectly good family dwellings. After a few years many moved to the outer rural areas, mainly starting market gardens, leaving the inner-city suburbs to the new gentrifiers, the artists, architects and many professionals who embraced inner city living.
**Early Development in The Greenbelt**

Prior to its abandonment, two major suburbs were developed within the greenbelt for public housing. This was due to the lack of large development sites in the then urban areas and the enormous pressure from public housing waiting lists.

The first termed **Green Valley**, just west of Liverpool Centre and renowned for its Radburn configuration in the suburb of Cartwright.

The other was at **Mount Druitt**, between Blacktown and St Mary’s.

**Population Forecast, 20 years’ out**

The County Plan’s population forecast was badly underestimated with the forecast of 2,250,000 people by 1980 being reached in 1961, 20 years earlier due to the commonwealth’s massive migration program and the post-war baby boom. It was obvious that a new plan was required and that the green belt, which made up most of Western Sydney and which contained Sydney’s growth needed to be abandoned and a new plan prepared.
9. The 1968 Sydney Region Outline Plan

A new plan had to address Sydney’s dramatic high population growth. The 1968 Sydney Region Outline Plan (SRP) for 1970-2000 was for a population of 5 million by the turn of the century and this time was based on the Copenhagen Finger Plan, which proposed growth along corridors, their spines being existing or proposed railway lines, the urban forms being a series of new towns like beads on a string, with their centres being at rail stations. The palm of the hand was the established central city.

It was this corridor format which guided the dramatic population growth of Western Sydney from the 1970s to the present day and is expected to be strengthened in the next few decades.

Regional Shopping Centres and Polycentric Sydney

An important policy of SROP was that regional shopping centres, a then recent import from the United States, were to be located at those city centres served by rail, unlike the American examples which were freeway based. This policy was to reinforce the polycentric concept for the Sydney region, the concept being that regional shopping centres would be the foundation of town or district centres.
The Growth Centres

Two of the corridors or sectors as they were called were designated as growth centres by the State and later the Commonwealth under the Whitlam Government’s Growth Centres Act. These were the South West Sector later named the Macarthur Growth Centre and the North-West Sector, which was to be the last of the sectors to be developed due to not being served by rail. Each was for a population of around 500,000 people making these of equal population size as the largest in the world, such as Irvine in California and the Parisian new towns.
10. Western Sydney’s Population Growth

The demand for outer area housing grew dramatically particularly in the more affordable areas as the established inner city suburbs were rapidly gentrifying (and to think they were all recommended for demolition in the 1950s). At the 2016 census, Western Sydney’s population reached 2,158,000 i.e 44.7% of the Sydney region’s population of 4,824,000. With Western Sydney growing at a rate of 2.12% p.a since 2011 compared with the rest of Sydney at 1.72%. The 2036 figures would be 3,283,000 Western Sydney, i.e 46.7% of Sydney’s total of 7,029,000 and when Sydney’s population reaches 8 million, Western Sydney could be 4.5m and the rest of Sydney 3.5m.
11. The Employment Growth Challenge

The Biggest challenge is to match the growing Western Sydney workforce with local employment. Today the gap is around 200,000 resulting in growing road congestion and public transport overcrowding. Over the next few years this gap could widen causing serious worsening of the transport situation, if additional employment is not generated in Western Sydney.

Whilst a considerable amount of employment lands has been zoned particularly the Western Sydney Employment Area, adjacent to the proposed Western Sydney Airport at Badgerys Creek, more industry needs to be established.

Much of Sydney’s traditional inner area employment lands and those on the Parramatta River, have been re-zoned and developed for high density housing with most remaining traditional industries shifting to Western Sydney during the past two or three decades. However, whilst these filled the gap, the number did not match the growth of the Western Sydney Workforce. However, it is not all doom and gloom, there are several opportunities on the horizon.
12. Western Sydney’s Aerotropolis

Sydney’s second airport is now committed and estimated to be completed by 2025, and together with the large amount of surrounding employment lands, is expected to generate considerable number of jobs both within the airport and the much discussed “aerotropolis”. The adjacent diagram shows what an aerotropolis could be. My view is a Western Sydney aerotropolis could emerge as the world’s benchmark due to the considerable greenfield land proposed for employment purposes surrounding the future airport, which allows no limit to the imagination of what an aerotropolis should really look like.

13. Parramatta, Centre of NSW

The most promising opportunity to provide permanent, highly accessible knowledge jobs opportunity for Western Sydney is to establish Parramatta as the State’s administrative centre by locating all State government head offices in Parramatta CBD including the State Parliament House. In other words, the administrative centre of NSW. When I have suggested this in the past, many could not imagine this and when I included Parliament House many laughed. My response is to cite the example of California, with a population of 40 million which is governed from Sacramento, then NSW can be governed from Parramatta.
14. Westmead Health Precinct

Westmead, adjacent to Parramatta Centre and with its own train station is currently the largest Health Precinct in Australia and is about to be substantially expanded. With Health being the fastest growing employment category, Westmead should provide many of the West’s jobs.
15. Western Sydney University

A Western Sydney University (WSU) currently has 41,864 students and a staff of 1,813 and has just opened its high-rise business school in the heart of Parramatta. WSU has campuses in several of Western Sydney’s Polycentric Centres. There is an opportunity to work closely with TAFE colleges to meet the requirements of advanced manufacturing which is currently being seriously discussed by several states including NSW.

16. Western Sydney’s Key Centres

Western Sydney contributes four of its centres to the two highest categories proposed in the current strategy “A Plan for Growing Sydney” i.e Parramatta, one of two CBDS (the other is Sydney) and the only three, occupying the second highest category, Regional City Centre, i.e Campbelltown/Macarthur; Liverpool and Penrith. (I would have added Blacktown).
17. Finalising Western Sydney’s Transport Proposals

The most urgent task for the state government is to finalise the routes and types of public transport to specifically serve Greater Western Sydney’s workforce and students with the necessary public transport links to serve the developing employment nodes. I suggest the priority is Parramatta CBD including from the “upmarket” suburbs of The Hills in the north and Sutherland Shire from the south, the location of current and future “executive housing”.

Transport to Western Sydney Airport

It is also vital to decide on the mode and location of transport to WSA at Badgerys Creek. Heavy rail from Leppington which would also link with Kingsford Smith Airport (KSA) and then north to the Western Line, or, the north west Metro from Rouse Hill to Marsden Park, St Marys and down to the Western Sydney Airport? Then how to link Liverpool, Its true administrative centre, being in its LGA. And of course, how to directly link but public transport with Paramatta, the only CBD in the West and hopefully the administrative centre of NSW.
18. The Greater Sydney Commission and the Three Cities

The most recent influence on Western Sydney has been the establishment of the Greater Sydney Commission (GSC), “an independent agency responsible for leading Metropolitan Planning for Greater Sydney” * Its first regional plan, published in October 2017, was developed in collaboration with a range of state agencies and councils.

The Greater Sydney region Plan to 2056, proposes a Metropolis of three cities, **Eastern Harbour** with **Sydney CBD** as its centre; **Central River City** with **Parramatta CBD** as its centre and **Western Parkland City** with **Western Sydney Airport** and **Badgerys Creek Aerotropolis**, as its centre.

This is a new concept for the Sydney Region and makes sense when considering a population of up to **8 million** by 2056, which when Sydney reaches a population of **9 million**, in say 2066, it could result in a metropolis of three cities each, broadly, with a population of **3 million people**.

*See forward by Chief Commissioner, Lucy Turnbull.*
19. Conclusion

Greater Western Sydney would then emerge as a region with 6 million people with two major regional city centres, each with a different priority. It makes sense, therefore to start planning today for such a vision.

Sydney’s three city centres would each have a different key role in addition to each serving its 3 million community with education, health, shopping and cultural facilities. The City of Sydney would remain as the state’s and perhaps the nation’s financial centre; Parramatta centre would be established as the Administrative Centre of NSW and the aerotropolis could be the focus of advanced engineering and research. Without a clear vision for each city, the various government agencies and the private sector would not have a clear direction as to their future roles.

The biggest task is for the highest level of cooperation and coordination by responsible government agencies and those in the private sector to give their “best to the West”.
Design for Disruption: Creating the Anti-Fragile City

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Design for Disruption: Creating the Anti-fragile City

ABSTRACT: Changes of many different sorts are happening, and some are disrupting current cities. Debbie and Sandy did, but also migration, and the flight of refugees impact the cities we live in. How can these disruptions be counterattacked, while knowing we are not capable preventing the changes to happen.

In this paper the answer to this problem is elaborated. Could we create a city that becomes stronger when a disruption occurs? Anti-fragility is the process of creating something that during the process of threat grows stronger, more resilient and able to become more beautiful than before. Creating anti-fragility therefore requires a design intervention to allow the disruption to occur, but at the same time creates a more interesting and lively city.

The intervention in urban fabric should lead to adaptation. Questions to be investigated here include: To what does the city needs to adapt? What is the trigger for change? And how can the city be changed in the ‘desired’ direction?

The city can be seen as a set of layers. The complexity of understanding all these layers at the same time is difficult hence most people deal with only one layer at a time. To create anti-fragility these layers are deconstructed. Each layer, e.g. energy, climate, food, waste, housing, transport and ecology, is optimally designed for change, or to make change happen. Together they may still divert. Thus, at the local level convergence is required to reassemble the resiliency specifications of all layers into a redesign understanding the inter-linkages, the tipping point and spatial change agents that create an anti-fragile environment.

This new anti-fragile city builds on stronger networks, uses smart technologies and follows adaptive systems rules.

Keywords: anti-fragility; urbanism; complex adaptive systems; disruption; intervention

1. Introduction

In periods of disruption different responses are possible. The most used is the response afterwards. After a disruption has occurred the damage is repaired and the city is rebuild. Another response is to create larger resilience in the city. That is, if a disruption occurs the city is so resilient it can keep its functions and bounces back to its old functionality. A third response is less well researched and used. The concept of anti-fragility, which makes a system stronger under stress, could be beneficial for cities when confronted with future disruptions. In this article this concept is further explored and tested on its usability in
spatial design. After a literature review of current responses to disruptions and complex adaptive systems, the theory of anti-fragility is described. In order to make the theory applicable to the complexity of the city a set of characteristics of anti-fragility are defined to be of use for a deconstructed layer system at the urban region level. Once these are understood, these layers are re-assembled at the local level according a set of criteria for anti-fragility. The lessons learned are then translated in three drivers for the design of the Anti-Fragile city: use of networks, design with adaptive systems and counterintuitive-ity. The theory is then illustrated in three spatial design examples.

2. Problem

The sustainable urban development model is under threat of a range of developments of an economic, social, environmental and spatial nature [EU, 2011, pp. VI], terrorism [Marcuse, 2006; Rossi-Hansberg, 2004] and climate change [Carter et al., 2015; De Sherbinin et al., 2007; Hallegatte et al., 2013] to name a few. While it is common to see disasters as “causes”, and the destruction of the built environment as “effects”, the intricate links between cities and disasters cannot be described by a unidirectional cause-and-effect relationship. The city–disasters nexus is a bidirectional relationship, which constantly shapes, and is shaped by, other processes, such as climate change [Wamsler and Brink, 2016].

The majority of current responses applied in cities focus on protection, safety and security, disaster risk reduction (DRR) and resilience, e.g. the capacity to bounce back after a disruption.

This leads to a controlled but narrow equilibrium. If developments work out a little different than projected the disaster will yet happen in a way the city is not prepared for. Instead the city should enhance its holistic capacity to deal with multiple and different complexities resulting from external disruptions. Or even more interesting, improve in quality whenever an impact occurs.

3. Goal

The objective of design research on disruptions threatening life in cities is to turn the threat into a benefit. How can the city get better using the power the disruption brings with it? The goal therefore is to find mechanisms that increase the quality of the city as result of the disruption occurring.

4. Hypothesis

Application of complex adaptive systems principles in the city supports the development of anti-fragility hence increasing the strength, ability and quality of the city.

5. Literature review
There are three streams of literature to be studied to test the hypothesis. First of all the way cities currently respond in spatial planning to crisis, threats or disruptions should give insights in the state of the art. Especially the responses to climate impacts are investigated here. Secondly, a deeper understanding of how cities work as a complex adaptive system illuminates the mechanisms of city forming hence can be used to define the principles of how to prepare the city to respond. The third body of knowledge is describing the phenomenon of anti-fragility to discover the way to make the city stronger when a disruption occurs.

5.1 Current spatial responses to disruptions

Most of the spatial responses to disruptions fall in two categories. Firstly, the city is defended-safeguarded-prevented, so the disruption does not occur or has as limited impact as possible. The second strategy is to increase the overall resilience of the city, which allows the city to bounce back in the best possible way after a disruption has occurred.

The defensive strategy aims to protect as much assets in the city by keeping the disruption out of the city. No matter whether migrants or floods are discussed, barriers are raised to keep the external impact out of the city. This response is often used in the Netherlands to keep the water out of the hinterland. The level of the dykes is raised and their strengths improved, new dams are created, which close of the dangerous sea from the valuable lives and goods in the city. However, tis equilibrium is set-up for disaster. Every protective shield is eventually not strong enough to withstand the smart, strong or surprising impact on the city. If sea levels rise, the storms accelerate and the tide is high, even the strongest dyke may breech. A defence based on natural principles may be more beneficial [Williams et al., 2016; Narayan et al., 2016; Temmerman et al., 2013].

Similar change can be witnessed in the planning domain. The strict boundaries of regulatory planning are loosened and spatial planning becomes more dominant. At the same time there are alternative scales introduced replacing the formal statutory scales of planning, leading to the emergence of soft spaces and fuzzy boundaries [Allmendinger and Haughton, 2008]. This can be underpinned by the revival of strategic planning for cities, subregions and regions at the end of the 20th century [Albrechts et al., 2003].

The resilience strategy focuses on the city as an ecosystem, which is capable of dealing with shocks and can then return to its original state. In particular planning for climate resilience is used as an entrance to design more sustainable cities, especially because resilience seems to be the remedy to growing uncertainty and unprecedented climatic events [Davoudi, 2012]. The concept of resilience is used to describe how cities and regions could embed security and risk management features into their built environment and governance systems as part of a broader drive towards more safe and sustainable communities [Coaffee and Bosher, 2008]. Measures are taken both to resist disruption as to recover rapidly afterwards [Coaffee, 2008]. The risk society puts more emphasis on anticipatory risk measures to organise society [Adams,
There are strong similarities between (evolutionary) resilience and relational understanding of spatiality, defined by simultaneity and multiple trajectories [Massey, 2005]. Both put emphasis on fluidity, reflexivity, contingency, connectivity, multiplicity and polyvocality [Davoudi and Strange, 2009], the understanding of place as complex interconnected socio-spatial systems with unpredictable feedback processes at multiple scales and timeframes [Davoudi, 2012], and where resilience discourages fixity and rigidity, interpretive planning discourages the 'will to order' [Davoudi, 2011]. Both acknowledge change, inherent uncertainties, the potential for novelty and surprise, and advocate the exploration of the unknown and the search for transformation [Davoudi, 212].

A useful interpretation of resilience for planning is the notion that resilience involved attending to the possibilities of life, not just survival [Leach, 2008], which holds the optimistic alternatives of hope renewal and transformation hence involves ‘bouncing forward’ to adapt, reinvent and innovate [Shaw, 2012]. Resilience could offer the frame for a common language across several sectoral and disciplinary interests and inform high-level strategic agenda’s in a practical way [Wilkinson, 2012]. In this sense resilience is the opposite of risk management. Where risk management aims at conserving the status quo, socio-ecological systems are always in flux and transformative, and risk management aims at identifying sources of risk and devises strategies for their treatment, which is not sufficient in dealing with system changes that occur without any sign of warning or external disturbance [Fuenfgeld and McEvoy, 2012].

Resilience reframes planning and design in three ways [Porter and Davoudi, 2012]:

1. It offers concepts and methods that consider transformation as normal and dynamism as an inherent part of how systems operate
2. An engineering mode of blueprint strategies for systems that are non-linear, complex and intrinsically dynamic are fundamentally futile
3. It brings ecological values to the forefront of planners concerns as it doesn’t decouple social and ecological systems

This thinking is further applied to the spatial planning and design of cities in many different forms. Some develop frameworks for urban climate resilience [Tyler and Moench, 2012; Leichenko, 2011; Hallegatte et al., 2011], use the concept of resilience to adapt to uncertain climate change at a regional scale [Wardekker et al., 2009], planning the resilient city [Jabareen, 2013] and planning for climate adaptation in cities [Hunt and Watkiss, 2011; Wamsler et al., 2013; Hallegatte and Corfee-Morlot, 2011], or use specific climate knowledge in urban planning [Eliasson, 2000; Walsh et al., 2004]. Others build on it to develop concepts
around adaptation planning [Füssel 2007] or spatial planning for climate adaptation [Wilson, 2006], and local planning for climate adaptation [Measham et al., 2011; Sheppard et al., 2011].

### 5.2 Complex Adaptive Systems: principles

Apart from responses to disruptions in the urban realm, cities are seen as complex and adaptive [a.o. Portugali, 2000; 2006]. Complex Adaptive Systems (CAS) are non-linear and perform self-organisation and are studied by many scholars, such as Prigogine and Stengers [1984], Gleick [1987], Lewin [1992], Mitchell Waldrop [1992], Cohen and Stewart [1994], Kauffman [1995], on which basis others further elaborated, e.g. Johnson [2001], Miller and Page [2007], Johnson [2007] and Northrop [2011].

Key concepts from complexity theory are seen as useful in a planning and design context. Amongst these are self-organization, the surge for actors to an attractor and depicting a fitness landscape, the change and transformation of a complex system in times of crisis (adaptive capacity) and the existence of bifurcation (few rules), ‘the point in time where for identical external conditions various possible structures can exist’ [Allen, 1996] and tipping points, ‘the point at which the system ‘flips’ from one state to another’ [Gladwell, 2000].

Adaptation of (or within) the system is an internal process of self-organization, which is the tendency in complex systems to evolve toward order instead of disorder [Kauffman, 1993]. The state of equilibrium is called an attractor. Complex adaptive systems self-organize and adapt in order to remain within their current attractor. The system only shifts to other attractors (alternative states) after a shock that drives the system out of its current state (e.g. due to significant change. Major adjustments are needed and after the shock the system will self-organize to achieve those.

This process can be represented in the form of a fitness landscape [Mitchell Waldrop, 1992; Langton et al., 1992]. This fitness landscape includes favorable (the mountaintops) and less favorable (the valleys) positions. A complex system tends to move, while crossing less favorable valleys, to the highest possible position in the landscape, the attractor. At the mountaintop, the adaptive capacity is highest, which allows the system to adapt more easily to changes in its environment. The pathway the system follows is represented in figure 1. When a system self-organizes it strives to reach a higher adaptive capacity by increasing order. When it reaches the mountaintop (B) it will continue to self-organize with minimum critical specification [Morgan, 1998] and keeps its status of organized chaos [Cruijff, 2011]. However, by increasing order at this stage, adaptive capacity is decreasing, causing a less stable system (the state of fixed and unchangeable regulations and standards) and starts to search for a new attractor. At this stage, the system is crossing the valley (from D to E) and searching for a new attractor, which allows the system to build up renewed adaptive capacity. After reaching point E (a more chaotic state) two things can happen: the system dies away (it didn’t reach the new attractor) or it self-organizes in a renewed way and starts to build up a transformed system by
increasing its order again until it reaches its highest adaptive capacity (the mountaintop) again (B). Point E is defined as the bifurcation point, or: the point where the system fundamentally separates the pathway towards a new equilibrium from the one ending its existence (‘die away’), also known as the tipping point, at which the system ‘flips’ from one state (die away) to another [Gladwell, 2000].

Figure 1. Process of growth and decline of a complex system [after Lietaer and Belgin, 2007]

Concepts such as self-organisation, the sense of wholeness or absence of a central directive [Mitchell Waldrop, 1992] and looking at the system as an organism are all characteristics derived from complexity theory and are used in the planning and design of cities [Roggema, 2012a].

A complex system is fundamentally different from other systems, and needs to be treated that way. The difference between simple, complicated, complex and chaotic systems [Snowden & Boone, 2007] is summarized in figure 2. A complex system, no matter whether it is an organisation, a landscape or the city, clearly distincts itself from complicated, simple or chaotic systems. In complex systems there are unknown unknowns. Because we don’t know what we don’t know, dubbed as ‘deep uncertainty’ [Lempert et al., 2006], flux and unpredictability drive
these systems and patterns are rather to emerge than a solution. There is no right answer for a problem. With these systems in mind the approach focuses on probing, then sensing and responding. The way to do this is to create environments and experiments that allow these patterns to emerge and use methods that can help generate ideas. Unpredictability meets creativity, but this is only possible when there is an open space for generating concepts and ideas. With a transformational purpose in place people will start filling this space with their contributions. This, ongoing, process of creating open space and a transformational purpose increases the adaptive capacity of the system.

Figure 2. Simple, Complicated, Complex, Chaotic [after Snowden and Boone, 2007]

Self-organisation [Kaufmann, 1995; Krugman, 1996], emergence [Goldstein, 1999; Krugman, 1996], absence of a central leader or hierarchy [Mitchell Waldrop, 1992] and a structure that is created by simple rules [Van Ginneken, 2009] are all characteristics of complex adaptive systems hence play an important role in explaining and designing the city organising these successful organisations.

The ability to make internal adjustments in response to, or in anticipation of, external environmental changes, is the essence of being adaptive [Johnson and Gheorghe, 2013]. The capacity of a city to adapt is large when the abovementioned principles of complexity (self-organisation, adaptive capacity, few rules and evolutionary purpose) are used. Adaptive capacity is seen as being highest when the system performs all these parameters successfully. However, every system has the tendency to fall apart eventually. When it starts moving
downward the hill, it will begin to search for a new mountaintop in the fitness landscape. The
easiness to find that new mountaintop is related to the choices made at bifurcation points. If
there is a new attractor, it is easier to choose the pathway towards higher adaptive capacity,
but if there isn’t a new attractor the system will derail and fade away. It is therefore essential
to anticipate or even create these bifurcation points and have a looming attractor in place to
ease the way to higher complexity and keep the system functioning and adaptable.

6. Anti-Fragility: theory

The key characteristics of a complex urban system, including self-organisation, the search for a
new attractor and to mechanism of implementing a design intervention to move the system in
a desired direction all play a crucial role in the concept of anti-fragility. Systems can vary in
their ability to withstand stress events (such as disruptive climate impacts). This ability exists
on a continuum of fragility that ranges from fragile (degrading with stress), to robust
(unchanged by stress), to anti-fragile (improving with stress) [Johnson and Gheorghe, 2013]. An
anti-fragile organization or system gains from uncertainty, randomness and disorder. They
create opportunities to learn from small mistakes, trial-end-error, to deal with new challenges,
to improve and innovate. Anti-fragility means that mistakes have reversible consequences, and
we can learn from them. In this situation there are more upside than downside effects from
random events (non-linear gains), as losses from mistakes are small, while a positive option
can appear that supports development [Platje, 2015].

By defining fragility, robustness and resilience, the difference of anti-fragility can be
illuminated. A fragile object is an object, which perturbations can only harm, damage or break.
Something is robust if events, perturbations, volatility, disorder—that is to say, time—cannot
harm, nor can they benefit it. Every robust thing is robust up to a point but in general almost
nothing can harm a robust object. But also nothing can benefit it. Resilience is the capacity of a
material, or in our case of an object, to absorb a shock without breaking, perhaps deforming
but then rebounding to its previous state or condition. Therefore, in the case of resilience as
well as robustness, the time, though in different ways, ultimately leaves the object or the
system unchanged [Blečić and Cecchini, 2017]. Anti-fragility is beyond resilience or robustness.
The resilient resists shocks and stays the same; the anti-fragile gets better. Some things benefit
from shocks; they thrive and grow when exposed to volatility, randomness, disorder, and
stressors and love adventure, risk, and uncertainty [Taleb, 2012, p21-22]. The city belongs to
the world of anti-fragility. It is a system that has proven through history to be capable to adapt,
self-organise, improve and take advantage of the unpredictable, in short to prosper in disorder
[Blečić and Cecchini, 2017].

7. Application in a complex context: the city
In order to apply anti-fragility to the city, it is useful to look at the characteristics of fragile planning [Blečić and Cecchini, 2017, p.6], as these are the opposite of anti-fragility. Hence the anti-fragile key characteristics are:

1. Global and more abstract predictions about the future. Accurate predictions with highly sensitive parameters make the future prediction fragile as it is very specific. The future is uncertain and a narrow prediction most certainly describes the future in a wrong way. Hence the predictions for future should be kept more abstract and global.

2. Decentralisation/localisation and manage the broad scope and objectives only. Developments at the local urban level determine the greater whole. There is no detailed direction from a higher-level agency other than the general objectives for future development of the entire urban area, such as to become more sustainable, liveable and beautiful.

3. Redundancy in the urban systems, work with only few rules and/or procedures. In the design for the city abundant spaces need to be taken up for unforeseen uses that might occur in the future and are needed as result of sudden climate impacts.

4. Diversification of the urban environment, multi-functionality, mixed use. In order to improve flexibility and adjustability different uses and combinations of uses should be made possible.

5. Increase of complexity in the city and allow for counterintuitive, feedback and autopoietic behaviour. Through an increase of the complexity the urban systems can respond in an adaptive way to unforeseen impacts and conscious interventions, which may be counterintuitive and stimulate feedback loops and autopoietic change.

6. Consensus about the direction of development of the city and its urban elements and systems (in combination with point 2). The major direction the city aims to change needs to be clear and work as a general guideline for change, not as a strict blueprint for future development.

7. Equality and equity; everyone has similar choices and freedom of choice. Places in the city are equally equipped with resources, access to housing, and have similar spatial qualities.

Johnson and Gheorghe [2013] have defined criteria for the anti-fragility of systems. In table 1 these criteria are interpreted into an ‘urban design for climate impacts’-context.

<p>| Table 1. Criteria for anti-fragile urbanism [Based on Johnson and Gheorghe, 2013] |
|-----------------|----------------------------------------------------------------------------------|
| Entropy         | Design a limited number of possible ‘system states’, e.g. a limited number of possible spatial configurations and a limited number of possible mixes of use. |
| Emergence       | Create small-scale spatial elements, public spaces or buildings, which in combination with each other perform better through anticipating future climate events. These |</p>
<table>
<thead>
<tr>
<th>Elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency vs risk</td>
<td>Create a certain amount of redundant space in urban areas, e.g. space that is not used for a particular cause, but can be used when necessary.</td>
</tr>
<tr>
<td>Balancing constraints vs freedom</td>
<td>Design for a stable framework (for instance the networks of ecology, mobility, energy, water and materials) and a free infill (residential, office, agriculture).</td>
</tr>
<tr>
<td>Loose/tight coupling</td>
<td>Loose fit between spatial entities in the urban system. Connections may vanish and rebuild elsewhere to keep the urban systems flexible. Create a lot of back-up connections and make sure every connection has alternatives.</td>
</tr>
<tr>
<td>Requisite variety</td>
<td>Regulators are the spatial nodes where crucial interventions are possible. These nodes determine whether a connection is open(ed) or close(d) and makes sure sufficient alternatives are available.</td>
</tr>
<tr>
<td>Stress starvation</td>
<td>The city should be exposed to regular minor climate impacts as this keeps the functioning of the urban fabric up to date. This way the cities’ public spaces and buildings, and the responses can be tested and rehearsed. In case of failure these can be repaired to keep the system as a whole capable of dealing with major climate events.</td>
</tr>
<tr>
<td>Redundancy</td>
<td>Create extra spaces in the city that can accommodate the impacts of sudden climate events. These extra spaces need to cater for unprecedented events.</td>
</tr>
<tr>
<td>Non-monotonicity</td>
<td>Make continuous adjustments of the spatial lay-out of the city possible on the basis of incoming new knowledge or information. In the city spaces and structures need to be designed to be flexible at all times in order to change function, size or quality whenever necessary.</td>
</tr>
<tr>
<td>Absorption</td>
<td>Create absorption zones in the city that are used to accommodate the impact, and simultaneously use the impact to renew the city starting from these zones.</td>
</tr>
</tbody>
</table>

Interpreting the key anti-fragile characteristics and the criteria in a practical way, the urban complexity is seen as a system of layers, each of which can become anti-fragile. In a way the anti-fragility of every layer makes not only the particular layer stronger under stress, it makes also sure the entire system increases in strength. Examples of urban layers are the energy system, water system mobility system, the ecological or green system, housing, traffic and transport, the social system and the communication network.

Layers can be built up with the characteristics of anti-fragility (see above), while the criteria for anti-fragile urbanism can be used to determine the local re-assemblage of the layers.

So every urban layer will have:

- A global idea for future direction that must be clear and operates as a general guideline
- Self-organising elements at the local scale towards that general direction
- Redundancy through creating space that is not allocated for any specific use
- Only few rules for order in place
- Multi-functionality and mixed uses
- Environments that allow for surprise and counterintuitive feedback
- Equally divided resources over the area
- Similar spatial quality.
If we take the water system as an example for applying these characteristics this system could for instance consist of a direction to clean all water in the system, recycle it and provide ecological water quality. It then should put mechanisms in place that allows for self-organisation towards these goals, natural cleaning, storage of water and slow release, and increase of water quality. It should have extra spaces available to perform these functions that can be used when necessary or applicable, but also to direct a sudden flood towards. The few rules could be to keep water as long as possible in the system, to clean water in every step or move it makes and to safeguard spaces for these water functions. Cleaning, storage and calamity spaces can be combined in one space, but also searching for linkages with features of other layers should be enhanced. Create spaces in which the water functionalities can take place, even if these are surprising or unprecedented. Water availability in the form of cleaned and stored water should be equally divided over the area and the water should be used to increase the spatial quality of the city, for instance on the form of lakes, canals or fountains.

After the deconstructed layers are designed at the regional level, a re-assemblage at local level will give the program for the design of an integrated proposition. The criteria for anti-fragile urbanism (table 1) can be used to inspire the design of the local combination of layers. As an example, when we integrate the food, water and energy layers at the local scale a limited number of possible spatial or mixed use options, e.g. self-sufficient local farms, are created and small scale elements are designed in a way they all work together to achieve a bigger objective. In this example the water is purified through the agricultural uses, which provides the biomass to generate energy, which is used to circulate the water. These functions add to the greater objective of keeping cleaned water in the area, generating renewable energy locally and produce food without extensive environmental impacts. When many of these self-regulating nodes are created in the city, the entire city will perform as a circular economy. Locally, redundant spaces need to be created to make extra space for unforeseen (climate) impacts, for instance to produce food, store water and generate energy in times of disruption. The area could be (made) subject of such a climate event on a regular basis to test the regulating function and the operation of the food-water-energy nexuses. In order to increase the flexibility of the system and to make continuous adaptation possible, connective networks (water system, transport of food, energy grid) are loosely related to each other through establishing multiple connections for the same purpose. This way the network between individual locations can be utilised in several ways at the same time, which makes adaptation and agility of the entire system larger. At the scale of the precinct absorption zones are to be established where larger integrated food-energy and water production could take place. These zones operate in two ways. They are the redundant surplus zones where extra water, food or energy can be generated when individual farms require this or the demand is high. Moreover these zones are the places where innovation starts, as these redundant zones people can use to invent new ways of integration of production. Here production is not (yet) needed, so people experience the freedom to develop new approaches.
At this scale the inter-linkages between the layers of food water and energy is redesigned, the tipping points or bifurcation points are established where the regulation nodes, e.g. local food-water-energy nexus farms, are and where spatial change agents find new pathways to switch to a new attractor, e.g. how the individual farms form a bigger system of circular and integrated flows of water, food and energy at the urban level.

8. **The Anti-Fragile city**

On the basis of the above the Anti-Fragile city is build upon three major drivers: networks [Roggema and Stremke, 2012], use of adaptive systems thinking in spatial planning [Roggema, 2012a; Roggema and Van den Dobbelsteen, 2012] and counterintuitive-ity [Roggema, forthcoming].

If in the city strong and abundant networks of different types are created the flexibility is increased establishing loose and abundant connections between self-regulating nodes. These networks can be used in multiple ways hence adaptive capacity is increased, depending on the diversity and abundance of networks.

For a city to be optimally adaptive, just the right mix of uses and spaces must be established to create a system in balance. This balance can be reached when no dominant central directive is operating, but the urban whole is build up from its smaller elements and is working towards a common goal in a self-regulating and self-organising way. The collaborative autopoietic way of emerging functions, spaces and uses will constantly transform as the search for new attractors will always continue and new bifurcation points will appear. The need for absorption zones in the city becomes apparent, as new configurations cannot be predicted but require space to develop.

The third characteristic of the Anti-Fragile city is counterintuitive-ity, the capacity to produce solutions to problems that are not regular and cannot be detected in a rational way. The city must allow room for surprises in absorption zones, and allow for redundancy in the system. Only then the capacity is available to invent novelty and respond to new, unprecedented problems in a counterintuitive way.

9. **Examples**

Anti-fragility *avant-la-lettre* has been driven several design solutions for climate impacts. The question how to strengthen the existing system instead of mitigating the damage, has been the driver for the design for Double Defence [Roggema et al., 2006], the Sydney Barrier Reef [Roggema, 2017] and the Floodable Eemsdelta [Roggema, 2012b].

The design for Double Defence (figure 3) not only protects the northern shore of the Netherlands against storm surges and sea level rise, it makes the wetland system of the Wadden Sea stronger. The extra row barrier islands provide the sea behind it with an
environment in which the sand sedimentation increases with higher sea levels. This enhances the system to grow sandbanks and allows the seals to frequent the area. Without the Double Defence the existing ecosystem would disappear in the future due to rapid sea level rise.

Figure 3. Plan for Double Defence  [Roggema et al., 2006]

The Sydney Barrier Reef (figure 4) makes use of future circumstances in the southern Pacific. With rising ocean temperatures in this area the sea becomes suitable for a tropical reef. Providing the conditions for a reef to grow on artificial materials such as shipwrecks or abandoned oilrigs a natural reef can be developed, which protects the coast against future cyclones that will occur in this area more often as a result of rising temperatures. The new reef creates a stronger system as the new environment emerges.
In the plan for the Floodable Eemsdelta (figure 5), a historic landscape in the north eastern part of the Netherlands, the threat of rising sea levels and storm surges is used to design a landscape that gains quality as result of potential flooding. The vulnerable landscape is exposed to the threat long before an actual risk appears. The seawater is allowed in the landscape, forming the conditions for high quality living in the midst of a controlled sea. The new floatable
houses are built in anticipating of the seawater flooding the landscape. Instead of a disaster the landscape increases quality.

Figure 5. Floodable Eemsdelta [Roggema and Van den Dobbelsteen, 2012]

10. Discussion and conclusion

The phrase that an anti-fragile system gets stronger under stress is appealing to many, yet at the same time open for interpretation. The concept of anti-fragility is used in several disciplines, such as IT, organisational theory and business, but to spatial design it is new. Interpreting the theory in this article three main drivers of the Anti-Fragile city are presented. The city becomes more anti-fragile if it creates a multiple use of its networks and regenerative nodes, uses the principles of adaptive systems to design and introduces counterintuitive ideas and concepts.

The concrete design at the local level should consist of a combination of urban layers, which on their turn are designed at the urban region level. The conditions for designing individual layers have been elaborated in this article as well as the criteria for re-assembling the layers at the local level. Important elements of the design of an Anti-Fragile city are to create spatial redundancy, design small elements as part of a bigger whole, make multiple uses and spaces possible in one and the same area, create absorption zones and regulating nodes as the starting points of innovation.

Anti-fragility is seen as a concept that goes beyond resilience. It makes systems stronger under stress, not only keeps their functionality intact when under threat of change. The application of the concept in cities allows cities to constantly improve. The understanding that cities are the
source of innovation and renewal is attributed to the fact that in cities human interactions take place at a higher level than in areas with lower population. However, it could well be that cities in themselves search for anti-fragility due to the available networks, adaptive systems capacity and counterintuitive developments that occur. Further research could investigate this hypothesis and identify the parameters of anti-fragility. Also, the capacity to increase anti-fragility through design interventions, as illustrated in this article, could be further researched, especially to anticipate and use of future disruptions.

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What will win in the new spaces; creativity and liveability?

_Lamenting the Loss of the Quarter Acre? Here’s the new one._

As this conference topic attests, the implications of technical disruption of urban life and urban systems are far reaching and continually emerging. The dramatic speed of change when a system such as Airbnb that opens private dwellings to strangers has transformed accommodation and travel experiences before its implications are fully understood.

The mix of potential release of public space due to changes in transportation combined with the changing priorities of cities leaves space for speculation.

As urbanists, we understand that Roads are important public spaces. I am speculating on the space potentially released as transport as a service is adopted.

**Scope**

The intention of this paper is to look at the public domain of the street. It explores how re-conceived streets can attract creative individuals, provide better environments for a wider range of urban dwellers and play an active role in fostering both innovation and quality of life by becoming high amenity, equitable environments. My interest is in how space made available in the public domain through disruptive technologies can be re-engaged to contribute positively to smarter more liveable cities that compete on the regional and global stage.

**CONTEXT**

**Global Context**

In a global context, economic and cultural change reflects in the spatial layout and form of cities and neighbourhoods. For example Detroit spread to the city edges with the rise of the automobile industry and then emptied this donut form with its decline. In the former industrial manufacturing parts of Sydney, such as Alexandria, Zetland, Rosebery expanding population has transformed the urban form horizontal factory buildings with the vertical forms of new accommodation and mixed use developments.

Some of these spatial and formal changes were very fast, others slow. We are currently looking at unprecedented rates of change. The rise of motorcars transformed the character of streets in 10-15 years then continued for the next 100 years transforming the spatial arrangements of cities.

**Population Context**

In the current context of increased urbanisation with 54% (United Nations Sustainable Development 2016) of people across the globe now living in cities and urban environments, cities acknowledge
the competition to attract people. This competition was a central theme in Richard Florida’s 2008 research, where he eschewed the benefits of attracting the “creative classes” to make cities flourish in the new economies.

A brief survey of urban environment population increases for selected Australasian cities reveals the scale of population growth projections currently anticipated.

If we look at the Brisbane metropolitan area the population in June 2016 was 2,360,241. Population projections to June 2036 for the Brisbane Metropolitan will increase it to 3,326,533 (Anon., 2017).

Figures released by the NSW Government show the city of Sydney population is expected to leap by more than 2.1 million people in the next 20 years, about 170,000 more than predicted only two years ago. The updated projections anticipate a 6.42 million population in 20 years.¹

Changes in policy context influence how these population increases are accommodated. The Metropolis of Three Cities proposed by the Greater Sydney Commission for the Sydney metropolitan region, takes a structural polycentric approach.

Federal policy has been picked up by the states as an aspiration of a “30 minute city” in Sydney, and the “20 Minute City” for Melbourne (Plan Melbourne 2017-2050). The latter is a stated strategy to keep Melbourne “attractive and liveable to stay globally competitive”.

**Environmental context**

The implications of global climate change seem at last to becoming part of city conversations as the ramifications become evident. The United Nations (UN) in its New Urban Agenda identifies that urgent effective action is required. Signatories commit to 8 actions, two of which directly address climate change;

- Provide basic services for all citizens
- Ensure that all citizens have access to equal opportunities and face no discrimination
- Promote measures that support cleaner cities
- Strengthen resilience in cities to reduce the risk and the impact of disasters
- Take action to address climate change by reducing their greenhouse gas emissions
- Fully respect the rights of refugees, migrants and internally displaced persons regardless of their migration status
- Improve connectivity and support innovative and green initiatives
- Promote safe, accessible and green public spaces

(UN New Urban Agenda 2016) ²

Australia’s Commonwealth scientific research body CSIRO, notes projections for the end of the century on the current emissions scenario;

- Australia’s average temperature is projected to increase by 3–5 °C
- The number of days with weather conducive to fire in southern and eastern Australia is projected to double
- Extreme rainfall events are projected to increase in intensity


² United Nations (UN) New Urban Agenda 2016
• Past and ongoing emissions commit us to further sea-level rise around Australia of around 6–19 cm by 2030.³

**Concept of Liveability**

The term ‘liveability’ is a contested and subjective notion. Its definitions, applications and measurability are far from agreed. In this research I am not aiming to answer questions of; what is a liveable city? Nor what I see as a necessarily partner question of; for whom is it liveable?

Dr Richard Florida (Florida, 2008) contributed to ongoing thought on the nature of cities seeing conurbations as the locations where most innovation occurs. His language around making cites attractive to what he termed the “creative classes” was easily understood and applied by others from lay people to governing authorities. However critique of his writings identified that on application, this divided cites further into inequality and gentrification. Florida himself acknowledges that applied as he proposed, lead to increased inequity in cities.

The Economist Intelligence Unit (EIU) measurement of “Liveability” highlights issues around measurability. In the EIU survey “Every city is assigned a rating of relative comfort for over 30 qualitative and quantitative factors across five broad categories: stability; healthcare; culture and environment; education; and infrastructure. Each factor in a city is rated as acceptable, tolerable, uncomfortable, undesirable or intolerable.” (EIU, 2017) The EIU rating places Melbourne in first place again this year.

While this assessment of liveability gives some broad scale information about each city, it fails to explore the complex finer grain that makes an urban environment “good to be in”. Jane Jacobs New York City based planner and journalist, drilled into this finer grain and nuanced complexity in her widely regarded “The Death and Life of Great American Cities” describing the city as a myriad of communities in which:

“… The trust of a city street is formed over time from many, many little public sidewalk contacts.” (Jacobs, Dec 1992)

Research which sees the human aspects of liveability continues. A research group for Deakin University Garduño Freeman, Gray and Novacevski, acknowledge the complexity of cities and are looking to qualitative aspects to identify how people experience cites and neighbourhoods. They introduce the concept of “lovability”. (Garduño Freeman et al, Nov 2016)

In acknowledging the range of interpretations, I have selected a range of qualities which occur across the strands of discussion above. I have also selected qualities from the equally diverse territory of resilience, given that a city or a neighbourhood in emergency or recovery mode has a questionable degree of liveability.

³ The new climate change projections for Australia are funded by the Department of the Environment in CSIRO, 2014. State of the Climate 2014: A clear picture of Australia’s climate
Liveability and creativity are fostered in environments that promote:

- **Health** by being multi modal, perceived as safe, comfortable, accessible, promoting walking and community connections and having clean air and water
- **Innovation** by being connected, open to new ideas and facilitating contact
- **Resilience** by being sustainable, responsive to climate, fostering community and having multipurpose elements and spaces and flexible systems
- **Connection** by being multimodal, technologically connected, equitable, and having good levels of amenities
- **Equality** by being safe, comfortable, universally accessible, mixed and diverse

**What is the space likely to be?**

I am interested in a scenario of retrofitting streets for increased density. I have selected a test site to speculate on in middle ring suburb of Sydney, Australia. The middle ring offers opportunities for densification and change to support new or expanded hubs or centres. While good practice urban design is necessarily place based, this test site has been chosen as having characteristics of residential streets that are suitably generic to be relevant to other locations. That is I am not seeking a place and context related response.

**Figure:** Test Site Campsie: Location in Sydney to Bankstown Urban Corridor

Source: Draft Greater Sydney Region Plan Greater Sydney Commission 2017

The test site selected is part of Campsie, Central Sydney, NSW Australia. Campsie has been identified by the Greater Sydney Commission as a priority growth area within the Sydenham to Bankstown Urban Renewal Corridor.

Campsie forms one of a string of suburbs following Canterbury Road and is serviced by a metropolitan rail line and bus routes. It is part of the Cooks River catchment with the river itself

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4 Campsie is identified in the Draft greater Sydney Region Plan as part of a priority growth corridor. Draft Greater Sydney Region Plan Greater Sydney Commission 2017
forming an open space recreation corridor. Its original Federation layout and built fabric has already experienced substantial degradation and intensification with a significant number of red brick 3-4 storey apartment blocks, typical of the 1960s, replacing previously detached and semi-detached housing.

Street environments are car dominated although with some established tree planting. Civic amenity is concentrated in the neighbourhood centre and in open spaces. Schools, churches and commercial buildings occur across the precinct with the concentration of commercial and retail activity on Canterbury Road and the main street.

The actual test site is a block of streets that includes Duke, Evaline, Oswald and Redman Streets as seen below.

Figure: Test Site: Suburban Block, Campsie

Source: Google Earth Maps November 2017

Figure: Test Site: Street Character Canterbury Road and Duke Street

Source: Author Photo November 2017
Transport as a Service Potential Land Release

My proposition is set up to explore opportunities rather than quantify with any accuracy any land that may be released. In order to focus on the opportunities I am speculating on a scenario in which:

- Data networks and technological advances continue to escalate as key platforms
- Services currently delivered on a citywide basis e.g. energy, parcel delivery, may change distribution format
- Cities take up challenges to reduce dependence on carbon
- Cities take up challenges to increase resilience
- Adoption of improvements to sustainability and environmental health
- Population increase is accommodated through increased density
- Public take up the convenience of mobility as a service and reduce individual car ownership
- Car storage as a result of mobility as a service is concentrated in locations other than private residences and streets
- Consequent reduction in demand for parking in both public and private domain
- Mass transit and public transport increases to provide networks across cities
- Streets remain as important public spaces.

DISCUSSION

Other Research and Knowledge Precincts

Qualities of campuses have fostered relevant research and provide precedents of application. Michaela Sheahan looked at hospital knowledge precincts and how external spaces foster knowledge sharing in “Walk, Talk, Work: The importance of Pedestrians and Public Space for collaboration in hospital knowledge precincts” in 2014.5

Other campus situations such as universities, research centres and technology or innovation hubs can also be designed with the fostering of knowledge sharing and liveability.

The technology hub of Tonsley, Adelaide, recently conferred in the Australian Urban Design Awards, applies strategies to promote knowledge sharing and liveability. Promotional material clearly identifies the qualities of its “public spaces”, citing;

“A designed community created for creatives...innovative infrastructure has created a sustainable community...... a connected community... supported by high-speed connectivity”.

An image from their website below communicates these messages in a clear and easily comprehensible way.

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Streets, like campuses, are a network of places organised into precincts. Campuses as an urban typology, can have varying degrees of integration with the urban fabric. For example the integrated urban campus of the University of Technology Sydney (UTS) compared to that of the University of New South Wales (UNSW) which occurs mainly within a road bounded precinct. In contrast, streets are public places and by definition form part of the urban fabric of the public domain.

One character of street networks that differs from campuses is the linearity of forms and systems. It is these linear spaces and their formation into networks that I shall interrogate for opportunity.

**Precedents Responding to Disruption of Context**

There are precedents of cites implementing changes to streets to respond to liveability factors. In a repurposing of public domain requiring policy change and urban design solutions to claim space from vehicular use, NY City has made radical changes to Times Square, Manhattan. (Refer to image)

Aspirations for improved comfort, amenity and resilience underpin the City of Moreland, Victoria’s development of the *Urban Heat Island Effect Action Plan* to help reduce impact of and prepare for a hotter future. Their research indicates "Increasing tree cover and greenery is one way to keep the city cooler. A 10% increase in tree cover can drop ambient temperatures by 1 degree."

The city of Rotterdam in the Netherlands is addressing resilience in its strategy to develop the city surface as a "sponge" to mitigate increased volume of rain events and decreased ability to remove excess water. Concurrently these spaces provide meeting places and contribute to liveability through health benefits and an active public domain. (Refer to image)
**Precedents of Element Design Responding to Disruption**

Turning to the finer grain of urban environments, there are also precedents for designed elements which foster liveability, connectivity and survivability. These include the emergency amenity centre the PREPHub developed at MIT\(^8\), flexible furniture elements e.g. UTS seats with power and usb points and the digital information hubs and Wi-Fi Maps of the Lower East Side, Manhattan. These are all illustrated.

Other designed elements support new systems or services including drone delivery stations, urban forests to address urban heat buildup for comfort, environmental improvement and resilience and low impact stormwater elements. These too are illustrated.

Figure: Resilience Preparedness Research from MIT

Source: [http://prephub.org/](http://prephub.org/)

Figure: Recharge Electric Vehicle Station

Source: Antares_Photovoltaic_Charging_Station_by_Pininfarina_01_gallery\(^9\)

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Mapping

Synthesis Diagrams

The following series of diagrams map how street space is currently allocated within the test site. They then explore how disruptive technologies particularly but not exclusively in the field of transport as a service, provides opportunity for changes to spatial allocation. The diagrams show how space could be reallocated and how elements or linear systems could be distributed in relation to each other.

In the local street, the overall corridor is approximately 17m wide. This is divided up as shown into:

- 70% dedicated to private vehicles
- 15% dedicated to tree planting shared with services
- 15% dedicated to walkable space.

On the wider arterial road we have an approximately 25m wide corridor but a similar proportional dedication to vehicles, trees and pedestrians with extra width generally dedicated to vehicles as additional moving lanes. The dominant visual appearance of roading elements with efforts to manage the vehicle dominance by limitation of vehicles through signs and objects rather than promotion of other functions such as walking.

Figure: Existing Allocation of Space in Local Street

Source base images: Google Earth November 2017

The next series of diagrams explores how space could be reallocated for networks and distribution of amenities that promote connectivity and liveability. I speculate that a narrower allocation for vehicles suitable for multi modal and some automated vehicles, and a consequent reduced demand for private parking could be anticipated. This could release an approximately 8m linear strip by replacing two parking lanes with integrated parking clusters and replacing two live lanes with one wider movement corridor.
The change in spatial allocation could be as below;

- 70% dedicated to vehicles becomes 40%
- 15% dedicated to tree planting becomes 30%
- 15% dedicated to walkable space becomes 30%
- Services are overlaid.

Figure: Reallocation of Space in Local Street

Source base images: Google Earth November 2017

Releasing Ecological Space

The traditional “nature strip” as expressed in this part of Campsie and as is typical of many middle ring suburbs constitutes two parallel strips of mown grass, underground and aboveground services, recycling collection and sometimes shrub or tree planting.

An additional 5m width in the corridor would enable a doubling of the urban forest, providing significant reduction in urban heat build-up and connected ecological corridors. This could provide enough surface area to catch, detain and treat surface runoff in rain gardens with the form and capacity adjusted to respond to position in the catchment and flood profiles.

A generous strip can integrate sitting places that encourage social interaction and serendipitous meetings in a cooled, green pleasant environment. Community gardens or productive landscapes could be provided in selected streets distributed across precincts.

The opportunities available in a greater ecological space strongly benefit to elevate amenities and contribute to resilience and health but with integrated design approaches promote a range of qualities that promote liveability and creativity. (Refer image below)
**Reconfigured Space for Mobility**

The current local road provision of two live lands and two parking lanes has evolved in a culture of private vehicle dominance. The disruption of providing transport as a service, enables an entirely new approach to mobility. Vehicles that are automated to varying degrees and group transit vehicles that are powered through a city infrastructure and all with high degrees of communication or vehicle to everything (V2X) technologies, require less space (Infrastructure Partnerships Australia 2017). Advanced communication technology not only increases the safety, and certainty of journey but enables people to have access to data and have services tailored to demand.

A smart, clean energy, accessible network, connected in to city wide networks contributes to liveability and knowledge sharing as shown in the diagram below.

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**Figure: Reduced Spatial Requirements for Transport**
Reconfigured Walkable Space

Environments which encourage walking through a safe, perceived as safe, accessible and welcoming environment are promoted as a major component of liveability. While the benefits to connectivity and health are foremost, again a wide range of opportunities for interactions, exchange of ideas are downstream benefits. See image below.

Figure: Increased Space for Pedestrian Speed Spaces

Networks for Services and Technology

Communication and service networks are less linear in nature although they may have linear components. Likewise where previously discussed amenities require dimensioned space, technology networks at times are unseen and only access points may occur as urban elements. With released space there is also opportunities to respond to the need for clean energies and the potential for neighbourhood energy schemes. Thus the street can become an overlaid network of energy and communication technology which improves connectivity and equity.

Disruption of the way services are currently provided, such as postal services, recycling etc. and the challenge of delivering service in increased density environments, could require new ways to look at these systems. Diverse activities integrated into the public domain adding further complexity and opportunities for interaction. See image below.
Local Governments of Australia’s major cities have committed to more sustainable energy sources. For example, the City of Sydney aims to source 50% of its electricity from renewable sources by 2030 and to reach net zero emissions by 2030.\textsuperscript{10} The City of Melbourne is aiming for 25% renewable electricity by 2018 and net zero emissions by 2020.\textsuperscript{11}

While energy capture and transmission currently occurs outside cities, streets are already the corridors of delivery. Is there the potential for streets to also facilitate energy capture also?

**Precedents of Reconfigured Streets**

The following examples give an idea of the qualities of the repurposed street spaces and additional elements that foster safety, inclusion creativity and liveability through a series of before and after images prepared as parts of other projects.

References: What will win in the new spaces; creativity and liveability?

Source images: At [https://inhabitat.com](https://inhabitat.com)\(^{12}\)

Figure: Reallocation of Space in Amsterdaam Straat, Antwerp

Source: [http://www.urb-i.com/before-after](http://www.urb-i.com/before-after)\(^{13}\)

Figure: The NYC Loop proposes a perimeter expressway for driverless vehicles\(^{14}\)

Source: [https://www.archdaily.com](https://www.archdaily.com)


\(^{13}\) A series of before and after images has been taken across the globe using the ubiquitous technology of Google Street view at [http://www.urb-i.com/before-after](http://www.urb-i.com/before-after)

CONCLUSION

Cities and neighbourhoods can offer quality environments that look good, feel good, and are perceived as safe and where connectivity enables people to come together through co-located facilities and networks of routes and spaces. There already exists opportunities to integrate walkable neighbourhoods, high amenity precincts and well connected urban environments. Environments which promote health, Innovation, Resilience, Connection and Equity as I have discussed, stimulate creativity and knowledge sharing and that much discussed attribute of liveability.

Much is achievable now, though not necessarily put in place. The promise of technological disruption may be so far reaching that the choice to implement or not becomes easy or alternatively overriding, radical change occurs anyway.

This potential for radical change to urban form is already influencing strategic leadership in some quarters. Concurrently other strategies, such as those associated with transport infrastructure remain firmly within the century of automobile domination.

With this speed of change the traditional institutions that set city making strategy and manage the public domain from federal to local government and from specialist agencies to local communities, run the risk of time lags in decision making.

I have discussed technological advances which are already conceived, some already implemented and speculated how these approaches and elements can be applied. As an exploration of opportunities, this is a snapshot of change through speculative retrofitting. The climate of change is fast and radical that this snapshot risks being outdated before it is tried.
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Using Urban Design Qualities for Building a New Composite Walkability Index for Cairo Streets

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Abstract

This paper aims to build a Composite Walkability Index (CWI) for Cairo Streets. It is based on the field manual of the study of Ewing and Clemente (2013) to determine the most relevant Urban Design Qualities (UDQs) and physical features of walkability. The CWI is constructed in two stages; the Benefit-of-the-Doubt (BOD) weighting scheme is applied to each one. The reason for applying this mathematical programming method is to endogenously determine the relative importance of all UDQ and physical features with respect to walkability. Therefore, to investigate the credibility of the BOD technique, it has been applied to a sample of 46 different paths from Cairo streets. The resulted CWI values are discriminated such that no two streets have the same score. This in turn helps decision makers to assess these streets by relying on the distinguishable ranks of CWI and UDQs.

Keywords Benefit-of-the-Doubt (BOD) • Composite Indicators (CIs) • Composite Walkability Index (CWI) • Urban Design Qualities (UDQs) • Physical features.

1. Introduction

Walkability is a measure of how friendly an area is to walking. It is referred to as, the extent to which walking is readily available as a safe, connected, accessible and pleasant mode of transport (Abley and Turner 2011. “Other references including Seilo mentions “Walkability - is a measure of the urban form and the quality and availability of pedestrian infrastructure contained within a defined area. Pedestrian infrastructure includes amenities developed to promote pedestrian efficiency and safety such as sidewalks, trails, and pedestrian bridges.”(Abley and Turner 2011). The USA National Centre for Chronic Disease Prevention and Health Promotion defines “Walkability is the idea of quantifying the safety and desirability of the walking routes”. Walkability has many health, environmental, and economic benefits. Increased walkability has proven to have many other individual and community health benefits, such as opportunities for increased social interaction, an increase in the average number of friends and associates where people live, reduced crime rates (with more people walking and watching over neighborhoods, open space and main streets), increased sense of pride, and increased volunteerism. Another benefit of walkability is the decrease of the levels of overweight and obesity among people. According to the World Health Organization, 1.5 billion adults were overweight in 2008, and approximately 500 millions of these adults were obese (World Health Organization [WHO], 2011) Given concern over increasing levels of overweight and obesity, identifying and modifying related built environment characteristics may be an important policy step for chronic disease prevention. One of most important benefits of walkability is the decrease of the automobile footprint in the community. Carbon emissions can be reduced if more people choose to walk rather than drive. It has also been found to have many economic benefits, including accessibility, cost savings both to individuals and to the public, increased efficiency of land use, increased livability,
Evaluating the role of urban design characteristics at street level is still a matter of subjectivity (Abley and Turner 2011). Therefore, adopting an objective scientific approach for measuring street features will help policymakers enhance the quality of the pedestrian environment. To quantify street walkability, which is a great challenge, a large number of studies suggested building a composite index of walkability. The idea of this index is to assemble all features together into one index to determine the influence of each indicator on the final score.

Walkability indices have been introduced in the literature at the neighborhood and street levels. At the macro level, neighborhood, there are examples such as Walk Score (Walk Score 2017) and Space Syntax model (Hillier et al. 1993). On the other hand, there is a limited number of walkability indices at the micro level, streets. The reason is that these indices depend on the perception of the environment, i.e. people’s preferences. Furthermore, walkability indices cannot be assessed by relying on pedestrian flows since a street of a large number of people walking on it is due to several factors such as density or connectivity (Neto 2015).

There are online attempts to assess walkability of streets based on users’ perceptions. For instance, “Rate My Street” evaluates streets using a five-star rating system (TRL 2014). Moreover, this index depends on eight categories to assess streets. Another online application is walkanomics (Walkanomics 2017) that estimates the quality of streets on a scale of zero to 5.

A remarkable contribution to the assessment of streets was introduced by Ewing and Clemente (2013). The authors relied on expert panels to evaluate walkability and urban design qualities for a sample of New York streets. Moreover, they investigated statistical relationships between ratings of expert panels and the physical measurements of these streets.

It is worth noting that the previous review of studies that constructed walkability indices is not comprehensive. The literature includes several trials to quantify this term (Park 2008; Neto 2015; ALasadi 2016).

This study adopts the same definitions of Urban Design Qualities (UDQ) and physical features of the study of Ewing and Clemente (2013). Nevertheless, the proposed methodology, to construct a Composite Walkability Index (CWI), follows the ten-step technique of the Organization of Economic Cooperation and Development (OECD 2008) to reliably assess Cairo streets.

2. Overview of CIs Construction (OECD 2008)

Composite Indicators (CIs) are widely accepted as a useful tool in different disciplines such as economy, environment and society (OECD 2008). Moreover, they are used to summarize multidimensional phenomena and assess the progress of different units over time. Despite the common use of CIs, they remain controversial since they provide decision makers with unreliable information if they are poorly constructed. Therefore, OECD (2008) introduced ten steps to build a robust CI. The first step defines the theoretical framework of the multi-dimensional phenomenon to be evaluated. The second step, data selection, focuses on assessing the available indicators that will be used for measuring the complex issue. The third step handles the problems of missing data and outliers. In the fourth step, multivariate analysis is applied to explore the overall structure of the dataset. In the fifth step a suitable normalization method is carried out to overcome the effect of different units of measurements. The next step, weighting and aggregation, assigns a weight for each sub-indicator to combine them into a single index. In addition, this
step is considered the most crucial as it reflects the sub-indicators’ importance (Zhou et al. 2012). The coming steps are mainly concerned with the reliability of the constructed CI. These steps are: conducting sensitivity analysis for assessing CI, decomposing the CI into the original indicators, linking CI to other indexes for deeper analysis and finally presenting the results in a clear visual way (OECD 2008).

Due to the importance of weighting process, several classifications were introduced in the literature for determining them. For instance, OECD (2008) defined two weighting schemes: the statistical and the participatory approaches. The first one evaluates sub-indicators’ weights from the data without any interference from the researcher. It includes methods such as Principal Component Analysis (PCA), regression analysis\(^1\), and Benefit-of-the-Doubt (BOD), which is adopted in this study. The second classification, on the other hand, determines weights exogenously such as imposing equal weights or depending on experts’ opinion.

Before illustrating the proposed methodology, the BOD, for assigning weights for the components of walkability, it is important to clarify the theoretical framework of this study. The main objective of this paper is to build a Composite Walkability Index (CWI) for Cairo streets on the basis of how friendly they are for pedestrians. The proposed CWI is calculated using two-stage BOD approach. In the first stage, each urban design quality (imageability - enclosure - human scale - transparency - complexity) is estimated for each street using a group of physical features, which are evaluated from the data collected from Cairo streets. Moreover, these qualities have the major impact on the overall walkability (Ewing and Clemente 2013). In the second stage, the overall CWI is obtained for each street by relying on the estimated values of urban design qualities.

Figure (1) below illustrates the two-stage structural components of the CWI. The classification of physical features under each urban design quality is slightly different from that of the field manual of Ewing and Clemente (2013). In the manual, these physical characteristics exist in an overlapping pattern between the five urban design qualities. This is not the case in this study. For building a robust CWI, all dimensions, i.e. the five urban design qualities, should be mutually exclusive in the sense that the effect of each physical feature should appear once on the overall CWI. In addition, this study depends on the results of Ewing and Clemente (2013) to determine these relationships. For instance, in the study of Ewing and Clemente (2013), the physical feature “proportion of active uses” is classified under two urban design qualities, human scale and transparency, with two different weights, at 0.306 and 0.533 respectively. Nevertheless, this study assumes that this physical feature is involved in transparency only since it has a higher weight, keeping other variables fixed.

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\(^{1}\) This technique is used in the study of Ewing and Clemente (2013) to assign weights for physical features and urban design qualities.
3. The Proposed Methodology for Building a CWI

Although there is no one-and-only true CI (Saisana and Tarantola 2002), this paper introduces an objective method for assessing the walkability issue in any street. The proposed methodology is built on the BOD technique, which is an application of the technique of Data Envelopment Analysis (DEA) to the field of CIs (OECD 2008). The essence of the BOD method is to provide each unit, street in this study, with the highest level in the CWI through maximizing the sub-indicators’ weights.

The following BOD model, which is used in this study, is a Linear Programming (LP) model that is mathematically formulated as Model (1) below.

Model (1): BOD Model (Cherchye et al. 2007)

\[ UDQ_n = \max_{w_{rn}} \sum_{r=1}^{R} w_{rn} I_{rn}, \quad n = 1, 2, \ldots, N \]  

Subject to:

\[ \sum_{r=1}^{R} w_{rn} I_{rk} \leq 1, \quad k = 1, 2, \ldots, N \]  

\[ w_{rn} \geq 0, \quad r = 1, 2, \ldots, R \]

The above-mentioned model is applied in the first stage to get a score for all UDQ for each street. It is repeated \( N \) times, once for each street \( n \) (\( n = 1,2,\ldots,N \)), when it is applied to each urban design.
quality. The symbol $I_{rn}$ indicates the value of physical feature $r$ ($r = 1, 2, ..., R$) for street $n$ and the corresponding weight is $w_{rn}$. Equation (1), the objective function, maximizes the UDQ for each street $n$ ($n = 1, 2, ..., N$) through maximizing the weights $w_{rn}$. Furthermore, Equation (2), the first constraint, guarantees that the UDQ for each street does not exceed one since the resulting values range between zero (the lowest performance) and one (the highest performance). The last constraint, Equation (3), ensures the non-negativity of the weights of physical features.

In the second stage, the CWI is calculated using the same model after slightly changing the form of the objective function, Equation (4) below, and keeping the above two constraints fixed. Consequently, the overall CWI is calculated for each street as follows:

$$\text{CWI} = \frac{\sum_{t=1}^{S} w_{tn}^* \cdot \sum_{r=1}^{R} w_{rn} I_{rn}}{n = 1, 2, ..., N}$$  \hspace{1cm} (4)

The symbols $I_{rn}$ and $w_{rn}$ are defined as in Model (1) above. The sum $\sum_{r=1}^{R} w_{rn} I_{rn}$ is evaluated from Model (1) above and it stands for the UDQ$_{tn}$, which is the urban design quality $t$ ($t = 1, 2, ..., 5$) for street $n$. The corresponding weight, $w_{tn}^*$, represents the effect of each urban design quality on the overall walkability.

It is worth mentioning here that the BOD model$^2$ was applied in different contexts. For instance, Cherchye et al. (2007) applied this technique to evaluate the Technology Achievement Index (TAI) for 23 countries. Another example is the composite sustainability index of Zhou et al. (2012). Blancas et al. (2013) applied this technique to evaluate CI scores for 20 firms in the fast-food franchising sector in Spain.

The BOD technique has several advantages compared to other weighting methodologies. First, the sub-indicators’ weights$^3$ are endogenously evaluated from the data. Second, the CI$^4$ is assessed for each unit such that its value is maximized to the greatest level. Finally, the BOD model is computationally straightforward since it depends on mathematical programming.

Inspite of the above-mentioned merits, the BOD technique has several shortcomings. Without imposing restrictions on weights, apart from the non-negativity constraint, the majority of units obtain a CI value equals to one which reduces the discriminating power of the model (Cherchye et al. 2007). Another issue is that the effect of some sub-indicators on the overall CI is ignored due to the problem of zero weights. Cherchye et al. (2007) addressed this problem through adding lower and upper bounds to the weights. However, this restriction requires a priori information about these weights which may not be valid.

To overcome the previously mentioned limitations, this paper applies the approach of Cook et al. (1996) that set an endogenous lower bound, $\varepsilon$, on sub-indicators’ weights. The essence of the approach of Cook et al. (1996) is endogenously estimating a lower bound on weights. Through applying this approach to the BOD model, the above-mentioned drawbacks are tackled. Consequently, the approach of Cook et al. (1996) for evaluating the non-Archimedean infinitesimal, $\varepsilon$, reinforces the discriminating power of the BOD model and handles the problem of zero weights.

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$^2$ For more understanding of the BOD model, readers are referred to Cherchye et al. (2007) and OECD (2008).

$^3$ The term sub-indicators is used in this paper to refer to physical features in the first stage or UDQ if talking about the second stage.

$^4$ The term CI is used to refer to an overall index, i.e. UDQ in the first stage or CWI in the second stage.
From the above-mentioned discussion, the proposed methodology for building a reliable CWI for Cairo streets is based on two major steps. These steps will be implemented for each stage to avoid the problems of discrimination and zero weights as follows:

i) Determining a lower-bound, $\varepsilon$, on sub-indicators’ weights through applying the approach of Cook et al. (1996) to the BOD model, as shown in Model (2) below.

ii) Evaluating a CI for each street using the BOD model, i.e. Model (1) above, after taking the estimated $\varepsilon$ value into account.

**Model (2): Estimating the $\varepsilon$ value using the BOD Model (Cook et al. 1996)**

$$z = \max_{w_{rn}} \varepsilon$$ \hfill (5)

*Subject to:*

$$\sum_{r=1}^{R} w_{rn} \leq 1, \quad k = 1,2, \ldots, N; \quad n = 1,2, \ldots, N \hfill (6)$$

$$w_{rn} \geq \varepsilon, \quad r = 1,2, \ldots, R; \quad n = 1,2, \ldots, N \hfill (7)$$

The symbols used are defined as in Model (1) above. This model is implemented once for all units. Equation (5), i.e. the objective function, maximizes the lower bound ($\varepsilon$) of weights to be large as much as possible. This is the essence of the approach of Cook et al. (1996) that was previously explained as a larger value of $\varepsilon$ gives more discrimination to the CI values. Constraint (6) ensures that the CI value for each street $n$, i.e. $\sum_{r=1}^{R} w_{rn} I_{rk}$, does not exceed one. Equation (7), the last constraint, sets $\varepsilon$ as a lower bound on weights.

4. **Results of Applying the Proposed Methodology to Assess Walkability of Cairo Streets**

To show the importance of the proposed methodology, it has been applied to evaluate urban design qualities and walkability of a sample of Cairo streets. The data are collected from Cairo streets using the manual derived by the team of Maryland Inventory of Urban Design Qualities (MIUDQ) (Ewing and Clemente 2013). However, this study does not depend on experts’ panel to evaluate walkability and urban design qualities of each street. The reason is that the subjectivity involved in the experts’ opinion could lead to bias in the final results. Therefore, this study avoids subjective judgments in quantifying these intangible terms through applying the BOD approach.

The data are collected using a group of 120 persons who were extensively trained to correctly evaluate the physical features of each street. The team gathered the data of all physical features for 46 paths from 34 different streets. In addition, all paths are of equal length, 1000 meters, for the purpose of fair comparison. Although it is preferred to use a random sample when selecting streets, this study adopts different criterion. The historical background of these streets was the major reason for their choice since their physical features are more valuable. Furthermore, all streets are chosen from Cairo governorate, in Egypt, since the author is familiar with this area, which makes it easier to find suitable streets for the purpose of this study.
Table (1) below shows descriptive measures (mean-median-standard deviation-minimum value-maximum value) for each physical feature of the chosen Cairo streets. Overall, the median is remarkably below the mean, which suggests that a distribution skewed to the right.

Another point that should be clarified is that this study excludes the ordinal variables used in the study of Ewing and Clemente (2013) such as the variable “noise level” that is rated from one (the lowest level) to five (the highest level). The reason for this exclusion is that these variables make the BOD model more complicated. The simple BOD approach, i.e. Model (1), handles ratio scale variables. Therefore, adding ordinal variables require further analysis (Shen et al. 2011).

Table (1): Descriptive Statistics for Physical Features of Cairo Streets

<table>
<thead>
<tr>
<th>Physical Features</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imaginability</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of courtyards, plazas, and parks</td>
<td>0.696</td>
<td>0</td>
<td>1.245</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Number of major landscape features</td>
<td>0.022</td>
<td>0</td>
<td>0.147</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Proportion of historic building frontage</td>
<td>0.238</td>
<td>0.035</td>
<td>0.338</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Number of buildings with identifiers</td>
<td>11.913</td>
<td>6</td>
<td>14.593</td>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>Number of buildings with nonrectangular shapes</td>
<td>5.652</td>
<td>3</td>
<td>7.109</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Number of outdoor dining</td>
<td>1.435</td>
<td>0</td>
<td>2.136</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Enclosure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of street wall - your side</td>
<td>0.837</td>
<td>0.835</td>
<td>0.073</td>
<td>0.6</td>
<td>0.98</td>
</tr>
<tr>
<td>Proportion of street wall - opposite side</td>
<td>0.779</td>
<td>0.85</td>
<td>0.209</td>
<td>0</td>
<td>0.98</td>
</tr>
<tr>
<td>Proportion of sky - ahead</td>
<td>0.324</td>
<td>0.3</td>
<td>0.14</td>
<td>0.05</td>
<td>0.73</td>
</tr>
<tr>
<td>Proportion of sky - across</td>
<td>0.356</td>
<td>0.3</td>
<td>0.197</td>
<td>0.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Human Scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of long sight lines</td>
<td>0.913</td>
<td>1</td>
<td>0.626</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Average building heights</td>
<td>19.739</td>
<td>18</td>
<td>7.255</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>Number of small planters</td>
<td>20.565</td>
<td>5.5</td>
<td>62.18</td>
<td>0</td>
<td>382</td>
</tr>
<tr>
<td>Number of miscellaneous street items</td>
<td>32.348</td>
<td>40</td>
<td>12.699</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>Transparency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proportion of windows at street level</td>
<td>0.65</td>
<td>0.7</td>
<td>0.177</td>
<td>0.2</td>
<td>0.92</td>
</tr>
<tr>
<td>Proportion of active uses</td>
<td>0.592</td>
<td>0.665</td>
<td>0.294</td>
<td>0.1</td>
<td>1</td>
</tr>
<tr>
<td>Complexity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of buildings</td>
<td>132</td>
<td>45</td>
<td>602.259</td>
<td>14</td>
<td>4126</td>
</tr>
<tr>
<td>Number of primary building colors</td>
<td>2.283</td>
<td>2</td>
<td>1.068</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Number of accent colors</td>
<td>3.826</td>
<td>2.5</td>
<td>3.826</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Number of pieces of public art</td>
<td>0.217</td>
<td>0</td>
<td>0.467</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Number of pedestrians</td>
<td>183.848</td>
<td>139.5</td>
<td>157.232</td>
<td>20</td>
<td>857</td>
</tr>
</tbody>
</table>

Normalization is essential to get rid of the effect of different units of measurements (OECD 2008). The “Min-Max” normalization method is adopted in this study. However, it is necessary to highlight the direction, positive or negative, of these physical features to the CWI before normalization. The direction of these variables is clearly shown in Column (4) of Table (3) in the appendix. Moreover, Equation (8) below is used for the normalization process if the variable has a positive direction, i.e. the higher, the
better. On the other hand, Equation (9) is applied if the variable, i.e. physical feature, has a negative contribution to the CWI.

\[
\text{Index} = \frac{\text{actual value} - \text{minimum value}}{\text{maximum value} - \text{minimum value}} \quad (8)
\]

\[
\text{Index} = \frac{\text{maximum value} - \text{actual value}}{\text{maximum value} - \text{minimum value}} \quad (9)
\]

It is worth mentioning that the log transformation\(^5\) is applied to some variables due to the presence of outlier cases. This transformation is applied before the normalization process as follows:

\[
\text{Index} = \frac{\log(\text{actual value}) - \log(\text{minimum value})}{\log(\text{maximum value}) - \log(\text{minimum value})} \quad (10)
\]

The proposed BOD method is applied to each dimension, i.e. urban design quality, which composes walkability. Table (2) below illustrates the estimated imageability values and ranks for the selected paths of Cairo. The results of the remaining urban design qualities are displayed in Columns (2)–(5) in Table (4) in the appendix. Also, the results show that all physical features have equal importance, weights, in each urban design quality as clearly shown in Column (5) of Table (3) in the appendix. In addition, the five urban design qualities have the same effect on the overall walkability, Column (2) of Table (3). The reason for the above-mentioned cases is that the approach of Cook et al. (1996) sets a lower bound on these weights that if ignored leads to zero weights in some variables. This approach has the advantage of enhancing the discriminating power of the BOD model.

To assess the reliability of the proposed CWI, it has been related to other indexes. However, to the best of our knowledge, there is no study that evaluated the same, or some of, Cairo streets using the same criteria so that a fair comparison can be made. The website “walkscore.com” (Walk Score 2017) is used to calculate walkability for each of the given streets, Column (7) of Table (4) in the appendix. Moreover, these scores are very high, which indicates that the chosen streets are highly walkable. The author tried to find if there is a link between the CWI values, Column (6) of the same table, and these scores. Nevertheless, the results show a low correlation between them. This was expected since this website evaluates walkability using macro-scale indicators, such as housing density and land use diversity, which cannot capture the effect of urban design qualities of a street on the walking behavior. This is not the case in the proposed CWI that assesses walkability on the micro-level, i.e. street level.

\(^5\) This transformation is applied to two variables, which are number of buildings and number of pedestrian.
Table (2): Estimated Imageability Scores and Ranks for Cairo Streets

<table>
<thead>
<tr>
<th>Path ID</th>
<th>Name</th>
<th>Imageability</th>
<th>Path ID</th>
<th>Name</th>
<th>Imageability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Al Sabtiah</td>
<td>0.53 (8)</td>
<td>24</td>
<td>El Nozha</td>
<td>0.089 (39)</td>
</tr>
<tr>
<td>2</td>
<td>El-Gomhoreya</td>
<td>0.236 (29)</td>
<td>25</td>
<td>Fareed Semeika</td>
<td>0.208 (31)</td>
</tr>
<tr>
<td>3</td>
<td>Al Fagalh</td>
<td>0.315 (24)</td>
<td>26</td>
<td>Fareed Semeika</td>
<td>0.202 (32)</td>
</tr>
<tr>
<td>4</td>
<td>EL-Galaa</td>
<td>0.08 (40)</td>
<td>27</td>
<td>Baghdad</td>
<td>0.358 (20)</td>
</tr>
<tr>
<td>5</td>
<td>Ramses</td>
<td>0.265 (26)</td>
<td>28</td>
<td>Baghdad</td>
<td>0.358 (20)</td>
</tr>
<tr>
<td>6</td>
<td>Kolot bak</td>
<td>0.139 (36)</td>
<td>29</td>
<td>Ibrahim</td>
<td>0.358 (20)</td>
</tr>
<tr>
<td>7</td>
<td>Mahamed Mahmoud</td>
<td>0.692 (4)</td>
<td>30</td>
<td>EL-Thawra</td>
<td>0.331 (23)</td>
</tr>
<tr>
<td>8</td>
<td>Tallat Harb</td>
<td>0.486 (11)</td>
<td>31</td>
<td>EL-Nozha</td>
<td>0.106 (37)</td>
</tr>
<tr>
<td>9</td>
<td>Talaat Harb</td>
<td>0.166 (33)</td>
<td>32</td>
<td>Abbas EL-Akkad</td>
<td>0.239 (28)</td>
</tr>
<tr>
<td>10</td>
<td>Talaat Harb</td>
<td>0.466 (13)</td>
<td>33</td>
<td>EL Nasr street</td>
<td>0.402 (18)</td>
</tr>
<tr>
<td>11</td>
<td>Kasr Al Nile</td>
<td>0.477 (12)</td>
<td>34</td>
<td>EL Nasr street</td>
<td>0.729 (3)</td>
</tr>
<tr>
<td>12</td>
<td>Kasr El-Nile</td>
<td>0.449 (14)</td>
<td>35</td>
<td>Makram Ebeid</td>
<td>0.407 (17)</td>
</tr>
<tr>
<td>13</td>
<td>AL Bustan</td>
<td>0.231 (30)</td>
<td>36</td>
<td>Omar Ibn El-Khattab</td>
<td>0.503 (9)</td>
</tr>
<tr>
<td>14</td>
<td>Champollion St</td>
<td>0.44 (15)</td>
<td>37</td>
<td>Syria</td>
<td>0.069 (42)</td>
</tr>
<tr>
<td>15</td>
<td>Opera</td>
<td>0.293 (25)</td>
<td>38</td>
<td>Wadi Al Nile</td>
<td>0.08 (40)</td>
</tr>
<tr>
<td>16</td>
<td>Mahmoud Bassiouny</td>
<td>0.349 (22)</td>
<td>39</td>
<td>Gameat AL Dewal</td>
<td>0.553 (6)</td>
</tr>
<tr>
<td>17</td>
<td>Mohammed Sabri Abou Alam</td>
<td>0.438 (16)</td>
<td>40</td>
<td>Lebanon</td>
<td>0.161 (35)</td>
</tr>
<tr>
<td>18</td>
<td>EL-Qobba</td>
<td>0.261 (27)</td>
<td>41</td>
<td>Lebanon</td>
<td>0.38 (19)</td>
</tr>
<tr>
<td>19</td>
<td>EL-Khalifa El-Maamoun</td>
<td>0.046 (45)</td>
<td>42</td>
<td>Gohar El Qaeed</td>
<td>0.531 (7)</td>
</tr>
<tr>
<td>20</td>
<td>EL Hegaz</td>
<td>0.035 (46)</td>
<td>43</td>
<td>Gohar El Qaeed</td>
<td>0.636 (5)</td>
</tr>
<tr>
<td>21</td>
<td>El Hegaz</td>
<td>0.069 (42)</td>
<td>44</td>
<td>Port Said</td>
<td>0.059 (44)</td>
</tr>
<tr>
<td>22</td>
<td>El Hegaz</td>
<td>0.094 (38)</td>
<td>45</td>
<td>Port Said</td>
<td>0.163 (34)</td>
</tr>
<tr>
<td>23</td>
<td>Ibrahim Al Lakani</td>
<td>0.501 (10)</td>
<td>46</td>
<td>Al Moez Ledin</td>
<td>0.924 (2)</td>
</tr>
</tbody>
</table>

*a* Ranks are shown in parentheses. The imageability values and ranks are calculated at the seventh decimal place. The written values are approximated to the nearest third decimal place.

It is worth mentioning here that the BOD methodology has been executed using the General Algebraic Modelling System (GAMS) software. Applying this methodology to Cairo streets does require less than a second to be implemented.

5. Discussions of the BOD Findings

Applying the BOD methodology to assess walkability of Cairo streets proves several merits that are introduced in this section to show the remarkable contributions of this technique to this study. Firstly, the BOD technique equally maximizes the CWI and urban design qualities for all streets. Consequently, subjective judgments and biased results are avoided. Secondly, weights of physical features and urban design qualities are endogenously determined which matches with the essence of the BOD method. Thirdly, all sub-indicators and dimensions of walkability have been taken into account since the approach of Cook et al. (1996) is applied to the BOD model. Therefore, the problem of zero weights is diminished. Another merit is that the execution time of the BOD model is very fast; although, there are two stages
required to get the final scores of the CWI. Finally and most importantly, all the selected streets have distinguishable rankings. These in turn help decision makers develop these streets by relying on the scores of the CWI and urban design qualities.

6. Comparing Statistical Analysis Results with Qualities of Urban Design:

In this part of the study, a revision of the analytical statistical study that used the BOD model was revised to derive the extent to which the statistical analytical study results are linked to the qualities of urban design: the three chosen streets were the streets that had the first ranking in each quality for revision and analysis to be compared to the statistical analysis results.

6.1 Imageability:
The result of statistical analysis showed that the best streets in terms of Imageability is Baghdad St with score of one, where the Proportion of artistic, architecture and historical building frontage (both sides, within study area) reaches 94% as shown in fig 1, The Number of buildings with identifiers (both sides, within study area) is 3 buildings, The Number of buildings with nonrectangular shapes (both sides)is 33 buildings, the Number of outdoor dining within study area 4 and the Number of pedestrians 132. The next street in the ranking is a AL Moez St. with score 0.924, where the Proportion of historic building frontage (both sides, within study area) is 70 % as shown in fig 2, The Number of buildings with identifiers (both sides, within study area) is 50 buildings, Number of buildings with nonrectangular shapes (both sides within study area)is 20 buildings, The Number of outdoor dining (within study side)is 3 and the Number of pedestrians (within study side) exceeds 450 person during the daytime. The Third street in the ranking is EL Nasr street with score of 0.729, where the Proportion of historic building frontage exceeds 0 %, The Number of buildings with identifiers (both sides, within study area) is 9 buildings as shown in Fig 3, Number of buildings with nonrectangular shapes (both sides within study area) is 1 buildings, The Number of outdoor dining (within study side) is 6 and the Number of pedestrians (within study side) exceeds 225 person during the daytime .By reviewing the physical features that affect the Imageability, these streets achieved large factors and are valid for statistical analysis.

6.2 Enclosure
The result of statistical analysis showed that the best streets in terms of enclosure is AL-Moez St with score of one, where the Number of long sight line equal zero, Proportion of street wall (within study side beyond study area) is 98%, Proportion of sky (ahead, beyond study area) is 10% and the width of the street is narrow, which confirms the feeling of enclosure as shown in Fig 4. The next street in the ranking is a EL- Champollion St with score of 0.899, where the Number of long sight lines equal one, Proportion of street wall (within study side) is 90% Proportion of street wall (opposite side, beyond study area) is 94%, Proportion of sky (ahead, beyond study area) is 20% and Proportion of sky (across, beyond study area) is 10% as shown in Fig 5,which confirms the feeling of enclosure but less than AL Moez St. The
third street in the ranking is a Gohar EL Qaeed St with score of 0.873, where the Number of long sight lines equal zero, Proportion of street wall (within study side) is 85%, Proportion of street wall (opposite side, beyond study area) is 85%, Proportion of sky (ahead, beyond study area) is 20%, Proportion of sky (across, beyond study area) is 15% as shown in Fig 6. By reviewing the physical features that affect the Enclosure, these streets achieves these factor which proves the validity of the statistical analysis.

![Figures 4, 5, 6](image)

6.3 Human Scale
The result of statistical analysis showed that the best streets in terms of Human Scale is AL Moez St with score of one, where the Number of long sight lines equal zero, Proportion of windows at street level (within study side) exceeds 90%, Proportion of active uses (within study area) exceed 100% and Average building heights (within study area side) does not exceed 8 meters. It also has space outdoor furnishing elements, lighting units that consider human factor, excessive details in buildings and some hawkers that enhance the human scale. The next street in the ranking is a Gohar El Qaeed St with score of 0.987, where the Number of long sight lines equal zero, Proportion of windows at street level (within study side) exceeds 70%, Proportion of active uses, within study area) exceeds 95%, Average building heights (within study area side) does not exceed 9 meters and the Number of miscellaneous street items (within study area side) exceeds 40 elements, All of these physical features emphasize the human scale of the street. The third street in the ranking is Ibrahim Al Lakani St with score of 0.947, where the Number of long sight lines equal one, Proportion of windows at street level (within study area side) exceeds 80%, Proportion of active uses, within study area) exceeds 76%, Average building heights (within study area side) does not exceed 12 meters and the Number of miscellaneous street items (within study area side) exceeds 40 elements, All of these physical features emphasize the human scale of the street determining that this street comes in the third rank.

6.4 Transparency
The result of statistical analysis showed that the best streets in terms of transparency is EL-Moez St with score of one. The street is characterized by being a commercial street on the level of the ground floor, where the Proportion of windows at street level (within study area side) is 90% as shown in Fig 7, the Proportion of street wall (within study area side) is 98%, and the Proportion of active uses (within study area side) reaches 100%. The next street in the ranking is Ibrahim Al Lakani St with score of 0.930, The street is characterized by being a commercial street also as shown in Fig 8, where the Proportion of windows at street level (within study area side) is 80%, the Proportion of street wall (within study area side) is 93%, and the Proportion of active uses (within study area side) reaches 78%. The third street in the ranking is Kasr El-Nile St with score of 0.901, The street is characterized by being a commercial street also as shown in Fig 9, where the the Proportion of windows at street level (within study area side) is
80%, the Proportion of street wall (within study area side) is 80%, and the Proportion of active uses (within study area side) reaches 95%. By reviewing the physical features that effect the Transparency found it is available in these streets which proves the validity of statistical analysis.

6.5 Complexity:
The result of statistical analysis showed that the best streets in terms of Complexity is Gameat AL Dewal Al Arabeya St with score of one, where the number of buildings (both sides, beyond study area) is 70 buildings, the Presence of outdoor dining (within study area side) is zero, the Number of primary building colors (both sides beyond study area) is two as shown in Fig 10, the Number of accent colors (both sides beyond study area) is 23 colors, the Number of pieces of public art (both sides, within study area) is zero, and the Number of pedestrians (within study area side) is 857 person. The next street in the ranking is Kasr EL-Nile St, where the number of buildings (both sides, beyond study area) is 14 buildings, the Presence of outdoor dining (within study area side) is zero, the Number of primary building colors (both sides beyond study area) is two as shown in Fig 11, the Number of accent colors (both sides beyond study area) is 3 colors, the Number of pieces of public art (both sides within study area) is zero, and the Number of pedestrians (within study area side) is 85 person. The third street in the ranking is Abbas El Akkad, where the number of buildings (both sides, beyond study area) is 26 buildings, the Presence of outdoor dining (within study area side) is zero, the Number of primary building colors (both sides beyond study area) is two as shown in Fig 12, the Number of accent colors (both sides beyond study area) is 5 colors, the Number of pieces of public art (both sides within study area) is zero, and the Number of pedestrians (within study area side) is 620 person. The physical features that effect the Complexity achieved with large extent in these streets, which is proves the validity of statistical analysis.

Conclusion:
From the previous study, a methodology for evaluating the walkability of Cairo streets was derived; the opinions of experts were avoided while the weights of physical features and qualities of urban design were determined without the interference of the human factor using Cook et.al, 1996. The research got some different values for each street to arrange them according to their walkability level.
• The statistical study results were revised and proved which resulted in arranging Cairo streets according to their level of walkability, physical features and qualities of urban design in these streets which verifies the used methodology in the analytical statistical study using BOD model for evaluating the walkability in Cairo streets. This methodology will be usable in evaluating any street in Cairo which provides decision makers with a tool to take suitable decisions to improve walkability in the Egyptian urban environment.

• Streets that has historical buildings, buildings of architectural value or buildings with architectural styles are the preferred streets for walking in Cairo such as, el Moez street and Gohar EL Qaeed St street in historical old Cairo, Ibrahim EL-Lakani and Kasr EL-Nile street.

• The walkable preferred streets in Cairo are featured with commercial and mixed uses.

• People in Cairo prefer walking in Cairo city in streets that consider human scale.

This is why its recommended to provide commercial and mixed used in building and designing new urban environments in Egypt, as well as using architectural styles and considering human factor to encourage people to walk.

Future print of research:
• There are a lot of statistical approaches to be used in the reference OECD 2008, and some other approaches to be analyzed and confirmed with the suggested approach in this research.

• The research linked the Macro level with Micro level but information about Macro level were not available on the level of the streets in Egypt, so in future studies it is recommended to collect these missing data and link them with the data from the research in order to get more holistic results.

References
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Appendix

Table (3): Weighting Scheme for Physical Features and Urban Design Qualities

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Dimension’s Weight</th>
<th>Basic Indicators (physical features)</th>
<th>Direction</th>
<th>Indicators' weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imageability</td>
<td>0.221</td>
<td>Number of courtyards, plazas, and parks</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>
|  |  | Number of major landscape features | + | 0.381  
|  |  | Proportion of historic building frontage | + |  
|  |  | Number of buildings with identifiers | + |  
|  |  | Number of buildings with nonrectangular shapes | + |  
|  |  | Number of outdoor dining | + |  
| Enclosure | 0.221 | Proportion of street wall-same side | + |  
|  |  | Proportion of street wall-opposite side | + | 0.255  
|  |  | Proportion of sky ahead | - |  
|  |  | Proportion of sky across | - |  
| Human Scale | 0.221 | Number of long sight lines | - |  
|  |  | Average building heights | - | 0.342  
|  |  | Number of small planters | + |  
|  |  | Number of miscellaneous street items | + |  
| Transparency | 0.221 | Proportion of windows at street level | + | 0.507  
|  |  | Proportion of active uses | + |  
| Complexity | 0.221 | Number of buildings | + |  
|  |  | Number of primary building colors | + |  
|  |  | Number of accent colors | + | 0.403  
|  |  | Number of pieces of public art | + |  
|  |  | Number of pedestrians | + |  

Table (4): Values and Ranks for Four Urban Design Qualities, CWI and Walk Score in Cairo streets

<table>
<thead>
<tr>
<th>Path ID</th>
<th>(1) Name</th>
<th>(2) Enclosure</th>
<th>(3) Human scale</th>
<th>(4) Transparency</th>
<th>(5) Complexity</th>
<th>(6) CWI</th>
<th>(7) Walk Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Al Sabtiah</td>
<td>0.745 (18)</td>
<td>0.849 (7)</td>
<td>0.901 (3)</td>
<td>0.497 (21)</td>
<td>0.727 (6)</td>
<td>85</td>
</tr>
<tr>
<td>2</td>
<td>El-Gomhoreya</td>
<td>0.724 (21)</td>
<td>0.687 (17)</td>
<td>0.746 (19)</td>
<td>0.699 (7)</td>
<td>0.612 (13)</td>
<td>93</td>
</tr>
<tr>
<td>3</td>
<td>Al Fagalh</td>
<td>0.636 (29)</td>
<td>0.874 (6)</td>
<td>0.366 (36)</td>
<td>0.66 (8)</td>
<td>0.561 (18)</td>
<td>89</td>
</tr>
<tr>
<td>4</td>
<td>EL-Galaa</td>
<td>0.748 (17)</td>
<td>0.709 (16)</td>
<td>0.239 (42)</td>
<td>0.441 (26)</td>
<td>0.411 (33)</td>
<td>89</td>
</tr>
<tr>
<td>5</td>
<td>Ramses</td>
<td>0.605 (36)</td>
<td>0.344 (45)</td>
<td>0.338 (38)</td>
<td>0.651 (9)</td>
<td>0.364 (40)</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>Kolot bak</td>
<td>0.792 (13)</td>
<td>0.769 (13)</td>
<td>0.211 (43)</td>
<td>0.446 (24)</td>
<td>0.452 (29)</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>Mahamed Mahmoud</td>
<td>0.812 (8)</td>
<td>0.658 (21)</td>
<td>0.456 (28)</td>
<td>0.472 (22)</td>
<td>0.614 (11)</td>
<td>94</td>
</tr>
<tr>
<td>8</td>
<td>Tallat Harb</td>
<td>0.759 (16)</td>
<td>0.487 (36)</td>
<td>0.417 (33)</td>
<td>0.612 (15)</td>
<td>0.519 (23)</td>
<td>93</td>
</tr>
<tr>
<td>9</td>
<td>Talaat Harb</td>
<td>0.835 (6)</td>
<td>0.66 (19)</td>
<td>0.493 (26)</td>
<td>0.416 (28)</td>
<td>0.498 (26)</td>
<td>94</td>
</tr>
<tr>
<td>10</td>
<td>Talaat Harb</td>
<td>0.842 (4)</td>
<td>0.596 (26)</td>
<td>0.901 (3)</td>
<td>0.278 (38)</td>
<td>0.614 (12)</td>
<td>94</td>
</tr>
<tr>
<td>11</td>
<td>Kasr Al Nile</td>
<td>0.797 (12)</td>
<td>0.671 (18)</td>
<td>0.411 (34)</td>
<td>0.873 (2)</td>
<td>0.646 (9)</td>
<td>94</td>
</tr>
<tr>
<td>12</td>
<td>Kasr El-Nile</td>
<td>0.792 (13)</td>
<td>0.45 (38)</td>
<td>0.901 (3)</td>
<td>0.272 (40)</td>
<td>0.546 (20)</td>
<td>94</td>
</tr>
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* Ranks are shown in parentheses. The four urban design qualities and CWI values are calculated at the seventh decimal place. The written values are approximated to the nearest third decimal place.
Abstract:

‘Link and place’ is a design rationale founded on the recognition that streets return value to the public as essential stages for public life that contribute deeply to healthy, social and prosperous communities - as well as conduits for moving people and things.

‘Link and Place: A guide to street planning and design’ (Jones et al, 2007) provides a thorough street design methodology centred around a street classification matrix that seeks to resolve these competing ‘place’ and ‘link’ functions. While several subsequent incarnations of the theory have been presented since, all retain a similar expression of this ‘link and place’ street classification matrix.

This paper argues that an inherent flaw exists in the evaluation of place value in these expressions of ‘link and place’. That is, by evaluating the place value of streets in a citywide (or sometimes national) context, contemporary ‘link and place’ expressions simply assign higher place value to places that attract more people. While seemingly a sound rationale, such a superficial evaluation of place value marginalises the role local scale streets can play in enriching the lives of people who spend time there, and ultimately does little to advance the routine delivery of excellent local residential streets.

This presentation will propose an alternative expression of link and place that evaluates place value based on the extent street environments support the broad set of behaviours, uses and characteristics valued by the people who spend time there.

1. Introduction

Streets are some of the community’s most important and prevalent public spaces. They are where the people of our towns and cities have the most regular, direct, and unfiltered interaction with their neighbours and broader communities. They are places to gather, meet, stroll, dine and play, and the character of an area’s streets are defining features that contribute to the identity of its trading and residential community. Street art, leafy street trees, autumn colour, cobbled laneways, music, tram lines, and street food are all street features that are inherently tied to how humans experience the public realm. The sights, sounds and smells all help form the connection visitors and locals alike have to their environment, and influence the way people use the street for walking, riding, shopping, meeting, browsing and entertaining.

All of these factors and experiences collectively describe the ‘place’ function of streets. Of course, streets also return value to the community by facilitating the movement of people, cars, and goods. This describes the more commonly recognised ‘link’ function of streets. Unfortunately, the dual link and place functions of streets tend to have opposing requirements in terms of space allocation and geometry within our street reserves, meaning that any initiative to improve the free, fast and unimpeded movement of cars...
will tend to come at the expense of the human experience of place. Street design practice in Australia has been slow to respond to these issues, resulting in a steady erosion of the place qualities of many of our best main streets throughout the latter half of the 20th century due to an over prioritisation of the movement needs of private cars. This experience is familiar to many cities throughout the world.

Addressing the incompatibility between the needs of cars and people within common street environments has been a theme in urban and transport planning for some time - that is, how can practitioners provide amenable, vibrant and activated streets for people while still providing road space for vehicle travel and the appropriate level of car parking to go with it? An additional layer of complexity is often added when respective communities express a desire for active and vibrant places to live, yet at the same time, adamantly do not want to sacrifice road elements that they have become accustomed to such as slip lanes, roundabouts and abundant car parking that support convenient car accessibility and mobility (usually at the expense of the pedestrian realm).

“Link and Place: A guide to street planning and design” (Jones et al, 2007) is a landmark publication that introduced the link and place concept as a clear and implementable design rationale to resolve the competing requirements of cars and places for people. The guide provides a robust method to evaluate the link and place functions of streets, and recommends design responses that correspond to these classifications.

Following in these footsteps, the link and place concept has gradually infiltrated planning and street design policy over the last decade, and has helped to address the marginalisation of the value of streets as important public spaces for people. For example, the Adelaide City Council Transport and Movement Strategy 2012-2022 adopts a street hierarchy defined by various link and place value combinations to ensure street design appropriately prioritises people space within the city. In Victoria, Vicroads’ ‘Smart Roads’ approach is continuing to develop a new way to manage the State’s road assets based on movement (link) and place thinking.

2. ‘Link and Place’: A New Way to Design Streets

‘Link and Place: A guide to street planning and design’ (Jones et al, 2007) is a landmark publication that provides a detailed methodology for determining the link and place classifications of streets and recommending corresponding street design outcomes. Previous publications have discussed place value of streets prior to Jones et al (2007), however it was this guide that introduced the link and place matrix as a means to classify various street types based on their link and place values. This matrix has been adopted in several street design guides and policies, albeit often with some minor modifications or variations in terminology.

The link and place matrix defined by Jones et al (2007) determines link and place values within the context of the broader street network as a whole. Link and place value combinations are expressed within a matrix with five columns corresponding to place value (local, neighbourhood, district, city, and national) and five corresponding to link value (local, neighbourhood, district, city and national). As such, 25 unique link and place combinations are defined by the 5x5 matrix. Each link and place combination (e.g. local link, local place) is provided with street design guidance and recommended street typologies.

The 5x5 link and place street classification matrix from Jones et al (2007) is provided in Figure 1.
3. A Flaw in the Matrix: the ‘Network Perspective’ or the ‘User Perspective’

Link and place is helpful in a conceptual sense simply by providing a reminder to practitioners that street design must deliver value to people using the street for non-movement purposes. However, to provide specific design guidance it is necessary to develop a means to measure both movement and place to transparently compare and prioritise these competing functions.

As previously discussed, the approach adopted by Jones et al (2007) addresses this issue by defining five categories of place status ranging from local to national. These same categories are also used to define movement value. A similar approach is adopted by a range of link and place based planning and street design policies (for example the UK Manual for Streets, Smart Roads, and the Adelaide Transport and Movement Strategy).

It is suggested that this method of classifying place value represents a flaw in the process that reduces the efficacy of these guides to create widespread, routine quality street design. This flaw is as such: by evaluating the place value of streets from a city-wide or network perspective, rather than through the lens of the people who spend the most time there, the link and place concept in this guise marginalises the place value of local streets to their residents, and provides very little policy leverage to encourage practitioners to maximise the place value of local streets.

That is, from a network or city-wide perspective, any particular local residential street is essentially insignificant in terms of both link and place value. Because they do not typically attract high concentrations of people and generally carry low volumes of traffic over short distances, they only warrant a low-link, low-place classification using this methodology, as demonstrated by the following figures extracted from Jones et al (2007) and Transport for London’s “Street Types for London” respectively.
Considering the place value of a local residential street from the perspective of a resident, however, renders a different evaluation of place value entirely. For a resident, their local street is likely to be one of their most valuable and important public spaces. While a local residential street generally need only to provide basic accessibility to fulfil the link component of its role, the place component encompasses a much deeper set of criteria that have a profound impact on the quality of life of the people who live there. Such considerations relate to the type of behaviours and experiences that the street must cater to in order
to satisfy the home-zone requirements of a truly high quality residential street that adds value to the adjacent land use. What constitutes a good residential street will logically depend on the priorities and aspirations of the particular residents, however some generalised qualities of a good residential street would usually include a streetscape that enables local children to walk, ride and play in or adjacent to the street, and should provide a comfortable, safe and beautiful walking environment to maximise active travel. In any case, from the residents’ perspective, their street should be low-link, high-place value.

A link and place model that articulates this high-place, low-movement value for local residential streets provides clear guidance for practitioners tasked with designing such streets given the reality of scarce space and budgets. That is, for a low-link, high-place local residential street, there is a clear mandate to provide street trees in lieu of on-street parking spaces at regular intervals, quality bike-paths and generous footpaths at the expense of wide traffic lanes, and kerb extensions and safe pedestrian crossings at the expense of easy manoeuvrability for garbage trucks and occasional larger trucks.

In contrast, a low-link, low-place classification delivered by considering place value from a network wide perspective provides little such clarity, and will be unable to deliver local streets with place value tailored to the people who spend the most time there. This place valuation method marginalises the place value of the street to its most important stakeholders (the people who spend time), and will therefore render street designs that continue to over-cater to the link function of streets – that is, the needs of the car over the needs of people.

Considering the place value of streets from the ‘network perspective’ rather than from the perspective of the most invested users in effect rations good streets to places with lots of people, however it does not necessarily help practitioners make the best possible local streets. Streets represent approximately 80% of public space in cities (Jones et al., 2008), of which local and residential streets represent a significant proportion. The key to achieving a truly vibrant and active street network is not so much maximising the place value of the relatively small number of main streets within our towns and cities (which of course are nonetheless highly valued and important to the community), but completing a mesh of connected, consistently high-quality streets for people, which necessarily requires a concerted effort to maximise the place value of local streets. The fact that Jones et al (2007) includes place value as a measure of the human experience of streets, yet neglects to measure place value from the perspective of the humans with the greatest experience of place value within a given street represents a huge missed opportunity, and robs the concept of much of its potency.

4. A Better Expression of Link and Place

The following link and place diagram has been prepared as an alternative expression of link and place theory.
The proposed alternative link and place matrix provides several benefits:

1. The expression of the compromise between link and place functions on a single axis is considered a more accurate representation of the reality that link and place are fundamentally competing concepts which cannot both be maximised within a single road reserve. That is, any initiative to improve the function of a street for vehicular traffic will tend to reduce the quality of the human experience within the same street. The proposed matrix requires practitioners to make a clear and simple prioritisation of either link (movement) or place.

2. The proposed matrix introduces land use as key element that defines how people will wish to use the street. That is, the adjacent land use defines who will use the street and for what purpose, and ultimately the specific behaviours and experiences the street environment will need to support.

3. The extent to which a street typology enables these behaviours and experiences defines the place value of the street. Hence, each street classification ‘box’ should correspond to a suite of place value behaviours and characteristics. As such, the matrix clearly describes how fewer place value behaviours are supported when moving from higher place value street categories to higher movement value street categories.

4. The proposed matrix invites practitioners to define customised place value profiles for specific street design projects through rigorous community engagement and data collection. This would
seek to establish how a specific community desires to use their street, and how they prioritise certain behaviours and characteristics. There are a range of burgeoning organisations that specialise in measuring place value through community engagement that may be engaged for this purpose.

The proposed matrix naturally requires further development to define a host of place value behaviours and experiences, design metrics and street cross-sections, however it is intended that this proposal provides a conceptually sound base to refine the link and place street design rationale.

5. Conclusions

This paper has provided a review of ‘link and place’ street design rationale and evaluated the measurement of place value within contemporary street design guides. Link and place recognises that streets effectively have two competing functions. The ‘link’ function provides a movement conduit for vehicles, people and goods, while the ‘place’ function caters to people and street-based activities.

While the link and place concept represents an important step in recognising the value of streets as crucial public spaces for people, contemporary expressions of the link and place concept carry over an inherent flaw relating to the way place value is measured from a city-wide or network perspective, rather than from the perspective of the people who spend the most time in the street (and are thus most affected by a street’s place qualities). This flaw is considered to reduce the efficacy of link and place design rationales to routinely deliver high quality local streets. It is recommended that a reformed street matrix is required.

This paper has presented a reformed matrix that incorporates a more direct expression of the compromise between link and place functions, and includes land use as a fundamental consideration that defines the range and quality of place functions that street users desire. Crucially, this refined link and place matrix evaluates place value in terms of how well a street satisfies its place function from the perspective of the people who spend the most time there. It is suggested that the adoption of the refined link and place matrix outlined in this paper will help encourage the routine delivery of excellent streets of all scales.

6. References


VicRoads (2011) SmartRoads – Connecting Communities, Victorian Government, Melbourne
Study on the Urban Earthquake Shelter Planning Using Central Place Theory and Voronoi Diagram: a Case of Futian in Shenzhen, China

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Abstract: Urban earthquake shelter (ES) planning is an important method which can mitigate the earthquake loss effectively. The principles and requirements of urban earthquake shelter planning are popular in China, but the study of planning methods and spatial layout is lack. The paper proposes a practical approach of urban earthquake shelters planning using GIS (Geographic Information System) based on Central Place Theory and Voronoi Diagram. As urban ES is hierarchical, it is divided into four levels from high to low which are the center ES, the district ES, the block ES, the neighborhood ES. The different level of ES have the special scales and functions, so it can serve the relative population, radius, and area. Meanwhile, the configuration of ESs considers security, fairness, and accessibility using GIS. Earthquake shelter zone represents the service area of ESs which can make sure the land use scale of ESs, matched emergency facilities, and policy and strategy development for emergency administrative management. The contribution of this paper is a practical approach to planning urban ESs that can reduce disaster losses and decrease urban vulnerability.

Keywords: Central Place Theory; Voronoi Diagram; Urban earthquake shelter; Geographic Information System (GIS)

1 Introduction

As the world is facing an increasingly severe disaster situation, security has become the basis for the urban sustainable development. The rapid urbanization process and the expanding urban areas keep absorbing population into the cities, as a result of which, the damage caused by the disasters gets severer along with the growing population aggregation (Burby, 1994; Frazier, 2013; Godschalk, 2003; Orencio, 2013; Weichselgartner, 2001). In China, the urban lands have been largely developed with a high density of buildings and high floor area ratio. Old communities and urban villages are very common here. Since the earthquake disasters are unlikely to happen frequently, cities are usually not fully aware of the necessity of relevant disaster prevention. In the process of rapid economic growth, cities easily neglect the planning and construction of urban disaster-prevention space, such as parks and green areas, which are often misappropriated. All these urban phenomena are warning the lack and disorder of urban disaster-prevention space, which undoubtedly aggravates city’s vulnerability to disasters. For example, Tangshan was caught by 7.8Mw earthquake in 1979 that took about 240,000 lives away from the population of 1.197 million, leaving 160,000 seriously injured and 54 million slightly injured. In the earthquake, 95.5% of the buildings were destroyed, contributing to the total direct economic losses of...
15 billion CNY while the indirect economic losses remained inestimable with a long-lasting impact until today (Zhang, 2012). Therefore, the urban disaster prevention space plays an important role in the urban sustainable development, and the planning of the space turns out to be an important strategy to enhance the urban resilience. Due to the frequent occurrence of major earthquakes, such as in Tangshan (7.6 Mw), Wenchuan (8.0 Mw) and Yushu (7.1 Mw), as show in Figure 1, people have gradually realized the importance of urban disaster prevention planning, which has turned into an opportunity to carry out the relevant research and practice on urban earthquake shelter (ES) design where the planning of the urban disaster-prevention space remains an important part (Liu, 2011; Dai, 2011). Earthquake shelters (ESs) are divided into three categories in Tokyo: open shelter that usually occupies a large area and is often based on the green space of large parks; temporary shelter that is the public space among the neighborhoods; and refuge that is facilities offering temporary protection (COGI, 2002). Taiwan divides earthquake shelters into temporary refuges, mid-to-long-term refuges, emergency shelters and temporary shelters, and has assigned six disaster prevention space systems in Taipei as well as 66 indirect asylum living areas and 96 direct asylum living areas. China has promulgated the "Urban Earthquake Disaster Prevention Planning Standard" and "Earthquake Emergency Shelter Site and Supporting Facilities Standards", while the local governments have also developed the local standards. However, there are some problems with the planning of ESs in China. First of all, the planning and technical standards for some urban ES are inconsistent with varied qualities and significant differences, causing a lot of issues to ES design, construction and acceptance. Secondly, most research methodologies are quantitative description without the technical support of quantitative methods. Thirdly, the spatial distribution of ES is quite stuck in the current city layout, such as designating some primary and middle schools and parks as the temporary shelters rather a design based on the consideration of overall sheltering needs, which might easily cause an unbalanced distribution from a whole picture.

Figure 1 Tangshan earthquake (7.6 Mw) and Wenchuan earthquake (8.0 Mw)

Based on the above problems, this paper studies the planning of urban earthquake shelters from the perspective of related needs, on the ground of the theory of Central Place Theory and technically supported by the Voronoi diagram with a specific case of earthquake shelter planning in Futian District, Shenzhen. The remainder of this article is organized as follows. Section 2 provides an introduction to the study site and a description of the data. Section 3 illuminates the method of planning urban earthquake shelters. Section 4 implements that method in a city central district of Shenzhen, China. Finally, a summary is presented in the final section.
2 Study area and data

Shenzhen located in the south of China and borders the Special Administrative Region of Hong Kong. It was the first Special Economic Zone of China and was established in 1979. After nearly 40 years of development originating in a small fishing village, Shenzhen has become a megacity and Chinese economic center over an area of 1996.85 km². It has a population of 11.34 million inhabitants and a high population density of 5698 per km². The study area, the Futian district, is located in the center of Shenzhen and has an area of 78.66 km². The district is the central business district, wherein there are large numbers of residence zones, a central business district and public service facilities (Figure 2). In the study area, urban ES planning requires greater attention and consideration due to the high concentrations of population and economy and high density of buildings, which could also enhance the resiliency of the city and realize sustainable development. For this article, data on urban geology (e.g., earthquake faults), land use (e.g., residential districts, business districts, entertainment zones, and open spaces), buildings, public facilities (e.g., schools, gymnasiums, stadiums, gas stations, hospitals, police stations and fire stations) and the road system were collected from the Shenzhen government department of urban planning.

3 Methods

3.1 From Central Place Theory to urban earthquake shelter planning

The central place theory is proposed by Walter Christaller in 1932. The theory focuses on the city, uses the deductive method to study the size, quantity and spatial distribution of the city within a certain
area, and forms a corresponding central place system through a series of different scale-levels of central places. The central place theory consists of two main concepts: central place and threshold. Before the construction of the central place system, Christaller proposed five assumptions: the relatively even distribution of resources and population; the same traffic conditions, and positive correlation between delivery cost and distance; the principle of purchasing on proximity; the consistency of goods and services; the same consumption modes of residents without competition. According to these assumptions, the central system is established under the three principles: the principle of market, the principle of traffic and the principle of administration. Under different principles, different central place systems are formed by different levels of central places. The planning study of urban ES mainly draws on the main concepts of the central place theory, the construction of the central place system and the proposal of assumed conditions. (Christaller, 1933)

This paper divides ES into four levels from high to low according to the administrative districts in China: center ES, district ES, block ES, and neighborhood ES. Different levels of urban ES are expected with different functions while higher-level shelters shall cover the functions of lower-levels. The scale of urban ES is determined by the scope of ES services, population density and per capita evacuation area. Safety is the fundamental optimization principle for the ES. Therefore, the planning of the ES shall avoid some dangerous elements, such as seismic fault zone, high-voltage corridor, floodwater storage basins, geological disaster points, gas stations and so on, to ensure the basic safety of the places and avoid secondary disasters (Chen, 2013). Different dangerous elements are required with different avoidance distances, as shown in Table 1. ArcGIS offers the buffer analysis function to calculate the avoidance area and run security evaluation. The shelters sitting in the dangerous areas shall be adjusted to ensure the safety.

<table>
<thead>
<tr>
<th>Dangerous elements</th>
<th>Avoidance distances</th>
<th>Dangerous elements</th>
<th>Avoidance distances</th>
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<tbody>
<tr>
<td>Seismic fault zone</td>
<td>250m</td>
<td>Floodwater storage basins</td>
<td>Land boundary</td>
</tr>
<tr>
<td>High-voltage corridor</td>
<td>Land boundary</td>
<td>Coastline</td>
<td>200m</td>
</tr>
<tr>
<td>Geological disaster points</td>
<td>50m</td>
<td>Major hazards installation</td>
<td>1000m</td>
</tr>
<tr>
<td>Gas stations</td>
<td>300m</td>
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</table>

Studies have shown that urban public space systems play an important role in the construction of urban ES (Villagra, 2014; Ishimoto, 2000). The location of ES and the adjustment need to be based on the consideration of the existing urban space elements such as squares, parks, stadiums, large open parking lots, schools and so on. These facilities can not only meet people's daily needs, but also provide the necessary shelter space during evacuation, satisfying a combination of urban spatial elements with the objective of “disaster-relieving”. According to this principle, the planned ES can be evaluated and optimized and the reference could be offered for the selection of new ES.

The principle of combining safety and "disaster-relieving" considers the shelters from an individual perspective while from the perspective of overall arrangement, the ES should ensure the equality of the spatial distribution. When the disaster breaks out, people in different locations should equally share the shelter resources and the equal spatial distribution of ES is the basic reflection of fair distribution of urban resources. The planning could refer to the service radius of ES, use ArcGIS’s buffer area analysis and run uniformity evaluation. If the urban construction area is not fully covered by the buffer areas, it means that the current arrangement of the shelters is too sparse and the number shall be increased. The location selection shall also follow the principles of combining the safety and
“disaster-relieving”. If the buffer is overlapped too much, it means that the arrangement of ESs is too intensive and the number needs to be reduced.

People usually evacuate to the nearest safe place first after the disaster occurs and then walk or ride through different types of urban facilities to the nearest ES. Although an even spatial distribution could ensure that the straight-line distance is the same, the actual distance and the time cost for passing different types of areas vary a lot, which means, the accessibility is different. The cost and distance analysis function of ArcGIS's allows the calculation of accessibility to different shelters. The calculation results could be used in the evaluation for the accessibility of different shelters and adjust the number of shelters for the areas with poor accessibility or with over-occupied shelters. But before the analysis and calculation, it is necessary to confirm the resistance degree according to the characteristics of different types of land and draw a resistance map.

3.2 Voronoi Diagram

The Voronoi diagram, also known as the Thiessen polygon and the Dirichlet grid, is a basic geometrical structure that is currently used for describing spatial proximity relations and searching for spatial objects. There is a specific area with n targeting point Ps. Based on the principle that every location in this area is nearest to every targeting point \( P_s \), the area is separated into several Voronoi areas and each Voronoi area only contains one targeting point. The spatial partition of Voronoi diagram is closely related to the spatial arrangement of the targeting points. When the targeting points are equally distributed in the space, the size and distribution of the Voronoi region also appear relatively even. When the targeting points are not equally distributed in the space, the size and distribution of the Voronoi region appear heterogeneity.

The Voronoi diagram can help to determine the service area, land size and facilities of the ESs. Each ES has its own service scope that is earthquake shelter zone (ESZ). A higher-level ESZ covers the functions of lower-levels, with a purpose of ensuring the integrity of the management for all levels of ESZ. According to the principle of integrity, the optimization of the ESZ takes into account not only the integrity of the administrative management from higher level to lower level, but also the accessibility of meeting sheltering needs from the lower level to the higher level, which is a two-way logic optimization process, as shown in Figure 3. According to the logical process calculation method proposed by Gong (2010), this paper uses the weighted Voronoi diagram to calculate the lowest level ESZ, then obtain the affiliation relationship between different levels of ES according to the planning of the evacuation route, and finally incorporate all into the highest level of ESZ.
According to the service scope of ESZ, the land size and emergency facilities for the ES could be further determined. The land size of the ES needs to be calculated on the basis of the population size and the serving area per capita within the service scope of ESZ. It is possible to determine a proper size of the served population only considering the service radius of ESs. Emergency facilities shall be not only set up inside the ES, but arranged within the service scope of the ESZ. The existing emergency facilities in the shelter living area shall be evaluated first before adding new facilities according to the demands.

4 Results and discussion

First, the current ES construction situation in Shenzhen has been fully understood. According to "Shenzhen Emergency Shelter Planning" (2009), there are 4 block ESs and 29 neighborhood ESs in Futian District, Shenzhen. Shelters should avoid all risk factors and buffer zones to ensure safety, according to the avoiding distance in Table 1. According to the safety evaluation results, the location of ESs is adjusted and optimized, such as adjusting the location of ESs too close to dangerous factors, and moving them to the safety areas nearby like parks, green space, primary and middle schools, sports venues or open parking lots, with a consideration of the principle of "disaster-relieving". And then based on the service radius of ES, the ArcGIS buffer analysis is used to assess the homogeneity of spatial arrangement of ESs to reduce the number of over-gathered ESs and increase the number in the sparse area. The adjustment output is repeatedly verified to achieve the optimized results. In the end, the overall layout adds another 1 center ES, 1 district ESs, 6 block ESs and 8 neighborhood ESs, as shown in Figure 4. The optimization results should basically satisfy the distribution homogeneity of ESs in the urban space.

The resistance map of Futian District is obtained by studying and assigning the value to the resistance degree of different types of land. Then the cost and distance analysis of ArcGIS is used to calculate the accessibility of block and neighborhood ESs, with the outcome for further classification. The darker the blue part in Figure 5, the better the accessibility while the darker the red part, the poorer the accessibility. In addition, it is found that the areas with poorer accessibility are mainly the urban
villages with intensive buildings that elevate the passing cost and cut the reachable paths to the ES. Apparently, the urban villages are the obstacles and major challenges in the construction of ESs. 9 neighborhood ESs are added after the accessibility evaluation and optimization, with the spatial location and number of ES being finally settled down, including 1 center ES, 1 district ES, 10 block ESs and 46 neighborhood ESs, as shown in Figure 5.

In terms of ESZ, based on the resistance map of Futian District, the spatial analysis function of ArcGIS 10.2 is used to calculate the neighborhood ESZ, to be consistent with the number of neighborhood ES. The number of block ESZ is the sum of the neighborhood ESZ under its administration, so it is necessary to count the neighborhood ESZ covered in each block ESZ. When planning the evacuation route for neighborhood ESs, every neighborhood ES chooses the shortest path to the nearest street-level shelter. This process identifies which block ES each neighborhood ES belongs to and offers the reference for the planning of ESZ. The district ESZ covers the entire Futian District and the center ESZ covers the entire city of Shenzhen, as shown in Figure 6. After determining the scope of the ESZ, the land size of the internal shelter space could be further determined according to the population size and shelter space per capita within each ESZ. At the same time, the facilities could be equipped for different levels of ESZ based on the existing public service facility resources in Futian District including community hospitals, community parks, primary and middle schools, fire stations, etc. Every ESZ are ensured to be equipped with full set of facilities.
5 Conclusion

The acceleration of urbanization absorbs more and more population and wealth into the city. Once the natural disaster breaks out, the urban areas will be faced with a huge loss of life and property, along with immeasurable impact in various aspects. Urban ES planning is an important means to improve the city's disaster prevention capacity. This paper studies the planning of ESs from the perspectives of fairness, homogeneity and accessibility, and puts forward some practical methods to lay the theoretical foundation and technical support for urban ES planning and practice. Urban ES planning and practice should be seriously emphasized rather than being ignored in the process of rapid economic development. At the same time, urban ES planning is also a long-term process, which needs several stages of practice and optimization to realize the purpose of improving urban disaster prevention capacity. For better implementation of urban disaster prevention space planning, some supports of planning strategies are necessary, such as the combination with the overall urban plan, especially with the public service facility system, green space system and road system; the combination with urban renewal to provide an opportunity to shape the disaster prevention space in the old communities; the combination with big data to better match the planning with the reality based on the dynamic population distribution.

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Reference


