Towards Verticalization A study of how high-rise housing can achieve social sustainability

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Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of MSc Urban Regeneration at University College London: I declare that this dissertation is entirely my own work, and that ideas, data and images, as well as direct quotations, drawn from elsewhere are identified and referenced.

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Table of Contents

List of Figures

Abstract

Academics have been attempting to define, measure and understand the dimensions of social sustainability in recent decades, which has been given considerably less attention compared to environmental and economic sustainability. As urban populations rise, cities are becoming increasingly dense, urging planners to search for new and innovative ways to accommodate this influx of residents. Constructing housing at greater heights and at higher densities has put topics of social wellbeing, mental health and standards of living in cities centre stage, thus making it essential to investigate whether high-rise high-density housing can achieve social sustainability.

As the concept of super high-rise high-density public housing has just emerged in Singapore, this paper sets out to explore the Pinnacle@Duxton in some detail, highlighting the unique qualities of this public housing development, such as its sky gardens and communal facilities, demonstrating their effectiveness as social devices. In order to measure social sustainability, the following dimensions, identified through academic literature review, are used: amenities and social infrastructure; social and cultural life; voice and influence; and space to grow. These four dimensions are evaluated through evidence from interviews with residents of the case study development and a professional specialist from the government body responsible for its realisation.

This investigation contributes valuable knowledge and insight towards the growing field of literature related to social sustainability and high-rise housing. For example, it is shown that larger households and household with children are more likely to be involved in social networks and community engagement in the Pinnacle@Duxton, but a lack of space has resulted in these families moving away from their community. This study concludes that verticalization can have a significant impact on the dimensions of social sustainability, due to the complexities and intricacies of such buildings, though it is asserted that the process of verticalization alone cannot influence social sustainability.

1 Introduction

1.1 Background Overview

> *"The high-rise was a huge machine designed to serve, not the collective body of tenants, but the individual resident in isolation." (Ballard, 1975).*

A rising urban population, diminishing resources and increasing need for land preservation have urged humans to build vertically. The densification and concentration of urban dwellers into taller—but fewer—buildings can potentially help resist the effects of climate change and other ecological issues, but whether humans will adapt to this emerging form of habitation remains uncertain. Although high-rise structures entered the mainstream in the early 20th century, the concept of building upwards is evident throughout human history, for reasons such as: defence, agglomeration economies, resource conservation and even prestige (Richardson, 2018).

Land is a vital natural resource for human beings. With the Earth's rising population, we are faced with a pressing need for land, which is currently confined to just 29.3% of the Earth's surface area (HarperCollins, 2005). This figure does not take into consideration mountainous, desertic and other uninhabitable areas, where human settlements cannot be located. Additionally, as the proportion of urban dwellers is expected to increase to 68% by 2050—from today's 55%—it is in our best interest to make sure that the land available to us is utilised efficiently and sustainably to sustain future growth (United Nations, 2018).

1.2 Research Question and Research Objectives

This paper seeks to answer the following research question:

> ***"To what extent does verticalization provide a socially sustainable solution to Singapore's land scarcity problem?"***

In order to fully investigate this research question, the following key research objectives will be achieved:

1. Identify and demonstrate concepts of social sustainability and verticalization.
2. Identify past and current research into high-rise and high-density living related to social sustainability.
3. Determine if verticalization could lead to more socially sustainable development, through interviews with organisations/individuals associated with high-rise development in Singapore, such as the Urban Redevelopment Authority, Housing Development Board and homeowners.
4. Analyse variables such as age, gender, employment status and household size to determine what affects residents' responses.

This paper seeks to achieve the research question and research objectives, through first discussing the definition and content of social sustainability and verticalization by reviewing a wide range of academic literature. This paper will then introduce the methodology, which develops a methodological framework and includes qualitative and quantitative data collection methods, including interviews for respondents from a housing development in Singapore, and representatives of the government body responsible for its inception. By collecting the relevant data and results from the methodology, this paper will then analyse and explore how verticalization could affect social sustainability within communities and neighbourhoods through various significant variables. Finally, the paper will provide a reflective conclusion, outline the limitations of this study and propose recommendations for government policies and future research.

This study could significantly contribute to the discussion surrounding new housing development and verticalization in cities and exploring the relationship between residents and their surrounding urban environments. This is especially significant in cities such as Singapore, with its geographical and physical limits, and also in cities in the developing world which are seeing a substantial influx of urban dwellers. This study could provide referential value and practical significance for socially sustainable development in future for both Singapore and the world.

2 Literature Review

2.1 Social Sustainability

Although the concept of 'sustainability' was first termed in the Oxford English Dictionary in the second half of the 20th century, parallel terms in other languages have been around for centuries, such as "durabilité" in French and "nachhaltigkeit" (meaning 'lastingness') in German (Van Zon, 2002, pp. 20-22). Van Zon highlights that humankind's demand for raw materials and ensuing impact on the environment have been contentious issues throughout history (Van Zon, 2002, pp. 1, 9-10; Jacobus, 2006, pp. 85-86). In the late 18th century, European foresters became aware that they were not sufficiently planting enough trees to replace the wood fibre lost to harvesting. Thus, in order to monitor the supply of wood and assess how much needed to be replanted, they began developing more responsible ways of using natural resources to protect supply for current and future generations (Davoudi & Layard, 2001, pp. 7-8; Jacobus, 2006, p. 85).

Today, the overarching concept has evolved to include social and economic aspects as key dimensions of sustainability, deviating from a previously environmental focus—although contemporary use of the term is still broad and difficult to define precisely (Jacobus, 2006, p. 94). Today, sustainability is often illustrated as a Venn diagram (see figure 1), showing the three interconnected elements: environmental, economic and social sustainability. However, even though the diagram suggests that each facet is given equal importance, social sustainability is an often-disregarded element, and discussions of sustainable development generally focus solely on economic and environmental issues, especially within the context of planning, communities and housing, whereby investment and policies have concentrated on low carbon neighbourhoods, renewable resources and supporting pro-environmental behaviour in households (ADEC, 2019; Woodcraft, et al., 2012, p. 15).

Figure 1: Venn diagram of sustainability (adapted from (Circular Ecology, 2019))

'Social Life', a social enterprise focusing on place-based innovation, define social sustainability as "a process for creating sustainable, successful places that promote wellbeing, by understanding what people need from the places they live and work. Social sustainability combines design of the physical realm with design of the social world—infrastructure to support social and cultural life, social amenities, systems for citizen engagement and space for people and places to evolve" (Woodcraft, et al., 2012, p. 16).

Using planning to achieve social sustainability requires four elements that are key in ensuring that new communities will be sustainable and successful in the long run. These elements are derived from the Young Foundation's framework for practical action in social sustainability (Woodcraft, et al., 2012, pp. 21-23). The four elements are illustrated in figure 2:

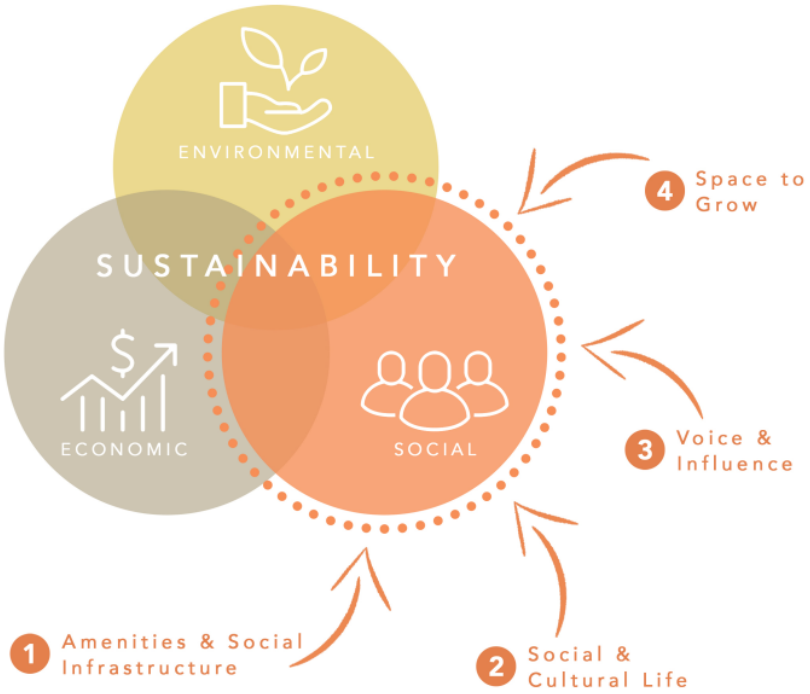


Figure 2: Venn diagram of sustainability highlighting the four elements of social sustainability (adapted from (Circular Ecology, 2019) & (Woodcraft, et al., 2012, pp. 21-23))

Gallent argues that housing, including its location and the physical structure itself, influences almost every aspect of our lives; from how often we interact with neighbours, to our overall happiness and wellbeing. Therefore, in order to enhance the wellbeing of individuals as well as communities as a whole, improving housing should be a priority, as it is where most people spend the majority of their lives (Gallent, 2001).

2.2 Verticalization

A considerable amount of literature has been written on the concept of verticalization. The first notable discussions and analyses of vertical cities emerged during the 1930s with Le Corbusier. He called the skyscraper "a magnificent instrument for the concentration of population, for getting rid of land congestion [...] for internal efficiency" (Le Corbusier, 1937,

pp. 51-52). His ideas—paradoxically—sought to decongest the city through increasing its density with high-rise buildings that would house "perfect human cells which correspond most perfectly to our physiological and sentimental needs" (Hall, 2002, pp. 222-225).

Scholars Gabay and Aravot have previously explored the idea that as cities become increasingly dense and congested, its two-dimensional plane reaches its elastic limit, forcing the city into a second stage of development, whereby it incorporates complex additional layers, including subways, transit and parking, to ease the freedom and choice of movement. This ultimately pushes the city to develop into the third dimension to accommodate greater density and movement (Gabay & Aravot, 2003, p. 73).

2.2.1 Density

The term 'density' itself—though seemingly simple and familiar at first glance—has many varying degrees and dimensions (Cheng, 2009, p. 3). Cheng emphasises the contrast between physical density and perceived density. The former is a quantitative, neutral and objective spatial indicator; a measure of the concentration of individuals or physical structures within a specific geographical unit. In contrast, perceived density is an individual's approximation of the number of people present in a specific area, the amount of space available and its organisation (Rapoport, 1975). Perceived density is highly relevant to the topic of social sustainability, as it can alter the way in which people interact with each other within a space, as well as with the space itself (Cheng, 2009, p. 12).

Within the urban environment, perceived density tends to be connected with the built form and urban features. Amos Rapoport highlights the key "environmental cues" believed to influence perceived density. These include openness of space, height-to-space ratios, the number of individuals, traffic, amount of greenery and levels of activity (Rapoport, 1975). Cooper-Marcus and Sarkissian outline design attributes in housing developments which contribute towards the perception of density, including building size, space between buildings, façades and visual access to green space (Cooper-Marcus & Sarkissian, 1988).

2.2.2 Debates on High Density

Since the 1950s, rapid urbanisation has put a significant strain on development in many urban areas, along with the continuously decreasing supply of available land in cities. Thus, densification and high-density development have become important topics of interest, and key aspects of planning policy worldwide (Dave, 2010). Densification can represent varying notions between different countries, cultures and people; and attitudes towards high-density development are similarly diverse (Cheng, 2009, pp. 13-14; Ellis, 2004). While some people criticise the disadvantages of high-density development and argue strongly against it, many others also recognise its advantages, advocating urban compaction and densification (Pomeroy, 2012).

Higher densities inevitably increase the proximity of people and places, improving the accessibility to and convenience for work, recreation and service. However, this proximity may lead to an increased competition for space and the use of services and facilities, resulting in social conflict. Proximity may also cause people to encounter some degree of unwanted social contact, a reduced sense of privacy, feeling of loss of control, leading to psychological stress and anxiety. Nonetheless, the proximity that stems from high densities can help to promote greater social interaction and improve neighbourhood relations with appropriate management and organisation (Pun, 1994; Breheny, 2001, pp. 40-41).

Regarding the social and psychological aspects of verticalization, Susan Young argues that higher-density housing developments tend to reduce community interaction and social contact between neighbours (Young, 1976). Collin Ellard also argues that “such buildings can be really alienating,” due to the large concentration of people in one area, meaning that residents tend to interact less with the same people, and instead only spend “brief sojourns” with many different individuals (Ellard, 2018). Furthermore, a study by the Centre for Urban Design and Mental Health found that city dwellers have a 50% higher rate of schizophrenia and a 40% higher risk of depression (Gardiner, 2017). It was also found that anxiety and mood disorders were also considerably higher in urban areas (Peen, et al., 2009). All of these issues particularly affect children, especially during their developmental years (Smith, 2016). Therefore, the question is how to build high-rise high-density developments without these

negative consequences. As stated by Layla McCay of the Centre for Urban Design and Mental Health, "the villain is not density itself, it's insensitive design […] It's about how you design in things that are protective to people's mental health—green spaces and opportunities for social interaction," which corresponds with the Youth Foundations elements for social sustainability (Hickman, 2017).

Though the term 'high-density' is also commonly associated with overcrowding, it has little to do with it. A high building density expressed as a plot ratio would indicate a high proportion of built-up floor area. For example, an increase in dwelling size and decrease in household size, along with a higher plot ratio, would lead to a lower occupancy density and thus serve to mitigate overcrowding (Ng & Wong, 2004). This occurred in Hong Kong, when the plot ratio of public housing developments increased from 3.0 to 5.0 from the 1970s to 1980s. In parallel, dwelling size also increased from 3.2 to 5 sq. metres per person, creating a higher building density while helping to ease the issue of overcrowding in Hong Kong (Sullivan & Chen, 1997, pp. 296-297).

2.3 Verticalization in Singapore

In Singapore, the topic of densification and verticalization has received increasing attention from urban scholars and policy makers alike. This is due to the geographical and spatial constraints that limit the country's ability to expand development and increase its population. With a fixed land area, Singapore faces a massive challenge to manage the problem of land scarcity. In recent history, Singapore has adopted land reclamation to help resolve this problem (Subramanian, 2017). However, this method has both technical and geographical limitations, as the government only plans to reclaim a further 7-8% of land by 2030 (The Economist, 2015). Furthermore, projections for increased population growth have meant that proposals for future housing have included taller and higher density developments, as outlined in the 2019 Draft Master Plan produced by Singapore's Urban Redevelopment Authority (URA) (URA, 2019).

Scholars have explored various methods of tackling this land-scarcity dilemma. In Jason Pomeroy's paper, 'Room at the Top: The roof as an alternative habitable / social space in the Singapore context', he examines the possibility of "topping-up" roof space to provide additional living spaces as well as new social infrastructure. In cities such as Singapore, space has become an increasingly valuable commodity, bringing topics of rooftop spaces and air-rights centre stage, and shaping the designs of future—and even existing—structures (Pomeroy, 2012). Furthermore, Le Corbusier emphasised the significance of rooftop spaces not just to replenish the space consumed by the building itself, but also to provide space for social wellbeing and health (Frampton, 1992, p. 157).

Following Singapore's independence in 1965, the development of housing progressed rapidly, as the government sought to apply Le Corbusier's modern city model to its urban development. The Housing and Development Board (HDB), a statutory board of the Ministry of National Development, is the exclusive provider of public housing in Singapore and sells flats on a 99-year lease agreement (HDB, 2017).

Joo-Hwa Bay argues that Singapore is not far from solving its quantitative housing problems, due to the various housing typologies—to cater to various income groups—that have been built over the years. However, he also argues that there have been very few studies attempting to evaluate Singapore's housing in qualitative terms (Bay, 2004). His investigation of the Bedok Court development highlighted the successes of the forecourts and communal spaces. However, one of the limitations of his study was that his focus was mainly on environmental concerns, such as the urban heat island effect and reducing the reliance of air-conditioning. Furthermore, Bedok Court is a gated private housing development, thus any communal spaces within the development are only used by residents.

As Singapore continues to develop, its land scarcity will dictate that future housing be built to even greater densities and heights. Plots ratios over 7.0 and higher are becoming more common. The main questions that arise from this are whether Singapore's residents will be able to adapt quickly enough to the ever-increasing densities and heights of housing developments and how living in this environment will affect social networks and community cohesion.

2.5 Conclusions from Literature Review

Many urban planners and architects advocate verticalization as a solution to land scarcity and urban sprawl. Although literature written by various academics contributes towards a better understanding of the environmental sustainability of high-rise housing, most discussion fail to fully address the social aspects of verticalization. Moreover, few studies have been conducted on the perceptions, experiences and needs of high-rise residents. And existing literature is generally focused on the residents or potential residents of regular tall developments, rather than super-tall structures. This is mainly due to the fact that very few super high-rise developments exist to conduct enough studies to achieve accurate and reliable data. As Rapoport argued, society and culture are intimately interconnected with the density of the human habitat (Rapoport, 1977). Thus, it is necessary to investigate the topic of verticalization and explore whether high-rise housing can achieve social sustainability.

3 Methodology

3.1 Methodological Framework

In order to investigate the main research question and achieve the research objectives, a methodological framework unique to this study has been created for data collection and analysis. The new methodological framework is shown in figure 3, and illustrates the multiple variables and dimensions used for collecting data and analysing the results.

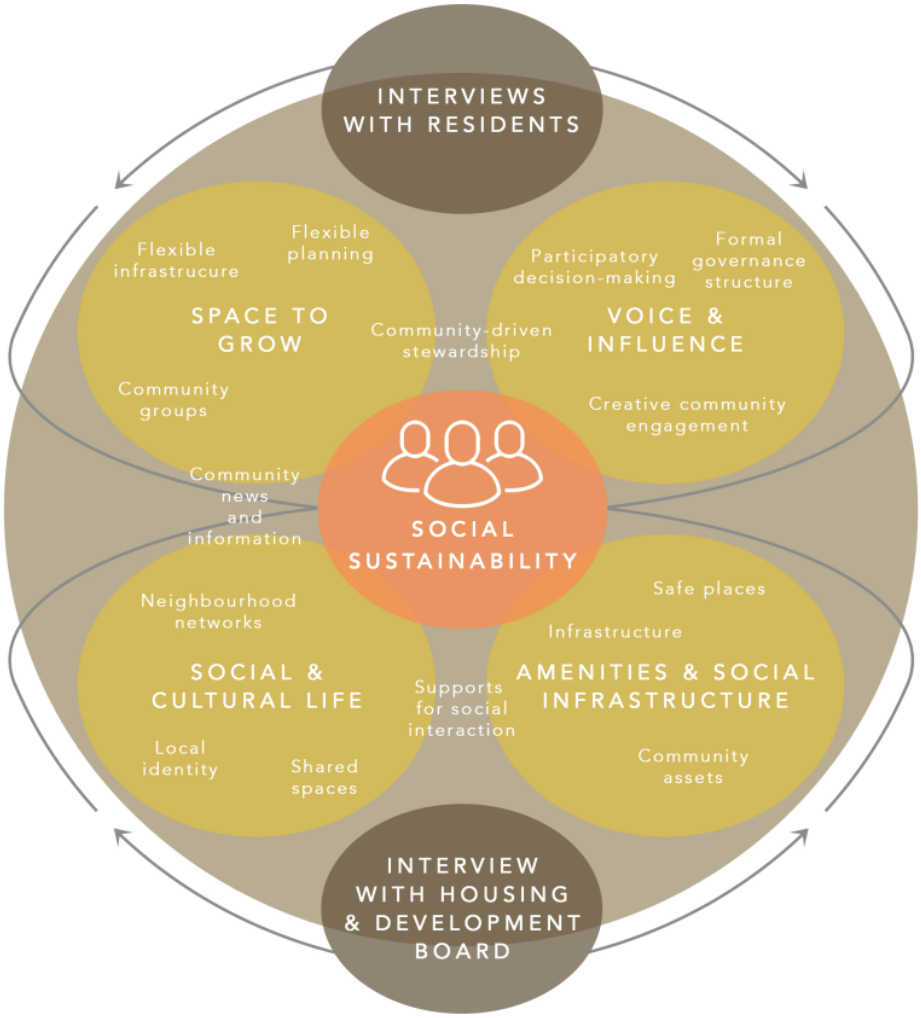


Figure 3: Methodological Framework

Figure 3 illustrates the main focus of the methodology in investigating the different elements of social sustainability in high-rise high-density housing. Data gathered from interviews with both the residents of a high-rise high-density development and the government body responsible for planning and developing it will be used to investigate the different dimensions of social sustainability. Variables such as age, household size, number of children and number of years as resident will be looked at to further investigate what affects residents' experience and perceptions of living in high-rise high-density housing. The methodological framework also emphasises the interrelation and interaction between the four elements of social sustainability.

3.2 Case Study

Having designed and constructed over one million flats, the HDB has endeavoured to continue to innovate and develop new-generation housing and sustainable neighbourhoods in Singapore (HDB, 2017). Today, 82% of Singapore's population resides in flats constructed by the HDB, and a further 92% of these HDB residents are owners of their apartment units (Keating, 2019). Since the 1960s, the high-rise high-density public housing model has been adopted to satisfy housing demand; and this model is expected to be the principle housing form to meet future needs (Joo & Wong, 2008). From land-saving initiatives, Singapore's high-rise high-density public housing has captured greater concern and debate about its sustainability, especially in terms of wellbeing and quality of life.

The Pinnacle@Duxton is a public housing development in central Singapore, proposed as part of the Singapore government's continued urban renewal strategy (Ho & Ee, 2010). It was a pioneering development for the HDB, as it was the first public housing development to reach 50 floors, integrating high-rise living with other uses within the same structure, such as recreational, commercial and community facilities (Sim, 2001, p. 6; Lim, 2002, p. 1). The Pinnacle@Duxton was constructed on the 2.5-hectare Duxton Plain on Cantonment Road, replacing the first social rental flats commissioned by the government in 1963 (Lee, 2011). Compared to the old estate, the HDB doubled the height of the blocks from 25 to 50 floors and

also increased the number of blocks from three to seven (Lim, 2010, p. 8). Launched in 2004 and completed in 2009, the development houses 1,848 residential units of various sizes and layouts.

The Pinnacle@Duxton was chosen as the main case study in the methodology for this investigation because it was the first super high-rise high-density public housing in Singapore. Furthermore, having been completed for 10 years at the time this study was conducted, this meant that the estate would have had time to "mature," and residents would be able to provide a more accurate account of their experience living in the development, as compared to investigating a newer project. Moreover, the range of diversities of residents could be a defining component that influences the experiences and perceptions of individual residents.

Figure 4: Images of Pinnacle@Duxton (author owns)

Figure 5 illustrates Singapore's position as an island city-state in Southeast Asia. Historically, it has seen a steadily increasing population density (figure 6), and is now the third most densely populated country in the world, with 7,953 people per sq. km as of 2018 (World Bank, 2019). With a land area of 724.2 sq. km and a population that is expected to reach 6.9 million by 2030—currently 5,638,700—the country is facing a dilemma that could potentially threaten the livelihoods of its citizens (data.gov.sg, 2019; Heng, 2013). Unlike many other cities which can expand outwards to accommodate a growing population, an island city-state such as Singapore can only support urban sprawl laterally until it reaches its coastline. As stated by David Tan, chief executive of Jurong Town Corporation in Singapore, "bigger countries have the luxury of not having to think about this. We've always been acutely aware of our small size"

(Subramanian, 2017). For this reason, future housing in the country will likely be built to even greater heights, higher densities and bigger plot ratios, thus making Singapore a compelling location to study the potential for verticalization.

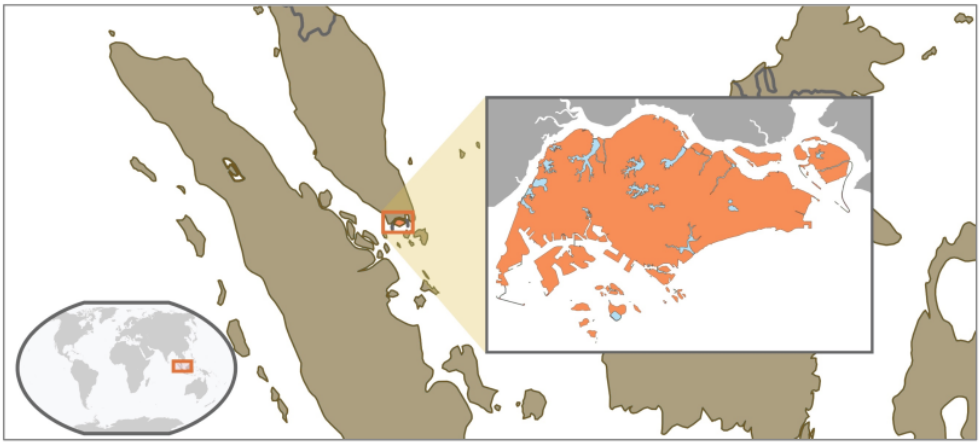


Figure 5: Location of Singapore in the World and within Southeast Asia (Adapted from (Jochim, 2018))

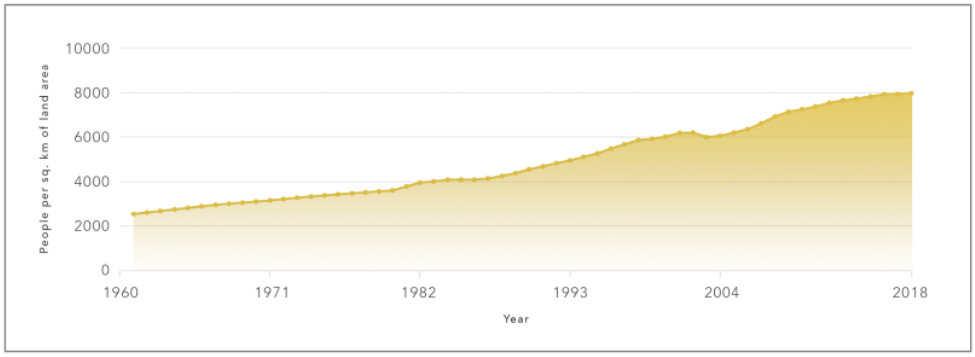


Figure 6: Singapore's population density over time (people per sq. km of land area) (Adapted from (World Bank, 2019))

The Pinnacle@Duxton was designed by ARC Studio + Urbanism, in collaboration with RSP Architects, drawing inspiration from the neighbouring linear plots in Duxton Park (Lim, 2010, p. 8). The seven towers are linked by skybridges on the 26th and 50th floors, creating an 800-metre jogging track and providing playgrounds and gardens. The development also incorporates other uses, such as a food court, child day care centre, preschool, basketball court, etc. (Low, 2011, pp. 33-34). The development has also won a number of awards, such

as the ‘Best Tall Building Asia and Australasia Award’ in 2010 by the Council on Tall Buildings and Urban Habitat, as well as ‘Design of the Year’ by the President's Design Award Singapore.

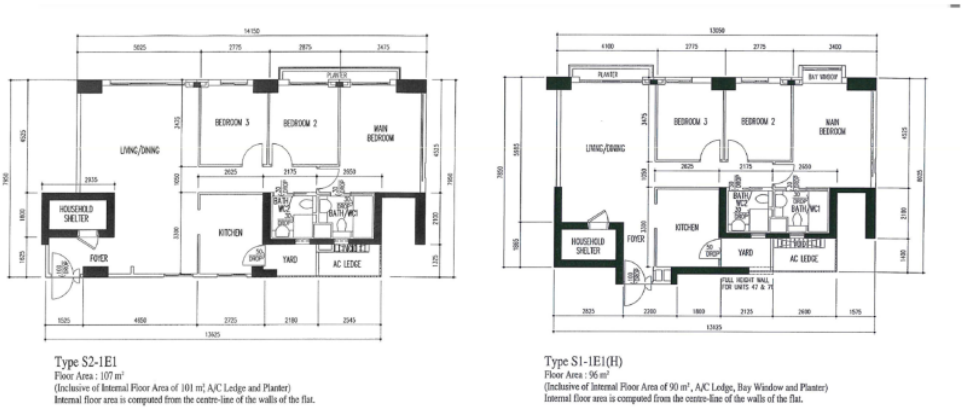


Figure 7: Example floor plans of Pinnacle@Duxton flats (Adapted from (SRX Property, 2018))

The development is located within the Central Region of Singapore and is part of the Outram planning area. Figure 8 shows part of Singapore’s building height plan, detailing the areas subjected to special height controls (in grey), mostly concentrated near the CBD. All other areas are subject to prevailing development control guidelines (URA, 2019). The area within the red boundary line is subject to a relaxation of residential building heights. Set within this boundary, this made it a suitable location to construct the Pinnacle@Duxton. Additionally, in conjunction with the launch of the first apartments in 2004, the Minister of National Development, Mr Mah Bow Tan, announced that the Pinnacle@Duxton would be a “one-off project,” and that it would not be replicated (Tan, 2004, p. 18).

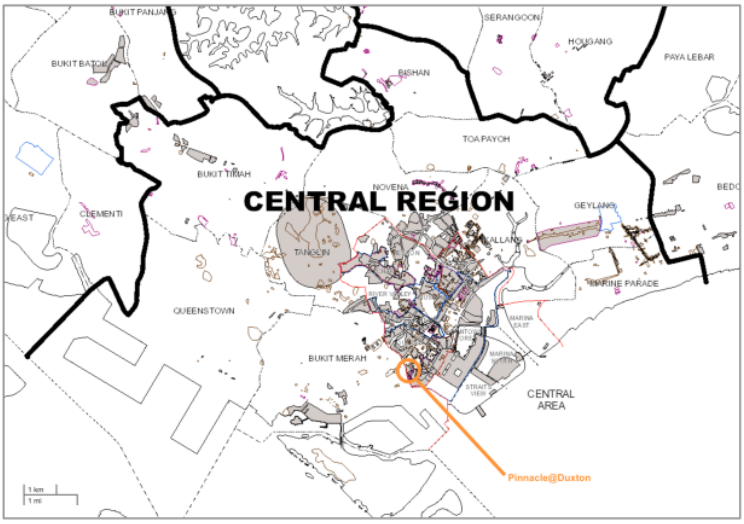


Figure 8: Building height control plan of Central Region in Singapore (URA, 2019)

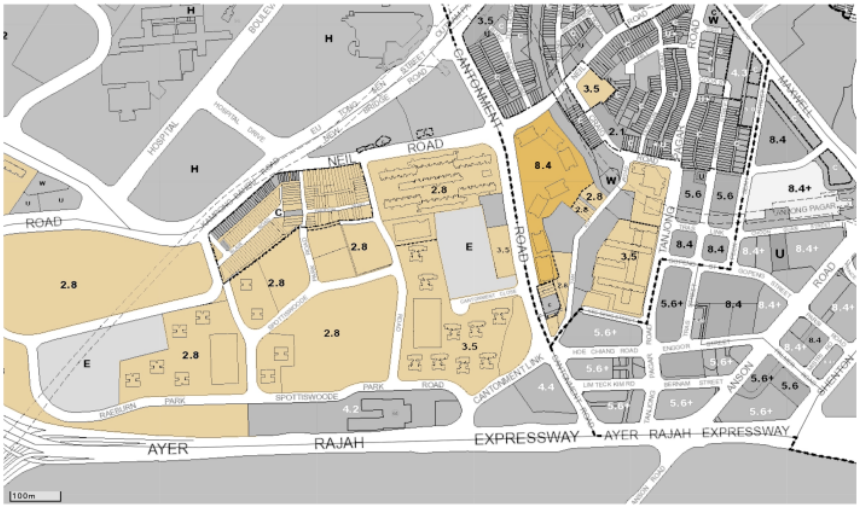


Figure 9: Map showing maximum permissible plot ratio of residential land-use zones near Pinnacle@Duxton (URA, 2019)

Figure 9 provides information about the maximum permissible plot ratios for land parcels near the Pinnacle@Duxton, shown in darker yellow. Other nearby residential land-use zones are shown in lighter yellow. The map shows that the Pinnacle@Duxton site has a plot ratio of 8.4, whereas the other residential sites only range between 2.8 and 3.5 (URA, 2019). This shows the significant difference in density between the Pinnacle@Duxton and other residential developments in the area.

The objective of the interview with the representative of the HDB was to gain a better understanding of the national public housing authority's intentions and future plans regarding the "verticalization" model in the city-state. The semi-structured interview can be organised into three key sections. The first sought to uncover the HDB's reasons for building the Pinnacle@Duxton, the first super-tall public housing block in Singapore. The second section aimed to find out if the HDB promotes forms of citizen participation in planning or studies into the livelihoods and experiences of residents at the Pinnacle@Duxton—which may influence similar projects in future. This leads into the third section, which sought to discover the HDB's future plans for applying similar super high-rise developments to public housing in the country.

3.4 Limitations

There are some limitations to this methodology, as it proposes a new and developing methodological framework, lacking practical implementation prior to this investigation. Firstly, fieldwork was conducted for only three weeks, thus limiting the amount of information gathered within this short period of time. Secondly, the aforementioned time constraints limited the overall sample size of this investigation to only 23 respondents, possibly leading to inaccurate statistics and results, leaving room for bias in the analysis stage. Thirdly, due to the subjective nature of this investigation and the need for individual information in interviews, this could further contribute towards biased results, as respondents could be dishonest in their responses. Interviewees may alter their responses to present a more positive outlook or choose to withhold certain negative aspects regarding their own neighbourhood.

4 Findings and Analysis

This chapter will focus on analysing the key results and findings through data derived from the methodological framework, comprised of interviews. This chapter is divided into four subsections and will explore the four elements of social sustainability within the Pinnacle@Duxton, based on residents' experience and perceptions of living in a high-rise high-density development. This section also aims to further determine factors which influence their experience and perceptions, in order to comprehensively answer the main research question.

4.1 Amenities and Social Infrastructure

The first element essential to creating a socially sustainable community is 'amenities and social infrastructure.' Communities require service and support to thrive, and not just the physical building itself. From the results of the residents' interviews we can analyse the successes and shortfalls of the Pinnacle@Duxton in fulfilling this aspect of social sustainability. When asked to list the various push and pull factors of living at the Pinnacle@Duxton, residents mentioned the availability (or absence) of social infrastructure such as educational facilities, childcare, communal spaces and transport connections.

Accessibility and transport were key topics among residents. 47.8% of respondents mentioned "good public transport connections" as a strong pull factor of living at the Pinnacle@Duxton, while a further 78.3% of respondents highlighted "good walkability" or the "ability to walk to work from home." However, 52.2% of respondents listed vehicular traffic in the area as an issue, especially during rush hour. In terms of accessibility within the estate itself, 4 residents highlighted that there were insufficient elevators per block for the number of people living in the development; and mentioned long waiting times for elevators in the mornings and evenings.

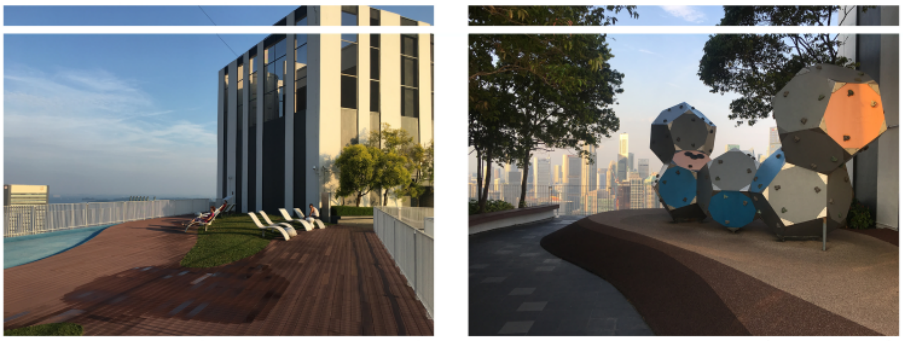


Figure 10: Images of public spaces on 50th floor sky garden at Pinnacle@Duxton (author owns)

Open and communal spaces are often harder to find in city centres, but the HDB aimed to incorporate this within the structure itself in the form of "sky gardens" (figure 10). 52.2% of respondents listed the sky gardens as a pull factor, but 60.9% of respondents also said there was a lack of public space in and around the Pinnacle@Duxton. Furthermore, a notable similarity between respondents from the '>65' age group was that all of them highlighted that the sky gardens provide a safe and convenient space to walk, without worrying about traffic and crossing roads. This contributes towards the provision of safe spaces in achieving social sustainability, especially to people across different age groups.

However, it was also discussed that although the sky gardens provide some green space, it cannot be said to replace traditional parks. One respondent stated that the "sky gardens do not replace authentic green spaces, where children can run around and play. There are a lot of rules restricting what you are allowed to do when you use the space." Images in figure 11 support this statement, showing the many signs that demonstrate the restrictive use of the space. These findings support Pomeroy's argument that alternative social and amenity spaces can be incorporated into high-rise buildings, especially in dense urban areas where land is a highly valuable commodity (Pomeroy, 2012). Although, restrictions towards the use of the space may hinder the residents' experience and ultimately does not provide a definitive replacement for more conventional green spaces.

Figure 11: Images of rules list on 50th floor Skybridge at Pinnacle@Duxton (author owns)

Figure 12: Image of 'Modern Montessori Pre-school' at Pinnacle@Duxton (author owns)

With regards to access to educational facilities, only 34.8% of total respondents mentioned good access to educational facilities as a pull factor. However, if we take into account only the respondents who have children in their household, the proportion increases to 50%. Facilities for early-childhood education were integrated into the Pinnacle@Duxton masterplan, providing a preschool and day care centre. Four residents highlighted in their interviews that at least one of their children are attending or have attended the on-site preschool (figure 12). On the other hand, 3 respondents emphasised a lack of educational facilities in the area. As one resident elaborated in her response, Cantonment Primary School is the only primary school in the area, while others are much further away. Another resident pointed out that there is insufficient access to secondary schools in and around the area. In line with the bid rent theory, land in the city centre is mainly used for commercial/retail

purposes, while residential use is located further away, meaning that supporting infrastructure (i.e. schools, etc.) would be located further away as well (Alonso, 1964, p. 21). However, this is often not the case for modern cities, as discussed in the interview with the HDB.

Speaking with the representative of the HDB, it was found that although land in Singapore's city centre has traditionally been reserved for retail and commercial uses, the HDB and URA aim to increasingly integrate residential developments in the area to create more mixed-use neighbourhoods. The HDB did acknowledge that most new housing in the area will be targeted towards young professionals working in the CBD but said that "recreational and social amenities to support residential developments would become more prevalent in the city as the local population increases."

4.2 Social and Cultural Life

Good social networks between residents and a diversity of local activities, both formal and informal, are the foundations of thriving communities (Livingston, et al., 2008). Figure 13 below shows residents' perception of whether living in a high-density and high-rise environment serves to foster greater social interaction. Respondents were asked to rank on a Likert scale from "strongly disagree" to "strongly agree" (i.e. 1 to 5). The findings show that the most common response among residents was "disagree," while the average score was calculated as 2.91.

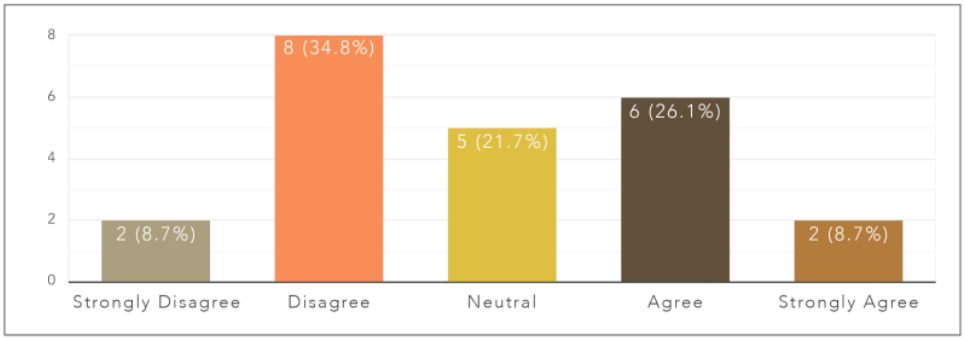


Figure 13: Pinnacle@Duxton residents who perceive that living in a high-rise high-density residential development serves to increase social interaction

However, when we compare the results above to the residents' overall experience of living at the Pinnacle@Duxton, the results show a clear positive correlation between experience and social interaction, which positively reflects Gallent's argument that social interaction between neighbours is a determining factor to the overall happiness and wellbeing of individuals (Gallent, 2001). This is shown in figure 14 below.

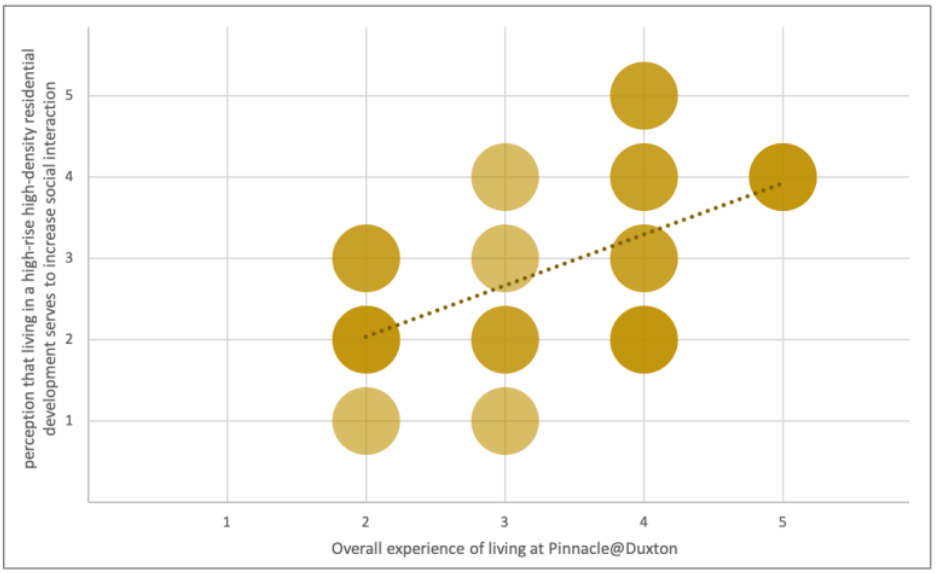


Figure 14: Correlation between residents' perception of whether living in a high-density and high-rise environment serves to foster greater social interaction and overall experience of living at Pinnacle@Duxton

The interviews with residents also highlighted that having children in the household may help to improve occurrences of social interaction. Three residents had similar responses indicating that when they brought their children to the playgrounds, they would socialise with other parents also looking after their children. One respondent stated, "In the evenings I bring my son down to the playground where he meets his friends, and I can socialise with the other mothers." This example reinforces the importance of 'supports for social interaction' in helping to achieve social sustainability, relating to both 'social and cultural life' and 'amenities and social infrastructure' (Woodcraft, et al., 2012). It was also calculated that respondents with children had an average score of 3.1 on whether they agree that high-rise high-density living serves to increase social interaction, while those without children in their household scored an average of 2.4.

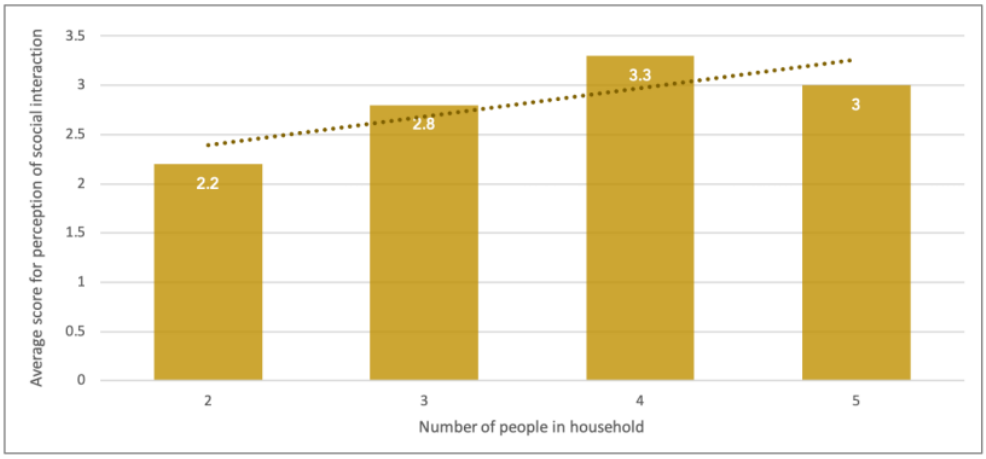


Figure 15: Average score of residents' perceptions whether living in a high-density and high-rise environment serves to foster greater social interaction and number of people in the household

Furthermore, figure 15 above shows the relationship between household size and social interaction, indicating a positive correlation between the two. Interviews with residents also highlighted the social networks that families created when they moved in. A respondent noted, "Everyone else was new when we first moved in, so by default neighbours got to know each other. The families who have been here since the start are part of a close community." Another resident stated, "A lot of the young couples who moved in from the start saw their children grow up together […] having other children of the same age is important for them." This reflects figure 16, which highlights a positive correlation between number of years living at Pinnacle@Duxton and overall experience.

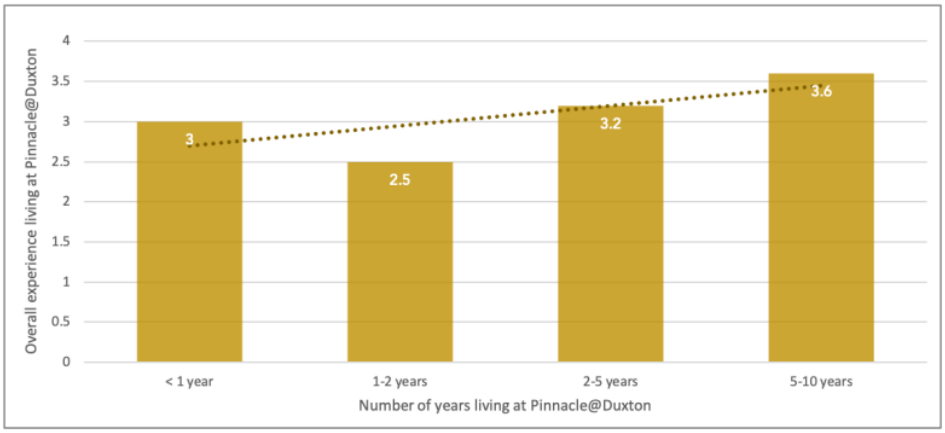


Figure 16: Average score of overall experience by number of years living Pinnacle@Duxton

One respondent who has lived at the Pinnacle@Duxton for less than a year explained that he had been living overseas prior to emigrating to work in Singapore and rented a room at the Pinnacle@Duxton to be close to the CBD. He stated, "Living with so many other people in such a dense and high-rise development can be overwhelming, especially if you are not used to living in such an environment." Another respondent—also a resident for less than a year—gave a similar account stating, "I haven't got to know my neighbours. I socialise more with my colleagues from work."

Through interviews with residents, it was discovered that many of the families who had moved in initially were no longer living at the Pinnacle@Duxton. As one resident stated, "[…] there aren't that many other families anymore. Most of them moved out after the 5-year period and rented out or sold their flats. Now it's mostly young professionals who work in the city." The reason why families have moved out could be due to the significant appreciation in the price of flats at the Pinnacle@Duxton, which owners were allowed to sell on the open market from 2014 onwards—after the 5-year Minimum Occupation Period (MOP) (Yeo, 2016) (HDB, 2019). Another resident mentioned, "the new residents here are all young, single, and working in the city. They just travel between work and home […] they are not part of the community."

These findings correspond to Ellard's argument that residents in high-rise and high-density developments tend only to interact with neighbours during brief moments, such as in

lifts, and are not likely to see the same neighbours each day, exacerbating feelings of alienation and isolation (Ellard, 2018). However, a higher concentration of families using the same facilities and social infrastructure has also showed the potential to improve social interaction and relations, as seen with the example of the playgrounds. This supports Silverman's and Lupton's view, whereby opportunities for adults to encounter and create social networks is enhanced through children, who provide a shared interest and common ground between individuals—in places such as preschools, playgroups and public spaces (Silverman, et al., 2005). Nonetheless, as larger families move out and are replaced by young professionals—who either do not have time or the opportunities to be part of the local community—this could potentially affect existing and developing social networks at the Pinnacle@Duxton.

4.3 Voice and Influence

Having the local community's voice heard and their influence in shaping their own environment is seen as a vital element for successful housing developments (Woodcraft, et al., 2012, p. 37). The representative of the HDB spoke in his interview about the public housing governance structure, indicating that the organisation retains overall control of the design, preparation and construction of their developments. He stated, "The HDB has always planned housing that fosters social cohesion, neighbourliness and a sense of belonging." Since its inception, the HDB has played a key role in planning and building public housing, but decision-making remains predominantly in the hands of professionals instead of the intended users. Although this top-down and systematic approach to planning may help to deliver a uniform standard of living, it lacks channels for citizen participation.

When residents were asked if they have had any say in the planning or development of Pinnacle@Duxton or if they have taken part in any studies by the HDB in relation to them living in the estate, only 1 out of the 23 respondents answered positively. This resident was asked to elaborate on his involvement. He recounted that because he had lived in the previous HDB estate that was on the site of the Pinnacle@Duxton, he was approached by the HDB upon moving into his new flat to give a comparison of the "old and new" for a publication by the

URA. Although this illustrates a small degree of a study into residents' needs by the Singapore government, the findings illustrate a lack of citizen participation in the planning and development stages of public housing estates.

However, even though residents lack a voice and influence in the planning and design of their neighbourhoods, the way in which it is managed has some channels for community-driven stewardship and creative community engagement. Speaking with residents of the Pinnacle@Duxton, respondents spoke about the Residents' Committee, which is managed by the homeowners, organising various events from art workshops, farmers markets and other activities. When asked about recent events organised by the Residents' Committee, one respondent spoke about her involvement in organising a children's art workshop. She also mentioned that the majority of residents who are involved are not employed. Figures 17, 18 and 19 illustrate the relationship between the number of people involved in the Residents' Committee and employment status, gender and children in household respectively.

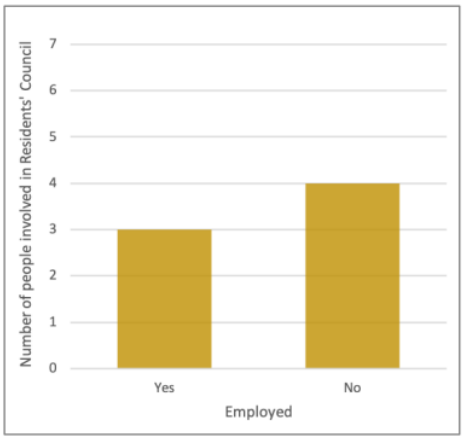


Figure 17: Number of people involved in Residents' Council by employment status

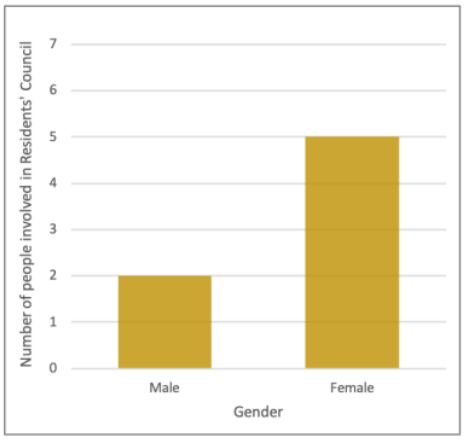


Figure 18: Number of people involved in Residents' Council by gender

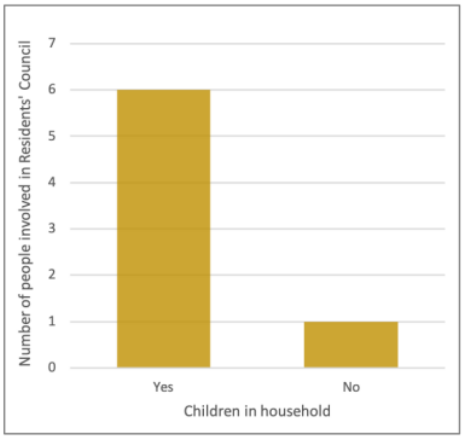


Figure 19: Number of people involved in Residents' Council by children in household

By looking at the graphs above, it is shown that female residents or those with children are more involved in community engagement at the Pinnacle@Duxton. However, as illustrated in figure 17, employment is not necessarily a defining factor of involvement within the estate, as there is only a minimal difference between those who are employed and those who are not.

Moreover, the residents' committee is also where residents can propose changes and improvements to the estate. However, final decisions are made by the Tanjong Pagar Town Council, which manages the estate. For example, one resident recounted that in 2013 there were proposals to redevelop the Yan Kit Swimming Complex, which closed in 2001. The proposed redevelopment was located next to the Pinnacle@Duxton, so the Town Council sought the opinion of local residents, who were asked to fill out an online survey voting for or against the swimming pool. Eventually, the pool was not constructed, but a community sports facility was proposed in its place.

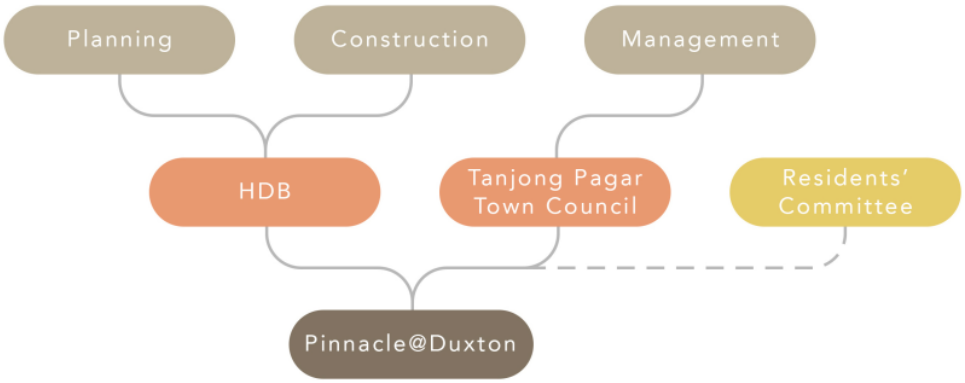


Figure 20: Formal governance structure of Pinnacle@Duxton

Figure 20 briefly outlines the formal governance structure of the Pinnacle@Duxton. The HDB retains overall control of the planning and construction, while the Tanjong Pagar Town Council is responsible for managing the estate. The Residents' Committee is granted a certain degree of participatory decision-making, but decisions are still approved by the Town Council.

These findings illustrate a lack of freedom for residents to participate in the shaping of their surrounding urban environment, though this does not seem to cause significant dissatisfaction among residents. However, as Singapore's government prepares for a growing population by improving infrastructure such as transport, such plans could neglect certain demographic changes like an ageing population or rising cultural diversity. In order to create inclusive spaces for all users, the government would need to shift its priorities away from solely focusing on providing infrastructure to keep up with population growth. It should, however, ensure higher degrees of citizen input in city planning to better cater to the needs of its current and future citizens.

4.4 Space to Grow

For a new community to achieve social sustainability and be successful, the housing stock, social infrastructure and amenities, should provide a certain degree of flexibility. This

would allow the place to adapt over time to cater to new possibilities and changing needs of residents (Sassen, 2011). A notion shared among the residents about the Pinnacle@Duxton was that the apartment sizes were inadequate for growing families. 47.8% of respondents highlighted that their apartments were too small, along with individual room sizes. This view was shared mostly among respondents who have children in their households, with 4 residents elaborating that they would need to find a bigger home should they have more children. Figure 21 below illustrates the positive correlation between the number of people in a household and having a flat that is too small.

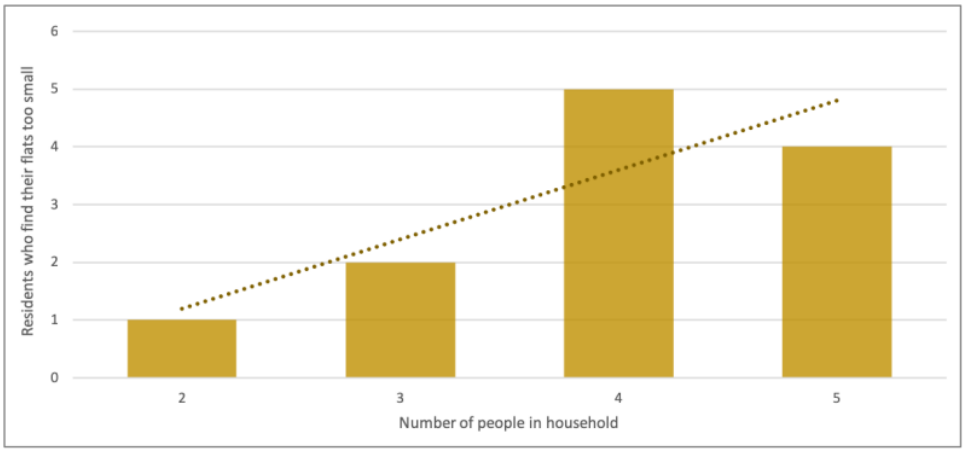


Figure 21: Residents who find their flats too small by number of people in household

The representative of the HDB stated in his interview that the Pinnacle@Duxton was originally "targeted at yuppie couples and young families." However, as mentioned previously, many families moved out of the Pinnacle@Duxton to be replaced by young professionals working in the city, many of which do not integrate with the local community.

Nevertheless, speaking with the HDB, it was found that the Pinnacle@Duxton did allow for some degree of flexibility within the flats. He explained that the project was marketed as a 'Built to Order' (BTO) scheme, meaning that buyers had the option to choose the layouts of their flats upon purchase. He also argued that families could easily reconfigure their living spaces based on their needs because the walls within the flats were constructed with lightweight concrete. However, it can also be argued that being able to easily change the flat

layout may not be enough for some families, as the overall size of the flat remains the same, prompting growing families to move out altogether. From these findings, it can be argued that high-rise and high-density developments such as the Pinnacle@Duxton are less suited for larger families with children.

Figure 22: (Left) Image of void Deck at Yishun Block 745 (Teo, 2013); (Right) Image of 50th floor sky garden at Pinnacle@Duxton (author owns)

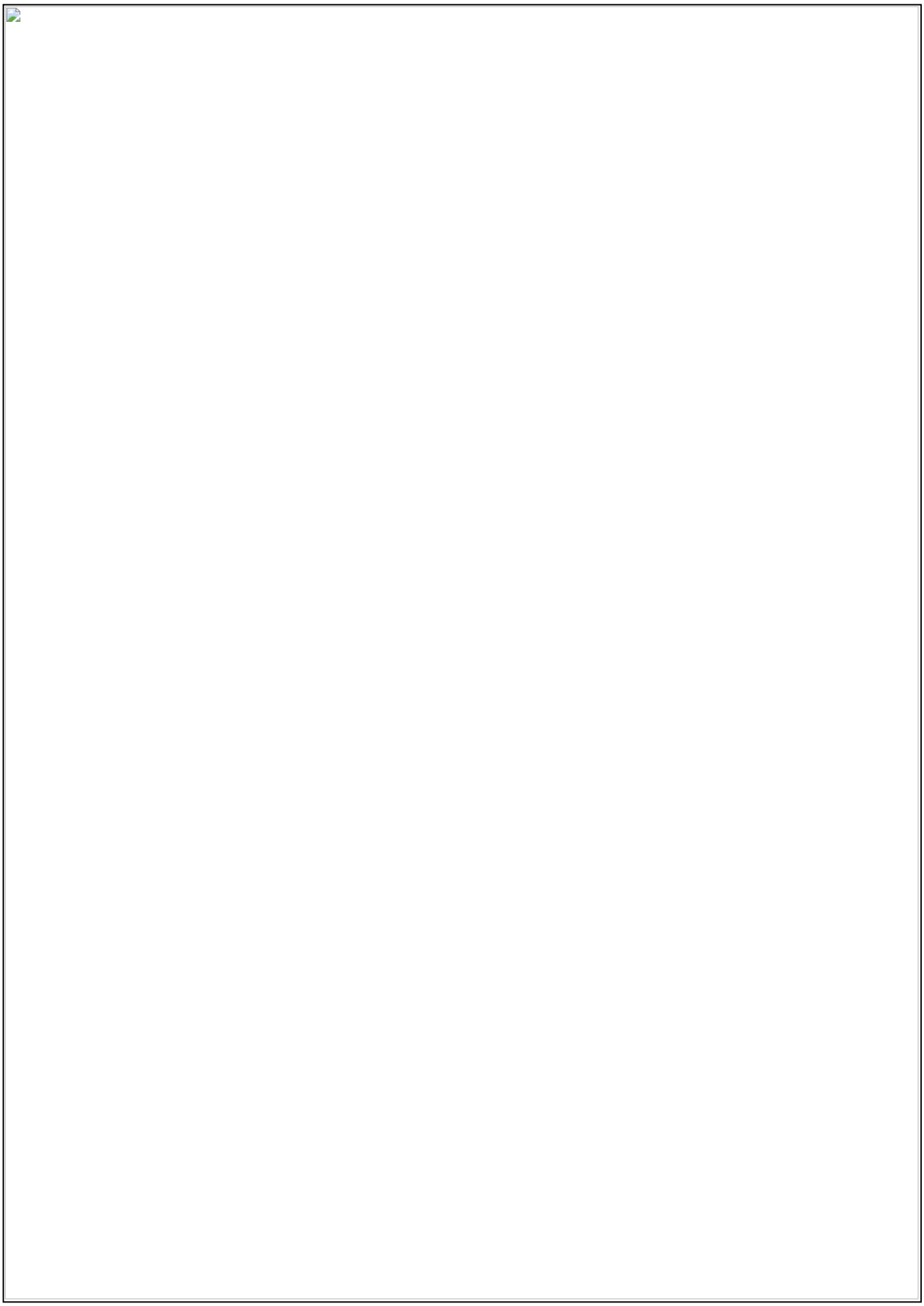
During the interview, the HDB representative also discussed the future of public spaces in HDB estates: "As Singapore expects its population to grow, it will have to develop more innovative ways to house its population." Previously, HDB estates were built with 'void decks' on the ground level of a block of flats, providing open spaces to be used for social and communal activities and events (Cairns, 2014). He also stated, "As we build homes at greater heights, the public realm has to follow […] older estates had the void deck to provide public space but the Pinnacle@Duxton was the first to show that it is possible to do the same, but at a hundred and fifty metres." Figure 22 shows the contrast between the older void decks and its contemporary counterpart, the sky garden. However, the HDB's stance that the sky gardens are the "new" void decks can be argued against. Referring back to figure 11, which shows the various rules and regulations associated with the sky gardens at the Pinnacle@Duxton, activities such as flea markets or ball games cannot occur, limiting residents' freedom to use the space.

Another notable topic discussed with residents was the sense of "crowdedness" within the estate, a sentiment shared among 9 respondents. One resident stated that the Pinnacle@Duxton felt "overcrowded […] you see many people you don't know. A smaller

estate is better, where you can recognise more people." Another respondent shared a similar view, stating, "Living in such a crowded place takes away the feeling of 'community' as there are so many people you don't know."

Furthermore, the interviews found that high proximity of a large number of flats can serve to increase tensions between some neighbours. One resident recounted, "I can often hear my neighbours, or if someone cooks something, I will be able to smell it from my flat." Another respondent said that she has made complaints to the Residents' Committee about noise from neighbours. Although these problems are not exclusive to high-rise buildings, proximity between residential units in buildings such as the Pinnacle@Duxton can increase occurrences of undesired social contact and diminish a sense of privacy, supporting Pun's argument that these can lead to higher levels of psychological stress and anxiety (Pun, 1994).

These findings also support Breheny's argument that individuals in high-rise and high-density housing may experience greater social conflict, as residents compete for space and the use of services and facilities (Breheny, 2001). However, within the context of the Pinnacle@Duxton and its location in the city centre, the provision of the sky gardens, preschool and day care centre serve to create a more friendly environment for growing families who still want to live in the city.



infrastructure and amenities for residential land-use (e.g. schools) are not as accessible. However, transport connections and proximity to the workplace were highlighted as strong pull factors for the Pinnacle@Duxton.

Furthermore, it was concluded that there is a clear correlation between a resident's experience of living in the Pinnacle@Duxton and their perception that high-rise high-density living serves to increase social interaction. It was also determined that larger households and households with children showed more positive results for social interaction. Paradoxically, it was also concluded that the Pinnacle@Duxton was less suited for growing families due to the small size of the apartments, and that higher densities meant that social conflict between residents were more likely.

The interview with the HDB found that the governance structure of public housing provision in Singapore did not allow for much citizen participation, even though residents had some degree of stewardship regarding the management of the estate. However, it can also be argued that due to the complexity of such high-rise projects, decisions for planning and implementation would be better made by planning professionals.

From this, it can be concluded that verticalization can achieve certain dimensions of social sustainability, such as the provision of amenities and social infrastructure, as well as social and cultural life, while other dimensions such as voice and influence, and space to grow could be improved. However, given that the project was the first of its kind in Singapore, the development could serve as a steppingstone for similar developments in future.

5.2 Limitations

Although this investigation has explored various aspects of social sustainability in high-rise high-density housing and the variables affecting it, there were a number of limitations to this research. Firstly, previous investigations with similar contexts to this study were limited, as most studies were conducted on residents of regular tall buildings instead of super-tall

developments. Thus, there is a possibility that significant discrepancies between this study and information from the literature review, regarding both practical and theoretical knowledge. Secondly, the selected case study is a reasonably new concept in urban planning, so relevant academic discourse about verticalization is also limited. Furthermore, on reflection, the sample size for data collection was small and interview questions were considerably subjective and personal, thus the final results of the investigation may contain a certain degree of bias. Moreover, the elements of social sustainability were investigated and analysed separately, which disregards the interrelationship between the elements and potential for inter-related analysis. However, in spite of these limitations, this study still contributes towards a better understanding of the way in which residents interact with each other and in their surrounding urban environments, providing referential value for future investigations.

5.3 Recommendations for Future Research

It would be interesting to explore this topic further, by investigating this project over a longer timescale to analyse future changes and the long-term effects of living in high-rise and high-density environments. It could prove beneficial to apply this investigation's methodological framework to other typologies of housing, to provide comparative analysis and ascertain where social sustainability would be easier (or more challenging) to achieve. Additionally, this research supplies a methodology for assessing social sustainability in different national contexts, providing a basis for research into verticalization in different countries.

Further research is also required to determine what "social sustainability" represents for new communities, as well as how to evaluate the effectiveness of different approaches for various types of communities.

5.4 Policy Recommendations

Housing should not be built merely to provide shelter, but rather, it must uniquely serve the needs of its residents in a manner that fosters health, social wellbeing, creativity and happiness. Today, the density of HDB estates range from around 25,000 to 30,000 people per sq. km. However, according to professor Heng Chye Kian from the National University of Singapore School of Design and Environment, if projects similar in scale to the Pinnacle@Duxton were to be built over one sq. km of land, density could reach up to 300,000 people per sq. km (Heng, 2011).

In countries such as Singapore, with a limited land supply, policy makers should attach a greater importance towards the social sustainability of new housing developments, in parallel with environmental and economic goals. For example, the government should provide developers with greater information about achieving social sustainability by publishing guidelines for planning and development. As Singapore expects its population to grow in the coming decades, planning authorities must recognise that housing needs to function as place for people, creating an urban environment that can be sustainable in all aspects in the long term.

Bibliography

ADEC, 2019. What is Social Sustainability?. [Online]
Available at: https://www.esg.adec-innovations.com/about-us/faqs/what-is-social-sustainability/
[Accessed 15 June 2019].

Alonso, W., 1964. Location and Land Use: Toward a general theory of land rent. In: R. J. Johnston, D. Gregory, G. Pratt & M. Watts, eds. The Dictionary of Human Geography. 4th Edition ed. Cambridge(MA): Harvard University Press, p. 21.

Ballard, J. G., 1975. High-Rise. London: Jonathan Cape.

Bay, J.-H., 2004. Sustainable community and environment in tropical Singapore high-rise housing: the case of Bedok Court condominium. Environmental Design, 8(3/4), pp. 333-343.

Breheny, M., 2001. Densities and sustainable cities: The UK experience. In: M. Echenique & A. Saint, eds. Cities for the New Millennium. New York(NY): Spon Press, pp. 39-51.

Cairns, S., 2014. Singapore's void decks. In: W. S. W. Lim, ed. Public space in urban Asia. Singapore: World Scientific Publishing Co., pp. 80-89.

Cheng, V., 2009. Understanding density and high density. In: Designing High Density Cities for Social and Environmental Sustainability. 1st Edition ed. London: Earthscan Ltd, pp. 3-17.

Circular Ecology, 2019. Sustainability and sustainable development - What is sustainability and what is sustainable development?. [Online]
Available at: http://www.circularecology.com/sustainability-and-sustainable-development.html#.XV06ZpNKhbU
[Accessed 29 June 2019].

Cooper-Marcus, C. & Sarkissian, W., 1988. Housing as if People Mattered: Site Design Guidelines for Medium-Density Family Housing. Berkeley(CA): University of California Press.
data.gov.sg, 2019. Total Land Area of Singapore. [Online]
Available at: https://data.gov.sg/dataset/total-land-area-of-singapore?view_id=e6e37f25-01ef-4c23-a7cb-5682ab5edb75&resource_id=f4bbfac9-c3ed-4f71-9b9a-238517b214ef
[Accessed 25 June 2019].

Dave, S., 2010. High Urban Densities in Developing Countries: A Sustainable Solution?. Built Environment, 36(1), pp. 9-27.

Davoudi, S. & Layard, A., 2001. Sustainable development and planning: An overview. In: S. Batty, S. Davoudi & A. Layard, eds. Planning for a Sustainable Future. London: Routledge, pp. 7-18.

Ellard, C., 2018. Why is living in a big city so isolating?. [Online]
Available at: https://www.citymetric.com/horizons/why-living-big-city-so-isolating-lonely-isolation-loneliness-4210
[Accessed 12 July 2019].

Ellis, J. G., 2004. Explaining residential density. Places, 16(2), pp. 34-43.

Frampton, K., 1992. Modern Architecture, A Critical History. London: Thames and Hudson.

Gabay, R. & Aravot, I., 2003. Using space syntax to understand multi layer, high-density urban environments. [Online]
Available at: http://www.spacesyntax.net/symposia-archive/SSS4/fullpapers/73Gabaypaper.pdf
[Accessed 29 May 2019].

Gallent, N., 2001. Housing, Homes and Social Sustainability. In: S. Batty, S. Davoudi & A. Layard, eds. Planning for a Sustainable Future. London: Routledge, pp. 115-130.

Gardiner, J., 2017. City-dwellers are prone to depression – are high-rises to blame?. [Online]
Available at: https://www.theguardian.com/sustainable-business/2017/mar/16/cities-depression-stress-mental-health-high-rises-urban-design-london-toronto
[Accessed 30 June 2019].

Hall, P., 2002. Cities of Tomorrow. London: Blackwell.

HarperCollins, 2005. Need to Know? The World. London: HarperCollins Publishings.
HDB, 2017. HDB History and Towns. [Online]
Available at: https://www.hdb.gov.sg/cs/infoweb/about-us/history
[Accessed 5 July 2019].

HDB, 2019. Conditions after Buying. [Online]
Available at: https://www.hdb.gov.sg/cs/infoweb/residential/buying-a-flat/resale/conditions-after-buying
[Accessed 30 July 2019].

Heng, C. K., 2011. Designing Asia's future 'vertical cities'. [Online]
Available at: https://www.eco-business.com/news/designing-asias-future-vertical-cities/
[Accessed 12 August 2019].

Heng, J., 2013. Look ahead to 10 million people by 2100?. [Online]
Available at: https://www.straitstimes.com/singapore/look-ahead-to-10-million-people-by-2100
[Accessed 28 June 2019].

Hickman, M., 2017. High anxiety: Can living in a tall building cause depression?. [Online]
Available at: https://www.mnn.com/health/healthy-spaces/blogs/high-anxiety-can-living-tall-

building-lead-depression
[Accessed 30 June 2019].

Ho, O. & Ee, J., 2010. Changing face of Duxton. The Straits Times, 9 April.p. 49.

Jacobus, A. D. P., 2006. Sustainable development - historical roots of the concept, Potchefstroom, South Africa: Taylor & Francis.

Jochim, M., 2018. Mark Jochim Flickr Page. [Online]
Available at: https://www.flickr.com/photos/am-jochim/28645957538/in/photostream/
[Accessed 3 June 2019].

Joo, T. T. K. & Wong, T.-C., 2008. Public Housing in Singapore: A Sustainable Housing Form and Development. In: Spatial Planning for a Sustainable Singapore. 1st Edition ed. Singapore: Springer Science + Business Media B.V., pp. 135-150.

Keating, S., 2019. Can Singapore's social housing keep up with changing times?. [Online]
Available at: https://www.bbc.com/worklife/article/20181210-can-singapores-social-housing-keep-up-with-changing-times
[Accessed 3 August 2019].

Le Corbusier, 1937. When the Cathedrals were White. New York(New York): McGraw Hill.

Lee, M., 2011. Pinnacle@Duxton. [Online]
Available at: http://eresources.nlb.gov.sg/infopedia/articles/SIP_1779_2011-02-18.html
[Accessed 25 June 2019].

Lim, L., 2002. This is the future of Singapore's public housing. The Straits Times, 1 May.p. 1.

Lim, Y. L., 2010. Life at the Top. The Straits Times, 20 October.p. 8.

Livingston, M., Bailey, N. & Kearns, A., 2008. The influence of neighbourhood deprivation on people's attachment to places. [Online]
Available at: https://www.jrf.org.uk/report/influence-neighbourhood-deprivation-peoples-attachment-places
[Accessed 30 July 2019].

Low, C., 2011. New green heights in public housing development: The Pinnacle@Duxton. Citygreen, Issue 2, pp. 32-37.

Ng, E. & Wong, K.-S., 2004. Efficiency & Liveability: Towards Sustainable Habitation in Hong Kong, Hong Kong: Hong Kong Housing Authority.

Peen, J., Schoevers, R. A., Beekman, A. T. & Dekker, J., 2009. The current status of urban-rural differences in psychiatric disorders, Amsterdam: John Wiley & Sons.

Pomeroy, J., 2012. Room at the Top — The Roof as an Alternative Habitable / Social Space in the Singapore Context. Journal of Urban Design, 17(3), pp. 413-424.

Pun, P. K. S., 1994. Advantages and disadvantages of high density urban development. In: V. Fouchier & P. Merlin, eds. High Urban Densities: A Solution for Our Cities?. Hong Kong: Consulate General of France in Hong Kong.

Rapoport, A., 1975. Toward a Redefinition of Density. Environment and Behavior, 1 June, 7(2), pp. 133-158.

Rapoport, A., 1977. Human Aspects of Urban Form: Towards a Man-Environment Approach to Urban Form and Design. 1st Edition ed. Oxford: Pergamon Press.

Richardson, L., 2018. A Brief History Of Vertical Structures. [Online]
Available at: https://verticalcity.org/a-brief-history-of-vertical-structures.html
[Accessed 2 May 2019].

Sassen, S., 2011. Living in the endless city, Speech by Saskia Sassen. [Online]
Available at: https://www.youtube.com/watch?v=vHcJbFjqXbU
[Accessed 30 July 2019].

Silverman, E., Lupton, R. & Fenton, A., 2005. A good place for children?: Attracting and retaining families in inner urban mixed income communities. Covenrty: Chartered Institute of Housing for the Joseph Rowntree Foundation.

Sim, A., 2001. Moving up to the 50th storey. The Straits Times, 18 August.p. 6.

Smith, N. B., 2016. Heart in the right street: Beauty, happiness and health in designing the modern city, London: Creates Streets Ltd.

SRX Property, 2018. Blk 1A The Pinnacle@Duxton (S)085101. [Online]
Available at: https://www.srx.com.sg/hdb/central-area/the-pinnacle-duxton-hbpin016/85101/floor-plans
[Accessed 17 July 2019].

Subramanian, S., 2017. How Singapore Is Creating More Land for Itself. [Online]
Available at: https://www.nytimes.com/2017/04/20/magazine/how-singapore-is-creating-more-land-for-itself.html
[Accessed 2 July 2019].

Sullivan, B. & Chen, K., 1997. Design for tenant fitout: A critical review of public housing flat design in Hong Kong. Habitat International, 21(3), pp. 291-303.

Tan, K., 2004. Pinnacle@Duxton - One of a Kind. The Straits Times, 19 June.p. 18.

Teo, C., 2013. My FIRST Participation as a Vendor in a Flea Market @ Yishun Block 745. [Online]

Available at: http://cavinteo.blogspot.com/2013/04/my-first-participation-as-vendor-in.html
[Accessed 13 August 2019].

The Economist, 2015. Such quantities of sand. The Economist, 26 February.

United Nations, 2018. 68% of the world population projected to live in urban areas by 2050, says UN. [Online]
Available at: https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
[Accessed 27 March 2019].

URA, 2019. Building Height Plan. [Online]
Available at: https://www.ura.gov.sg/maps/#
[Accessed 3 June 2019].

URA, 2019. Draft Master Plan 2019. [Online]
Available at: https://www.ura.gov.sg/Corporate/Planning/Draft-Master-Plan-19/
[Accessed 3 July 2019].

URA, 2019. Master Plan - Latest. [Online]
Available at: https://www.ura.gov.sg/maps/#
[Accessed 29 July 2019].

Van Zon, H., 2002. Geschiedenis & duurzame ontwikkeling: Duurzame ontwikkeling in historisch perspectief: enkele verkenningen.. Amsterdam: Netwerk Duurzaam Hoger Onderwijs.

Woodcraft, S., Bacon, N., Caistor-Arendar, L. & Hackett, T., 2012. Design for Social Sustainability: A framework for creating thriving new communities. [Online]
Available at: http://www.social-life.co/media/files/DESIGN_FOR_SOCIAL_SUSTAINABILITY_3.pdf
[Accessed 15 June 2019].

World Bank, 2019. Population density (people per sq. km of land area). [Online]
Available at: https://data.worldbank.org/indicator/EN.POP.DNST?locations=SG&most_recent_value_desc=true&year_high_desc=true
[Accessed 25 June 2019].

Yeo, S. J., 2016. Pinnacle@Duxton flat goes for $1.12 million. [Online]
Available at: https://www.straitstimes.com/singapore/housing/pinnacleduxton-flat-goes-for-112-million
[Accessed 12 August 2019].

Appendix A: Interview with Residents (information sheet)

Participant Information Sheet for Residents of Pinnacle@Duxton

UCL Research Ethics Committee Approval ID Number: _____

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of Study:
To what extent does verticalization provide a socially sustainable solution to Singapore's land scarcity problem?
Department:
University College London, Bartlett School of Planning, MSc Urban Regeneration
Name and Contact Details of the Researcher:
Mr Dominique Mirepoix (dominique.mirepoix.15@ucl.ac.uk)
Name and Contact Details of the Principal Researcher:
Ms Tatiana Moreira De Souza (tatiana.souza@ucl.ac.uk)

1. **Invitation Paragraph**
   You are being invited to take part in a research project. Before you decided it is important for you to understand why the research us being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

2. **What is the project's purpose?**
   The main aim of this research project is to explore whether living in a high-rise, high-density project such as the Pinnacle@Duxton serves to increase or decrease social interaction, and therefore social sustainability.

3. **Why have I been chosen?**
   You have been chosen to take part in this research project because you are a resident at the Pinnacle@Duxton, a prime example of a high-rise, high-density development in Singapore. Your responses will contribute towards a better understanding of social interaction and social sustainability within such developments. Other Pinnacle@Duxton residents will be selected to take part in this study.

4. **Do I have to take part?**
   It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep. As this is an anonymous survey, responses towards this survey implies consent, and for which data cannot be withdrawn. You may withdraw at any time without giving a reason and without it affecting any benefits that you are entitled to.

5. **What will happen to me if I take part?**
   This survey will last about 5-10 minutes. It will involve a spoken interview and notetaking on the researcher's part. The research project will last until 2 September 2019. Although this survey is anonymous, personal information such as age, gender, marital status, household size and ethnicity will be recorded. You only need to participate once, and you will not be contacted for future research for this specific project.

6. **What are the possible disadvantages and risks of taking part?**
   Taking part in this research project will not expose you to any risks or physical discomfort/harm.

7. **What are the possible benefits of taking part?**
   Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will help researchers better understand the social interactions between residents in high-rise, high-density developments, shaping future research towards residential development and habitation in future.

8. **What if something goes wrong?**
   Taking part in this research project will not expose you to any risks or physical discomfort/harm. However, should you wish to contact the researcher for any queries or complaints after the survey has ended, please use the contact details below:

   Mr Dominique Mirepoix (dominique.mirepoix.15@ucl.ac.uk)
   Ms Tatiana Moreira De Souza (tatiana.souza@ucl.ac.uk)

Should you feel your complaint has not been handled to your satisfaction, you may contact the Chair of the UCL Research Ethics Committee (ethics@ucl.ac.uk)

9. **Will my taking part in this project be kept confidential?**
All the information that we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any ensuing reports or publications.

10. **Limits to confidentiality**

- *Please note that assurances on confidentiality will be strictly adhered to unless evidence of wrongdoing or potential harm is uncovered. In such cases the University may be obliged to contact relevant statutory bodies/agencies.*
- *Please note that confidentiality will be maintained as far as it is possible, unless during our conversation I hear anything which makes me worried that someone might be in danger of harm, I might have to inform relevant agencies of this.*
- *Please note that confidentiality may not be guaranteed; due to the limited size of the participant sample.*
- *Confidentiality will be respected unless there are compelling and legitimate reasons for this to be breached. If this was the case, we would inform you of any decisions that might limit your confidentiality.*

11. **Use of Deception**
Research designs often require that the full intent of the study not be explained prior to participation. Although we have described the general nature of the tasks that you will be asked to perform, the full intent of the study will not be explained to you until after the completion of the study.

12. **What will happen to the results of the research project?**
The data collected during research will be published in a Masters-level dissertation for the UCL Bartlett School of planning. The data collected during the course of the project might be used for additional or subsequent research.

13. Local Data Protection Privacy Notice
The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk

This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice: https://www.ucl.ac.uk/legal-services/privacy/ucl-general-research-participant-privacy-notice

The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices.

The categories of personal data used will be as follows: Age, gender, marital status, household size and ethnicity.

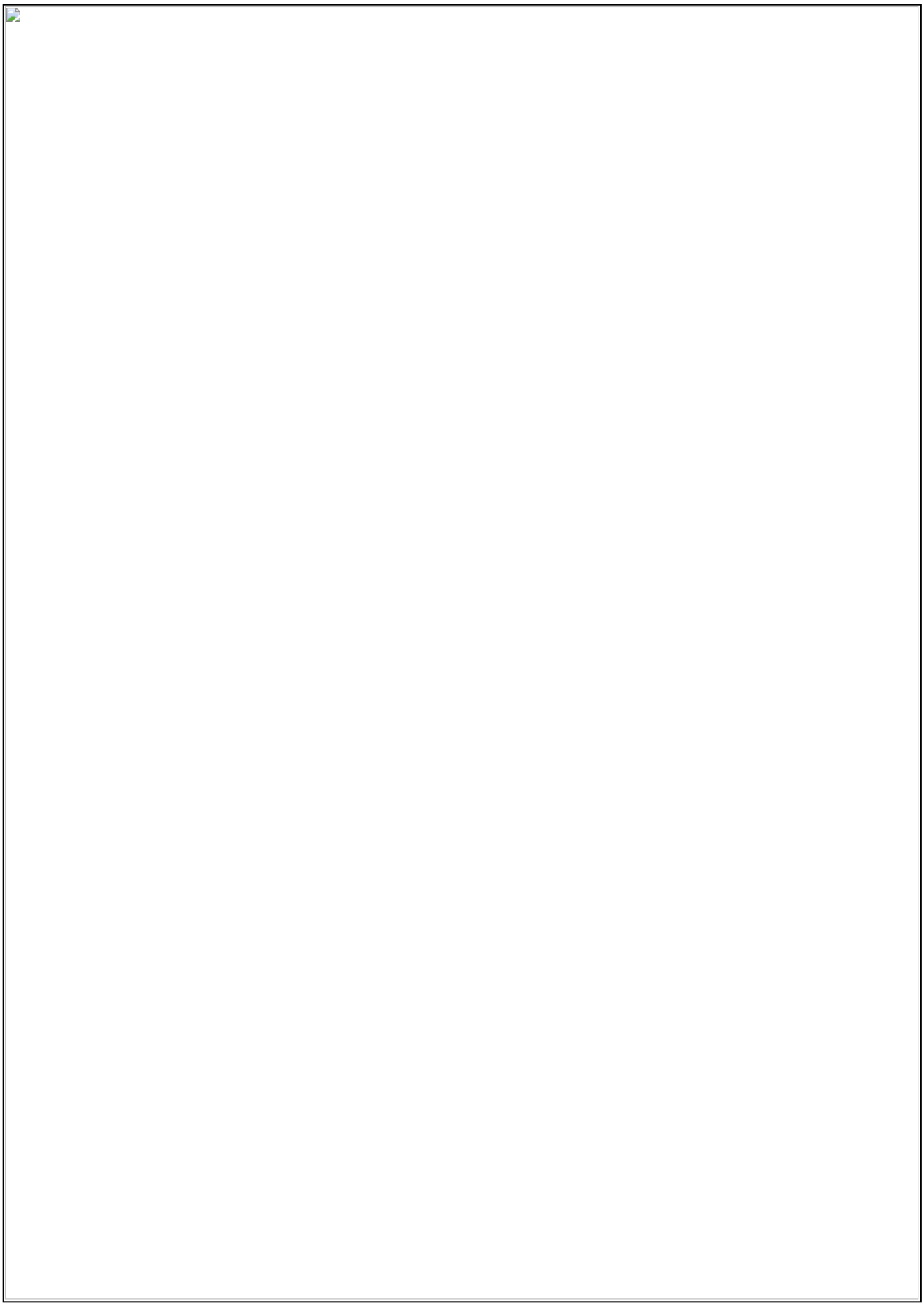
The lawful basis that would be used to process your personal data will be the performance of a task in the public interest. The lawful basis used to process special category personal data will be for scientific and historical research or statistical purposes

Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal data you provide, we will undertake this and will endeavour to minimise the processing of personal data wherever possible. If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

16. Contact for further information
Should you wish to contact the researcher for any queries, please use the contact information below:

Mr Dominique Mirepoix (dominique.mirepoix.15@ucl.ac.uk)
Ms Tatiana Moreira De Souza (tatiana.souza@ucl.ac.uk)

Thank you for reading this information sheet and for considering taking part in this research study.



Appendix C: Interview with HDB Representative (Questions)

1. What made the HDB decide to pursue the Pinnacle@Duxton project, the first 50-floor public housing in Singapore?

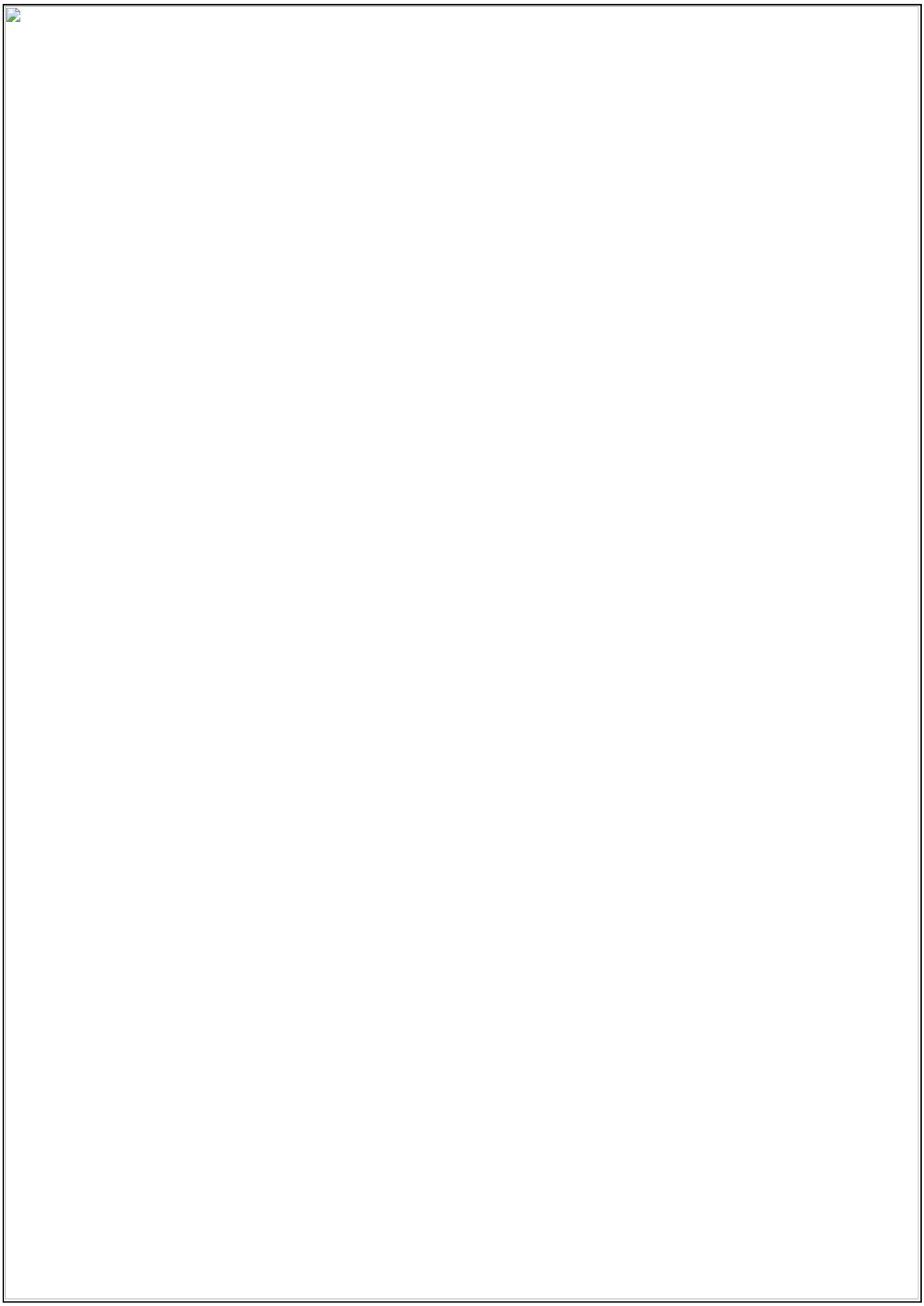
2. Please explain the process that went into planning and developing the Pinnacle@Duxton.

3. Does the HDB involve residents in the plan-making process?

4. How does the concept behind the Pinnacle@Duxton provide infrastructure for social wellbeing?

5. Does the HDB have any plans to replicate similar verticalization concepts elsewhere in Singapore?

6. How will the HDB improve on such concepts?



EQUIPMENT	Is equipment used?	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. clothing, outboard motors.	Examples of risk: inappropriate, failure, insufficient training to use or repair, injury. Is the risk high / medium / low ?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for equipment is followed
☐	participants have been provided with any necessary equipment appropriate for the work
☐	all equipment has been inspected, before issue, by a competent person
☐	all users have been advised of correct use
☐	special equipment is only issued to persons trained in its use by a competent person
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

LONE WORKING	Is lone working a possibility?	Yes	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. alone or in isolation lone interviews.	Examples of risk: difficult to summon help. Is the risk high / medium / low?		

Low

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for lone/out of hours working for field work is followed
☐	lone or isolated working is not allowed
☐	location, route and expected time of return of lone workers is logged daily before work commences
☒	all workers have the means of raising an alarm in the event of an emergency, e.g. phone, flare, whistle
☒	all workers are fully familiar with emergency procedures
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

ILL HEALTH	The possibility of ill health always represents a safety hazard. Use space below to identify and assess any risks associated with this Hazard.
e.g. accident, illness, personal attack, special personal considerations or vulnerabilities.	Examples of risk: injury, asthma, allergies. Is the risk high / medium / low? Low

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	an appropriate number of trained first-aiders and first aid kits are present on the field trip
☒	all participants have had the necessary inoculations/ carry appropriate prophylactics
☒	participants have been advised of the physical demands of the trip and are deemed to be physically suited
☒	participants have been adequate advice on harmful plants, animals and substances they may encounter
☐	participants who require medication have advised the leader of this and carry sufficient medication for their needs
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

TRANSPORT	Will transport be required	NO		Move to next hazard
		YES	✓	Use space below to identify and assess any risks
e.g. hired vehicles	Examples of risk: accidents arising from lack of maintenance, suitability or training Is the risk high / medium / low? Low			

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☒	only public transport will be used
☐	the vehicle will be hired from a reputable supplier
☐	transport must be properly maintained in compliance with relevant national regulations
☐	drivers comply with UCL Policy on Drivers http://www.ucl.ac.uk/hr/docs/college_drivers.php
☐	drivers have been trained and hold the appropriate licence
☐	there will be more than one driver to prevent driver/operator fatigue, and there will be adequate rest periods
☐	sufficient spare parts carried to meet foreseeable emergencies
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

DEALING WITH THE PUBLIC	Will people be dealing with public	Yes	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. interviews, observing	Examples of risk: personal attack, causing offence, being misinterpreted. Is the risk high / medium / low? Low		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	all participants are trained in interviewing techniques
☐	interviews are contracted out to a third party
☐	advice and support from local groups has been sought
☒	participants do not wear clothes that might cause offence or attract unwanted attention
☒	interviews are conducted at neutral locations or where neither party could be at risk
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

WORKING ON OR NEAR WATER	Will people work on or near water?	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. rivers, marshland, sea.	Examples of risk: drowning, malaria, hepatitis A, parasites. Is the risk high / medium / low?		

CONTROL MEASURES **Indicate which procedures are in place to control the identified risk**

- ☐ lone working on or near water will not be allowed
- ☐ coastguard information is understood; all work takes place outside those times when tides could prove a threat
- ☐ all participants are competent swimmers
- ☐ participants always wear adequate protective equipment, e.g. buoyancy aids, wellingtons
- ☐ boat is operated by a competent person
- ☐ all boats are equipped with an alternative means of propulsion e.g. oars
- ☐ participants have received any appropriate inoculations
- ☐ OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

MANUAL HANDLING (MH)	Do MH activities take place?	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. lifting, carrying, moving large or heavy equipment, physical unsuitability for the task.	Examples of risk: strain, cuts, broken bones. Is the risk high / medium / low?		

CONTROL MEASURES **Indicate which procedures are in place to control the identified risk**

- ☐ the departmental written Arrangement for MH is followed
- ☐ the supervisor has attended a MH risk assessment course
- ☐ all tasks are within reasonable limits, persons physically unsuited to the MH task are prohibited from such activities
- ☐ all persons performing MH tasks are adequately trained
- ☐ equipment components will be assembled on site
- ☐ any MH task outside the competence of staff will be done by contractors
- ☐ OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

SUBSTANCES	Will participants work with substances	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. plants, chemical, biohazard, waste	Examples of risk: ill health - poisoning, infection, illness, burns, cuts. Is the risk high / medium / low?		

CONTROL MEASURES **Indicate which procedures are in place to control the identified risk**

- ☐ the departmental written Arrangements for dealing with hazardous substances and waste are followed
- ☐ all participants are given information, training and protective equipment for hazardous substances they may encounter
- ☐ participants who have allergies have advised the leader of this and carry sufficient medication for their needs
- ☐ waste is disposed of in a responsible manner
- ☐ suitable containers are provided for hazardous waste
- ☐ OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

OTHER HAZARDS	Have you identified any other hazards?	No	If 'No' move to next section If 'Yes' use space below to identify and assess any risks
i.e. any other hazards must be noted and assessed here.	Hazard: Risk: is the risk		

CONTROL MEASURES **Give details of control measures in place to control the identified risks**

Have you identified any risks that are not adequately controlled?		
	NO ☒	Move to Declaration
	YES ☐	Use space below to identify the risk and what action was taken

Is this project subject to the UCL requirements on the ethics of Non-NHS Human Research? No

If yes, please state your Project ID Number

For more information, please refer to: http://ethics.grad.ucl.ac.uk/

DECLARATION The work will be reassessed whenever there is a significant change and at least annually. Those participating in the work have read the assessment.

Select the appropriate statement:

- ☒ I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
- ☒ I the undersigned have assessed the activity and associated risks and declare that the risk will be controlled by the method(s) listed above

NAME OF SUPERVISOR Tatiana Moreira De Souza

SIGNATURE OF SUPERVISOR DATE