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APPLYING A CIRCULAR ECONOMY APPROACH TO SUSTAINABLE HOUSING ADAPTATION IN SYDNEY

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ABSTRACT

Housing affordability in Australia is a critical issue affecting an increasing proportion of people, and it is at its most acute in Sydney. Coupled with this economic circumstance, there are increasing impacts of climate change to contend with and a housing stock poorly designed to accommodate increasing temperatures and heat shocks. Furthermore, 20th century improvements in health and well-being are creating a larger proportion of aged people in our society. Some of these issues are noted in the resilience plans and strategies many cities are now developing to prepare for the future. These issues can be classed as acute, where they occur at unpredictable frequencies with high impacts, or chronic issues which are ongoing over the long term. It follows that our existing housing stock will need adaptation. How can we best adapt our housing to ensure issues such as affordability, increasing temperatures and ageing populations?

This paper provides an overview of the housing stock in a selected Sydney Local Government Area (LGA) and explores priority areas for adaptation addressing economic, social and environmental sustainability and resilience issues.

Keywords: Housing affordability, ageing population, climate change, resilient cities, housing adaptation, Sydney.

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INTRODUCTION

Housing unaffordability in Australia affects an increasing proportion of people (Ironfish 2018), and is at its most acute in Sydney (City of Sydney 2016). In addition, the increasing impacts of climate change are more evident and most of the existing housing stock is very poorly designed to withstand increasing temperatures and heat shocks. Concurrently, improvements in health and well-being are creating a larger proportion of elderly people in Australia, and elsewhere (ABS 2017; United Nations 2017).

Some of these issues are noted in resilience plans and strategies many cities are developing to prepare for future stresses and shocks. Resilience issues of ageing, inadequate and unaffordable housing are classed as chronic as they occur over long terms, whereas weather events caused by climate change such as flooding or heatwaves are acute, and occur at unpredictable frequencies with high impacts (City of Sydney 2018; Rockefeller Foundation 2018). It follows our existing housing stock needs adaptation to accommodate chronic and acute resilience issues.

Housing design and specification follows standards and design preferences at the time of construction. Therefore, over a geographic area the quality, age of construction and condition of housing varies, as does its ability to accommodate variations in heat, humidity and rainfall intensity. Distribution of populations can also vary in age demographics with some areas having younger or older populations.

In addition, a paradigm gaining popularity is the circular economy approach, where urban resilience can be built upon sharing resources, goods and services, to support local economies and enhance social networks (Wilkinson & Remøy 2018).

The question is how can we best adapt our housing to address issues such as increasing temperatures, ageing populations and affordability? This paper provides an overview of the housing stock in a selected Sydney Local Government Area (LGA) and explores priority areas for adaptation addressing economic, social and environmental sustainability and resilience issues.

RESILIENCE ISSUES

The effects of urbanisation, growing and ageing population and climate change are global (City of Sydney 2018) and resilience has become an important goal for cities - urban areas that house the majority of the world's population (Meerow, Newell & Stults 2016).

Urban resilience is defined as:

> The ability of an urban system and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity (Meerow, Newell & Stults 2016, p.39).

Resilience planning and preparedness may require a focused rather than broader approach, i.e. a balance should be found in terms of which issues can and cannot be addressed, as each resilience concerns may require a different approaches (Spaans & Waterhout 2017).

As Amico & Currà (2014, p.186) realise: 'many studies concerning the role of built environment in improving cities' resilience focus on street patterns, transportation networks and lifeline (water, electricity, communication and gas) infrastructures'. In contrast, innovations in the residential building sector could address some resilient issues concurrently such as affordability, ageing population and adaptation for climate change.

Acute Shocks Sydney - Extreme Weather

Extreme weather was ranked as the highest risk to Sydney (City of Sydney 2016), with heatwaves having the greatest impacts in terms of mortality and numbers of people hospitalised (City of Sydney 2016). Extreme heat is having significant impacts on Sydney with 47.3^{o}C recorded in January 2018 in Penrith - the hottest day since 1939 (Australia Government - Bureau of Meteorology 2018).

In 2016 the Australian Business Roundtable for Disaster Resilience and Safer Communities (2016) calculated the cost of natural disasters to Australia at $9 billion per year. The Roundtable estimate this cost will rise to $33 billion per year by 2050 without including the impacts of climate change, thus reducing these costs is a priority (City of Sydney 2016).

Chronic Stresses Sydney - Health and Housing Affordability

Furthermore, many of Sydney's highest impact stresses are associated with planning and investment to support the rapid growth and social changes of the population (City of Sydney 2016). The city is experiencing a loss of housing affordability and high rates of household debt (City of Sydney 2018), although house price increases are slowing and declining in some areas in late 2018. Policy drivers, an existing stock of affordable housing and diversity of housing types are lacking in Sydney (City of Sydney 2016).

Health infrastructure was assessed as the most vulnerable asset type (City of Sydney 2018). The incidence of sickness and disability rises with age and older people tend to be higher consumers of health care services. The growing ageing population is predicted to dominate health service planning over the next few decades (Hamza & Gilroy 2011; City of Sydney 2016). Climate changes, such as increased temperatures, may exacerbate health concerns related to ageing populations and failure to address this challenge could mean poorer health and greater pressure on government budgets (City of Sydney 2016).

Nevertheless, a better match between housing design and people's needs as they age is often disregarded (Bevan 2009; Judd et al. 2014; Yavari & Vale 2016). For aged people, there are key factors hindering the process of moving to a more appropriate dwelling: poor availability of suitable housing types, high costs and affordability of housing, and finally the suitability of location (Judd et al. 2014). Limited housing choices for older people as well as other personal factors lead to a demand for ageing in place (Yavari & Vale 2016; NSW Government 2016).

'Ageing in place' has emerged as a key strategy to reduce the cost burden of aged care on government and to encourage independent and active ageing (Demirbilek & Demirkan 2004; Judd et al. 2014, 2010). It is regarded as a win–win policy as it is also the often-stated preference of older people themselves to live independently in their own homes as long as possible (Judd et al. 2014).

To cope with that issue, home modifications to make dwellings more accessible may be a way of preventing forced downsizing in response to health crises, particularly where dwellings are still suitable (Judd et al. 2014). Different types of 'internal moves', such as de-cluttering, re-organisation, renovation and re-arrangement of bedroom and storage space (e.g. for care assistance) may enable people to remain in their homes (Judd et al. 2014). This requires finding effective design solutions for redeveloping the existing housing stock buildings to

achieve a better quality of life, wellbeing and independence for those aged 65+ (Yavari & Vale 2016). Elderly people should be provided with specifically designed facilities to meet their physical and cognitive strengths, capabilities and limitations, and to match their body dimensions (Rashid et al. 2008).

Accepting the need for longer term thinking of housing design and adaptation, which reflects the uncertainty of future occupation and housing demand, is imperative (Schneider & Till 2005). Otherwise, as Schneider and Till (2005) note, the housing sector is building in obsolescence through inflexibility.

Research suggests considerable proportions of the ageing population live in large houses with two or more spare bedrooms (Yavari & Vale 2016). In addition, Khajehzadeh and Vale (2015, p.161) state that, apart from house size, all families spend the majority of time at home in the same spaces, i.e., 'people who live in large houses actually spend most of the day living in a small area within the house'. One way of addressing downsizing within the property is suggesting ways to subdivide it to allow people to age in place and generate some income or release capital with the rest of the house in the form of affordable rents. These rented spaces could link in with some form of assistance for the aged person(s) – whether it is cleaning, shopping, taking them out or sitting with them for some hours per week, which could be comprehended as a circular economy feature for the property.

THE CIRCULAR ECONOMY

The circular economy has the potential to change the way we design, build and manage our built environment. Compared to the existing, extractive industrial model, the circular economy is restorative and regenerative. Relying on system-wide innovation, a circular economy approach aims to redefine products and services to design waste out while minimising negative impacts. Underpinned by a transition to renewable energy sources, the circular model builds economic, natural and social capital. The question is, how might this approach manifest itself in respect of ageing populations, housing affordability and sustainable housing adaptation in Sydney?

The 2013 report *Towards the Circular Economy: Economic and business rationale for an accelerated transition*, from the Ellen MacArthur Foundation and McKinsey (2013), outlined opportunities in an economy that is regenerative and waste-free. It sets out six principles:

1. all materials are recycled infinitely in technical or biological cycles
2. all energy is derived from renewable or sustainable sources
3. human activities should support ecosystems and rebuilding natural capital
4. human activites should support a healthy and cohesive society and culture
5. human activities should support human health and happiness
6. resources are used to generate financial and other forms of value.

A circular economy aims to minimise waste and maximise reuse and recycling, moving from an open ended, linear model of production consumption to a circular one, in which wastes are reconceptualised as resources (Wilkinson & Remøy 2018). Adapting the existing housing stock attempts to keep existing materials and assets in use in a profitable manner, which can positively contribute to the emergence of a circular economy (Wilkinson & Remøy 2018) that could improve urban compactness measures such as density, mixed use, and intensification (Mahriyar & Rho 2014).

Given the issues for Sydney identified above such as additional space in the form of spare rooms in existing property, ageing people with health and social needs, and a housing stock unsuited to increased temperatures, the six principles above can be applied.

METHODOLOGY

This initial study comprises a desk top study using secondary sources of one Sydney Local Government Authority (LGA); the Inner West. This section identifies the types of residential buildings used in the analysis and comparison. Data was collected from the Australian Bureau of Statistics (ABS) on Inner West, Greater Sydney and Australia demographics and residential building stock to determine housing density, size and typology.

This is exploratory research to determine priority areas and the potential adaptations to address reducing housing unaffordability, excess space in housing occupied by elderly single people and increasing resilience to excess heat. An advantage of case study research is that it is a flexible and adaptable method which can be adapted during the research (Robson & McCartan 2016). This was the case with this research as the original intentions regarding the types of buildings to be considered in the study were impossible to fulfil as a result. The researchers are not able to draw like for like conclusions based on similar building, types, sizes and locations to any great extent. However, this is not to say that the conclusions drawn from the study are not valid.

A limitation of the case study technique is that the researcher does not sample widely enough and that studies may represent the peripheries and not the average (Robson & McCartan 2016), though Yin (2008) stated that case study is concerned with analytical and, not, statistical generalisation. Care was taken to ensure conclusions drawn are noted as analytically general rather than statistically representative. The criticism of case study as a 'soft option' was rejected as the method requires preparation, knowledge of procedures (in this case adaptation of residential buildings) and analytical skills (Robson & McCartan 2016). It is soft in the sense that no hard and fast rules exist for the researchers to follow. Furthermore, the researchers were able to capture all typologies and adaptations. Bias, a question raised about case study approach (Robson & McCartan 2016), was eliminated because the researchers had no personal or professional contact with any project.

Given the objectives of identifying priority areas for action and to understand the potential for sustainable adaptations within individual residential buildings, ungraded stock only was extracted for analysis. As this study examines the potential for adaptation within Sydney LGA, some characteristics of the buildings are examined and discussed. The results are a uni-variate and a bi-variate analysis of the data. The answer to the question; *what is the potential for applying circular economy principles to sustainable adaptations in relation to residential building stock in the Inner West?*, is given on the basis of a quantitative statistical analysis derived from the database and reflects the empirical reality.

The research investigated potential for adaptations in a developed, mature market – Sydney Inner West – which was set out around 1850 (Inner West Council 2018a) and has been continuously occupied. It is one the most mature property market in NSW with a diverse range of stock. The area covered in this study is highlighted in Figure 1.

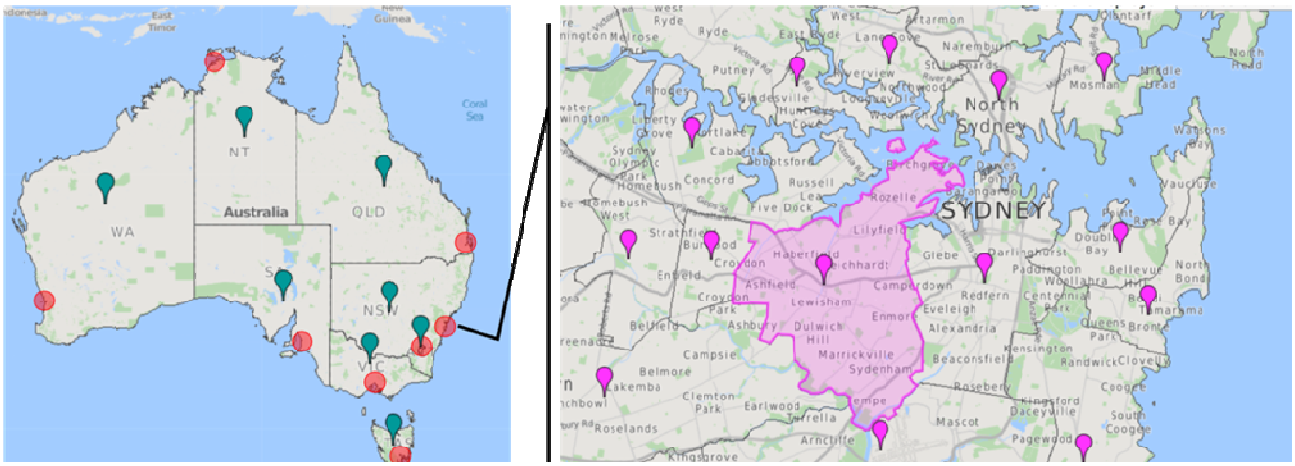


Figure 1 - Inner West (Sydney LGA) Location (ABS 2017)

FINDINGS

Analysis of Demographics and Housing Stock in Inner West – Sydney LGA

Table 1 and Table 2 presented summarise demographic and residential building data obtained from the ABS (2017). From these data, it was possible to draw some analysis over the potential benefits for Inner West to have its housing stock adapted for ageing populations, increased temperature and housing affordability.

Table 1 - Demographic and building statistics of Inner West (ABS 2017)

Description	2011	2012	2013	2014	2015	2016
Population density (persons/km^2)						5429
Selected Government Pensions and Allowances:						
Age Pension - Centrelink (no.)		14199	14349	14403	14533	14465
Carer Payment (no.)		1045	1115	1191	1218	1160
Disability Support Pension (no.)		5149	5042	5009	4854	4479
Total Personal Income (weekly):						
Persons earning $1-$499 per week (%)						20.3
Persons earning $500-$999 per week (%)						19
Persons earning $1000-$1999 per week (%)						27
Persons with a disability living in private dwellings (%)		14.2				
Households with rent payments greater than or equal to 30% of household income (%)	15.4					15.9

The Inner West population density is 5,429 persons/km^2, whereas Greater Sydney is only 400 persons/km^2 (Population Australia, 2018). Its density is higher than other well populated LGAs, such as Randwick, Woollahra, Mosman and Parramatta. The age profile of this population is distributed according to Figure 2, with

elderly people (above 65 years old) representing 12% of total population in 2016. Also, it is shown in the graph that since 2012, the elderly population has increased 0.6%. Likewise, the number of people receiving Age Pension has increased since 2012.

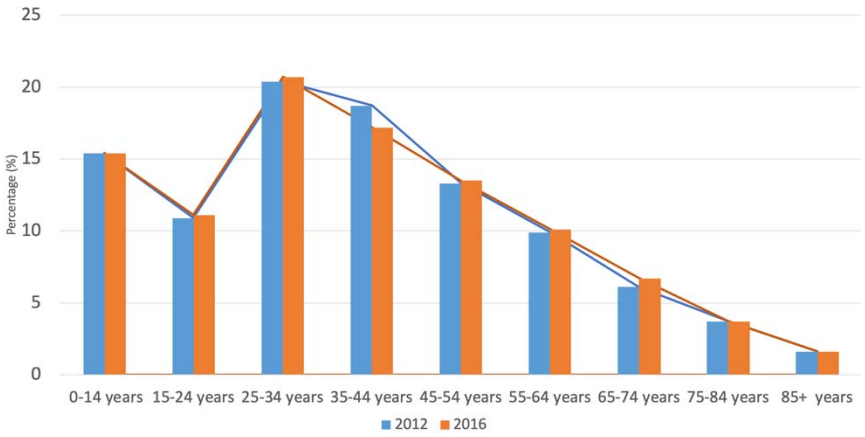


Figure 2 - Inner West's Estimated Resident Population (2012-2016) (ABS 2017)

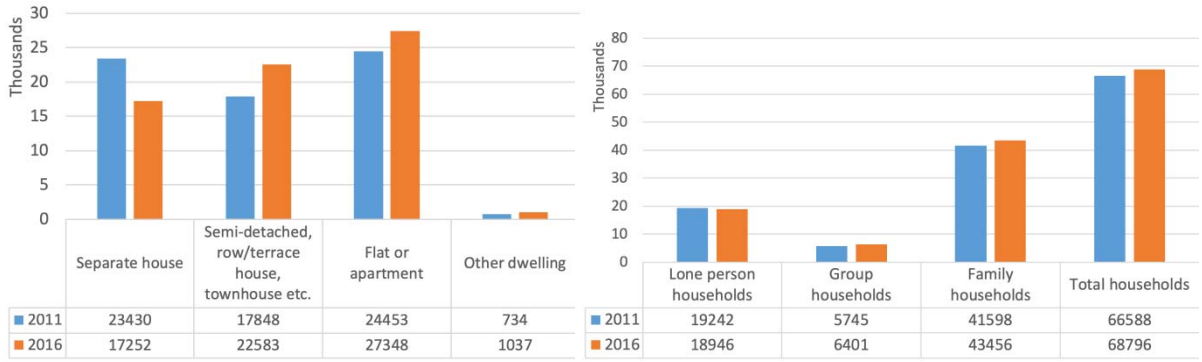
For the housing stock, some pertinent comparisons between Inner West (IW), Greater Sydney (GS) and Australia can be gathered from Table 2. Firstly, only 24.7% of occupied private dwellings in IW are owned outright and the rented tenure type is 43.6%. This is almost 28% higher than the rented percentage for Greater Sydney. In terms of housing suitability, 56% of the existing and occupied housing stock has bedrooms spare, which could be potentially converted in the event of housing adaptation.

Table 2 - Comparison between Inner West, Sydney and Australia demographic and building data (ABS 2017)

Description	**Inner West**	**Greater Sydney**	**Australia**
Median Age - Persons (years) – 2016	36.4	35.8	37.2
Proportion of non-employing businesses (%) – 2017	61	59	61
Proportion of health care and social assistance businesses (%) – 2017	7.4	6.1	5.7
Mean total income (excl. Government pensions and allowances) ($) – 2015	77,873	67,806	61,036
Persons who have needs for assistance with core activities (%) – 2016	4.5	4.9	5.1
Average household size (no. of persons) – 2016	2.4	2.8	2.6
Average monthly household rental payment ($) – 2016	2,195	1,996	1,524
Housing Suitability – Proportion of occupied private dwellings – Census 2016:			
Dwellings with bedrooms spare (%)	56%	67%	77%
Dwellings with no bedrooms needed or spare (%)	37%	26%	19%
Tenure Type - Occupied private dwellings – 2016:			
Owned Outright (%)	24.7	29.1	31
Owned with a mortgage (%)	28.4	33.2	34.5
Rented (%)	43.6	34.1	30.9

Figure 3 (a) illustrates the proportion of different housing typologies in IW and how it has changed since 2011. The number of separate houses has decreased almost 26% while the number of semi-detached housing and row/terrace housing have increased by the same proportion. The number of apartments has increased by 12% since 2011. Medium density housing corresponds to 46.6% of total dwelling structures in IW (.Id The population experts 2016). This is compatible with the growing population density of this area. However, even though 64.5% of dwellings in IW have two or three bedrooms (.Id The population experts 2016), the average household size for IW is 2.4 persons, which is less than the average for Greater Sydney and Australia. Lone person households account for 27.5% of total households in 2016 (see Figure 3(b)). These are contrasting points which can be addressed with adaptation and sub-division of dwellings.

In terms of income, persons receiving less than $999.00 per week account for 39.3% of the total IW population. However, the average household rental payment in IW is $549.00 per week (44% higher than the average for Australia), which represents more than 50% of total income for these persons. Although the mean total income is about $1,498.00 per week, that is around 36% of total mean income. It is not surprising that the percentage of households with rent payments equal or greater than the stress level of 30% of household income have increased since 2011 to 15.9%.



(a) *(b)*

Figure 3 - Inner West's private dwellings structure (a) and households by type (b) according to previous Census (ABS 2017)

Regarding the economy in general, 61% of all businesses in IW are sole proprietorships, partnerships without employees and micro businesses. Additionally, the proportion of healthcare and social assistance businesses is higher in IW than for GS and Australia, and this type of businesses employs 11.1% of the total employed population in this area. In terms of unpaid work, 20.2% of total population related providing unpaid assistance to persons with disability, or care, or help, to others. 14.2% of IW population live with some kind of disability in private dwellings and 4.5% need assistance for core activities.

Finally, it is implied that because of the proximity of IW to Sydney Central Business District (CBD), a higher proportion of people use public transport to work. Analysing the mode of travel to work of IW residents, 39% commute to work sustainably, either by public transport, walking or biking, and 5% work from home. This is a much better proportion than GS (26% total) and Australia (17%). If more employment opportunities derived from circular economy possibilities within residential adaptation in IW emerge, this number could increase further.

From this data, some inferences can be articulated for IW. As is happening worldwide, the aged population is increasing, and the need for care or assistance with some activities is likely to grow as they age. In relation to this, the great majority of current businesses in this area are micro and small business and the proportion of healthcare and social assistance businesses is already higher in this area than the average. Furthermore, as public transport, walking and biking are highly used by employees, it is inferred that their work is within proximity. More than 40% of properties are rented and the current inflated market implies a high rental payment (as seen in Table 2), putting pressure financially on this population and an unaffordable residential market, whose average household size comprises 2.4 persons, and with almost 30% being lone person households. In addition, 56% of occupied housing stock has spare bedrooms not being used, which indicates current inefficiencies in the housing stock.

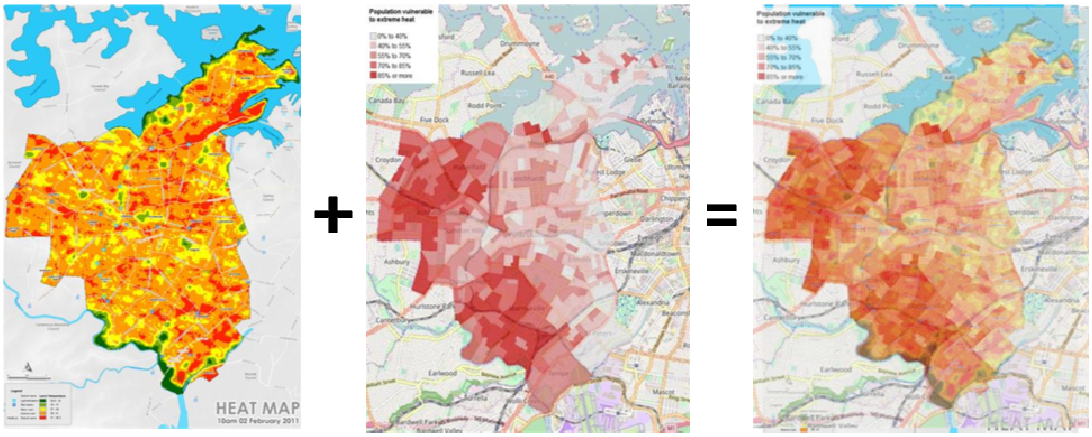
Applying building adaptation into this housing stock to sub-divide and use these spare bedrooms for generating some extra income for elderly people, while providing affordable rent to persons willing to help their elderly landlords with some activities such as shopping or maintaining their garden could be a way of building urban resilience and improving social, environmental and economic characteristics of IW. Micro businesses of healthcare and social assistance could grow more easily to address these circumstances, enabling people to work close to home. Circular economy principles related to supporting a healthy and cohesive society and generating value from existing resources are directly applied within this development opportunity.

Priority Areas according to Maps Analysis

Analysing some thematic maps for the IW LGA, it was possible to identify priority areas which demand action in terms of needs and/or potentials for adapting the existing housing stock to address affordability, increasing temperatures and ageing populations.

When it comes to the best dwelling type for the suggested adaptation, specific research on technical and building characteristics still needs to be done. This will be addressed in a future stage of this research. However, from some other previous papers (Yavari & Vale 2016), medium density housing terraces offer great potential for subdivisions, because they are usually narrow in width, longer in depth and the back lane access could be used as a separate entrance, allowing both tenant and landlord to have privacy while living in the same lot. Therefore, when identifying priority areas for this suggested adaptation, the authors considered four factors: extreme high temperatures, vulnerable population, predominantly rented and medium density housing.

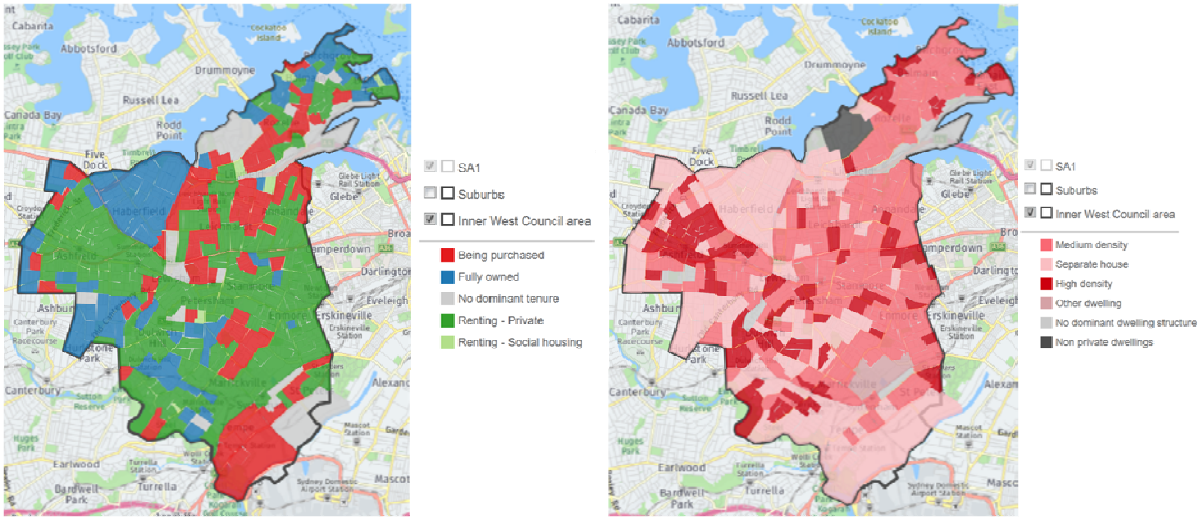
Firstly, according to the maps presented in Figure 4, it is possible to locate areas that are most affected by the high temperatures in heatwave days (red and orange colours in Figure 4 (a)) and which have, concurrently, greater percentages of population vulnerable to extreme heat (darker shades of red in Figure 4 (b)). Superimposing one map to the other (Figure 4(c)), it is notable that the west area is heavily affected – including suburbs such as Haberfield, Croydon, Ashfield, Dulwich Hill and Marrickville. Also, northern suburbs as Lilyfield and Birchgrove deserve the same special attention. These areas can be designated priority areas in terms of needs of action. Although IW east coast is very affected by extreme heat, there are not significative proportions of vulnerable population living in this area.



(a) (b) (c)

Figure 4 – Inner West's Heat Map – 2011 (a), Vulnerable Population Map (b) and Combined Map for Priority Action (c)
Source: (Inner West Council 2018b)

Secondly, when analysing dominant tenure type and dwelling structure, as seen in Figure 5, it is possible to identify areas that offer better potential for the building adaptation suggested in this paper when matching predominantly rented dwelling tenure type and predominantly medium density dwelling structure. In this case, areas in the east side (Annandale, Stanmore and Enmore) offer great potential. Anyway, this is not a priority area as designated above. Areas in the west side also offer good potential for adaptation, such as some parts of Ashfield, Dulwich Hill and Marrickville and these areas were also identified as priority areas within the previous analysis. Consequently, considering the four factors outlined above, those are the areas that offer the best potential for adaptation and also have the greatest need in terms of providing better housing for elderly people in extreme heat conditions.



(a) (b)

Figure 5 - Inner West's Dominant Tenure Type (a) and Dominant Dwelling Structure (b)
Source: (.Id The population experts 2016)

Strategies for Adapting the Existing Housing Stock

As this paper relates to an ongoing PhD research, the next step of this study will look into different strategies for adapting the existing housing stock to the resilience issues discussed in this paper. Existing strategies will be used as references, such as the BASIX Certificate (NSW Government 2018), 'Your Home' Australian Government's Passive Design Guidelines (Australian Government 2018) and the Livable Housing Design Guidelines (Livable Housing Australia 2017). The BASIX Certificate addresses thermal comfort, water and energy efficiencies for new construction and major renovations. Its principles refer to hot water systems, ventilation and exhaust, lighting, heating and cooling, and so on. 'Your Home' addresses many passive architectural strategies like shading, passive solar heating and cooling, sealing, glazing, skylights, etc. Finally, the Livable Housing Certification promotes 'more versatile houses to better meet the changing needs of occupants over their lifetimes', allowing for cost effective future adaptations (Livable Housing Australia 2017). There are 15 criteria which cover from step-free paths, location of bathroom and bedroom on the ground floor, larger spaces to allow ease of movement to slip resistant floor coverings and window heights.

Best practices for universal design will be acknowledged, as well as other regulations for accessibility and fall prevention. When introducing the subdivision of the unit, researchers will address issues like privacy and safety for all new units, while supporting social networks and local economy within the circular economy approach.

CONCLUSIONS

Sydney has a very varied housing stock in terms of age, quality, condition and performance. Also, it is experiencing issues related to ageing populations, housing affordability and increasing temperature and heat. Some stresses are acute, whereas others are chronic. Addressing these issues is vital if Sydney is to be resilient and sustainable. It is important to develop a framework or decision-making tool for managing these social, economic and environmental issues, in order that people can be comfortable, healthy and safe in affordable houses, without spending excessive amounts either in rent or to cool the property adequately.

It is time to start planning for the future proactively, analysing whether some planning legislation needs review and developing the technical capacity to adapt existing buildings. Which areas or suburbs and which varieties of the housing stock offer the best potential for adaptation? The current PhD research tries to answer this question. This present paper refers to a preliminary and pilot assessment in Inner West's Sydney LGA. Adaptation is possible, but we still lack knowledge of the parameters on which to focus our efforts to deliver the best outcomes in terms of urban resilience.

This exploratory research looks at these parameters and their potential. Physical and technological criteria for building adaptation are acknowledged. Economic and environmental conditions also pose desirable, feasible and achievable outcomes for adaptation. The social benefits of building adaptation are currently being researched. In terms of the urban resilience issues stressed in this paper, it is possible to propose a new lifestyle model: subdivision of existing under-occupied residential properties with the aim of providing elderly people with some home and care assistance – having someone help with shopping, looking after for them, and/or maintaining their garden in return for an affordable rent. In this way the circular economy can deliver sustainable and resilient adaptation in existing Sydney housing.

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