RESILIENCE, RESIDENTIAL BUILDINGS AND RATING TOOLS IN AUSTRALIA

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Abstract:

Resilience is emerging as an important component of building and urban design. The Rockefeller Foundation has established the 100RC (Resilient Cities) to demonstrate the scope of issues and the ways in which different cities globally are addressing their issues and challenges. Sixty-eight resilience issues have been identified; some are social, economic, governance or environmental in nature. Our ability to be resilient to chronic and acute resilience issues such as overpopulation and flooding, and to cope with resilience challenges such as heatwaves or lack of affordable housing, increasingly concern city authorities.

Rating tools provide benchmark and objective indications of sustainability within buildings or precincts. Since 1990 many have been launched, for example BREEAM, BASIX, and NatHERS. They are developed by government and/or private bodies and can focus on a limited issues such as energy and water, or a wide range of metrics including social and environmental criteria. Some are mandatory, imposed by government, such as the European Energy Performance Certificates (EPCs) others are voluntary. Some measure design and construction sustainability, whereas others focus on operational or in use sustainability. A number of questions arise with respect to rating tools used to evaluate building sustainability. For example, what choices are available to people in respect of new build and adaptive reuse for housing? And, given the focus here; do any of the tools, explicitly or implicitly, adopt resilience issues? This paper reviews two Australian sustainable building tools in the residential sector and evaluates their potential contribution to increasing resilience in the two 100RC cities; Melbourne and Sydney.

Keywords: *Residential, Resilience, Housing, Sustainability, Rating tools*

1 Introduction

Many cities worldwide are developing resilience plans to address issues such as population growth, urbanisation and the impacts of climate change. The Rockefeller Foundation set up the 100 Resilient Cities (100RC, 2016) to help cities to meet the physical, social and economic challenges they face. The 100RC supports the adoption and incorporation of acute and chronic manifestations of resilience. Acute or shock events include bushfire and floods. Chronic stresses undermine and weaken the fabric of a city on a daily or cyclical basis include inefficient public transport systems; high levels of unemployment; and chronic shortages of water and food. In tackling shocks and stresses, a city becomes more able to respond to adverse events, and is better able to deliver basic functions in both good times and bad, to all citizens. Melbourne, Australia was among the first wave of 32 cities to join the 100RC network and published its resilience strategy in May 2016.

The 100RC has identified and collated 68 challenges facing a number of global cities. For example, weather related issues can include flooding or heatwave and the way buildings are designed, built and adapted can impact resilience. Residential buildings provide shelter for citizens and need to fulfil requirements of safety and have resilience built into them. Clearly different solutions suit different cities and locations, and have different degrees of importance.

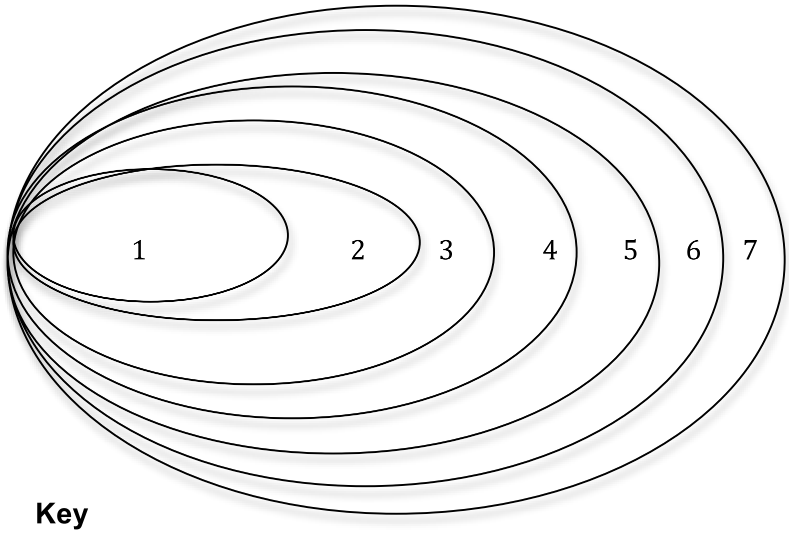
In 2016 the Australian Sustainable Built Environment Council (ASBEC) outlined a national Plan Towards 2050 Net Zero Emissions Buildings; targeting 100Mt GHG savings and A$9b savings through existing building retrofits as part of their policy solution (ASBEC, 2016). This is an encouraging development as they see building retrofit as the second highest opportunity for savings after, distributed energy which is estimated to deliver up to 300Mt GHG savings, whereas savings from appliances and equipment delivers 71Nt GHG and new builds 47Mt GHG savings to 2050 (ASBEC, 2016).

Building rating tools have been around since 1990 to enhance sustainability and include criteria relating to energy and water efficiency, embodied energy, waste and so on. Depending of the amount of measures included various rating tool points are awarded. However should resilience issues be incorporated into these tools or, are they already there implicit in existing criteria? What choices are available to people in respect of new build and adaptive reuse for housing in Australia? And, given the focus here; do any of the tools, explicitly or implicitly, adopt resilience issues?

2 Resilience issues

Our ability to be resilient to the 68 chronic and acute resilience issues such as overpopulation and flooding, and to cope with resilience challenges such as heatwaves or lack of affordable housing, increasingly concern city authorities. Resilience impacts at many scales, from building to worldwide (see figure 1) (100RC, 2016). Measures taken at the building level impact up to a global level. After building scale, there is the suburb, district or precinct scale. After the district is the city scale and the level where policy is made and executed and governance applied. After the city scale come metropolitan areas, followed by the national scale, and here national policy and governance decisions are made and executed. After national, comes the regional scale such as Europe, whereby some collective decision-making may be exercised. The final scale is worldwide or global.

Figure 1 Resilience Scales



Key
1 Building
2 District or Precinct
3 City
4 Metropolitan area
5 Country
6 Region
7 World

(Source: Adapted Rotterdam Resilience Strategy, 100RC, 2016).

3. The concept and qualities of resilience

The concept of urban resilience is used in policy and academic discourse (Meerow et al, 2016; NSW Government Planning and Environment, 2014) to explain complex socio-ecological systems and their sustainable management here; cites and buildings. Theorists claim resilience offers a framework for dealing with future uncertainties (Meerow et al, 2016).

Resilience is seen as positive action to reduce vulnerability to climate change, natural disasters and/or man-made disasters such as economic downturns or collapse. Resilience is an attractive perspective with regards to cities, which are complex adaptive systems (Batty, 2008) and have changed from 10% of the population living in urban settlements in 1990 to 50% in 2010 (UN DESA, 2010). Towns exceeding 50,000 people, use 71% of global energy related carbon emissions, though they cover only 3% of the area. In accommodating growth and expansion, cities and their buildings need resilience.

Resilience literally means to bounce back, though in the 19th century, evolved to embrace adversity (Alexander, 2013). The term is used by many disciplines, which understand and interpret it differently with five attributes emerging as shared qualities of urban resilience;

(1) Equilibrium versus non-equilibrium,
(2) Positive versus negative conceptualisations,
(3) Mechanisms of system change,
(4) Adaptation versus general adaptability and;

(5) Timescales of action (Meerow et al., 2016).

Meerow et al (2016) defined urban resilience as ability; *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*. The 100RC define urban resilience as *'the capacity of individuals, institutions, businesses and systems within a city to adapt, survive and thrive no matter what kind of chronic stresses and acute shocks they experience'* (100RC, 2016). In both urban resilience is dynamic and changing.

Cities and urban systems are complex networked systems (Desouza & Flanery 2013:91); conglomerations of ecological, social and technical components (Ernstson et al 2010). Cities and hinterlands are highly inter-dependent with delineation of boundaries difficult, as some systems, such as water supply, extending beyond physical city limits.

Another issue is equilibrium; with scholars debating single state, multiple-state and dynamic non-equilibrium (Davoudi et al, 2012). Single state equilibrium is the ability to return to a previous state of equilibrium post disturbance; prevailing in disaster management where post flood, buildings are reinstated. Multiple-state equilibrium recognises many states of equilibrium in any system. Systems exist in dynamic non-equilibrium, that is no constant state can exist and there is continuous flux and change. Here systems are 'safe to fail' as opposed to fail-safe, and post disturbance, cities and buildings, may not return to a prior state. A return to 'normal' may be inappropriate as it is undesirable to perpetuate vulnerability (Sanchez et al, 2016).

Resilience was seen as positive (Meerow et al 2016); able to maintain basic functions and prosper. Others question if existing states are desirable (Cote and Nightingale 2011), for example, areas with inadequate housing. Questions arise; resilience *'for whom'* and; *'to what?'* and power inequalities determine whose agenda prevails (Cote and Nightingale 2011).

Three mechanisms of change exist. The first is persistence; where efforts are made to return or maintain the built environment and systems to an existing state, e.g. after a storm buildings are reinstated (Chelleri, 2012). In this sense, retrofit is an example of persistence. Transitional is the second mechanism and implies some adaptation to a new state or incremental change. Change of use from a former land use such as warehousing to accommodate a new residential land-use as an area transitions post industrialisation is an example. The third, most extensive change is transformative, where wide-scale change occurs and areas totally transform. Change of use adaptation can be examples of transitional systems change and resilience and; collectively, transformational systems change.

The fourth aspect, adaptation, refers to the differences between specific adaptations, such as high adaptability compared to generic adaptability (Haase et al, 2014). Wu and Wu (2013) argued that too much emphasis on specified resilience undermines flexibility and ability to adapt to unexpected threats. Others perceived adaptability as synonymous with adaptive capacity and noted the importance of maintaining general resilience to unforeseen threats in addition to specified resilience to known risks. An example, here might be a known risk of pluvial flooding affecting a city or region, and taking measures in the design, construction and adaptation of buildings to reduce the risk of water damage arising and ensuring faster recovery. Equally, adopting flexible design and construction in buildings might accommodate a greater variety of alternate uses over time, thereby having adaptive capacity. The UK Tower of London has high levels of adaptive capacity; in its 900 year history, it has been a home, prison, barracks, armoury and now a museum and tourist attraction. Warehouse buildings are a design with good adaptive capacity, and globally are used for housing, hotels, art galleries and retail.

Finally there is timescale. Some perceive immediate and rapid recovery as essential; however it depends on whether the focus is on rapid onset events such as storms or long-term gradual states such as changing climate (Wardekker et al, 2010). The measurement of timeframes is unclear and can be hours, months or years. Reinstatement of energy supply after a storm would be preferably within hours, whereas reinstatement of flood damaged buildings may take months. Then there is the question of reinstatement being a return to a prior, or an improved state that would be more resilient to the same event. Sanchez et al (2016) noted urban transformation requires engagement in setting long term goals at city or state level, however flexibility is a pre-requisite to adapt to changes that occur as unintended adverse consequences may arise. Though issues are dealt with at city level, building level is where many adaptations occur.

Resilience is complex with multiple attributes and levels of interpretation. Meerow et al (2016) proposed consideration of the '5 Ws'. These are who, what, when, where and why? When considering resilience, 'who' is determining what is desirable for an urban system, whose resilience is prioritised and who is included or excluded from the urban systems. In respect of 'what'; what should the system be resilient to, what networks /sectors are included in the urban system, and is the focus generic or specific resilience? On the question of 'when'; is the focus on rapid or slow onset disturbances, short or long term resilience, and is it the resilience of current or future generations? The fourth W covers 'where'; in respect of the boundaries of the urban system, and whether resilience of some areas is prioritised over others, and whether resilience in some areas affects the resilience in other areas. Finally the issue 'why'; what is the goal, what are underlying motivations and is the focus on process or outcome (Meerow et al, 2016)?

Other concepts distinguish between built environment resilience (referring to the physical built environment that accommodates human activities), whereas community resilience refers to the resilience of individuals or a group of inhabitants and their social constructs. This literature focuses on well-being, governance and economy. Sanchez et al (2016) give the example of stakeholders having a different focus, with built environment resilience, engineers focus on engineering infrastructure and restoration to operation as soon as possible after a disaster, whereas a community engineering resilience will focus on social and economic outcomes.

4. Resilience challenges for Sydney and Melbourne

The resilience challenges faced globally vary depending on socio-economic, technical, climate variables. Within the 100RC network, cities identify their challenges and those affecting the two Australian cities in the network, of Sydney and Melbourne are set out in Table 1. It is apparent that some challenges affect both cities (ageing infrastructure, lack of affordable housing, rising sea level and coastal erosion and terrorism) whereas others differ.

Table 1 Resilience challenges in Sydney and Melbourne

City	Resilience Challenges (100 Resilient Cities)	
Sydney	1.	Ageing infrastructure
	2.	Heat wave
	3.	Infrastructure failure
	4.	Lack of affordable housing
	5.	Overtaxed/ under developed/unreliable transportation system
	6.	Rapid growth
	7.	Rising sea level and coastal erosion
	8.	Social inequity
	9.	Terrorism
	10.	Wildfires
Melbourne	1.	Ageing infrastructure
	2.	Coastal/tidal flooding
	3.	Declining population / human capital flight
	4.	Lack of affordable housing
	5.	Disease outbreak
	6.	Drought
	7.	Coastal/tidal flooding
	8.	Sea level rise / coastal erosion
	9.	Terrorist attack
	10.	Rainfall flooding

(Source: Author).

5 Residential rating tools

Rating tools provide benchmark and objective indications of sustainability within buildings or precincts (Hurley and Horne, 2006). Since 1990 many tools of residential buildings have been launched, for example BREEAM, and is Australia BASIX, and NatHERS. They are developed by government and/or private bodies and either focus on limited issues such as energy and water or, a wide range of metrics including social and environmental criteria. Some are mandatory, such as the European Energy Performance Certificates (EPCs) others are voluntary (Wilkinson et al, 2015). Some measure design and construction sustainability, whereas others focus on operational or in use sustainability. The aim is to encourage more uptake of sustainability and in this way, could they also enhance resilience?

The residential sector accounts for around 20% of total built environment GHG emissions (Pérez-Lombard et al., 2008) and are worthy of researching as they have a significant impact on sustainability and also affect some resilience issues. In Australia the Nationwide Home Energy Rating Scheme (NatHERS) measures predicted residential building energy performance; using a star rating going from zero to ten (NatHERS, 2017). 10 stars is 'Excellent' indicating the best building performance where a 0 star rating indicates the building is 'under performing'. It can be applied to new build and renovation projects and thereby can impact in an on-going and potentially changing way.

The Building Sustainability Index (BASIX) was launched in 2004 as part of the NSW planning system to reduce water consumption and greenhouse gas emissions for new homes in NSW (BASIX, 2017). BASIX is assessed online using the BASIX assessment tool, which checks elements of a proposed design against sustainability targets. If a development application is submitted in NSW for a new home or for any adaptation or addition of $50,000 or more to an existing home, owners need to get a BASIX certificate. The certificate shows commitments made in respect of water, energy and thermal comfort and confirms the proposed development will meet NSW Government sustainability requirements. Water and GHG reduction targets for BASIX are based on average per person residential use of potable water and average GHG emissions in NSW prior to 2004 and the introduction of BASIX (BASIX, 2017). For water, the NSW benchmark is 90,340 litres of water per person per year (or 247.5 litres per day). For energy, the NSW benchmark for residential GHG emissions and is 3,292 kg of CO2 per person per year (or 9.01 kg per day). By multiplying water and energy per-capita benchmarks by average occupancy rates, taken from the Australian Bureau of Statistics for dwelling size and location, water and greenhouse budgets for proposed dwellings can be calculated. Savings are estimated by comparing the dwelling's modelled performance to this benchmark figure. The size of NSW housing has increased in many parts of Australia (Clune et al, 2012) over this period and therefore the validity and reliability of the baseline data may be questionable, however it is the tool required by the State.

NatHERS and BASIX tools both measure residential building environmental performance in design. They are important, because in providing a measure of environmental performance; they are an effective way to promote building retrofit.

6. Evaluation and discussion

The review has shown that some resilience issues are clearly and directly related to the built environment and buildings in particular. The relationship of resilience issues faced in Sydney and Melbourne and buildings is shown in Table 2 below. In the table, X equals an indirect relationship exists and XX indicates a direct relationship exists.

Table 2 Sydney & Melbourne Resilience Challenges & Relationship To Buildings

City		Resilience Challenges (100 Resilient Cities)	Relationship of buildings to resilience
Sydney	1.	Ageing infrastructure	X
	2.	Heat wave	XX
	3.	Infrastructure failure	
	4.	Lack of affordable housing	X
	5.	Overtaxed/ under developed / unreliable transport system	
	6.	Rapid growth	X
	7.	Rising sea level and coastal erosion	
	8.	Social inequity	X
	9.	Terrorism	XX
	10.	Wildfires	XX
Melbourne	1	Ageing infrastructure	X
	2	Coastal/tidal flooding	
	3	Declining population / human capital flight	
	4	Lack of affordable housing	X
	5	Disease outbreak	
	6	Drought	XX
	7	Coastal/tidal flooding	
	8	Sea level rise / coastal erosion	
	9	Terrorist attack	XX
	10	Rainfall flooding	XX

(Source: Author)

Looking at the challenges, it is possible to determine how buildings could mitigate or reduce the resilience issue faced. For example with ageing infrastructure, the problem is exacerbated by population growth placing greater demand on the system. Taking building partially or wholly off grid in terms of water or energy would extend the life of the existing systems. With heatwave issues, the adoption of passive haus design approaches, with high thermal mass, would make homes less prone to excessive heat gain thereby affording greater protection to occupants. Urban design and housing in vulnerable areas can be made more secure by design thereby making them and their occupants less vulnerable to terrorist attack or invasion. Similarly in areas prone to wildfires, housing design can be focussed on reducing flammability and promoting active fire fighting measures. Where rainfall flooding is an issue, measures to increase water sensitive urban design (WSUD) are available such as green roofs and soft landscaping. Conversely where drought prevails measures to maximise resilience include onsite rainwater harvesting measures, water saving devices to sinks, showers and baths and waterless closets.

The lack of affordable housing needs addressing at policy level but could be mitigated with partial or shared ownership programmes or compulsory percentages of affordable housing in developments to ensure areas are more reflective of broader society. Again rapid growth is something that can be managed at policy and government level with the establishment of new towns or promotion of urban regeneration of areas in transition. With rising sea levels action is required at all levels including, Federal level. Housing can be constructed on stilts to allow quicker recovery times post inundation, however long term governments need to assess whether major flood prevention barriers are a solution or managed retreat. These issues are not easily integrated into existing tools. Equally flood issues, security (terrorism) and wildfires are not featured in rating tools. The resilience issues of affordable housing, rapid growth, rising sea levels and coastal erosion are not within the scope of these rating tools and do need to be addressed elsewhere.

Overall there is a range of physical measures are possible to make our buildings more resilient to the challenges we face. The question is; do any feature in our sustainability rating tools? The two most popular residential rating tools in Sydney and Melbourne are NatHERS and BASIX and they are restricted to energy and energy and water efficiencies respectively. Therefore currently they indirectly can be said to contribute towards two resilience challenges in respect of heatwave impacts and drought migitation, however this is not explicit or a goal of the tool currently. As both NatHERS and BASIX cater for new build and adaptation projects, there is potential for the tools to acknowledge resilience challenges throughout a buildings lifecycle. As ASBEC note (2016) retrofit offers the second biggest opportunity for GHG emission savings. Resilience has a positive connotation and can reduce our vulnerability (Batty, 2008) however we do need to remain cognisant that, over time, the degree and type of resilience required in a geographical location will vary. This change needs to be reflected in on-going amendments to the tools and some flexibility is needed (Wu & Wu, 2013).

3 Conclusions

This paper set out the issues of chronic and acute resilience identified by the Rockefeller Foundation for the 100 Resilient Cities. Twenty two of the 68 challenges are either social, governance, political and or economic issues outside of the physical building metrics (100RC, 2017). However, 27 issues can be addressed in some way in the design and construction and operation of buildings. Some examples of how resilience issues can manifest at building level were discussed and the resilience scales figure shows how buildings affect and contribute to resilience at all other scales.

The choices of rating available to people in respect of new build and adaptive reuse for housing in Australia include NatHERS and BASIX. This initial scoping study has explored nature of extent of two Australian existing sustainable residential building rating tools and the degree to which they overlap with resilience challenges affecting Sydney and Melbourne. NatHERS and BASIX share similarities and have been in the market since the mid 2000s. These tools have also been adopted by the residential sector, though the percentage of buildings achieving the highest levels of sustainability in these tools is low and therefore their impact is limited currently.

The second question posed asked if any of the tools, explicitly or implicitly, adopt resilience issues? Currently in Australia, we do not address resilience in our sustainable residential building rating tools for adaptive reuse or conversion or, for new build or building performance. It is evident we are missing an opportunity here; firstly, to acknowledge resilience as it relates to heatwave (energy) and drought (water) challenges. Second, the question of whether to extend the scope of the tools to other building related resilience issues such as wildfire and flood events needs further investigation. This gap needs addressing; as we need to raise awareness at all levels, and within the property and construction industry and professions of resilience issues and how our new and existing residential buildings can play an important part in delivering a more resilient built environment for all.

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