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Creating liveable cities in Australia

Mapping urban policy implementation and evidence-based national liveability indicators

Jonathan Arundel, Melanie Lowe, Paula Hooper, Rebecca Roberts, Julianna Rozek, Carl Higgs, Billie Giles-Corti

RMIT UNIVERSITY | Centre for Urban Research

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THE UNIVERSITY OF WESTERN AUSTRALIA

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Mapping urban policy implementation and evidence-based national liveability indicators

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Abbreviations

ABS	Australian Bureau of Statistics
ASGC	Australian Standard Geographical Classification
ASGS	Australian Statistical Geography Standard
CAUL	Clean Air and Urban Landscapes Hub, National Environmental Science Program (Australian Government Department of the Environment and Energy)
CRE	National Health and Medical Research Council Centre of Research Excellence in Healthy Liveable Communities
CSEPA	Corporations Sole 'Minister administering the Environmental. Planning and Assessment Act 1979'
G-NAF	Geocoded National Address File (produced by PSMA Australia Ltd)
GCCSA	Greater Capital City Statistical Area
GIS	Geographic Information System
Gross Density	The gross density for an area is the number of dwellings in that area, divided by the total area including non-residential land.
LGA	local government area
Mesh Block	Mesh Blocks are the smallest geographical area defined by the Australian Bureau of Statistics (ABS). The majority of populated Mesh Blocks contain between 30 and 60 dwellings.
MTWP	method of travel to work
MSEI	Melbourne Social Equity Institute (at the University of Melbourne)
MSSI	Melbourne Sustainable Society Institute (at the University of Melbourne)
Net Density	The net density for an area is the number of dwellings within the residential parts of the area (as defined by ABS Mesh Block classifications) divided by that same residential area. For areas that are entirely residential, the net density will be the same as the gross density.
NHMRC	National Health and Medical Research Council
POS	Public open space
PSMA	PSMA Australia Ltd
SA1, SA2 etc	Statistical Area 1, Statistical Area 2, etc (defined by the ABS)
SD	Statistical Division (defined by the ABS)
SEIFA	Socio-Economic Indexes for Areas
SOS	Section of State
SSC	State Suburb Code
TAPPC	The Australian Prevention Partnership Centre (National Health and Medical Research Council)
UCL	Urban Centre and Locality
UN	United Nations
WHO	World Health Organization

Executive Summary

The co-benefits of urban liveability for the economy, social inclusion, environmental and social sustainability, and public health are now well recognised by all levels of government in Australia and internationally. Liveable communities are safe, socially cohesive and inclusive, and environmentally sustainable. They have affordable housing that is linked (via public transport, walking and cycling infrastructure) to employment; education; shops and services; public open space; and social, cultural and recreational opportunities.

This report assesses the availability and implementation of policies governing seven characteristics of cities that can contribute to creating liveable communities, in Australian capital cities:

- Walkability;
- Public transport;
- Public open space;
- Housing affordability;
- Employment;
- Food environments; and
- Alcohol environments.

The research reported here received Federal grant funding from multiple sources. The aims were to:

- Identify state government urban planning policies and legislation and their targets that relate to key urban liveability policy domains;
- Create and map indicators of urban liveability, based on state government policy documents, to assess the degree of policy implementation and spatial inequities in liveability across Sydney, Melbourne, Perth and Brisbane; and to
- Map a set of evidence-based national liveability indicators from the Australian National Liveability Study found to be associated with chronic disease risk behaviours and/or health outcomes (for all Australian capital cities where data were available).

Two types of indicators were developed:

- In four cities (Melbourne, Perth, Brisbane and Sydney) we reviewed state government urban planning, transport and infrastructure policies and legislation, to identify measurable spatial policy standards or targets that could be developed and mapped to benchmark and monitor the level of implementation of urban policies aimed at creating liveable communities; **policy implementation indicators**.
- In all Australian state and territory capital cities where comparable data were available, we developed and mapped **national liveability indicators** shown to be associated with the health and wellbeing of Australians. This allowed us to make comparisons between cities.

1.1. Findings from the policy review

Although making Australian cities more liveable is an objective widely shared across all levels of government, our review of state government policies conducted between 2014 and October 2016 identified only a limited number of measurable spatial policy standards that could be used to assess progress towards maintaining and increasing the liveability of Australian cities.

We found that the policy environment was dynamic, with new policies being developed and adopted even during the course of the data collection period. Relevant spatial policies were identified for walkability, public transport and public open space, in all states where

the policy review was conducted i.e., Victoria, Western Australia, Queensland and New South Wales. However, these policies varied markedly in the specific urban characteristics sought and measured, and in their levels of policy ambition. No measurable spatial policy standards were identified for local employment, housing affordability, promoting access to healthy food choices, or limiting access to alcohol outlets.

Variation in quantifiable urban policy standards observed may reflect a lack of agreement – or different interpretations – among policy-makers and decision-makers about how land-use, transport and infrastructure planning can be used to improve the liveability of Australian communities. Most metropolitan strategic plans aspire to achieve walkable, liveable, 30-minute (or 20-minute) cities. But in most cities, policy standards do not support these aspirations. In some cases the policy ambition is modest, and inconsistent with the growing body of quantitative evidence about how to achieve liveable cities.

1.2. How well are Australian cities doing at providing healthy, liveable communities?

Overall, no Australian city performs well on all indicators of policy implementation or national liveability, with some cities performing better on some indicators, and weaker on others. We found little evidence – whether in new or established areas – that Australian cities are achieving contemporary policy targets across the entire metropolitan area for walkability, public transport, and public open space. Within every city, there is considerable spatial variation. The attainment of policy standards differs significantly between – and even within – neighbourhoods, suburbs and local government areas (LGAs). With few exceptions, people living in outer- (and many middle-level) suburbs are substantially less well served than inner-city residents by the integrated planning required for the urban design, amenities and infrastructure that create liveable communities.

The national health-related liveability indicators allowed direct comparison of all cities. This revealed considerable variation both between and within capital cities in achieving the urban design characteristics, amenities and infrastructure required to create healthy, liveable communities. The main results for each liveability domain are summarised as follows:

1.2.1. Walkability

- Higher residential densities and street connectivity, mixed land-uses, and high-quality pedestrian infrastructure are all needed to achieve walkable 30-minute (or 20-minute) cities.
- In some cases, there is a mismatch between the aspiration of creating walkable communities, and the policies that are in place.
- Melbourne, Sydney and Brisbane still have dwelling-density policies for suburban development of 15 dwellings per hectare. This is too low to achieve walkable neighbourhoods.
- Perth's target of 26 dwellings per hectare and Brisbane's target of 30 dwellings per hectare for urban development are more likely to result in walkable neighbourhoods – when integrated with other urban design interventions, and with policies governing access to destinations and public transport.
- However, all Australian cities generally fail to meet even these very modest targets. Average dwelling densities are very low, ranging from 5.7 dwellings per gross hectare in Brisbane, to 12.9 dwellings per gross hectare in Sydney. Indeed, all cities except Sydney are well below the respective state suburban-density targets.
- Street connectivity is required to create pedestrian-friendly street networks and to increase the proximity of local destinations. Victoria, Western Australia and Queensland have guidelines for street connectivity (block and/or lot size), but no specific targets.
- Measurable spatial policies for access to local destinations are critical for encouraging active modes of transport such as walking and cycling. Only Perth and Melbourne appear to have these policies. Even then, only a minority of dwellings and suburbs in these two cities meet the applicable standards (10% and

40% respectively).

- An evidence-based 'walkability index' was developed and mapped. This combined dwelling density, daily-living destinations and street connectivity. It showed that only a minority of residents in Australians cities live in walkable communities. With few exceptions, walkability is generally concentrated in the inner (and, in some cases, middle-level) suburbs.
- Despite the health and environmental benefits of walkable communities, Australian cities are still being designed for the motor vehicle. We found a notable exception: some new, walkable areas being built in outer-suburban Perth. This demonstrates that it is possible to produce higher-density, mixed-use, walkable neighbourhoods in outer-suburban areas of Australian cities if good urban policies are well implemented.
- Nevertheless, while local walkable neighbourhoods provide the foundation of a liveable city, they must be supported by integrated regional metropolitan planning that provides public transport, accessible employment and amenities. But most outer-suburban areas – even if walkable – lack this other infrastructure and amenities.

1.2.2 Public transport

- We identified measurable spatial policies for proximity to public transport in all Australian cities. We found that policy ambition varies from 60% of dwellings having access, up to 100%.
- Sydney has the most ambitious target of all cities, combining both proximity and frequency of service, but only 38% of dwellings meet this policy standard.
- Compared with other cities, more residential dwellings in Melbourne (almost 70%) have access to a bus, tram or train stop within the state's public transport proximity standards, despite falling short of the target of 95% (of dwellings having this access) the second-most ambitious target of those reviewed.
- Perth is the only city that exceeds its state target (60%) for dwellings having nearby public transport access. This has been achieved for 64% of dwellings, but the Western Australian government's target is substantially lower than those of other states.
- The national liveability indicator found to be associated with walking for transport, assessed access to proximate and frequent public transport services during weekday work hours. We found that the majority of dwellings in state capital cities lack this level of access. Around 36% of dwellings in Melbourne, Adelaide and Sydney enjoy this level of access, but only 18% in Perth, 12% in Brisbane, Canberra and Hobart, and 4% in Darwin.
- Most cities show a clear pattern of better access to proximate and frequent public transport in areas closer to the centre of the city.
- Integrated land-use, transport and infrastructure planning is required to meet even current public transport targets, with higher-density development required in particular around public transport nodes and activity centres.
- Other states might consider following the New South Wales government's lead in adopting more ambitious policies that combine both proximity and frequency of services with short-, medium- and long-term targets for policy implementation, even though such policies are more difficult to achieve.

1.2.3. Public open space

- All four states reviewed have a policy requiring access to public open space within 400 m (or a five-minute walk), and three of the four states also have policies requiring access to larger parks of specified sizes within longer walking distances.
- More Melbourne dwellings (82%) have access to a park within 400 m than do other cities (39–58%), although Melbourne still falls a little short of its ambitious target of 95%.
- Sydney is the only city to achieve its target for small proximate parks, which

requires ‘most’ (which we interpreted as 50%) dwellings to have access to public open space: 59% of residences had access to public open space greater than 0.5 ha within 400 m.

- Fewer dwellings in Melbourne, Sydney and Brisbane suburbs have proximate access to larger open space, compared with Perth. Overall, 89% of Perth residential addresses are within 800 m of a public open space larger than 1 ha.
- Using both policy standard indicators and national liveability indicators, we found that more dwellings have access to larger public open space areas within longer walking distances, but fewer dwellings across the four cities have access to larger parks within 400 m. Nevertheless, all dwellings in Sydney and Brisbane have access to larger parks within 2–3 km.
- There is considerable variation between cities in the spatial patterning of public open space access.
- However, unlike other indicators of liveability, outer-suburban areas appear to have better access to public open space than do some inner-city areas.
- Park size appears to be important for encouraging recreational walking. Victorian evidence suggests that parks greater than 1.5 ha are needed to encourage recreational walking, and that smaller pocket parks may do little to encourage recreational walking or to improve mental health. Hence, to get the greatest health benefits, it may be preferable to provide fewer, larger, higher-quality local public open spaces within closer walking distances of dwellings. Nevertheless, this requires further investigation, taking into account the loss of private space as Australian cities become more compact, the need to protect biodiversity, and the need for heat-island mitigation.

1.2.4. Housing affordability

- We found no state-specific spatial or measurable standards for housing affordability. For this reason, we assessed cities using the 30/40 housing affordability measure (households whose income is in the bottom 40% and who spend more than 30% of household income on housing costs), and the proportion of households renting which were the national liveability indicators found to be associated with health.
- Using the 30/40 measure, more than one-third of lower-income households in Sydney, Brisbane, Melbourne, Darwin and Perth appear to be experiencing housing affordability stress.
- Compared with other cities, fewer lower-income households in Canberra (31%) appear to be experiencing housing affordability stress.
- The proportion of households renting varies significantly between cities, with Darwin having the highest percentage of renters (43%).
- In Sydney and Brisbane, and to a lesser extent in Melbourne, housing affordability stress appears to be spread across large areas of the city. However, those suburbs suffering the greatest stress were located towards the urban fringe.
- Given that outer suburbs also have poor access to public transport, and are less likely to be walkable, household expenditure on private motor-vehicle transportation is likely to be higher there than in other areas. This suggests that continued suburban expansion without considering these other factors will not relieve the housing affordability stress being experienced by these households.

1.2.5. Employment

- We found no measurable spatial policies for local employment access or provision. For this reason, we assessed employment access by using the national liveability indicators found to be associated with better health.
- Across all state capital cities, a minority of the working population works and lives in the same local government area (24–49%, excluding Canberra), with a larger proportion living and working in the same metropolitan region (43–89%), and more residents of smaller cities doing so than in the larger cities.
- Inner-city residents are more likely to live and work in the same area. The

percentage tends to be lower in the middle 'commuter' suburbs, and then rises again towards the city edge.

- Across all cities, the vast majority of workers travel to work by private motor vehicle.
- Travel to work by public transport varies from 16% in Sydney down to 5% in Darwin.
- Darwin has the highest rate of residents using active transport to get to work (9%), with prevalence in other cities ranging from approximately 4% to 8%.
- There appears to be an opportunity to increase active modes of transport, given that 26–43% of the working population in all capital cities live and work in the same local area (SA3).
- Patterns of commuting longer distances to work in the middle suburbs and some outer suburbs suggests the need for more equitable distribution of employment. However, we found no measurable spatial policies or targets for increasing access to employment in these areas.

1.2.6. Food environment

- We found no measurable spatial policies for access to healthy food choices, with the exception of Victoria, which requires that 80-90% of households are within 1 km of an activity centre with a supermarket. For this reason, we applied national health-related liveability food environment indicators found to bring health benefits.
- Across Melbourne, Perth, Sydney and Brisbane, on average there are more fast food outlets than supermarkets within 3200 m of residents' homes.
- Although supermarket access varies significantly between cities, well over half of residential dwellings in all Australian capital cities are further than 1 km to a supermarket.
- Compared with other cities, a much lower proportion of Darwin dwellings have access to a supermarket within 1 km (17%).
- The inclusion of food environment targets in urban policy across Australia, following the example of the Victorian Precinct Structure Planning Guidelines, could help improve people's access to healthy food.

1.2.7. Alcohol environment

- We found no measurable spatial policies for access to alcohol outlets. For this reason we developed national liveability indicators based on previous research into factors that protect public health: the percentage of residences without access to an on-licence outlet within 400 m, and without access to an off-licence outlet within 800 m.
- In Perth and Brisbane, only 10–14% of residential addresses are within 400 m of an on-licence alcohol outlet, but in Melbourne and Sydney 20–23% of residential addresses are.
- Access to off-licence outlets within 800 m is more prevalent, with 56% of Sydney residential addresses within 800 m of an off-licence. The proportion was 48% in Melbourne and 34% in Perth.
- Given the health and social harms caused by alcohol, there is a notable lack of spatial planning policy across Australian cities for the distribution of alcohol outlets.

1.2.8. Conclusions and recommendations

We found a mismatch between the widely held aspiration of urban liveability and walkability, and many of the current measurable policy standards identified across Australian cities. However, the policy environment changes quickly and since this study took place, new state government policies have been developed which may include additional, or more ambitious targets and standards.

Nevertheless, there was little evidence that the policies, standards and guidelines included in this review, are being informed by the growing body of evidence on how to create healthy, liveable and walkable cities. Given current population projections in

Australia, evidence-informed policy and practice will be needed in order to maintain and improve urban liveability, improve the health and wellbeing of residents, and ensure that people's quality of life is maintained as our cities grow.

To avoid inequities within and between cities, consistent evidence-based policy standards for all urban liveability domains are needed, with the aim of maintaining and improving the liveability of Australian cities. For these standards to be useful in benchmarking and monitoring progress over time, they need to be spatial and measurable. For infrastructure and services such as parks and public transport, policy standards should consider both proximal access and quality of service.

We found that policy standards were only achieved in cities with unambitious targets. Cities with more ambitious policies appeared to be getting better results for the residents whom they serve, even if they fell short of the target set. For example, there is evidence from Perth that communities comparable in walkability to Perth's inner-city areas are being achieved on the urban fringe. Walkable communities are important because they create the building blocks for healthy, liveable communities, which requires comprehensive urban design policy. However, creating liveable communities also requires integrated planning and policies that ensures timely delivery of amenity and infrastructure.

Ambitious targets, though harder to achieve, are needed and should be encouraged, as they will ensure that cities continue to strive to maintain and improve liveability across the entire city, which would lead to greater equity, particularly for outer-suburban areas. State governments could consider setting both achievable short- and medium-term targets, and more ambitious longer-term targets.

Importantly, cities with unambitious targets for suburban development of 15 dwellings per hectare need to rethink. Even at these modest levels of ambition, targets are not being reached. Higher densities are essential to achieve more compact development, create walkable communities, and provide cost-effective access to public transport and physical and social infrastructure.

Achieving liveable cities involves many policy sectors and all levels of government, with requirements not only for local urban design but also regional metropolitan planning of employment, infrastructure and services. With no Australian capital city performing well on all indicators, and widespread evidence of geographical inequities within and between cities, our findings could be used to specifically target future interventions. As Australian cities grow, if stated aspirations to maintain or improve liveability are to be realised, evidence-based targets and standards need to be part of Federal, state and local government policy.

Based on our findings, we make seven recommendations:

Recommendation 1: Evidence-informed integrated transport, land-use and infrastructure planning is needed to deliver affordable housing, public transport, accessible employment and amenities, and to create walkable neighbourhoods as the foundation of a liveable city.

Recommendation 2: Include measureable spatial standards in state government urban, transport and infrastructure policies, regulations and/or guidelines, including short-, medium-, and long-term targets as appropriate.

Recommendation 3: Develop spatial indicators of Australian cities to benchmark and monitor the implementation of state-based policies designed to create liveable communities.

Recommendation 4: Develop agreed standards for the collection and categorisation of state government data that could be used to benchmark and monitor the implementation of urban policies in Australian cities.

Recommendation 5: Update liveability indicators at least every five years, to coincide with the ABS Census, and more frequently when possible.

Recommendation 6: Expand the Federal government's National Cities Performance Framework, to include policy implementation indicators for access to public transport, walkability, public open space, employment and affordable housing.

Recommendation 7: Move towards metropolitan governance of cities, starting by ensuring that state and local government policies are consistent and evidence-informed, and specifically designed to create healthy liveable communities.

Introduction

2.1 What makes a city liveable?

The term 'liveability' is widely used in urban policy in Australia and across the world, yet it is rarely defined, whether in policy documents or the academic literature. Following a comprehensive review of academic and policy literature in 2013 [1], our team defined a 'liveable' community as one that is 'safe, attractive, socially cohesive and inclusive, and environmentally sustainable; with affordable and diverse housing linked by convenient public transport, walking and cycling infrastructure to employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities' [2, p.138]. Liveable neighbourhoods have the potential to improve public health and the economy, and to increase social inclusion and environmental and social sustainability [3, 4]. Designing healthy, liveable communities will therefore help nations reach the UN Sustainable Development Goals [5] and New Urban Agenda [6].

Australian cities are generally regarded, by international standards, as very liveable. Yet significant work remains to be done. One important task will be to remove well-recognised inequities within and between Australian cities in the provision of infrastructure and services that create liveable communities [7]. Affordable housing located in outer-suburban areas lacks nearby access to employment, shops and essential infrastructure and services, resulting in long commutes and car dependency, and low levels of walking, cycling and public transport use. Conversely, amenity-rich areas closer to employment and the inner city face significant housing affordability barriers [8-10].

Urban, transport and infrastructure policies influence city planning decisions, which in turn influence the health and wellbeing of residents. For example, urban, transport and infrastructure policies help determine people's access to the underlying determinants of health, such as employment and education opportunities, healthy food, and health and social services. The location of amenities needed for daily living also influences transport mode choices that can increase or decrease residents' physical activity levels, which in turn affect levels of obesity and patterns of major preventable chronic disease [11]. Hence, city planning decisions are increasingly being recognised as a priority for public health intervention, with the World Health Organization declaring that health, and health governance, should be at the heart of city planning decision-making [12], and that the health of the population should be regarded as an indicator of sustainable development [13, 14].

In the last five years, the team of researchers now known as the Healthy Liveable Cities group located at RMIT University in Melbourne has undertaken a comprehensive program of research examining the health effects of urban liveability. This work received seed funding from the Victorian Department of Health North-West Metropolitan Region, and the University of Melbourne's Institutes for Social Equity (MSEI) and Sustainable Society (MSSI). Subsequent Federal government funding was attracted from bodies including the National Health and Medical Research Council (NHMRC) Centre for Research Excellence in Healthy Liveable Communities (CRE), The Australian Prevention Partnership Centre (TAPPC) and, more recently, the Clean Air and Urban Landscapes Hub (CAUL) of the Australian Government's National Environmental Science Program. This research program has allowed our team to explore how liveability indicators can be used to measure and monitor city planning [2, 3, 11, 15] and to study associations between the underlying policy domains of liveability and a range of health and health-behaviour outcomes [16-28].

Based on our definition of urban liveability, we initially defined 11 domains of liveability [1, 2]. We subsequently refined these to seven domains [3] that were easily measured using routinely collected data: walkability, public transport, public open space, housing affordability, employment, social infrastructure, and the food environment [29]. These were all tested in Victoria, as part of the CRE. The Australian National Liveability Study (funded by TAPPC), enabled us to apply this work on a national scale [15]. Four of the urban liveability domains were tested against a range of health measures in Perth, Melbourne, Brisbane and Sydney: walkability, public transport, public open space, and the food

environment [24, 25, 30-32]. Given TAPPC's focus on preventing chronic disease, one additional domain was added: the alcohol environment, due to growing concerns about the health harms caused by alcohol consumption [18].

Through the TAPPC research we identified a number of health-related national liveability indicators: policy-relevant indicators of liveability found to be associated with health and wellbeing. The CAUL Hub liveability study facilitated extension of the TAPPC research, enabling policy analyses for five domains of liveability (walkability, public transport, public open space, employment, and housing affordability) to be conducted in four Australian capital cities (Perth, Melbourne, Brisbane and Sydney). The aim of this research was to create and map indicators to assess the level of implementation of policies across these four cities. Given the national interest in urban liveability, the CAUL study prompted us to also map the five health-related liveability indicators for all eight Australian state and territory capital cities identified through TAPPC and the CRE (walkability, public transport, public open space, housing affordability, and employment). Indicators of the food environment and the alcohol environment were also mapped for Perth, Melbourne, Brisbane and Sydney. (Food and alcohol environment indicators are not yet mapped for other cities due to difficulties in obtaining suitable data).

The result is this report, which assesses and maps the implementation of policies designed to create liveable Australian cities, as well as policy-relevant health-related national liveability indicators. The next section sets out our health and wellbeing rationale for selecting the underlying domains of urban liveability considered in this study.

2.2 How does urban liveability impact health and wellbeing?

One significant way to improve people's health and wellbeing is through urban design and planning that create walkable, pedestrian-friendly neighbourhoods. Areas with high walkability have higher residential densities and street connectivity, mixed land-uses and high-quality pedestrian infrastructure. Walkable, pedestrian-friendly neighbourhoods encourage higher levels of walking for transport, by creating shorter and more convenient walking routes between homes and accessible destinations – including jobs, retail and essential infrastructure and services [11, 33-35]. Given the well-established benefits of a physically active lifestyle in preventing major chronic diseases, increasing walking is an international priority [11].

Access to public transport is an underlying determinant of health. Public transport facilitates access to regional jobs and services [36], while shorter distances to public transport stops are associated with more transport-related walking [37-39], which decreases the risk of obesity [40]. Conversely, there is evidence that for each additional hour spent driving a car, people's risk of obesity increases by around 6% [40]. Motor-vehicle traffic also increases the risk of traffic-related injuries [41], which are the eighth-leading cause of death and disability globally [11]. Traffic also reduces air quality [42] and is a major source of noise in cities, which is detrimental to mental health [11].

Access to local public open space not only increases the urban liveability of communities by creating convivial, attractive environments [28], it is also important for the health and wellbeing of people of all ages. Green space helps cool the city and protect biodiversity [43]. Access to public open space [34, 44, 45], particularly high-quality public open space [46, 47], also promotes recreational physical activity. There is also evidence that access to high-quality public open space improves mental health [34, 48-50]. As cities densify, providing more public and semi-private open space is critical for population health and wellbeing, and to increasing biodiversity, particularly as the amount of private open space declines [43, 51].

Housing affordability, along with quality, location and density of housing, affects people's health, wellbeing and quality of life [3, 52], making access to housing a health-equity issue [12]. It has long been understood that poorer-quality housing is linked to poorer mental and physical health [53, 54]. However, housing affordability has become a pressing public policy issue in Australia, leading to construction of lower-cost, low-density housing on the urban fringe, which is poorly serviced by public transport and infrastructure [52, 55]. The car-dependence of these areas makes residents increasingly vulnerable to mortgage stress, in the face of rising oil prices and mortgage interest rates [9]. Conversely, well-designed, well-located, higher-density housing with access to local employment, services and shops, and high-quality public transport, can promote good health by encouraging social connections and active forms of transport [51].

Employment is not only good for the economy, but is also well established as a determinant of health [16, 56]. Hence, the spatial availability and location of employment are important elements of urban liveability [3, 16], influencing access to opportunities, as well as the length of daily commutes, transport choice, and time spent driving.

The local food environment helps determine the availability and accessibility of healthy food options [23], which in turn influences food choices and what people eat: unhealthy diets are a leading cause of chronic disease globally [57]. Having nearby access to a source of healthy food, such as a supermarket, is associated with higher consumption of fruit and vegetables [34]. Food purchasing may also be influenced by the ratio of healthy to unhealthy food outlets [58]. Further, having shops nearby may encourage the use of active transport for shopping trips [59].

Finally, the local alcohol environment has been found to affect health risk factors, particularly in areas of socio-economic disadvantage. For example, higher densities of alcohol outlets are associated with harmful consumption of alcohol [60] and alcohol-related violence [61]. There is evidence of more alcohol outlets [62] and greater harm [18] in more disadvantaged areas.

In the following section we consider the policy context for creating urban liveability.

2.3 The policy context

Across Australia, there is a complex division of responsibility for city planning. The Federal government provides funding for major infrastructure and specific programs [63], while the role of the private and not-for-profit sectors in delivering infrastructure and services is increasing [63-66]. The Federal Government has demonstrated growing interest in creating smart liveable cities through investment and inter-governmental partnerships on city deals and its National Cities Performance Framework. However, primary responsibility for governance and management of urban areas rests with state and local governments [63].

State governments produce regional and metropolitan strategic plans, such as Plan Melbourne [67, 68], A Plan for Growing Sydney [69], South East Queensland Regional Plan 2009–2031 [70] and Directions 2031 and Beyond for Perth and Peel [71]. State governments provide the legislative framework for local planning schemes, ensuring that they are consistent with state government policy. The states are also responsible for funding and providing major infrastructure that helps determine urban liveability, such as roads, public transport, and government schools and hospitals [63, 65]. However, state governments delegate responsibility for many decisions on land use and development to local governments, and local governments also deliver and run a range of local services [63, 72].

State governments are divided into political portfolios and public service departments, each governing a distinct area of policy. Delivering services and infrastructure in a way that creates complete, liveable communities requires the involvement of many state government departments. Thus, to achieve urban liveability, integrated planning is essential to overcome policy silos and achieve coherent and consistent policy between many departments and agencies [73, 74].

All levels of government are increasingly recognising the benefits of urban liveability [68, 75-77]. But, as already noted, the concept of urban liveability is rarely defined or measured, and any measurement that is undertaken is typically not linked to current Australian urban planning policies, and ignores inequities within cities [2]. As Australian cities grow, if aspirations to maintain or improve liveability are to be realised, evidence-based targets and standards need to be integrated into policies. Importantly, current planning standards are generally not derived empirically or based on evidence – nor have they been empirically evaluated. The next section considers the role of indicators in measuring and monitoring policies that create urban liveability.

2.4 What is the role of indicators?

Evidence-informed planning and better monitoring of urban policy can assist in assessing progress towards maintaining and strengthening the liveability of Australian cities. This is increasingly important given projected population growth [78]. Indicators can assist by enabling the underlying domains of urban liveability to be benchmarked and

monitored over time.

An indicator is 'a measure or a set of measures that describes a complex social, economic or physical reality … that acts as a gauge to tell us how well or poorly we are doing with respect to an indicator' [79, p.104]. Urban liveability indicators can be useful for describing where, what and why any difficulties relating to urban liveability exist, assessing policy effects and results over time [2], and understanding what aspects of a policy are (or are not) being implemented [80]. Hence, to bring the greatest benefits, indicators need to be relevant to the planning policies and practices that underpin the development of liveable cities and neighbourhoods.

For measurement to influence policy, geographic scale is important. Policy-makers and city planning practitioners have identified neighbourhood-level indicators to be particularly useful in removing geographic inequities. Based on research conducted with local and state government planners and policy-makers, Lowe et al. [2] argue that, to be credible, indicators must be developed through rigorous research, and must be linked to, or incorporated into, policy documents. Hence, the conceptualisation of indicators in this report was based on a series of workshops with policy-makers and practitioners held in Victoria and nationally, with input from a national advisory group that included Federal and state policy-makers [15]. Next, the projects that have underpinned the research presented in this report are briefly described.

2.5 National urban liveability research projects that underpin findings described in this report

The original urban liveability research reflected in this report was seed-funded by a grant from the Victorian Department of Health (now the Department of Health and Human Services) and joint funding support from the University of Melbourne's Social Equity Institute and Sustainable Society Institute. The research was initiated by regional managers in the Victorian Department of Health, who were concerned about rapidly expanding growth areas in Melbourne's north-west, and particularly about the health effects of the lack of infrastructure. This seed funding enabled our team to undertake qualitative research with local government and regional and central officers of state government; to undertake a national and international literature review; and to define 'liveability' [1, 2]. From this initial seed funding grew a national program of research supported by major national research funding programs. This report is based on findings of urban liveability indicator research, supported by three major national research programs.

2.5.1 NHMRC Centre of Research Excellence (CRE) in Healthy, Liveable Communities

The CRE, funded by the National Health and Medical Research Council, aims to generate new knowledge about:

- measuring policy-relevant built environment features associated with leading non-communicable disease risk factors and health outcomes
- causal relationships and thresholds for built environment interventions using data from longitudinal studies and natural experiments
- the economic benefits of built environment interventions designed to influence health and wellbeing
- factors, tools and interventions that help translate research into policy and practice [81].

The CRE has well-established advisory groups in Perth and Melbourne (which include representatives of state and local governments, non-government organisations, professional associations and the private sector) and a smaller advisory group in Brisbane. It also has national industry partners from the government, private and non-government sectors (the National Heart Foundation of Australia and the Planning Institute of Australia). The CRE's liveability work was led by Associate Professor Hannah Badland, with foundational work conducted in Melbourne, focusing on measuring and testing key urban liveability domains in adults [16-23, 28]. The Kids in the Community study (described in Appendix 4) is also focusing on developing a child (or family) liveability index [27, 28, 82-84].

2.5.2 The Australian Prevention Partnership Centre – The Australian National Liveability Study

The Australian Prevention Partnership Centre (TAPPC) involves researchers from more than 20 Australian universities, institutes and health departments, and funds a number of projects aimed at investigating how we can 'build an effective, efficient and equitable system for the prevention of lifestyle-related chronic disease' [85].

In 2013, TAPPC began funding the Australian National Liveability Study to develop and validate a set of national spatial liveability indicators associated with selected non-communicable disease risk behaviours and health outcomes [15]. The Australian National Liveability Study is overseen by a national advisory group comprising the CRE national advisory group members, plus state government and private representatives from Victoria and New South Wales. It involves a national research team drawn from the University of Western Australia, RMIT University (the CRE and Healthy Liveable Cities group formerly located at Melbourne University), the University of Wollongong, the University of Canberra and the Australian Catholic University (previously located at Queensland University of Technology). After a national advisory group workshop in 2013, it was agreed that the liveability indicators were to be:

- aligned with urban policy
- developed using readily available data
- standard and consistent over time
- suitable for monitoring progress towards creating more liveable and sustainable communities
- validated as being associated with chronic disease risk factors and/or health outcomes [15].

The study was limited to liveability for adults, with validation research for individual urban liveability domains conducted in four cities where suitable data were available: Melbourne, Perth, Brisbane and Sydney. In the first stage of this project, the study team identified a number of policy-relevant urban liveability indicators shown to affect people's health and wellbeing. In this report, these evidence-based 'national liveability indicators' are mapped for all state and territory capital cities across Australia, where data were available.

2.5.3 The Clean Air and Urban Landscapes Hub – Liveable Urban Systems Theme

The Clean Air and Urban Landscapes (CAUL) Hub is part of the Australian Government's National Environmental Science Program. The CAUL Hub undertakes research to improve environmental quality in Australia's urban areas, including air quality, urban greening, liveability and biodiversity [86]. It focuses on translating research into policy and practice, Indigenous Australian participation, and community engagement. The CAUL Hub involves researchers from four Australian universities: the University of Melbourne, RMIT University, the University of Western Australia and the University of Wollongong [86, 87].

Research undertaken by the CAUL Hub's Liveable Urban Systems project on urban liveability aimed to assess current policy and progress towards creating liveable neighbourhoods in Australian capital cities. Its focus was on developing and mapping indicators of urban liveability suitable for assessing the implementation of urban policy in Melbourne, Perth, Brisbane and Sydney [87]. It builds on and complements research undertaken by the NHRMC Centre of Research Excellence and The Australian Prevention Partnership Centre.

Aims & Structure

The specific aims of this report are therefore to:

1. Identify state government urban planning policies and legislation and their targets that relate to key urban liveability policy domains;
2. Create and map urban liveability indicators based on state government policy documents, to assess the degree of policy implementation and spatial inequities in liveability across Sydney, Melbourne, Perth and Brisbane; and
3. For all Australian capital cities where data are available, to map a set of evidence-based national liveability indicators from the Australian National Liveability Study found to be associated with chronic disease risk behaviours and/or health outcomes.

The next section outlines the research methods used to identify, measure and map indicators. Then we describe the results, according to each of the urban liveability domains: walkability, public transport, public open space, employment, housing affordability, the food environment, and the alcohol environment. Each results section describes, firstly, the selected indicators for that policy domain and, secondly, the findings for state-specific policy implementation and national health-related liveability indicators. The results allow comparison within and between cities across Australia, with maps highlighting within-city geographical variation in performance for key liveability domains. In the concluding section, the results are discussed and analysed in relation to the literature. The data sources and data processing used to calculate and map the indicators are outlined in Appendix 3.

Methods

4.1. Research approach

The project was undertaken in a series of phases, as illustrated in Figure 1. Each phase is described in detail in the following sections.

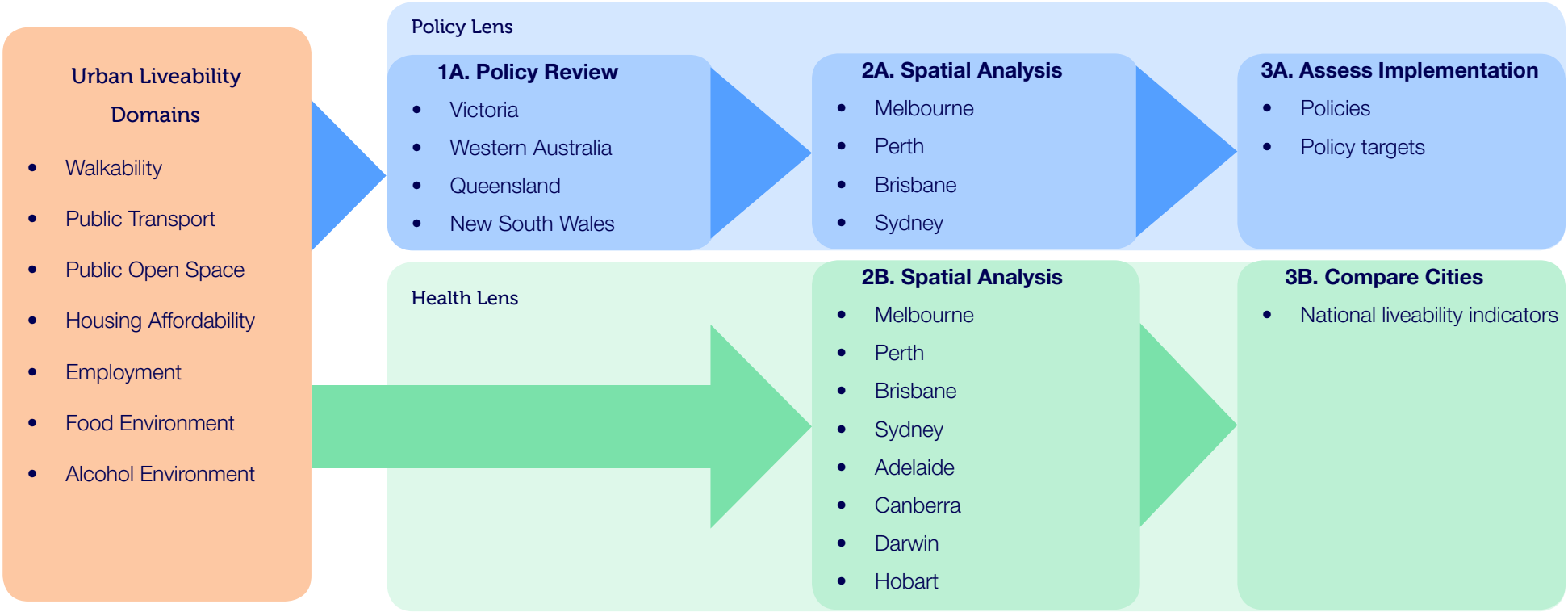


Figure 1: Summary of report scope and methods

4.2 Policy review

The first phase of the study was a policy review. We aimed to identify policies that shaped each of the seven urban liveability domains: walkability, public transport, public open space, housing affordability, employment, the food environment, and the alcohol environment (Figure 1). Between 2014 and October 2016, we reviewed all relevant state government urban planning policies and legislation for Western Australia, Victoria, New South Wales and Queensland. This review commenced as part of the Australian National Liveability Study [15], and was extended for the Clean Air and Urban Landscapes Hub project.

We used the internet search engine Google and searched websites of relevant state government departments and agencies to identify current state policies for Melbourne, Sydney, Perth and Brisbane, for all seven policy domains. The full list of policies reviewed is in Appendix 1.

Each policy was screened to identify any spatial standards or targets related to the policy domains. The spatial standards were then assessed and selected for inclusion in the study, based on whether they could be measured with a geographic information system (GIS), using available spatial data. Appendix 2 lists the specific policy standards selected for inclusion. The aim was to calculate and map state-specific policy implementation measures drawn from identified state policy standards, for Melbourne, Perth, Brisbane and Sydney. Due to study scope, policy implementation indicators were not calculated and mapped for other state and territory capital cities. However, all capital cities were included when considering national liveability indicators.

Some additional steps were followed to identify, create and validate national health-relevant indicators, described fully elsewhere [32, 88, 89]. In brief, where no appropriate spatial standards could be identified in policy documents, alternative evidence-based measures derived from research and consultation with relevant experts and relevant local data authorities (e.g. NSW Ministry of Health) were identified and created. This resulted in a list of recommended measures for each urban liveability policy domain. As part of the Australian National Liveability Study, associations between these GIS-based urban liveability measures and a variety of health behaviours and outcomes were tested. From this initial research, a number of indicators were identified as the strongest potential 'health-enhancing' measures, and selected as the evidenced-based 'national liveability indicators', to allow comparison across all Australian capital cities.

4.3 Spatial analysis

Selecting, calculating and mapping policy and national liveability indicators across all Australian capital cities was a complex undertaking. Not only did it involve sourcing and processing large amounts of data, it also required data to be cleaned, and many decisions and assumptions to be made before analysis and mapping could proceed. This section describes the decisions and assumptions made, to enable these indicators to be replicated in the future.

4.3.1 Interpreting policy indicators spatially

The manner in which policies are defined presented some difficulties for computing a spatially explicit measure that corresponded with each policy. For example, the Western Australian government's Liveable Neighbourhoods 2009 (Element 2 Movement Network) defines a policy for the transport domain that 'at least 60 per cent of dwellings should be in a safe 400 m walk from a neighbourhood or town centre, or an existing or potential bus stop, or in a safe 600 m walk from a railway station' [90]. Although it is straightforward to determine the presence of an existing bus stop or railway station, publicly available data did not allow identification of a 'potential' bus stop, such as one planned for a new housing development. Similarly, while it is straightforward to calculate walking distances along the street network, no criteria defined what was meant by 'safe'. In cases like this, the definition and mapping of the policy was limited to what could be measured explicitly and unambiguously, indicated here with strikethrough: 'at least 60 per cent of dwellings should be in a ~~safe~~ 400 m walk from … an existing ~~or potential~~ bus stop, or in a ~~safe~~ 600 m walk from a railway station'. Similarly, other policy documents, such as the NSW Government's Recreation and Open Space Planning Guidelines for Local Government [91] referred to measures that should be achieved for 'most' dwellings. We interpreted this

literally, meaning that compliance was achieved if more than 50% of the dwellings met the policy requirement. In each urban liveability domain results section that follows, we describe the policy and how it was measured.

4.3.2 Defining a residential address

The majority of indicators in this study were calculated for all residential addresses in the capital cities. Exceptions include indicators based on ABS (Australian Bureau of Statistics) Census data, with these indicators were developed at various appropriate (or permitted) scales according to data availability. The scale used is indicated throughout the report. Across Australia, the definitive source of data on all addresses is the Geocoded National Address File (G-NAF), produced by PSMA Australia [92]. In G-NAF, each residential dwelling across the country is assigned a primary address. In the case of townhouses or units, a secondary sub-address is also assigned. To simplify analysis and aggregation of results, we considered only the primary addresses. Hence, in the case of a block of units, all units were scored identically across all measures. A consequence of this decision is that a block of units as a whole has the same weight in suburb-level averages as a detached house. Clearly this is a limitation, but was done for pragmatic reasons, given the scale of the project.

4.3.3 Defining study areas

As the aim of the study was to produce indicators for Australian state capital cities, the starting point was to define the study areas for each city. We used the 2011 capital city statistical divisions defined by the ABS in the Australian Standard Geographical Classification (ASGC) [93]. For Western Australia, both the Perth and Peel statistical divisions were joined together to define the capital city, because metropolitan Perth development now extends down the coast to join Peel.

The ABS Section of State (SOS) structure of the Australian Statistical Geography Standard defines areas classed as urban. Thus, within each capital city Statistical Division boundary, we further identified the urban areas of each capital city. The SOS aggregates the Urban Centre and Locality (UCL) areas of each state or territory, based on population ranges: UCLs with populations greater than 100,000 are aggregated into ‘major urban’ regions, while UCLs with populations between 1,000 and 99,999 are aggregated into ‘other urban’ regions. Together, ‘major urban’ and ‘other urban’ encapsulate all urban areas of each capital city.

The next step was to identify the residential addresses to be included in the study. The smallest geographical area defined by the ABS is the Mesh Block. Within the study area, residential addresses were initially collated for all Mesh Blocks containing one or more dwellings.

The final refinement to study areas and residential address listings was the application of the ABS Socio-Economic Indexes for Areas (SEIFA) to exclude non-residential areas for which our results would be irrelevant (for example, a cemetery). The SEIFA exclusion rules work under a two-phase system, firstly excluding areas based directly on their characteristics, then further excluding areas where insufficient data exist for computing the SEIFA index scores. The first-phase exclusion criteria applied at Statistical Area 1 (SA1) level are as follows [94]:

- Population of 10 or fewer
- Employed persons of 5 or fewer
- Number of classifiable occupied private dwellings of 5 or fewer
- Proportion of people in private dwellings: 20% or lower
- No address
- Offshore.

The same exclusions were applied across all cities for analysis across all domains, with the exception of public open space for Brisbane, where we were unable to obtain a reliable dataset for the entire study area. When we began the Australian National Liveability Study, we were unaware of any city-wide public open space dataset for the entire Brisbane study region. Consequently, analysis of the public open space indicator was undertaken only within the Brisbane City Council LGA, using a dataset that had previously been cleaned

and verified. Although this did limit the area of analysis in Brisbane, and may misrepresent access to green space across that city, it is worth noting that, with a population in excess of 1 million residents, the Brisbane City Council encompasses a large proportion of the Brisbane metropolitan area and is the most populous LGA in Australia (more than twice the size of the next most populous LGA). Newer datasets are now available with whole-of-state coverage for public open space in Queensland, which will allow additional analysis to be undertaken in the future [95].

4.3.4 Defining study periods

Because our analyses were done before the release of all the relevant ABS 2016 Census data, for most urban liveability domains we used data from the 2011 Census. Any exceptions to this are noted in the relevant urban liveability domain section later in this report. However, now that the methods have been developed and the analyses undertaken, analyses with more up-to-date data can be replicated in future.

The policies reviewed were current at the time of analysis, but many had been developed and adopted some years earlier. We were unable to establish which areas of each city were developed under which policies, so we applied analysis uniformly across all cities at a point in time.

4.3.5 Sourcing data

Throughout this study we have attempted to use the best available data to calculate each measure for each capital city. This has required drawing on a wide range of datasets. Datasets specific to each domain are noted in the relevant sections of the report below. Datasets common across multiple domains included data used to:

- define the study areas (discussed in Section 4.3.3 above)
- identify residential addresses within scope (discussed in Section 4.3.2 above)
- calculate distances between origins (residential addresses) and domain-specific destinations
- summarise results at suburb and LGA level.

For both policy implementation and national liveability indicators, distances are typically specified as walking distances. To calculate walking distances, we used the PSMA Travel and Topography dataset. From the street network data, we derived a pedestrian-accessible street network dataset suitable for network analysis by removing non-pedestrian roads such as freeways. We also converted roundabouts to street intersections, to enable consistency when measuring street connectivity. However, data on footpaths and pedestrian links is not readily available nationally and was not used. To summarise results at suburb and LGA level we used the administrative boundaries provided by the ABS. In the case of suburbs, the ABS provides State Suburb Codes (SSCs), an approximation of the official Gazetted Locality.

4.3.6 Computing measures and summarising results

Many of the policy implementation and national liveability indicators assess the proportion of dwellings with access to a type of destination or facility within a specified distance. The benefits of computing measures for these indicators at residential address level are threefold:

1. Accuracy – calculating measures at finest level of detail necessarily produces more accurate results than calculating measures at an aggregate level. Inequities can be revealed not just at neighbourhood level, but down to individual residential address level.
2. Flexible aggregation – each residential address in this study is part of a suburb, an LGA and a city. In providing summary results, averages can be computed directly from individual residential address scores rather than as an average of averages. If averages are needed for other aggregations (such as postcodes or electoral boundaries), these can be quickly calculated from already available results.
3. Linking – many of the national liveability indicators used in this project were derived from research that linked built environment data to individual health-survey participant results. Calculating built environment measures at residential address

level will allow researchers to reduce measurement error in exposure measures, in order to gain the best possible insights from studying the relationship between the built environment and health and health behaviour. At the same time, it allows the data to be aggregated, which is more useful for local and state government policy-makers.

As mentioned above, in this report all results have been summarised at suburb, LGA and metropolitan-wide levels. For residential address-based measures, the metropolitan-wide average is the average for all residential addresses in the study area. For measures based directly on ABS data, the metropolitan-wide average is the average for the Greater Capital City Statistical Area (GCCSA) as reported by the ABS. For a simplified visual representation of this difference, see Figure 39 in Appendix 3.

4.3.7 Mapping results

This report produced a very large number of indicators, of which only a limited number could be included in a written report. Hence, each indicator produced has been uploaded into our prototype online Urban Observatory, where users can navigate to an area of interest and visualise the indicator summarised at suburb level. The Urban Observatory prototype is currently under development; for updates and more information please refer to our project page at http://cur.org.au/project/urban-observatory/.

Maps were produced for selected liveability policies and national liveability indicators using desktop GIS technologies. Policy indicator maps (for example, Figure 4) comprise two map panels; the left-hand panel shows colour shading of the policy measure, while the right-hand panel shows the suburbs that meet the policy-specific threshold. Health-indicator maps (for example, Figure 6) typically comprise eight panels – one for each capital city. In mapping suburb averages, an important consideration was to avoid allowing sparsely populated urban fringe suburbs to visually dominate the map. To alleviate this problem, we have greyed out non-residential Mesh Blocks across the study areas.

4.3.8 Technologies and software

A range of open-source and commercial software was used to process the spatial data and generate the maps. Data were processed using ESRI ArcMap, PostgreSQL and PostGIS, KNIME and Selenium Nodes, and, to a lesser extent, QGIS. Building on work undertaken by the NHMRC Centre of Research Excellence in Healthy Liveable Communities, Python (including ArcPy) was used extensively to automate the production of indicators. Maps were produced in QGIS. The Urban Observatory is based on Leaflet, GeoNode and Boundless Exchange open-source technologies.

4.4. Assessing implementation and comparing cities

Once state-based policy indicators were identified and developed, we assessed the extent to which those policies had been implemented across the relevant cities. Mapping the implementation of policies revealed spatial inequities in the implementation of policy, and provided insights into where across the city policy implementation was optimal (or not).

Nevertheless, assessing state policy implementation precluded direct comparison between Australian cities, because most state policies differ from state to state. To overcome this problem, we developed policy-relevant indicators that our TAPPC and the CRE research found are associated with health-related benefits. All of these indicators were ‘policy-relevant’ because an analysis of urban policies from multiple cities had been undertaken, and their associations with health benefits examined. The policies most strongly associated with better health and wellbeing were selected as our ‘health-related national liveability’ indicators. This approach had three advantages: first, it allowed cities to be directly compared with one another using common metrics; second, it provided insights into policy-relevant indicators identified as promoting health and wellbeing in Australians; and third, it enabled us to identify inequities in the delivery of urban policies likely to promote health and wellbeing. It also reconnected urban planning policies to public health, and to the very origins of city planning.

Walkability

5.1 Selected policy targets and indicators

We reviewed policies in Melbourne, Perth, Brisbane and Sydney to identify walkability-related indicators. The selected state government walkability policy standards are outlined in Appendix 2 - Walkability. Methods used to source data and calculate and map the walkability indicators are described in Appendix 3 - Walkability.

State policy standards for Melbourne, Perth, Brisbane and Sydney all stipulated suburban residential development density targets. However, the policy ambition was very low for most of these cities, with 15 dwellings per hectare being the common target for Melbourne, Sydney and Brisbane. With a policy target of 26 dwellings per hectare, Perth's ambition was more in line with levels of density likely to encourage walking, and to deliver better public transport services [96]. Similarly, Brisbane's 'urban' target was 30 dwellings per hectare. We measured both gross density and net density. The gross density for an area is the number of dwellings in that area, divided by the total area including non-residential land. The net density for an area is the number of dwellings within the residential parts of the area (as defined by ABS Mesh Block classifications) divided by that same residential area. For areas that are entirely residential, the net density will be the same as the gross density. Victoria set a target for the proportion of dwellings that should be within walking distances of neighbourhood centres of activity, and Western Australia also had a policy related to walkable catchments around activity centres: 'most' or a 'substantial majority' of residential dwellings should be within 400 m of a neighbourhood activity centres. Victoria, Western Australia and Queensland also set policy guidelines for the length and width of street blocks, to ensure block sizes that support walkability.

The national liveability indicators (those found to be associated with a health benefit) were broadly aligned with the state-specific policy requirements, but were based on current research findings (where national data were available). Consistent with policy requirements in Victoria and Western Australia, one national liveability walkability indicator included the average distance to an activity centre, defined by a supermarket within a commercial zone. In addition, the national liveability walkability indicators included variables that could be combined to create a 'walkability index'. This included a measure of dwelling density within a walkable distance from each residential address (within 1600 m along the street network) [97]; street connectivity (measured as the number of intersections of three or more streets per km^2 [97]); and access to daily-living destinations – a convenience store (including petrol stations and newsagents), a public transport stop, and a supermarket. The research literature highlights the importance of accessible destinations for encouraging walking [47, 98, 99]. Access to daily-living destinations was included as an alternative to the land-use mix variable commonly used in the academic literature [97]. This is because, despite our best efforts, it was not possible to create a reliable mixed-use variable using nationally available data [89]. A methodological study (as yet unpublished) comparing the mixed-use variable with our daily-living destinations produced comparable walking results. We also found the daily-living destination variable to be associated with public transport and driving variability [100]. Street connectivity, daily-living and dwelling-density variables were combined to create a city-specific composite walkability index that ranked areas in each city from lowest walkability to highest. Because this ranking is a relative measure calculated within each city, it is not appropriate to directly compare the actual walkability scores between cities. However, the ranking does provide an indication of levels of inequity in walkability within each city, and how each city area compares in actual walkability to other areas in that same city.

5.2 Measuring policy implementation: state-based policy-derived indicators

Table 1 summarises the findings for policy-derived walkability indicators and policy implementation across the four capital cities where policy analyses were undertaken. Only Victoria and Western Australia appeared to have specific, spatially measurable policies governing access to destinations: 40% of dwellings in Melbourne were within 1 km of an activity centre anchored by a supermarket, which was below the state policy target of 80%. Notably, however, only 11% of suburbs in Melbourne met the target (80% of dwellings within 1 km of an activity centre). Perth's guidelines require 'most' dwellings to be within 400 m of a secondary or district centre, or within 200 m of a neighbourhood centre, but only 10% of dwellings across Perth's metropolitan area have this level of access.

Only in Perth, Melbourne and Brisbane did we identify measurable spatial policies on street connectivity, but no specific targets. Around 70% of metropolitan Perth residential street blocks had a perimeter of less than 720 m. In Melbourne, 60% of street blocks had a perimeter of less than 720 m. In Brisbane, 43% of street blocks were less than 560 m in perimeter.

Irrespective of whether density is measured as gross or net density, dwelling densities of Australian cities are very low. With suburb averages for gross dwelling density ranging from 5.7 to 12.9 dwellings per hectare, Melbourne, Perth and Brisbane were all well below their respective state targets for suburban density (15–26 dwellings per hectare). Sydney came the closest to meeting its density policy target of 15 dwellings per hectare, with average suburb-level densities ranging from 12.9 to 19.7, depending upon whether gross or net density is measured. Indeed, applying the more lenient net density measure, 37% of Sydney's suburbs achieved that city's policy target of 15 dwellings per hectare, as did 21% of suburbs in Melbourne. Perth had the most ambitious density target for suburban development of all Australian cities, at 26 dwellings per hectare. However, at this stage only 2% of Perth suburbs appear to be achieving this target (perhaps unsurprising as the target is relatively new). Similarly, only 2% of Brisbane suburbs appear to be achieving that city's urban target of 30 dwellings per hectare, while only 13% of suburbs met its suburban target of 15 dwellings per hectare.

The spatial distribution of net dwelling density, based on 2011 Census data, is seen in the upper panels of Figure 2. The lower panels show compliance with state policies, using 15 dwellings per hectare as the cut-off. We can see that Sydney was the only city where high densities extended beyond the inner city, with a larger number of suburbs (particularly south of the city) complying with or exceeding this policy standard. This was followed by Melbourne. Given rapid densification of cities in recent years, this probably under-estimates the densities now seen in these cities, but provides a baseline against which progress can be measured once all ABS 2016 Census data are available.

Table 1: Policy implementation indicators for walkability

City	Policy implementation indicator	Policy target	Metro-level % of all residential addresses	Suburb average	LGA average	Percentage of suburbs that achieved the policy target
Melbourne	% of street blocks with a perimeter of < 720m (i.e. between 120m and 240m long and 60m and 120m wide)	-	64.71	59.00	64.19	-
	% of residential addresses within 1km of an activity centre (i.e. a supermarket)	80-90	39.78	38.73	44.45	11% (n = 403)
	Dwellings per hectare	15	-	7.98 (gross) 12.91 (net)	7.45 (gross) 13.83 (net)	21% (net) (n = 403)
Perth	% of street blocks with a perimeter of < 720m (i.e. <240m long and <120m wide)	-	70.53	64.80	71.01	-
	% of residential addresses within 400m of a secondary or district centre or 200m of a neighbourhood centre	-	9.97	9.72	15.49	-
	Dwellings per hectare	26	-	5.93 (gross) 9.05 (net)	5.36 (gross) 9.71 (net)	2% (net) (n = 298)
	% residential lots by area ≤350m^2	-	2.64	3.03	5.47	-
	>350 - ≤550m^2	-	10.76	10.59	14.31	-
	>550 - ≤750m^2	-	41.59	33.54	30.96	-
	>750 - ≤950m^2	-	25.13	21.49	22.25	-
	>950 m^2	-	19.88	31.34	27.00	-
Brisbane	% of street blocks with a perimeter of < 560m (i.e. between 100m and 200m long and 40m and 80m wide)	-	43.34	38.51	40.55	-
	Dwellings per hectare	15 (suburban) 30 (urban)	-	5.71 (gross) 9.16 (net)	1.32 (gross) 4.61 (net)	13% > 15 (net) 2% > 30 (net) (n = 337)
Sydney	Dwellings per hectare	15	-	12.94 (gross) 19.67 (net)	11.23 (gross) 18.53 (net)	37% (net) (n = 562)

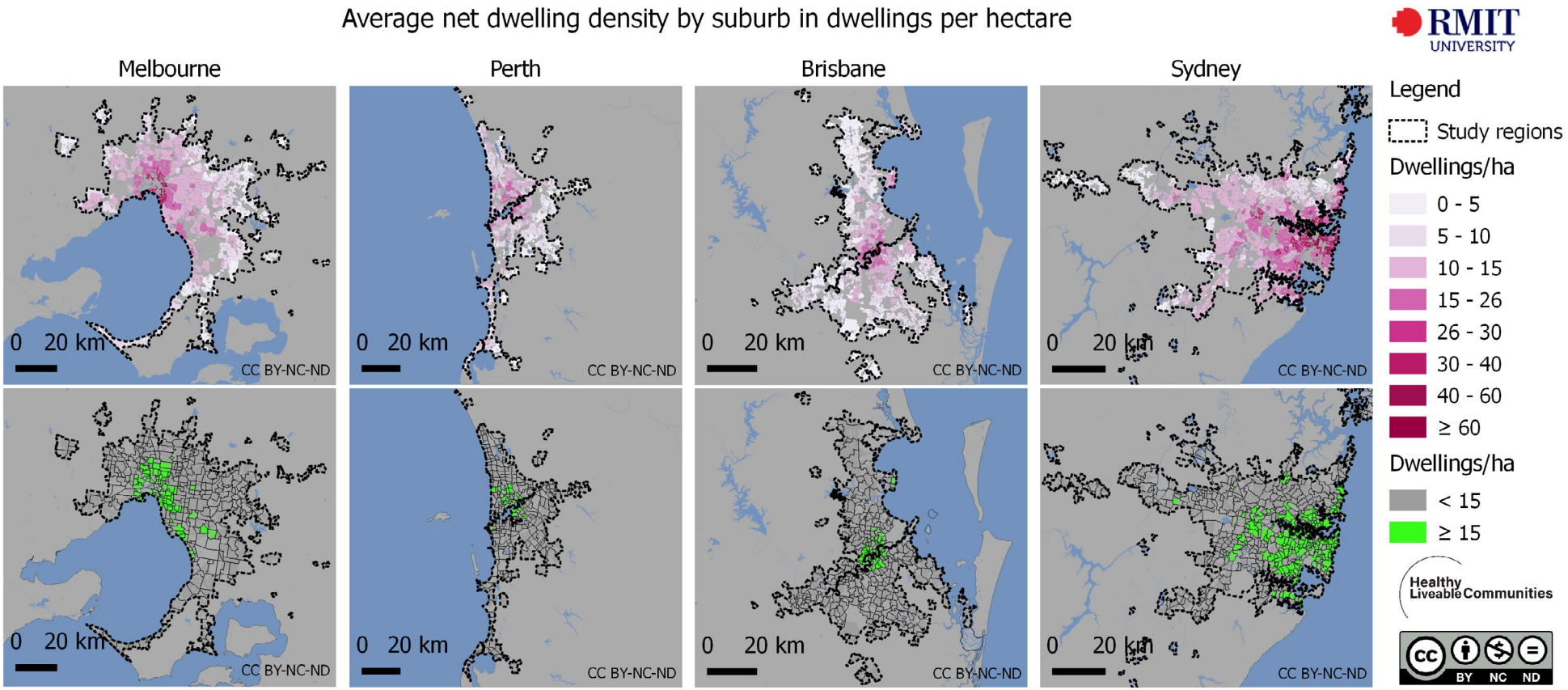


Figure 2: Average net dwelling density (by suburb) in dwellings per hectare (top); and suburbs achieving this level of implementation of this policy (bottom)

Figure 3 shows the net dwellings per hectare by LGA. Melbourne, Brisbane and Sydney's density target is very modest at 15 dwellings/hectare. When net density is considered, Sydney is the only city achieving even this modest level of dwelling density target on average across its LGAs. Few LGAs in Melbourne and none in Brisbane are achieving this very modest target. Perth has a suitably ambitious target for suburban development at 26 dwellings per hectare: yet has some way to go before achieving this target. Based on 2011, Census data, Figure 3 shows that only one Perth LGA is achieving this target.

Figure 4 shows the percentage of Melbourne residences that are within 1 km of an

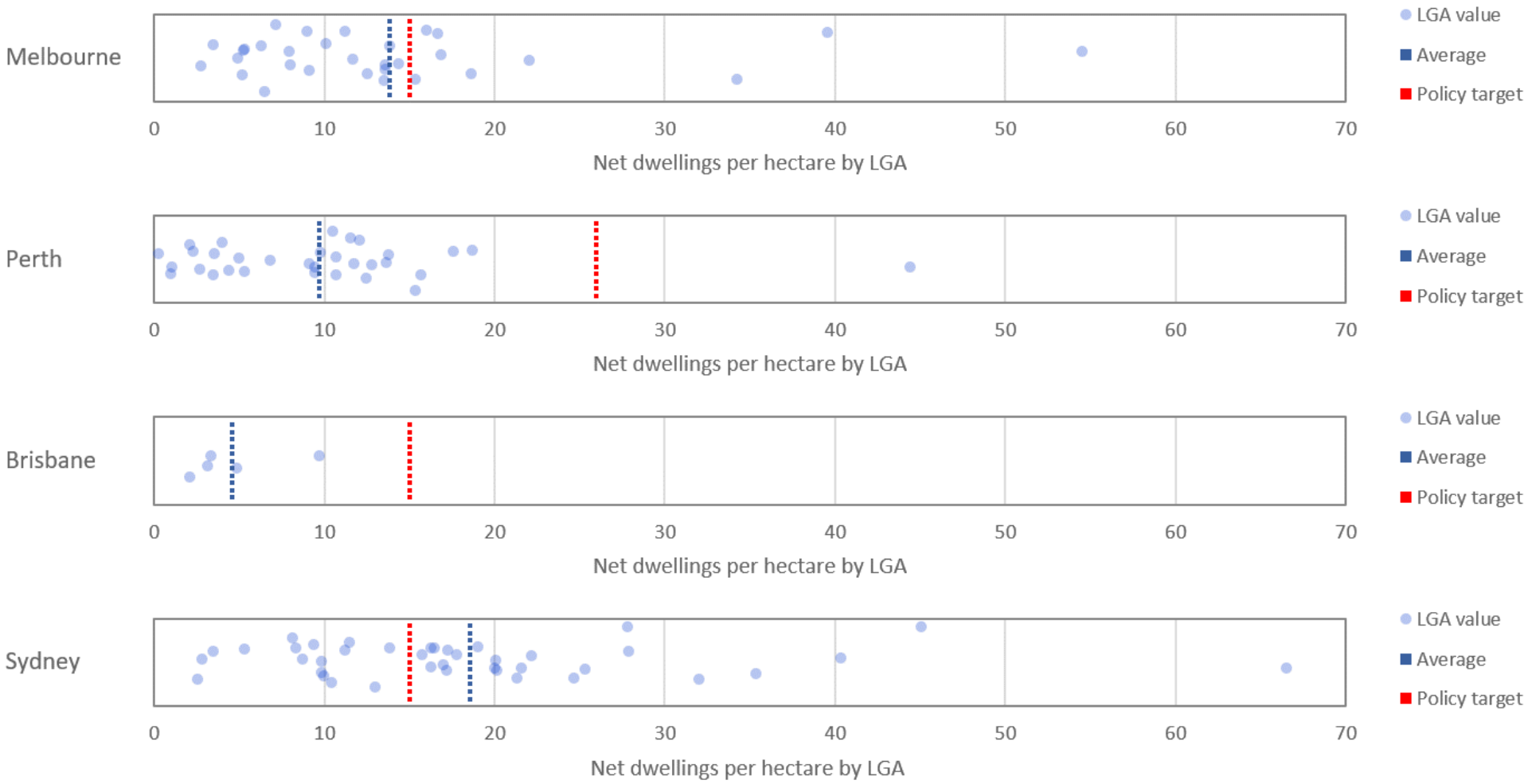


Figure 3: Net dwellings per hectare by LGA and city

activity centre with a supermarket. The suburb average for Melbourne was 39%. Indeed, as can be seen in the right-hand panel, very few suburbs met the state government's target of 80% of dwellings within 1 km of an activity centre. Most that did were in the inner city or inner-north. In Melbourne, the LGA average of dwellings within 1 km of an activity centre with a supermarket was 44%. This is shown graphically in Figure 5. Indeed, only three LGAs met the state target.

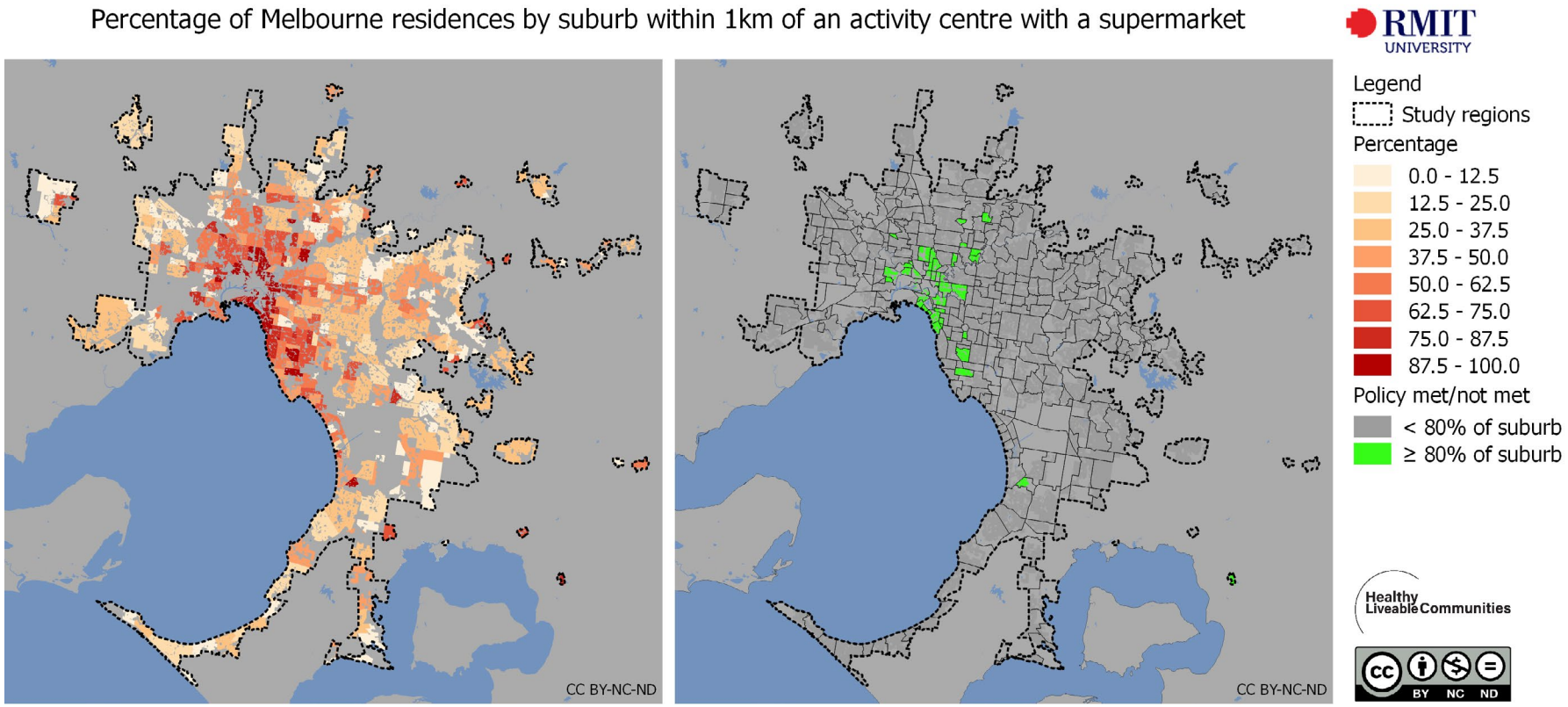


Figure 4: Melbourne: percentage of residences (by suburb) within 1 km of an activity centre with a supermarket (left); number of suburbs complying with the policy (right)

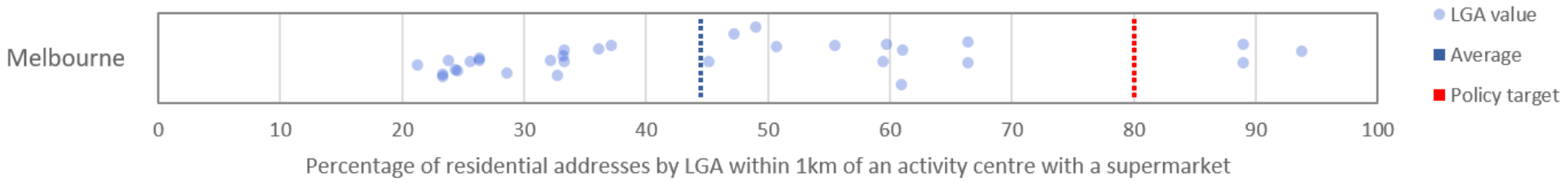


Figure 5: Melbourne: percentage of residential addresses (by LGA) within 1 km of an activity centre with a supermarket

5.3 National liveability indicators

The state-based policy walkability indicators are useful for assessing the level of policy implementation in cities, while the national liveability walkability indicators allow comparisons between cities. As can be seen in Table 2, residential dwellings in Adelaide, Sydney and Canberra had the shortest distances to the closest activity centre anchored by a supermarket (1256–1295 m) at the metropolitan, suburb and LGA average level. On average, residents of Darwin, Hobart and Perth travel further to reach an activity centre (1482–2039 m).

Pedsheds are a measure of street connectivity, representing the ratio of the 'as the crow flies' buffer to the street network buffer. The higher the pedshed, the more connected the street networks. Pedsheds of at least 60% are required around major destinations to create pedestrian-friendly neighbourhoods. The average pedshed at the SA1 level across all cities ranged from 36.9% in Darwin to 43.9% in Hobart. Adelaide, Sydney and Melbourne also had pedsheds just over 40%.

Three variables were measured at the neighbourhood scale (1600 m from residential dwellings), and later combined to create a walkability index. The first is street connectivity measured as the number of intersections with three or more legs in a given area. Using this measure Canberra and Sydney scored highest on street connectivity at the metropolitan level, and for the suburb and LGA average. Darwin was the city with the lowest level of street connectivity.

The next variable is dwelling density at the local neighbourhood scale: metro-level averages varied from 17.8 dwellings per hectare in Sydney and 14.1 per hectare in Melbourne, to 8.3 per hectare in Hobart.

The final measure was daily-living destinations. Across metropolitan areas, on average dwellings in most cities had two or more daily-living destination types within 1600 m. Perth had the smallest average number of daily-living destinations within 1600 m of homes (1.99), followed by Darwin.

At the neighbourhood scale, residences in Sydney, Melbourne and Adelaide had access to slightly more daily-living destinations (2.59–2.66), with Perth having fewer than other cities (1.99). The results suggest that Melbourne, Sydney and Adelaide are the most walkable cities in Australia, because these cities on average had higher levels of street connectivity, dwelling densities and daily-living destinations than other cities.

Table 2: National liveability indicators for walkability

Indicator	Scale	City							
		Melbourne	***Perth***	***Brisbane***	***Sydney***	***Adelaide***	***Canberra***	***Darwin***	***Hobart***
Average distance to closest activity centre, where activity centre is defined as a supermarket within a commercial zone	Metro-level[1]	1331.91 m	1498.82 m	1481.57 m	1285.45 m	1256.10 m	1295.33 m	2038.95 m	1548.66 m
	Suburb average[2]	1561.42 m	1751.29 m	1839.80 m	1384.80 m	1333.17 m	1464.63 m	2561.50 m	1888.91 m
	LGA average[3]	1249.26 m	1473.17 m	1634.03 m	1298.21 m	1191.97 m	1295.33 m	3595.02 m	1680.82 m
Average pedshed ratio, defined as the buffered area of the 400m street network distance from each residential address divided by the radial "crow flies" area within 400 m; i.e. 50.2 ha.	SA1 average[4]	41.91	39.28	38.43	42.32	43.23	37.13	36.86	43.92

Average number of daily living types present, measured as a score of 0-3, with 1 point for each category of (convenience store/petrol station/newsagent, PT stop, supermarket) within 1600m network distance	Metro-level[1]	2.59	1.99	2.43	2.66	2.66	2.46	2.10	2.44
	Suburb average[2]	2.49	1.92	2.24	2.60	2.61	2.47	1.95	2.20
	LGA average[3]	2.64	2.12	2.26	2.68	2.69	2.46	1.69	2.27
Street connectivity, measured as 3+ leg intersection count/area in km^2, where the area is computed from the 1600m pedestrian-accessible street network buffered by 50m	Metro-level[1]	0.70	0.73	0.68	0.82	0.78	1.10	0.51	0.71
	Suburb average[2]	0.66	0.69	0.63	0.84	0.74	1.09	0.47	0.63
	LGA average[3]	0.74	0.73	0.64	0.86	0.78	1.10	0.35	0.65
Dwelling density, calculated as the aggregate sum of dwellings recorded in the Mesh Block polygons intersecting the 1600m pedestrian-accessible street network once buffered by 50m ("neighbourhood") and divided by the "neighbourhood" area in hectares.	Metro-level[1]	14.13	11.91	12.55	17.83	12.57	10.48	10.61	8.33
	Suburb average[2]	13.43	11.24	11.62	18.65	12.35	10.25	9.64	6.95
	LGA average[3]	15.36	12.34	11.00	20.29	12.84	10.48	6.81	7.24

[1] The average connectivity score for ALL residential cadastre within the metropolitan region of the city; [2] The average connectivity residential cadastre within each suburb; [3] The average connectivity residential cadastre within each local government authority

Figure 6 shows spatial distribution of the 'walkability' indicator, a composite index combining dwelling density, daily-living destinations and street connectivity. As can be seen, walkability is spatially patterned: few residents in outer-suburban areas enjoy the benefits of a walkable neighbourhood. With few exceptions, higher levels of walkability in each capital city are concentrated in the inner and (in some cases) middle-level suburbs. Notably, in outer-suburban Perth, there are areas that appear to be highly walkable. This is likely to reflect the trial of the Western Australian government's Liveable Neighbourhood subdivision code [101], which began in 1997, and includes a policy to increase densities in outer-suburban areas. This result shows that, with well-designed and well-implemented policy, it is possible to create more walkable neighbourhoods, even in outer-suburban areas of Australian cities. Canberra also appears to have some highly walkable areas in more established outer-suburban areas, possibly reflecting the fact that these older neighbourhoods were designed to include local neighbourhood activity centres.

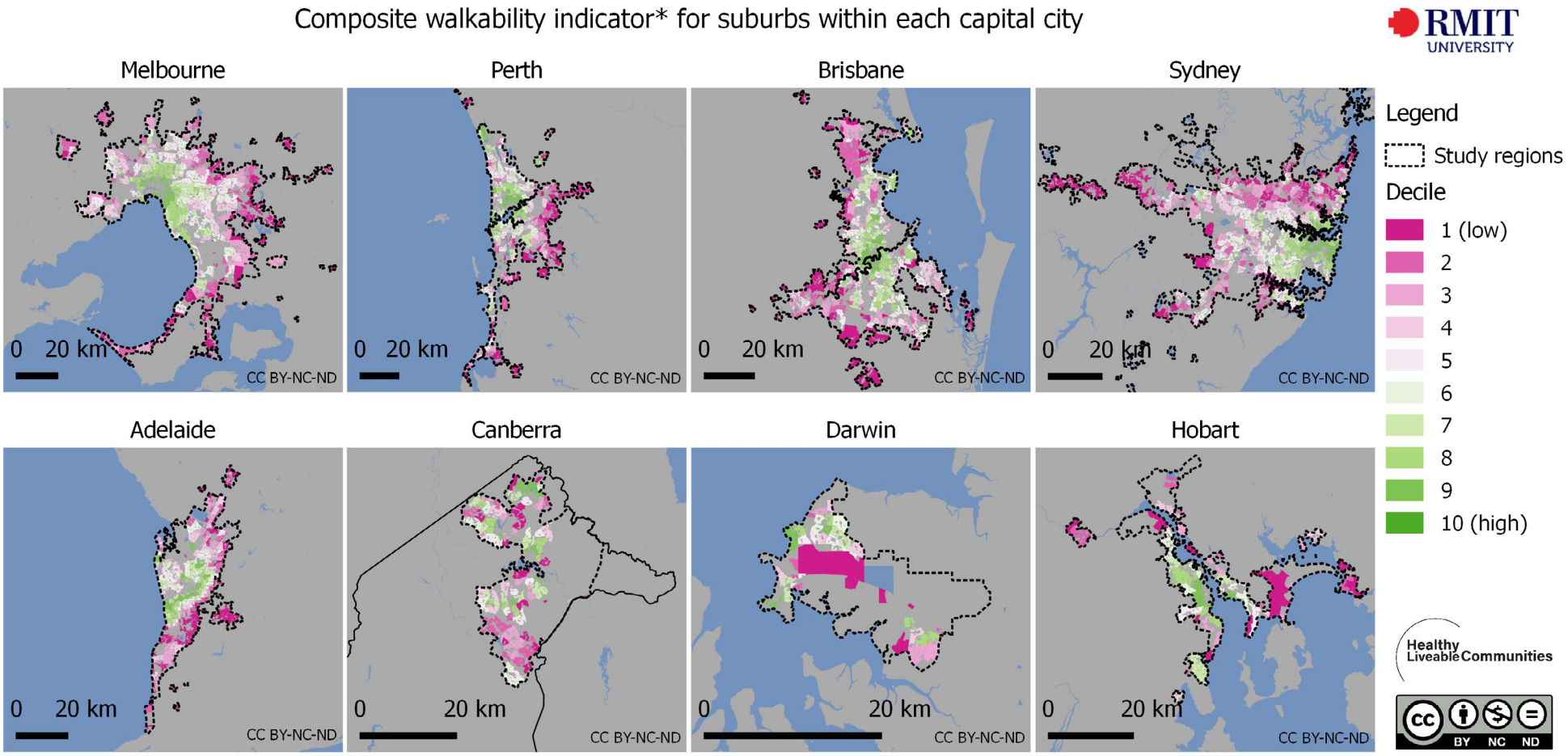


Figure 6: Composite walkability indicator for suburbs within each capital city

Public Transport

6.1 Selected policy targets and indicators

Policies in Perth, Melbourne, Brisbane and Sydney were reviewed to identify policies and targets for public transport for which spatial indicators could be created. The selected state government public transport targets are outlined in Table 3. Further details of the source of policy measures are given in Appendix 2 – Public Transport. Methods used to source data and calculate and map the public transport indicators are in Appendix 3 – Public Transport.

All public transport policy targets identified aimed to ensure that a significant proportion of (or all) residences have access to public transport within walking distance of their home, with shorter distance requirements for bus stops (400 m) and tram stops (600 m) than for train stations (800 m). However, the policy ambition for the proportion of residences with nearby access varied markedly between states. For example, the Western Australian policy aimed to provide only 60% of Perth residences with access to public transport, whereas in Brisbane the target was 90% of residences, in Melbourne 95%, and Sydney 100%.

Unlike the other states, New South Wales has particularly ambitious public transport policy and desirable targets, with policies requiring residents to have access to public transport stops served at particular frequencies. As noted in Appendix 1 – New South Wales, the Integrated Public Transport Service Planning Guidelines [102, 103] contain very detailed requirements for service frequencies by tier and time-of-day but these could not be mapped using publicly available data. Therefore, the policy standard from the 2001 Integrated Transport and Land Use Guidelines (still available at the time of analysis) was selected for inclusion [104]. This guideline more simply states that households should be within walking distances to bus stops that are serviced every 30 minutes and train stations serviced every 15 minutes. Notably, the Australian National Liveability Study found that a combined measure of public transport access and frequency was a stronger predictor of walking for transport than was a measure of access alone [32]. Hence, the national liveability public transport indicator (Table 4) is defined as the percentage of residential dwellings within 400 m walking distance of a public transport stop that has a service at least every 30 minutes on a normal weekday.

6.2 Measuring policy implementation: state-based policy-derived indicators

Table 3 summarises the findings for public transport policy-derived indicators across the four state capital cities where policy analyses were undertaken. Overall, 70% of dwellings in Melbourne had access to a public transport stop in accordance with Victoria's policy target. Just over 60% of dwellings in Perth and Brisbane met their respective states' 400 m targets. However, only 38% of residential dwellings in metropolitan Sydney achieved the New South Wales government's more ambitious access and frequency targets.

At the metropolitan level, Perth appeared to do better than other Australian cities at meeting its public transport access policy targets. However, Perth's policy ambition is significantly lower than those of other cities, at only 60%. Overall, approximately 64% of all residential addresses across metropolitan Perth and Peel were within a 400 m walk of a bus stop, or 800 m from a train station, exceeding the state government's target of 60%. Almost 70% of residential dwellings in metropolitan Melbourne are within 400 m of a bus stop, 600 m of a tram stop or 800 m of a train station, but this fell short of the state's more ambitious target of 95% (Table 3). Similarly, 61.4% of dwellings in Brisbane were within 400 m of a public transport stop, but this also fell short of its ambitious target of 90%.

The most ambitious target for public transport access was that of New South Wales, because it incorporated both proximity and frequency of service. Only 37.8% of residential

dwellings across metropolitan Sydney achieved the New South Wales state government's comprehensive public transport indicator, significantly short of its target of giving 100% of dwellings access to this level of service. Analysis at the suburb level highlights significant inequities in the provision of public transport in metropolitan regions. In general, there is a pattern of better access to public transport in the inner cities (see Figure 7 through Figure 10), within declining access in outer-suburban areas.

Although Perth met its policy target at a metropolitan level, only 54% of Perth's suburbs overall did so (Table 3). As shown in Figure 7, residents in Perth's outer north and outer east have the lowest level of access to public transport in that city. Fewer suburbs in the states that set more ambitious targets than Perth met their state's policy targets. For example, in Melbourne, only 14% of suburbs met the policy target of 95% of dwellings having proximate access, and these are mostly clustered in the inner city (Table 3 and Figure 8). Similarly, in Brisbane only 13% of suburbs met the state policy target of 90% of dwellings having access, and these were mostly clustered around the inner city and central Ipswich districts (Table 3 and Figure 9). Only nine inner-city Sydney suburbs (1.6% of all Sydney's suburbs) met the more stringent target of 100% of dwellings having accessible and frequent bus and train services (see Table 3 and Figure 10).

Table 3: Policy implementation indicators for public transport

City	Policy implementation indicator	Policy target	Metro-level % of all residential addresses	Suburb average	LGA average	Percentage of suburbs that achieved the policy target
Melbourne	% of residential addresses within 400m of a bus stop, 600m of a tram stop or 800m of a train station	95	69.40	67.00	71.99	14.1 (n = 403)
	% of residential addresses within 400m of a bus stop	95	62.93	59.23	63.32	3.5 (n = 403)
	% of residential addresses within 600m of a tram stop	-	12.51	14.31	17.74	-
	% of residential addresses within 800m of a train station	-	11.66	13.06	14.19	-
Perth	% of residential addresses within 400m of a bus stop or 800m of a train station	60	63.80	60.64	71.24	54.1 (n = 307)
Brisbane	% of residential addresses within 400m of a public transport stop	90	61.4	56.82	53.96	12.8 (n = 337)
Sydney	% of residential addresses within 400m of a bus stop serviced every 30 minutes or 800m of a train station serviced every 15 minutes	100	37.76	38.97	45.66	1.6 (n = 562)
	% of residential addresses within 400m of a bus stop serviced every 30 minutes	-	34.61	34.83	42.10	-
	% of residential addresses within 800m of a train station serviced every 15 minutes	-	7.48	9.59	9.11	-

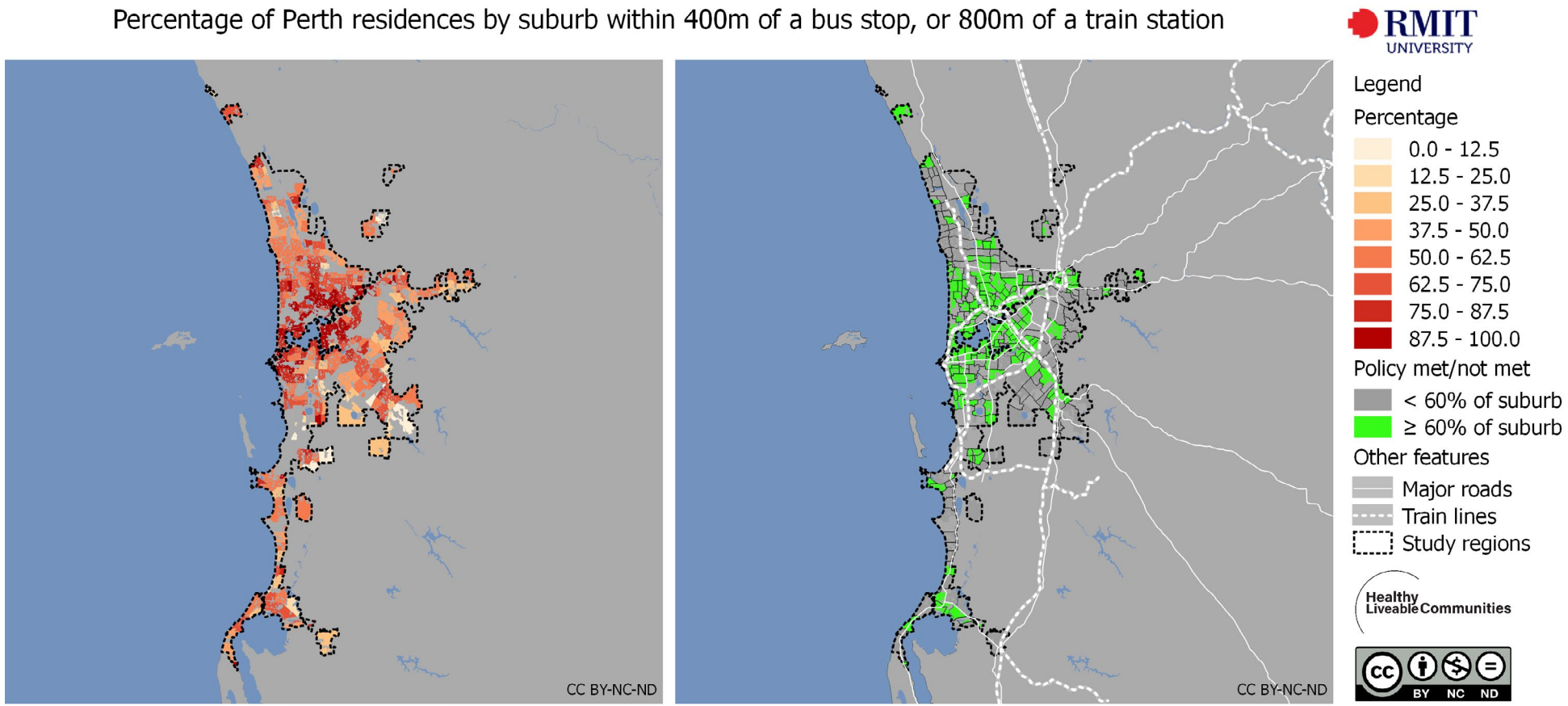


Figure 7: Perth: percentage of residences (by suburb) within 400 m of a bus stop, or 800 m of a railway station (left); suburbs that comply with the state policy (right)

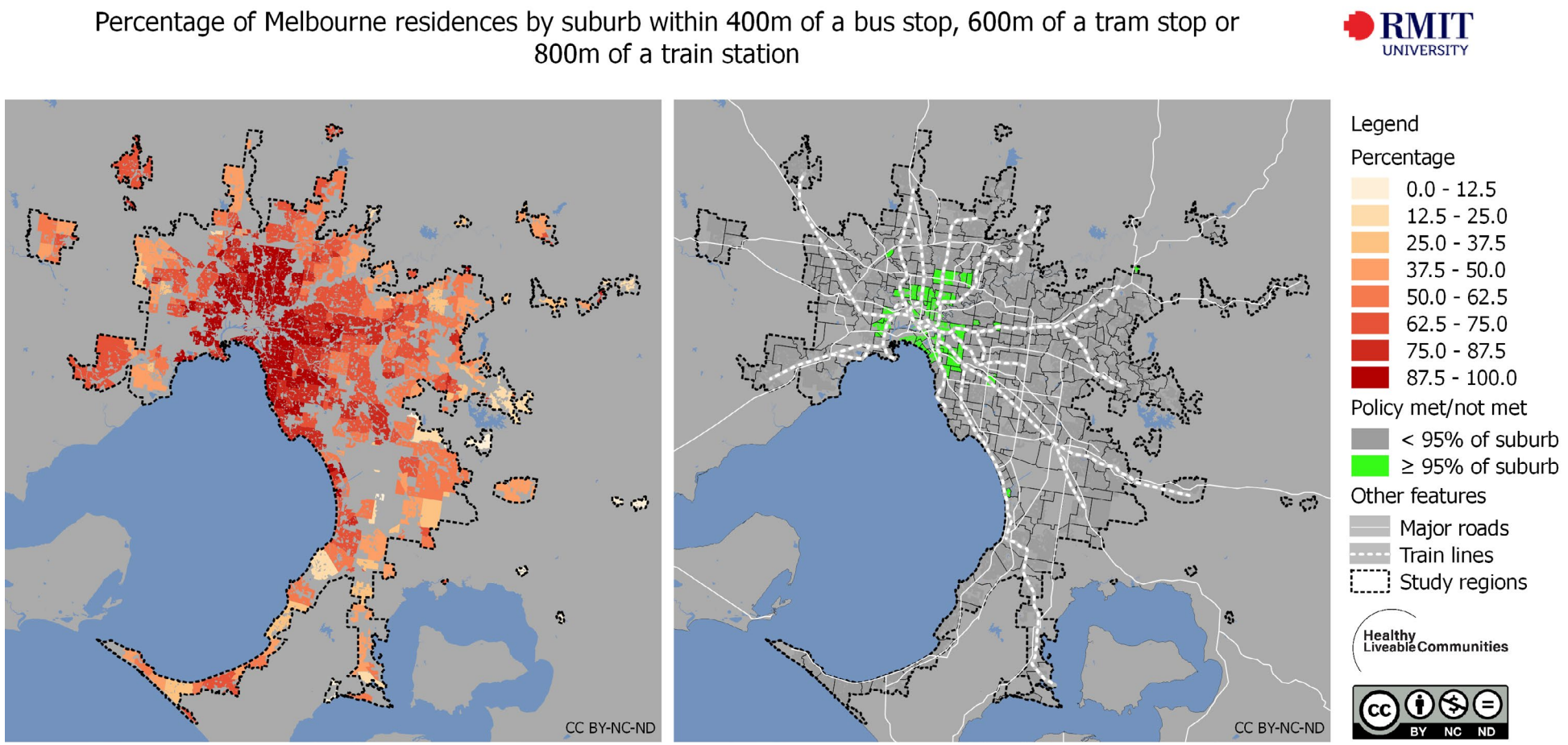


Figure 8: Melbourne: percentage of residences (by suburb) within 400 m of a bus stop, 600 m of a tram stop, or 800 m of a train station (left); suburbs that comply with the state policy (right)

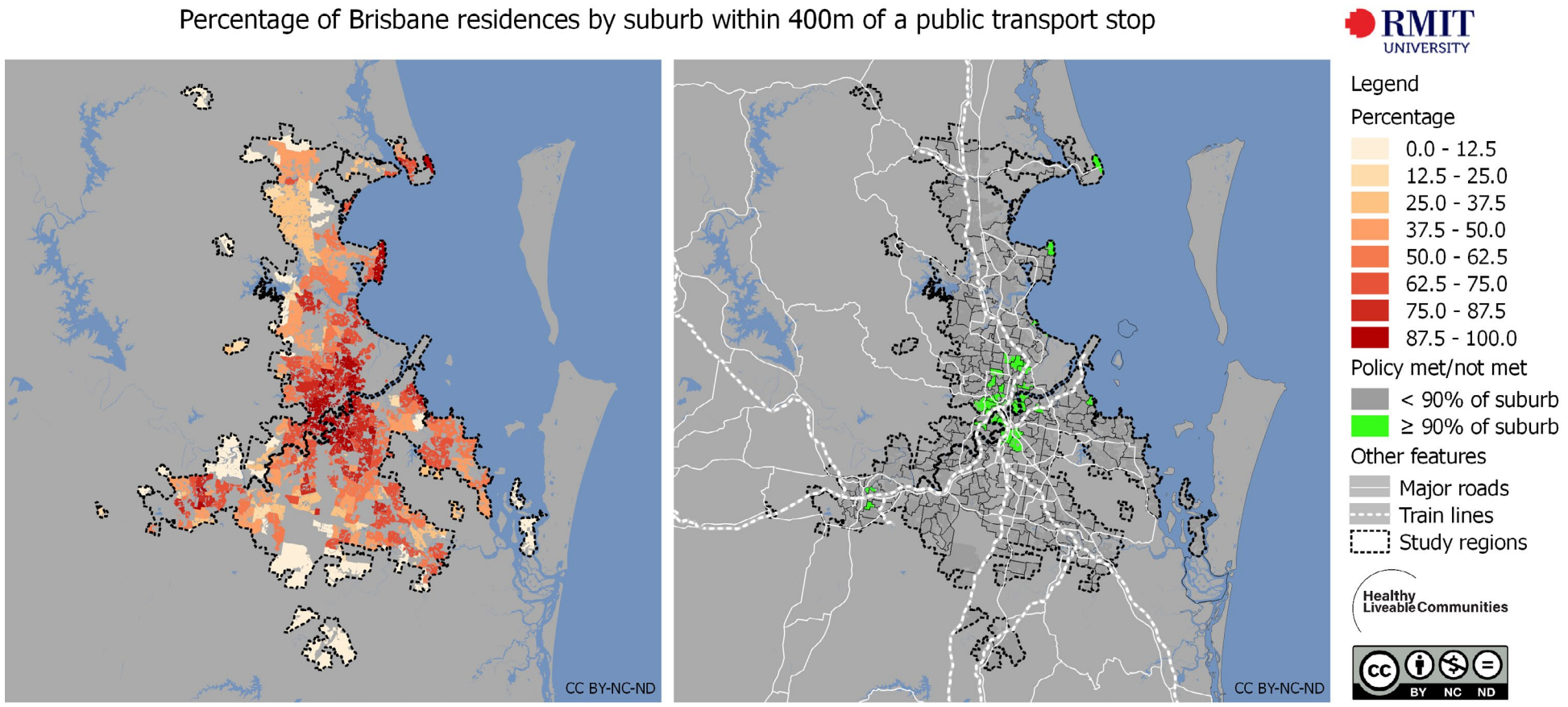


Figure 9: Brisbane: percentage of residences (by suburb) within 400 m of a public transport stop (left); suburbs that comply with the state policy (right)

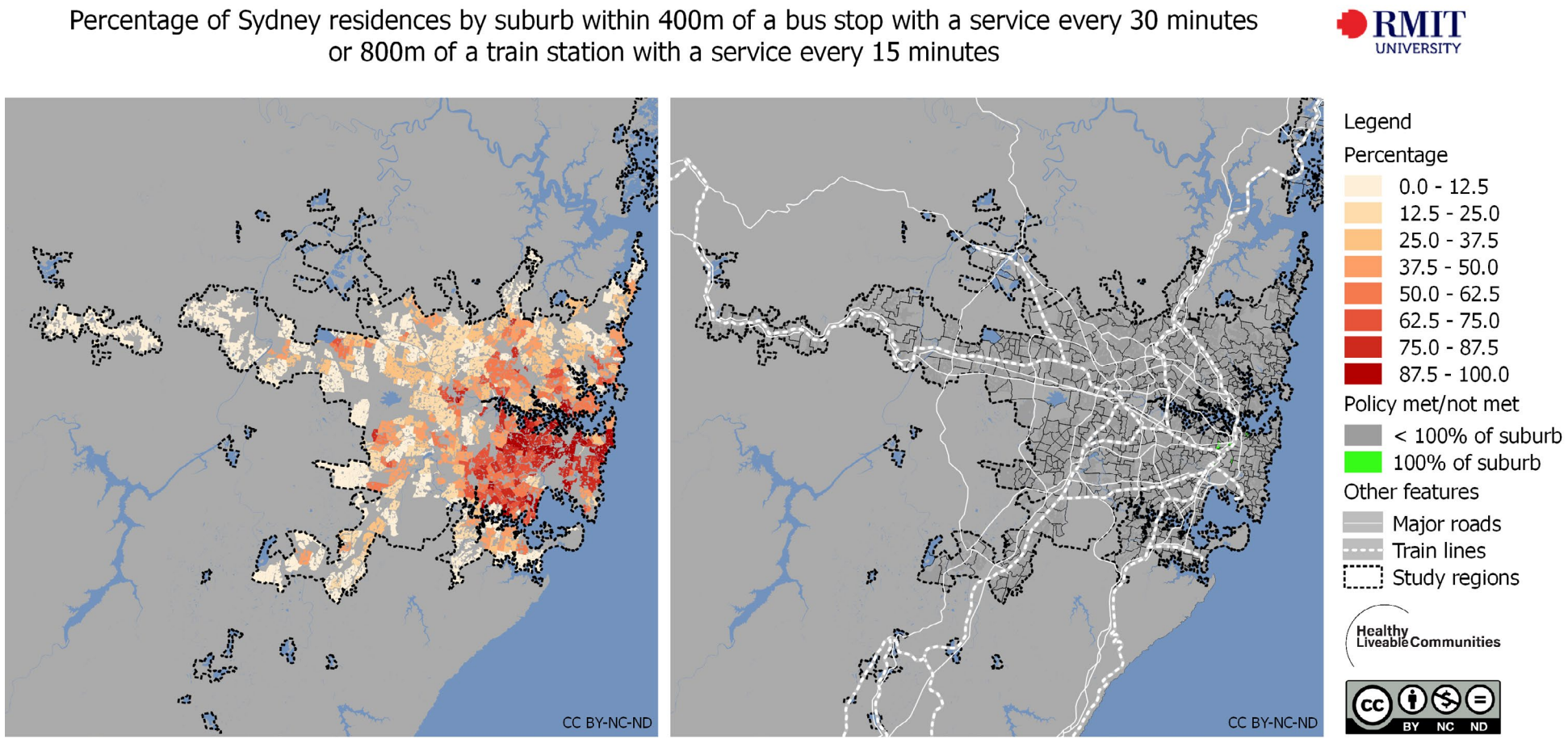


Figure 10: Sydney: percentage of residences (by suburb) within 400 m of a bus stop with a service every 30 minutes or within 800 m of a train station with a service every 15 minutes (left); suburbs that comply with the state policy (right)

Turning to the LGA level, Table 3 and Figure 11 through Figure 15 show the LGA averages for the state-specific policy-derived public transport indicators. These reveal significant variation in the level of public transport access between different LGAs in each city, with the greatest variation observed across Sydney. Similar to the findings at the metropolitan level, LGA averages are below the policy target for all cities assessed, except for Perth, with its significantly lower policy target. Notably, no LGAs in Sydney or Brisbane met the relevant target.

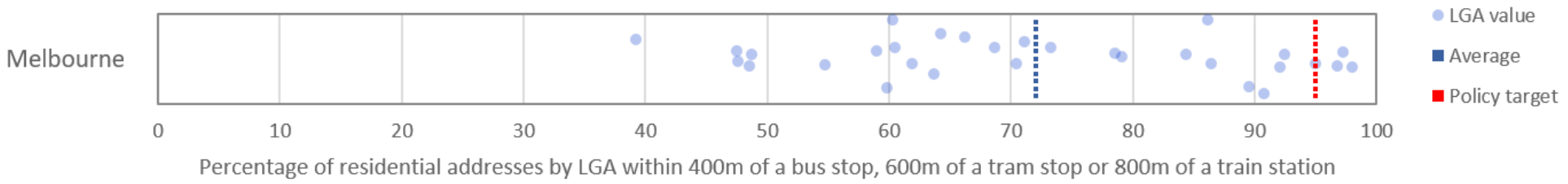


Figure 11: Melbourne: percentage of residential addresses (by LGA) within 400 m of a bus stop, 600 m of a tram stop or 800 m of a train station

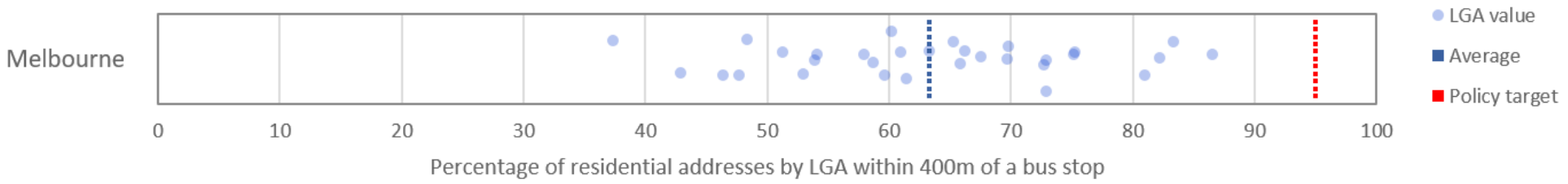


Figure 12: Melbourne: percentage of residential addresses (by LGA) within 400 m of a bus stop

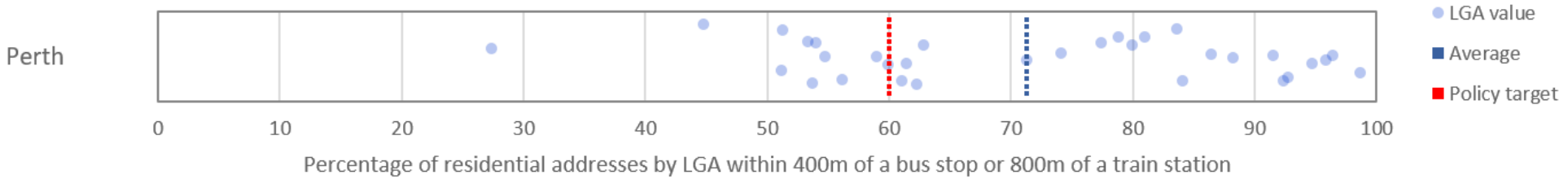


Figure 13: Perth: percentage of residential addresses (by LGA) within 400 m of a bus stop or 800 m of a train station

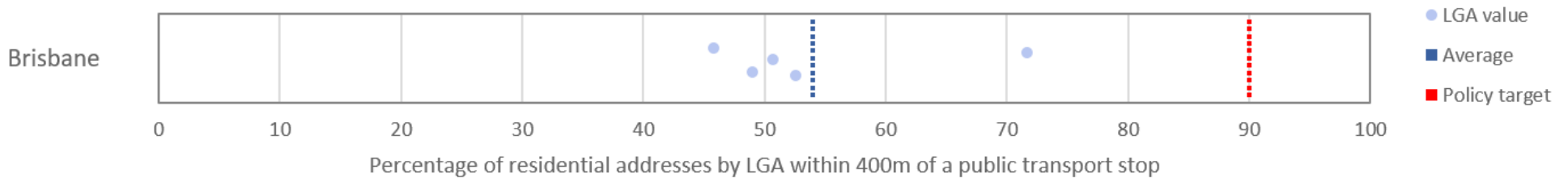


Figure 14: Brisbane: percentage of residential addresses (by LGA) within 400 m of a public transport stop

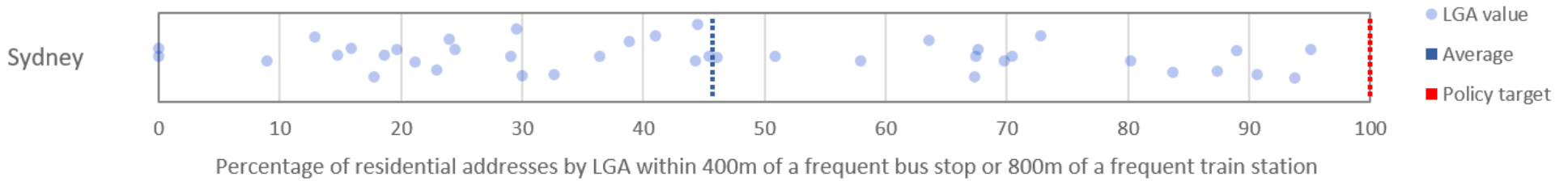


Figure 15: Sydney: percentage of residential addresses (by LGA) within 400 m of a bus stop serviced every 30 minutes or within 800 m of a train station serviced every 15 minutes

6.3 National liveability indicators

While the state-based policy-derived indicators are useful for assessing the level of policy implementation within cities, the national liveability public transport indicator allows comparison between cities, by applying a consistent measure to all cities. Table 4 shows the results for the selected national liveability public transport indicator.

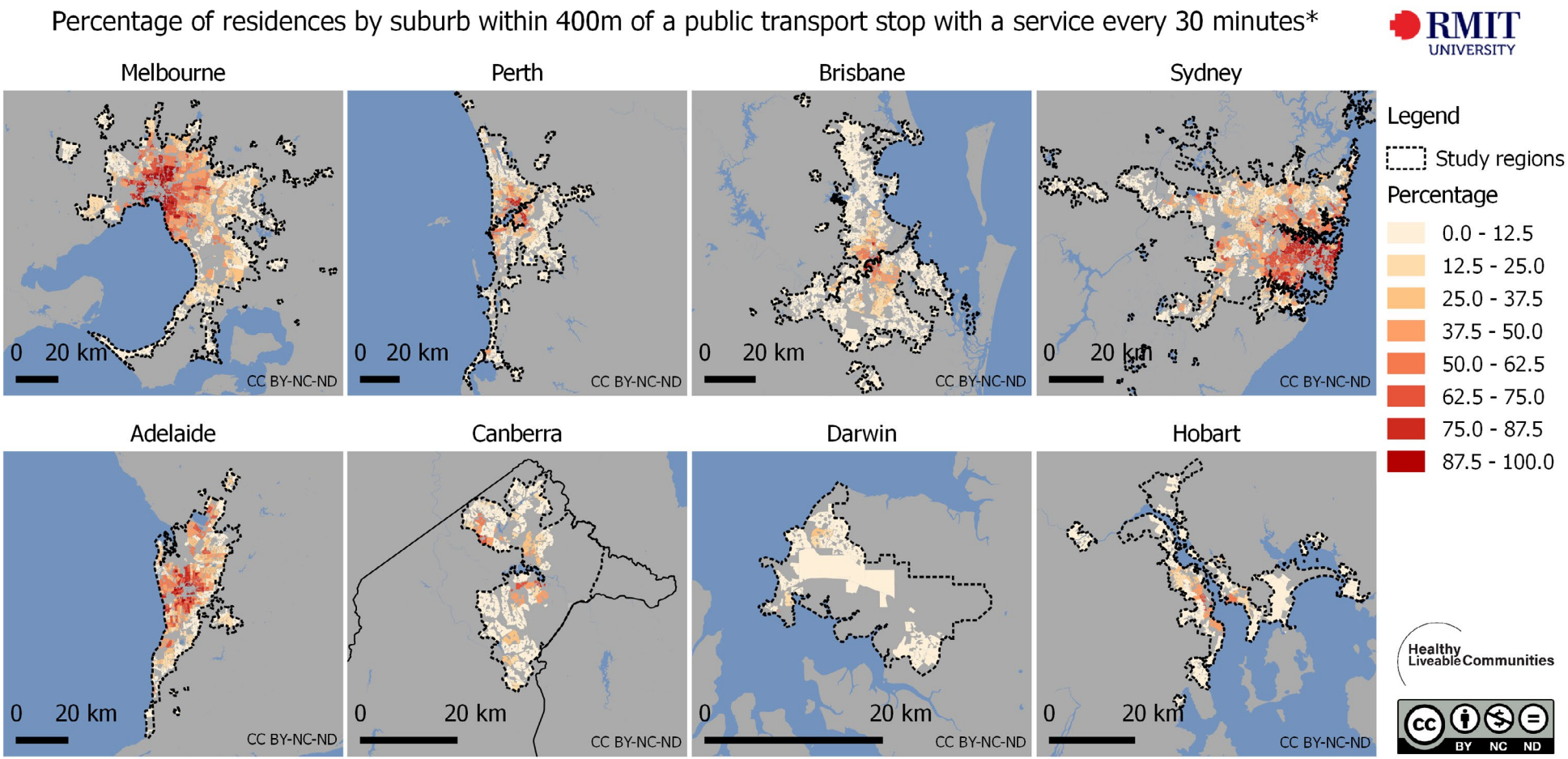
At the metropolitan level, the percentage of residences within 400 m of a public transport stop with a scheduled service at least every 30 minutes between 7 am and 7 pm on a normal weekday varied greatly between cities, from only 4% in Darwin to more than 35% in Melbourne, Adelaide and Sydney. Only 18% of Perth's residential dwellings had this level of access, as did between 11% and 13% in Brisbane, Canberra and Hobart. While residents of some cities face greater public transport access barriers than others, in all Australian state and territory capital cities the vast majority of dwellings do not have access to proximate and frequent public transport services during weekday work hours. The best services are in Adelaide, Melbourne and Sydney. The suburb averages follow a similar pattern to the metropolitan-level results, varying from approximately 4% of residences having access to proximate and frequent public transport in Darwin, to around 36% in Adelaide, Melbourne and Sydney.

Table 4: National liveability indicators for public transport

Indicator	Scale	City							
		Melbourne	***Perth***	***Brisbane***	***Sydney***	***Adelaide***	***Canberra***	***Darwin***	***Hobart***
% of residential dwellings within 400m of a public transport stop with a scheduled service at least every 30 minutes between 7.00am and 7.00pm on a normal weekday	Metro level[1]	36.16	17.90	11.76	35.47	36.48	11.20	4.00	13.00
	Suburb average[2]	35.07	17.60	10.86	36.20	36.32	15.07	3.74	8.11
	LGA average[3]	41.43	25.76	4.43	43.12	42.05	11.20	1.55	7.86

[1] The percentage for all residential addresses within the study area; [2] The average of all suburb-level percentages within the study area; [3] The average of all LGA-level percentages within the study area

Figure 16 shows the geographical variation in access to public transport at the suburb level, using the national liveability public transport indicator that enables comparison between cities. Australia's largest cities (Sydney, Melbourne, Brisbane and Perth) show a clear pattern of better access to proximate and frequent public transport in areas closer to the inner city. Areas to the north of Melbourne's central business district had better access to public transport than did areas to the south. Conversely, in Sydney, areas to the south of the city had better access to proximate frequent services, than did areas to the north. The spatial patterning of public transport access in Adelaide and Hobart was also better closer to the city. Overall, fewer areas in Canberra, Darwin and Hobart had comparable access to public transport, and the spatial patterning was less obvious.



* between 7.00am and 7.00pm on a normal (e.g. non-school holiday) weekday, excluding Fridays

Figure 16: Percentage of residences (by suburb) within 400 m of a public transport stop with a service every 30 minutes

Public Open Space

7.1 Selected policy targets and indicators

Policies in Perth, Melbourne, Brisbane and Sydney were reviewed to identify policies and targets for public open space (POS) for which spatial indicators could be created. The selected state government POS targets are outlined in Table 5. Further details of the source of policy measures are detailed in Appendix 2 – Public Open Space. The methods used to source data and calculate and map the indicators are in Appendix 3 – Public Open Space.

All POS policy targets identified aimed to ensure that a significant proportion of (or all) residents had access to POS within walking distance of their home. In most states, the policies specified shorter distances for access to smaller parks and longer distances for larger parks. However, the policy ambition for the proportion of residences with nearby access varied markedly between states. In Melbourne, the requirement was for 95% of residences to have access within 400 m, and in Brisbane the requirement was for 90%. In both Perth and Sydney policies require 'most' residences to have access: in our analyses we took this to mean more than 50%. Perth also has a relatively new requirement that all residences (100%) have access to POS within 300 m.

In all states other than Western Australia, public open space was referred to in policy documents as 'parks' (see Appendix 2 – Public Open Space). This definition distinguished between green space designed and able to cater for a range of active and passive leisure or recreational activities, and areas of native vegetation [105]. While the latter class of green space is important for biodiversity and for mitigating urban heat-island effects [43], it was not included in our formal definition of public open space. In Western Australia, the terms 'parks' and 'open space' were used interchangeably in policy documents.

With the exception of Victoria, all other states specified POS policies requiring parks of different sizes to be accessible within different walking distances. Notably, all states required POS to be accessible within 400 m, equivalent to a five-minute walk. While Victoria did not specify a size for this POS, Queensland and New South Wales required it to be a park greater than 0.5 hectares (ha), and Western Australia required it to be a park between 0.4 and 1 ha. Parks of larger sizes were also expected to be accessible within walking distance in Perth, Brisbane and Sydney. For example, parks greater than 2 ha were required within 2 km of Sydney residences, and parks greater than 5 ha were required within 2 km of Perth and 2.5 km of Brisbane residences.

As outlined in Table 6, the national liveability indicators (those found to be associated with a health benefit), were broadly similar to the state-specific policy requirements of each state, but were based on current research findings [31, 106]. Consistent with policy requirements in Victoria, one national liveability indicator was access to POS within 400 m. Just as each of the remaining states in which policies were reviewed also stipulated a minimum park size to be accessible within 400 m, a second national liveability indicator was POS greater than 1.5 ha within 400 m. As there was no nationally consistent source of POS data suitable for computing access and size indicators (for further details see Appendix 3 – Public Open Space), we included a national liveability indicator based on ABS data that measured the proportion of each capital city that was parkland.

7.2 Measuring policy implementation: state-based policy-derived indicators

Table 5 summarises the findings of the policy-derived POS implementation indicators for each state capital city. Victoria was the only state that has a proximity to POS standard, without considering its size. Overall, 82% of dwellings across metropolitan Melbourne met the Victorian government's target of being within 400 m of POS, falling a little short of the target of 95%. However, only 48 of Melbourne's 403 suburbs (12%), met the target.

Western Australia, Queensland and New South Wales standards all combined proximity

and size into their standards, with desirable distances varying by the size of the POS. Perth had the most demanding set of standards, ranging from walkable proximities to POS of between 300 m and 2 km. Only three standards were directly comparable between these three states: POS of at least 0.4–0.5 ha within 400 m. When these indicators are compared, 40% of dwellings in Perth and Peel region met this target, and 59% of dwellings in the Sydney metropolitan area. Data were not available for the Brisbane metropolitan area overall, but 65% of dwellings in the City of Brisbane met this target (see LGA average) and 14 of its 173 suburbs (8%). Sydney's level of implementation (59%) was above its state government target of 50%, while Perth's implementation (40%) fell a little short of its target (50%). However, when larger parks were considered, both Perth and Sydney were well above their targets for having larger parks across the metropolitan area: for example, 89% of Perth and Peel region dwellings were within 800 m of a neighbourhood park (between 1 and 5 ha); and 76% within 2 km of a district park (larger than 5 ha), while 98% of Sydney dwellings across the metropolitan area were within 2 km of a park greater than 2 ha. Similarly, 99% of dwellings in the City of Brisbane met the standard of being within 2.5 km of a district recreational park, as did 98% of all residential lots in each suburb on average.

When the other standards were considered, 64% of all residential lots across the Perth and Peel metropolitan area were within 300 m walking distance of any POS – falling short of the very strict 100% target earmarked for inclusion in a revised version of the state's Liveable Neighbourhood design guidelines for new suburban development [107]. This is a new requirement (the previous target being that 10% of land be allocated to POS). Hence, only one out of 298 suburbs in Perth met this strict policy standard. However, on average, 59% of all residences in each suburb, and 63% of all residences in each LGA, were within 300 m of a park. This ranged from 0% (across 17 suburbs) to 100% (for just one suburb). The extent to which this policy achieves good outcomes requires research. For example, there is a trade-off between access to green space and walkability: the one Perth suburb where all residential addresses were within 300 m of POS was in the sixth decile of walkability, which suggests that fewer people would walk for transport. Research is required to explore the optimal level of green space, and whether these new Perth requirements for proximate open space will produce the best results for suburban development. Previous research conducted in Perth found that access to larger, attractive public open spaces encouraged more recreational walking [46, 108], while high-quality parks support better mental health [50]. To this end, almost 90% of dwellings in the Perth and Peel regions were within 800 m of any neighbourhood park (between 1 ha and 5 ha in size), and 76% were within 2 km of a larger district park.

Figure 17 through Figure 22 show the spatial distribution of access to POS using two sets of indicators: the percentage of residential lots within each suburb that have access to: 1) POS within 400 m (with the size (if relevant) specified depending on the state policy); and 2) in Perth and Sydney, access to larger POS as per the specific policy target in each state. Each figure also illustrates the suburbs that meet the respective policy standard. As shown in Figure 17, except for areas in the south-east of the city, more dwellings in outer-suburban Melbourne have access to POS in accordance with the 400 m standard. Brisbane's policy combined proximity and size, with more dwellings in outer areas of the City of Brisbane complying with the policy, than those closer to the city (see Figure 20). There is a mixed pattern of policy compliance across the city, with only a small number of suburbs in outer and inner Brisbane meeting the policy target of 90% of dwellings within 400 m of a park larger than 0.5 ha.

Table 5: Policy implementation indicators for public open space

City	Policy implementation indicator	Policy target (% of dwellings)	Metro-level % of all residential addresses	Suburb average (%)	LGA average (%)	Percentage of suburbs that achieved the policy target
Melbourne	% of residential addresses within 400m of public open space	95	81.8	80.0	81.7	12 (n = 403)
Perth	% of residential addresses within 300m of any public open space	100	64.4	59.1	62.6	< 1 (n = 298)
	% of residential addresses within 400m of any local park > 0.4ha and ≤ 1ha	50	39.7	37.2	38.4	32 (n = 298)
	% of residential addresses within 800m of any neighbourhood park > 1ha and ≤ 5ha	50	89.2	81.0	87.5	88 (n = 298)
	% of residential addresses within 2km of any district park > 5ha and ≤ 20 ha	50	76.2	67.2	70.9	70 (n = 298)
Brisbane	% of residential addresses within 400m of a neighbourhood recreation park > 0.5ha	90	[1]	63.3	65.0[1]	8 (n = 173)
	% of residential addresses within 2.5km of a district recreation park > 5ha	90	[1]	97.8	99.3[1]	55 (n = 173)
Sydney	% of residential addresses within 400m of a park > 0.5ha	50	58.5	60.8	55.8	67 (n = 562)
	% of residential addresses within 2km of a park > 2ha	50	98.4	97.1	98.0	98 (n = 562)

[1] Only a single LGA, Brisbane City Council, was analysed.

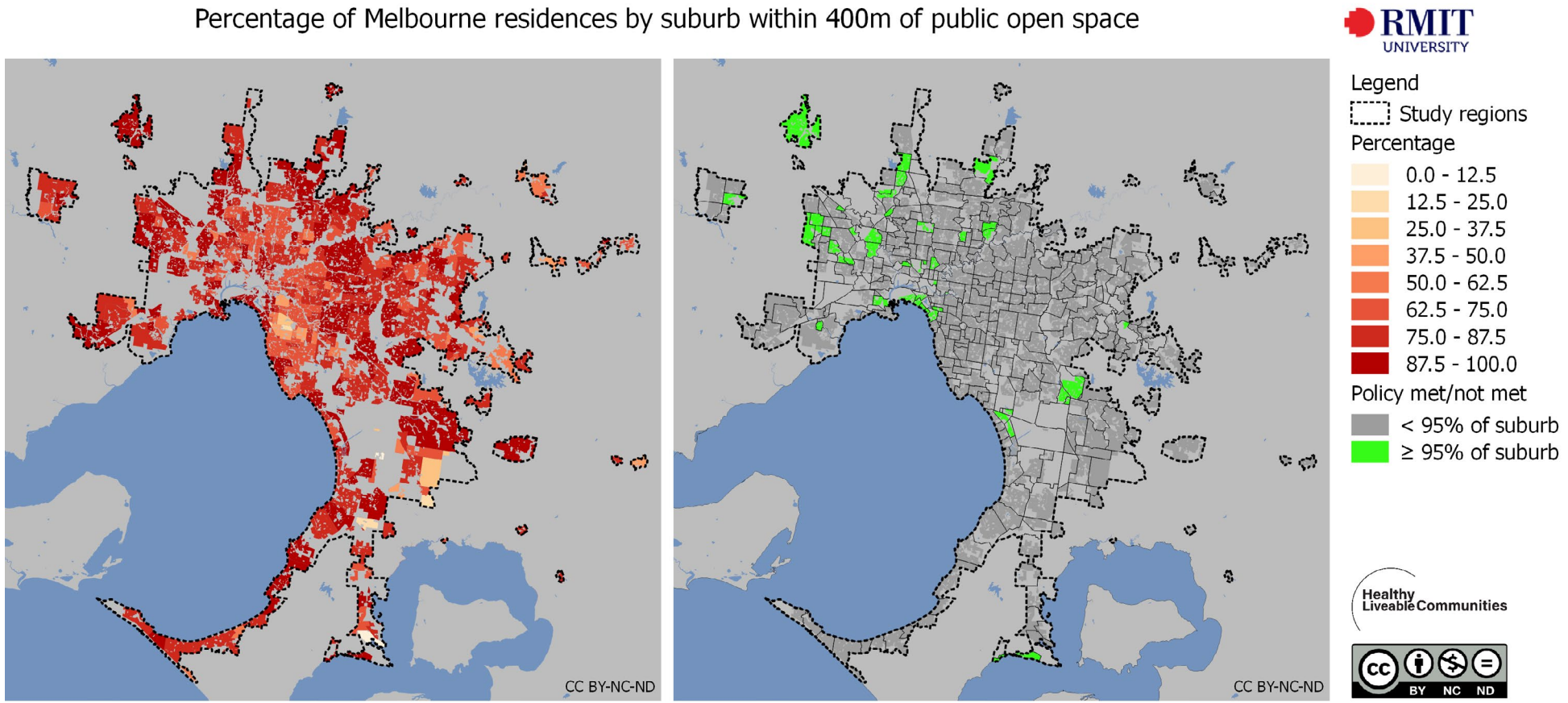


Figure 17: Melbourne: percentage of residences (by suburb) within 400 m of public open space (left); suburbs that comply with the state policy (right)

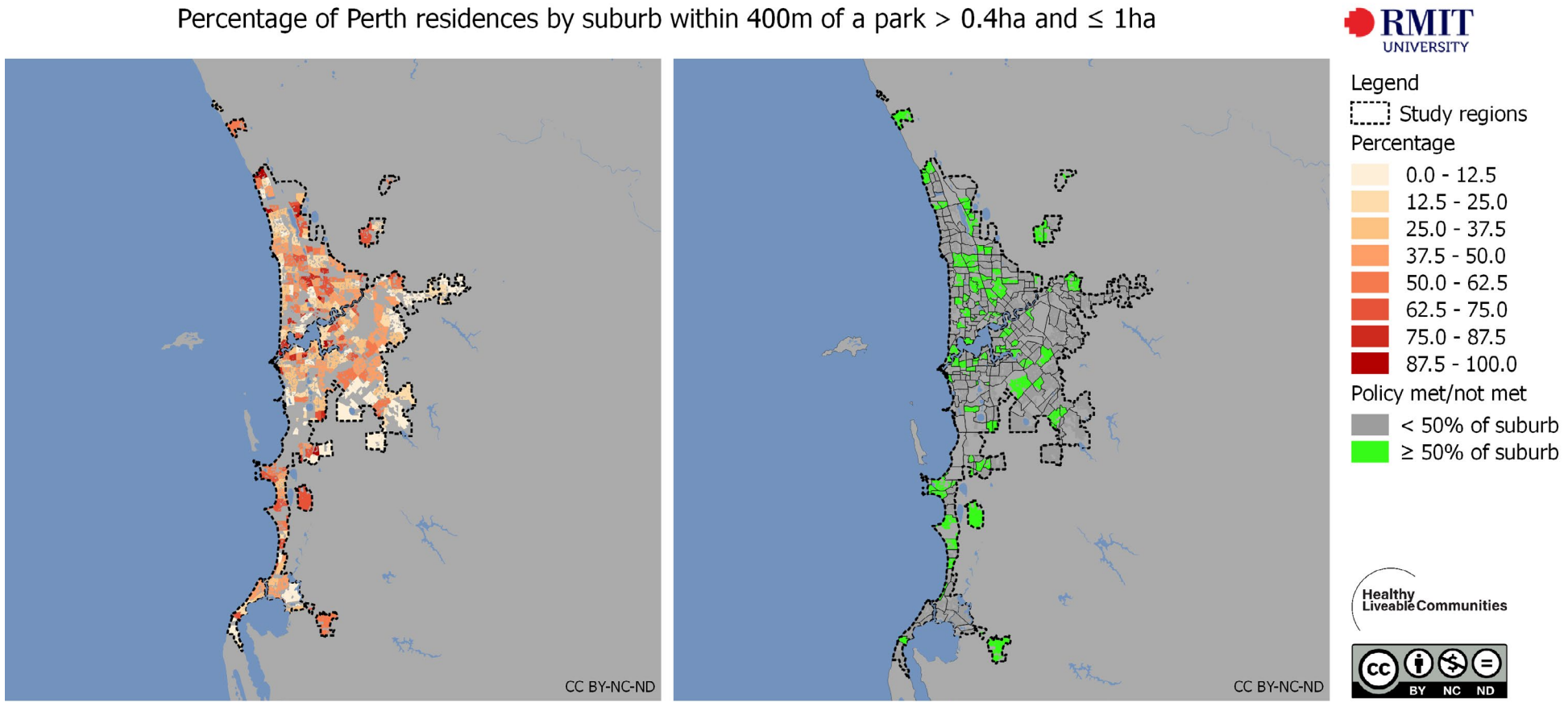


Figure 18: Perth: percentage of residences (by suburb) within 400m of a park 0.4-1.0 ha (left); suburbs that comply with the state policy (right)

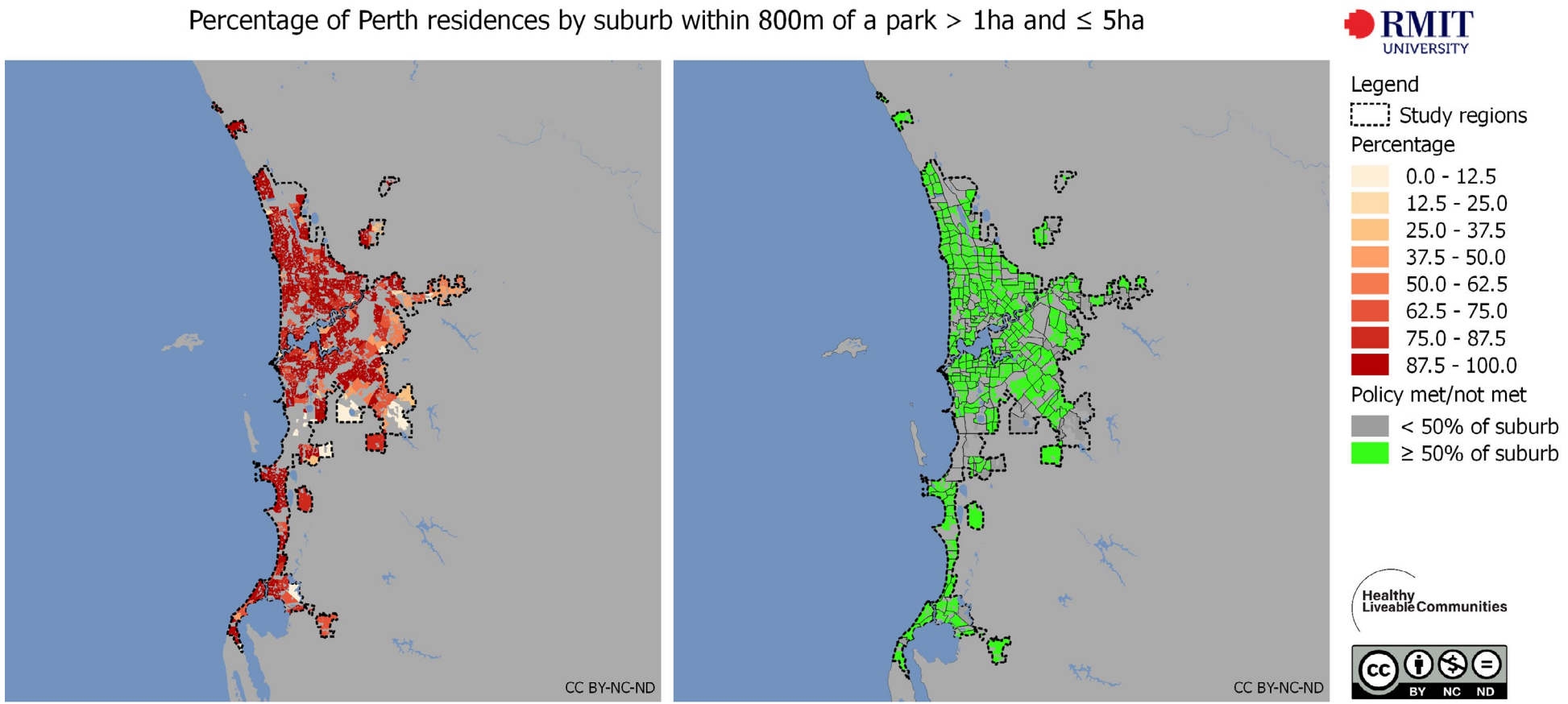


Figure 19: Perth: percentage of residences (by suburb) within 800 m of a park 1–5 ha in size (left); suburbs that comply with the state policy (right)

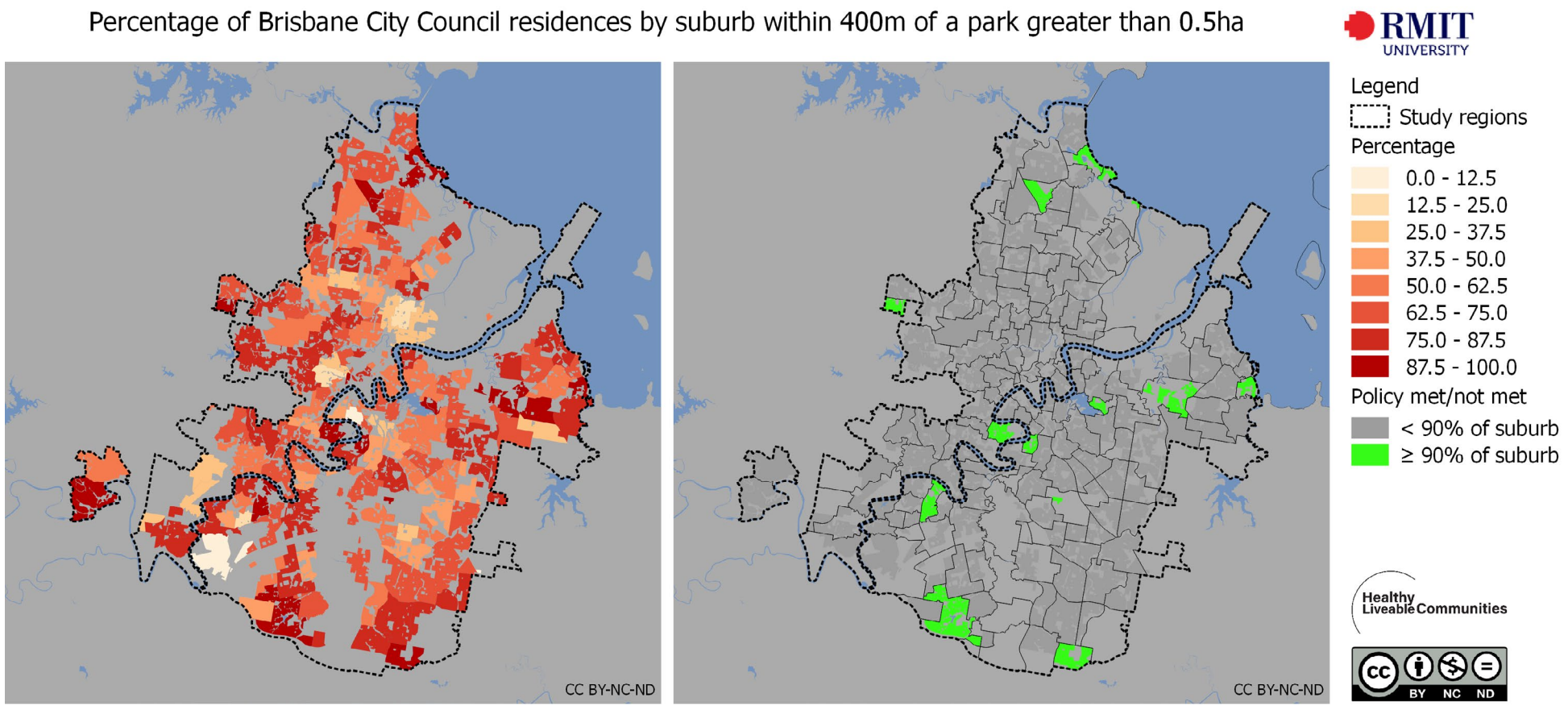


Figure 20: Brisbane City Council: percentage of residences (by suburb) within 400 m of a park larger than 0.5 ha (left); suburbs that comply with the state policy (right)

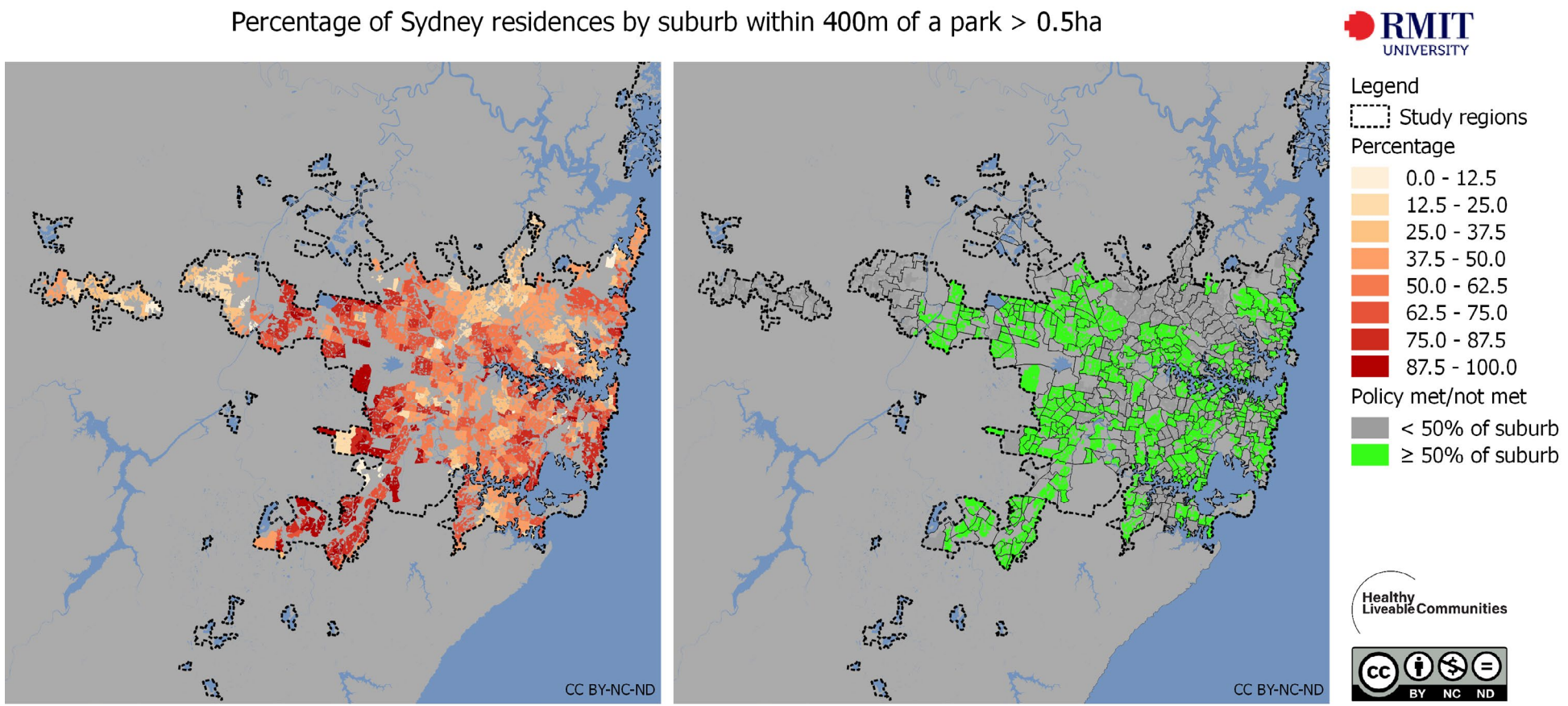


Figure 21: Sydney: percentage of residences (by suburb) within 400 m of a park larger than 0.5 ha (left); suburbs that comply with the state policy (right)

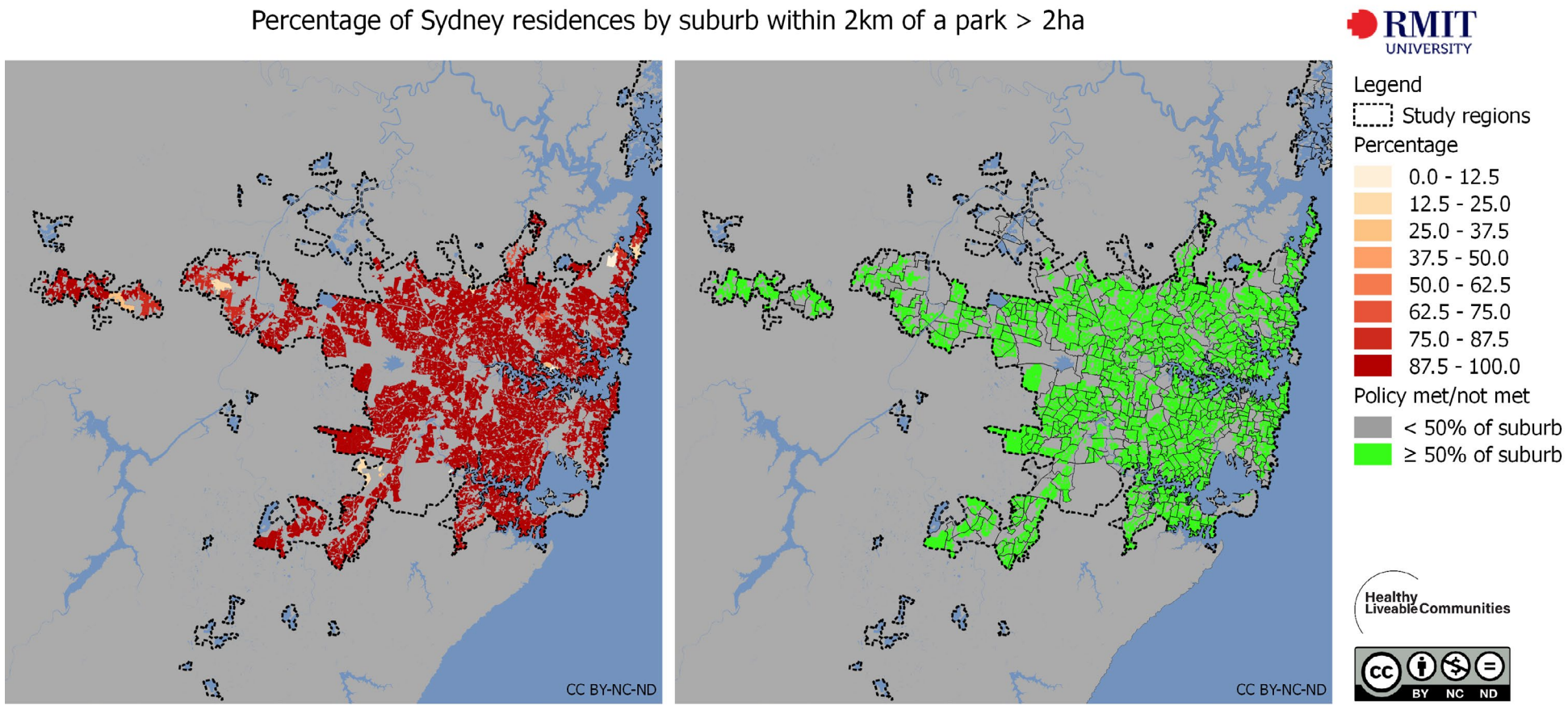


Figure 22: Sydney: percentage of residences (by suburb) within 2 km of a park larger than 2 ha (left); suburbs that comply with the state policy (right)

Figure 23 through Figure 25 show the percentage of residential lots in each LGA with access to open spaces, and how these compared with the state's policy target and average levels of access for all LGAs in the state. These figures exclude compliance in Brisbane, as the POS indicator for Brisbane included only the City of Brisbane (and not other LGAs) because comprehensive POS data were not readily available elsewhere.

As shown in Figure 23, on average 82% of dwellings in the LGAs across Melbourne have access to POS within 400 m, with all but one LGA (less than 60%) having more than 70% of their residential dwellings within 400 m of POS. Figure 24 shows the levels of compliance with the very comprehensive range of policies in Perth. As noted earlier, the Western Australian policies specifying short distance to POS are relatively new, and hence there is a very low level of compliance. (Moreover, the effects of this policy have not yet been assessed.) Notably however, most Perth LGAs comply with policies requiring access to larger neighbourhood and district parks. Only 19% of LGAs comply with the policy that 50% of dwellings have access within 400 m to a local park larger than 0.4 ha. The results for Sydney LGAs appear in Figure 25. As can be seen, a majority (55.8%) of Sydney LGAs comply with the policy that 50% of dwellings are within 400 m of a park larger than 0.5 ha, and all LGAs comply with the policy that there is a park larger than 2 ha within 2 km.

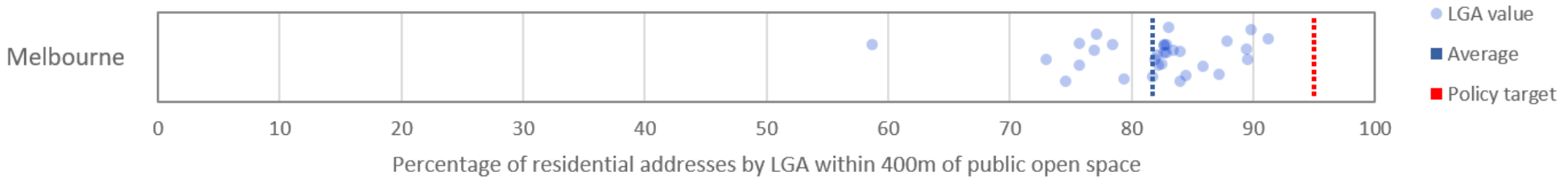


Figure 23: Melbourne: percentage of residential addresses (by LGA) within 400 m of public open space

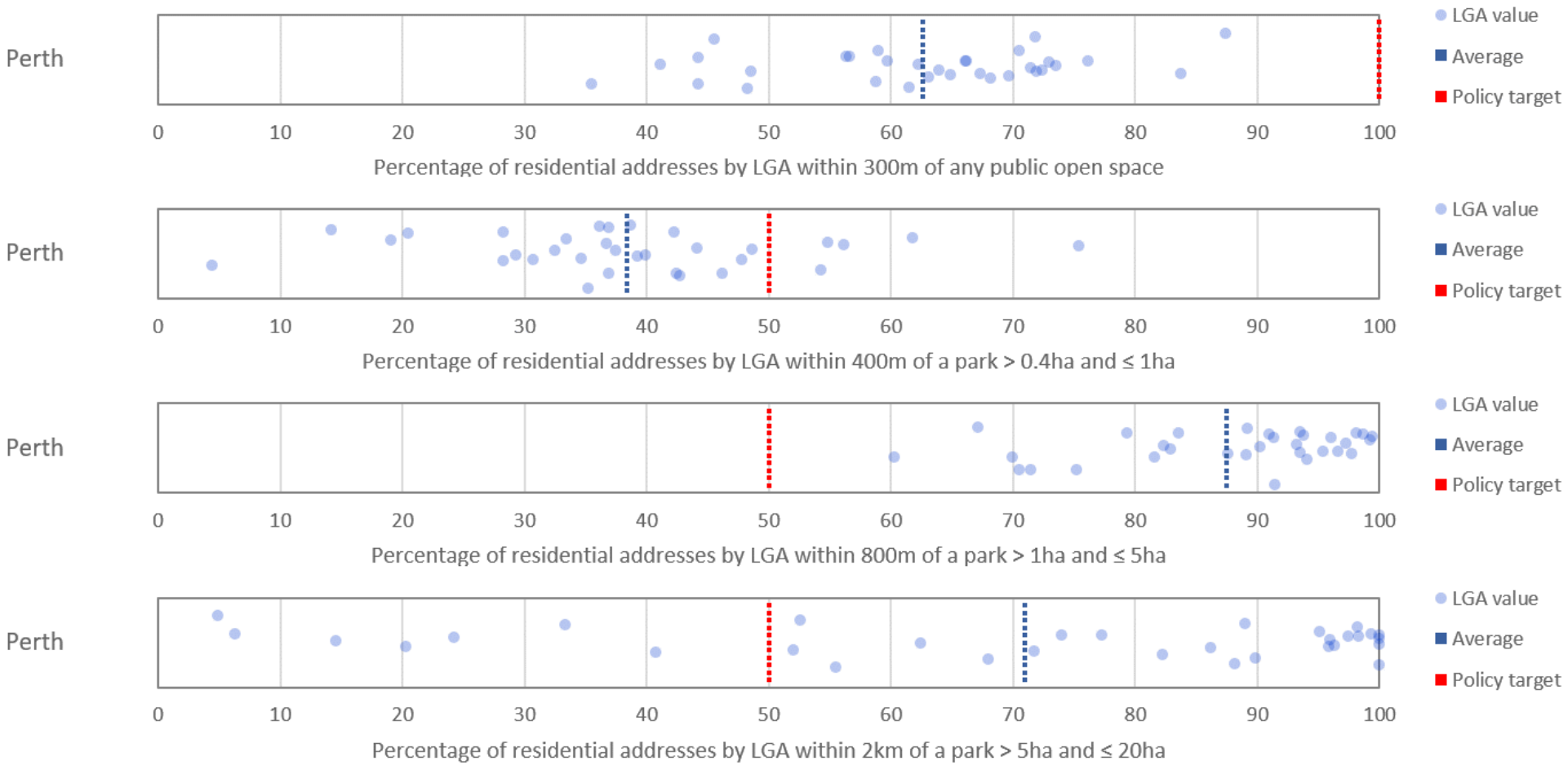


Figure 24: Perth: percentage of residential addresses (by LGA) within specified distances of parks

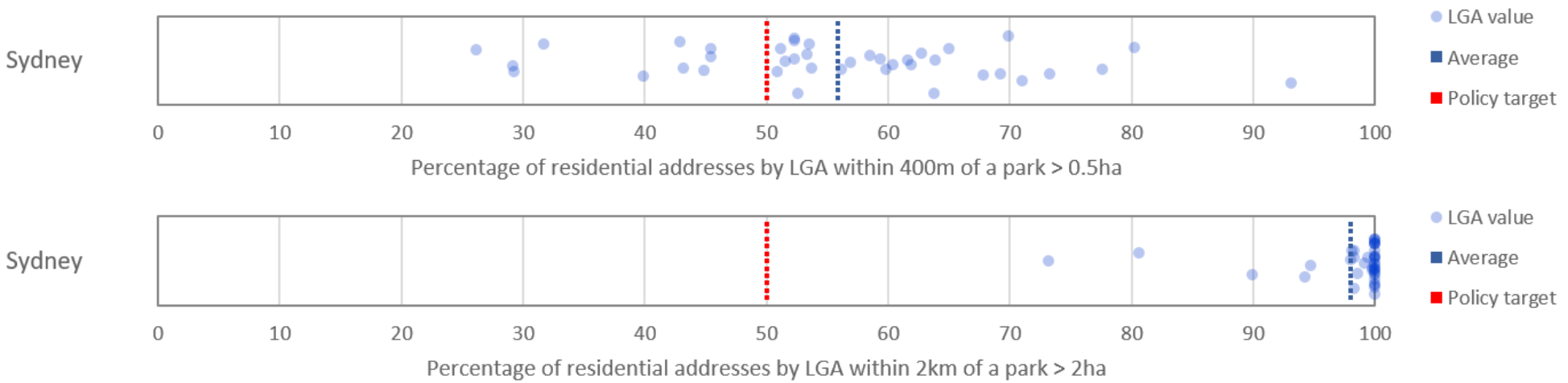


Figure 25: Sydney: percentage of residential addresses (by LGA) within specified distances of parks

5.3 National liveability indicators

Table 6 shows the results of the national liveability indicators for POS for each state and territory capital city in Australia. In states where more detailed data were available (Melbourne, Perth, Brisbane and Sydney), we were able to calculate the percentage of dwellings within 400 m of POS overall (found to be associated with recreational walking in Perth) [31], and 400 m to larger POS over 1.5 ha (found to be associated with recreational walking in Melbourne) [106]. To enable a comparable indicator for all Australian capital cities, the two additional indicators, based on ABS Mesh Block data, measured the percentage of gross area allocated to parkland, and the percentage of suburbs allocated to parkland.

At the metropolitan level, compared with Brisbane (75%) and Perth (78%), Melbourne and Sydney had the highest proportion of residential dwellings with access to POS within 400 m, at around 82% each. In all cities, fewer residential dwellings had access to larger POS within the same distance. Overall, 63% of Perth dwellings had access to a park of at least 1.5 ha within 400 m, compared with 52% in Brisbane, 49% in Melbourne and 43% in Sydney. This is important, given evidence that access to larger POS is associated with recreational walking [109]. The results for suburbs and LGAs were similar to the overall metropolitan results.

Figure 26 compares access to POS within 400 m across the four cities included in the policy analysis. As can be seen, there is considerable variation in the spatial patterning of POS access. In Perth, with the exception of suburbs lying to the east, there was an even distribution of access to POS. However, in Melbourne and Brisbane, there are higher levels of access in outer-suburban areas. Residences in western Sydney appeared to have better access to POS than those in southern Sydney suburbs, with lower levels of access in northern Sydney suburbs.

One of the national liveability indicators for POS was more rigorous than simply a proximity measure, as it included a size requirement of at least 1.5 ha. This is because research undertaken in Melbourne found no association between access to parks within

400 m and recreational walking, unless they were at least this size. Figure 27 shows the distribution of larger POS, and offers one explanation for the Melbourne findings. As can be seen, fewer residents in Melbourne, Sydney or Brisbane suburbs had access to larger POS compared with Perth. Notably, in Perth, we found that people living within 400 m of POS were more likely to participate in recreational walking, and this is likely to be because the parks in Perth were larger. This may change with current policy directions in Perth, which include increasing access to smaller POS in outer-suburban developments.

The results for the percentage of gross area that is parkland allows all Australian cities to be compared. As can be seen in Table 6, nearly three-quarters of the Canberra GCCSA (i.e. the ACT) is allocated to parkland, as is 29% of Canberra's suburbs on average. Notably, 57% of the metropolitan area of Sydney and 40% of Perth is allocated to parkland, followed by Hobart (22%) and Melbourne (20%). Adelaide has the lowest percentage of parkland (approximately 10%) with the next lowest being Darwin (15%). When broken down into categories, the results indicate that many suburbs have less than 5% Mesh Block parkland, particularly in Melbourne, Brisbane, Adelaide, Hobart and Darwin. The smaller cities (Canberra, Hobart and Darwin) had the highest percentage of suburbs (21–25%) with over 40% of the gross area made up of parkland, while in Perth and Sydney between 18% and 19% of suburbs were more than 40% parkland.

Figure 28 shows the percentage of suburb gross area that is parkland. As can be seen, a higher proportion of Canberra suburbs are parkland than any other capital city. Traditionally, dwelling densities in Australian capital cities have been low, and until relatively recently, Australian homes have contributed green space through their backyards. As Australian cities become more compact as cities densify and block sizes reduce, to meet the needs of apartment dwellers more attention may need to be given to the amount, size and location of public open space in Australian cities.

Table 6: National liveability indicators for public open space

Indicator	Scale	City							
		Melbourne	***Perth***	***Brisbane***	***Sydney***	***Adelaide***	***Canberra***	***Darwin***	***Hobart***
% of residential addresses within 400m of public open space	Metro level[1]	81.81	78.08	74.69	81.90	-	-	-	-
	Suburb average[2]	79.96	71.76	72.98	82.19	-	-	-	-
	LGA average[3]	81.72	77.22	74.69	82.16	-	-	-	-
% of residential addresses within 400m of public open space > 1.5ha	Metro level[1]	49.03	62.63	51.87	43.44	-	-	-	-
	Suburb average[2]	49.13	55.37	52.06	46.80	-	-	-	-
	LGA average[3]	48.30	59.33	51.87	41.24	-	-	-	-
% of gross area that is parkland	Metro level[4]	20.43	39.85	18.04	56.58	10.28	72.29	14.80	22.24
	Suburb average[2]	14.95	21.84	14.81	21.47	9.92	29.49	18.68	19.96

% of suburbs by % Mesh Block parkland	<5% parkland	34.54	16.30	34.84	21.97	52.41	2.88	32.88	25.89
	≥5 - ≤10% parkland	19.54	16.03	13.78	13.57	15.79	12.50	12.33	16.07
	>10 - ≤20% parkland	19.54	25.27	23.43	25.45	13.38	19.23	17.81	17.86
	>20% - ≤40% parkland	16.70	24.46	17.52	20.17	13.38	40.38	15.07	17.86
	>40% parkland	9.68	17.93	10.43	18.85	5.04	25.00	21.92	22.32

[1] The percentage for all residential addresses within the study area; [2] The average of all suburb-level percentages within the study area; [3] The average of all LGA-level percentages within the study area; [4] The average for the entire Greater Capital City Statistical Area

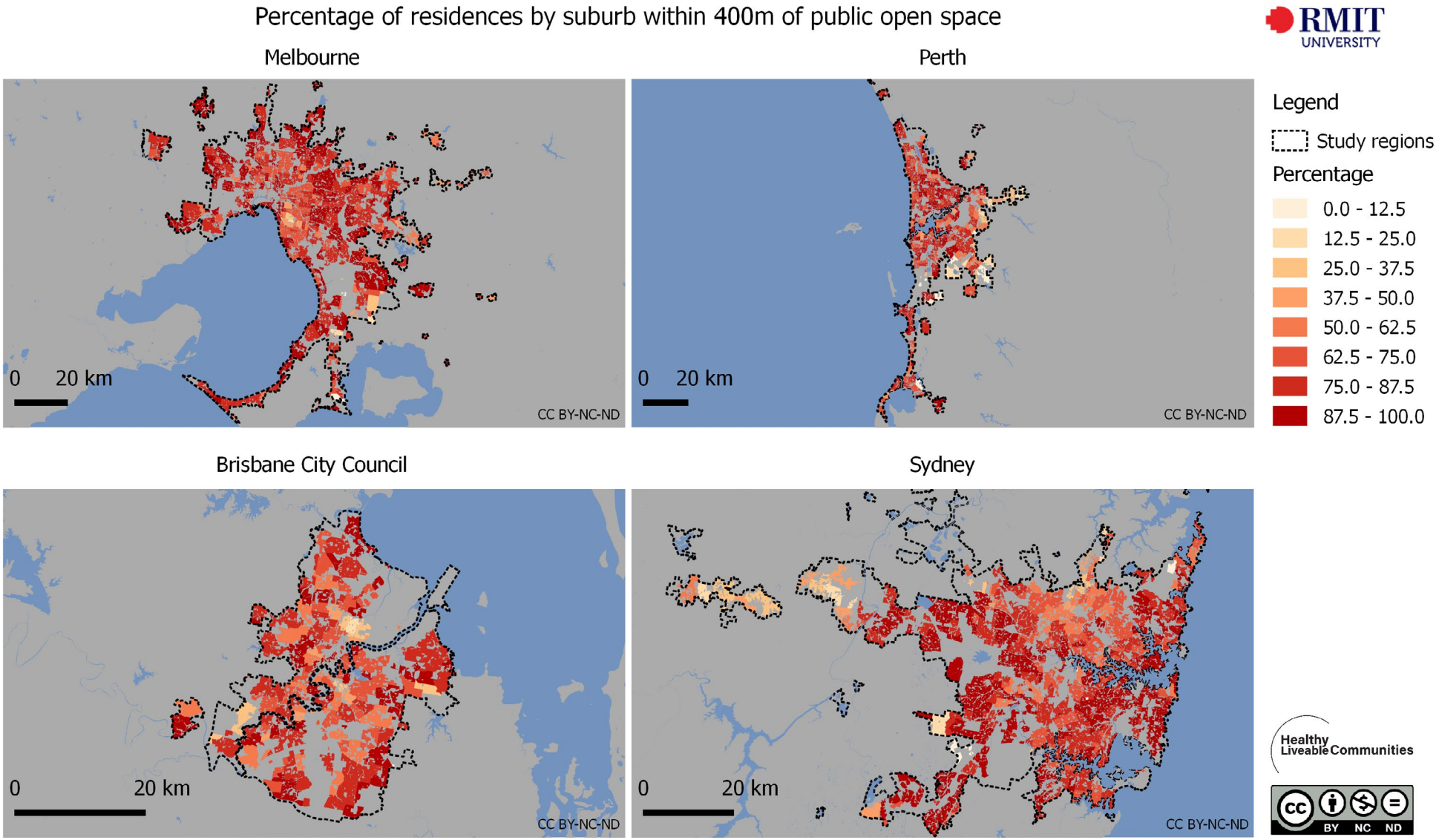


Figure 26: Percentage of residences by suburb within 400m of public open space

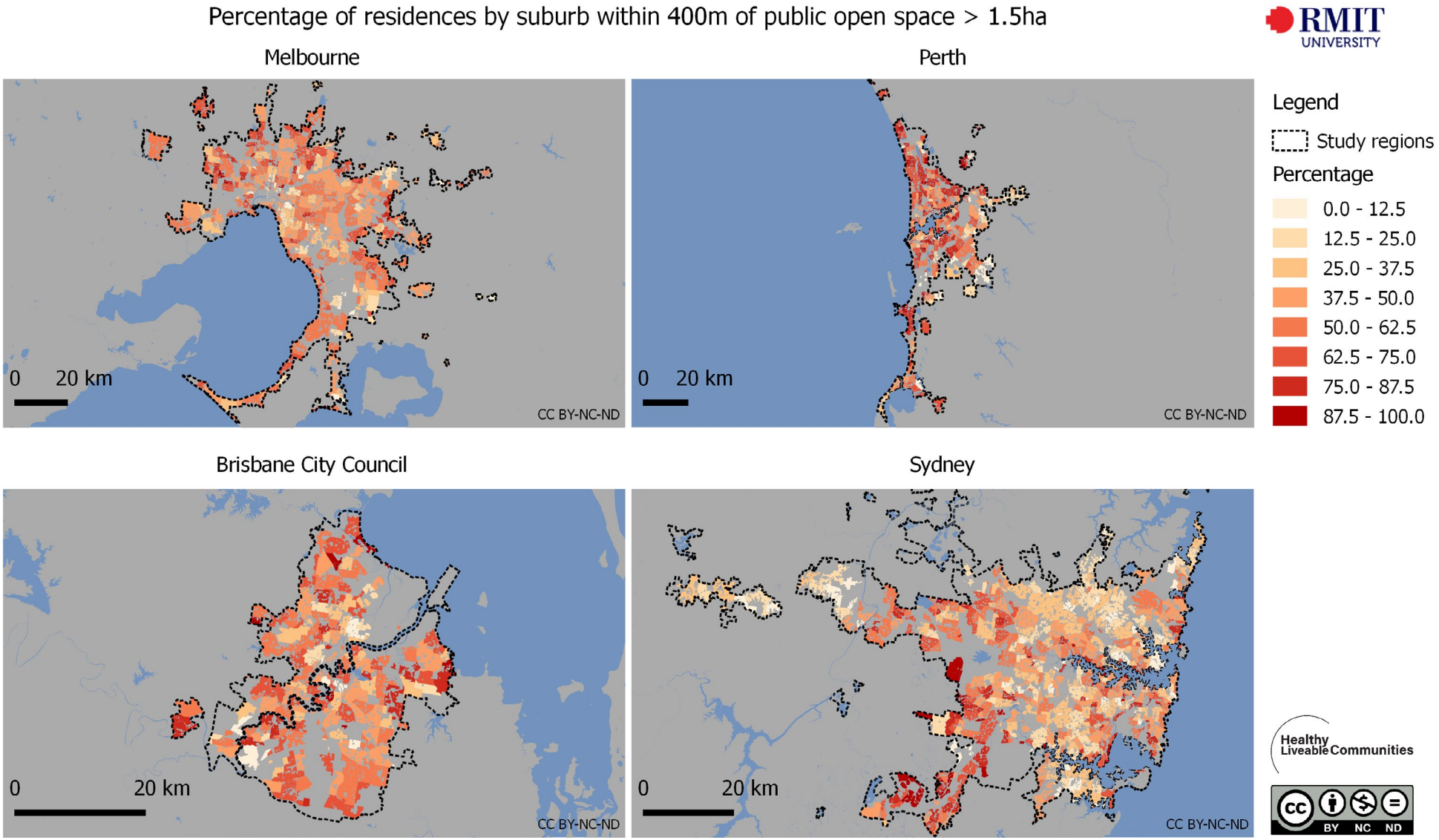


Figure 27: Percentage of residences by suburb within 400m of public open space larger than 1.5ha

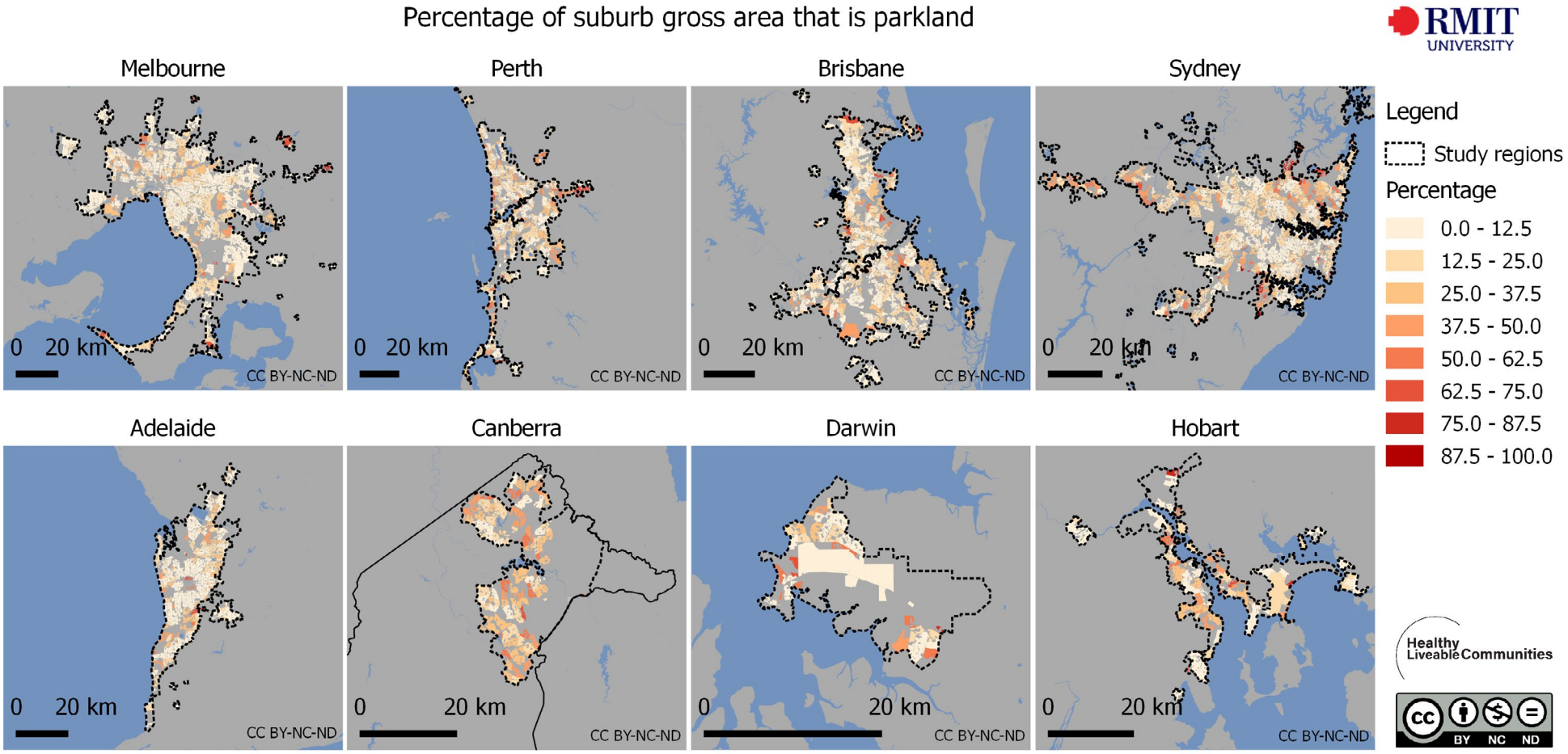


Figure 28: Percentage of suburb gross area that is parkland

Housing Affordability

8.1 Selected policy targets and indicators

The policy review was conducted in Perth, Melbourne, Brisbane and Sydney between 2014 and 2016, at which time we found no suitable state-specific policy standards for housing affordability, availability or quality. This is largely because any housing-specific measures identified were either not spatial, or could not be operationalised using GIS. Thus, this section includes only the national liveability indicators for housing (Table 7).

The Australian National Liveability Study [17] found that increases in housing unaffordability, the proportion of households renting, and higher housing density were all associated with poorer self-rated health. The finding on housing density is noteworthy because, in general, higher levels of density are associated with walking, which promotes health. This suggests that there may be an optimum amount of density associated with health, a factor that should be considered by cities shifting towards more compact, high-density development [51]. A measure of housing density was included in the walkability domain in Section 5. Hence, only two housing measures are included in this section, both related to housing affordability: the 30/40 measure of housing affordability, and the proportion of households renting.

The 30/40 measure identifies households whose income is in the bottom 40% and who spend more than 30% of household income on housing costs. It is a well-known indicator of housing affordability [110]. As well as being associated with poorer self-rated health, areas with less affordable housing are more likely to have residents who feel unsafe, and higher community dissatisfaction [17].

The proportion of households renting indicator is derived by dividing the number of households either renting or purchasing under a rent/buy scheme by the total number of households, excluding non-responses. In areas where more than 36% of households are renting, there is a 30% increase in community dissatisfaction [17].

6.2 National liveability indicators

More than one-third of lower-income households in Sydney, Brisbane, Melbourne, Darwin and Perth were experiencing housing affordability stress, using the 30/40 indicator (see Table 7). Perhaps unsurprisingly given its high median house prices, Sydney had the highest percentage (38%), followed closely by Brisbane (37%). The lowest result was recorded in Canberra, where 31% of lower-income households were encountering housing affordability stress.

The proportion of households renting varied significantly between cities, from 28% in Melbourne to 43% in Darwin. Hobart, Perth and Adelaide (29%) also recorded relatively low proportions of households renting. Despite being the smallest city by a significant margin at the time of the 2011 Census, Darwin had the second-highest median house price nationally, which may in part explain the high proportion of households renting [111].

Figure 29 shows the spatial distribution of housing affordability stress for each Australian capital city. Building low-density housing on the urban fringe is seen by most governments as a solution to Australia's housing affordability problem. But, in most cities, the suburbs recording the highest levels of housing affordability stress tended to be located towards the urban fringe. In Sydney and Brisbane, higher housing affordability stress appeared to be spread across large areas of the city, as was the case – though to a lesser extent – in Melbourne, where housing affordability stress was more prevalent in the most outer-suburban areas. As suggested by Dodson and Sipe [112], these are the suburbs also most at risk of mortgage stress, partly because they have very poor access to public transport and walkability, which increases household expenditure on private motor vehicle transportation.

Table 7: National liveability indicators for housing affordability

Indicator	Scale	City							
		Melbourne	***Perth***	***Brisbane***	***Sydney***	***Adelaide***	***Canberra***	***Darwin***	***Hobart***
% of households with income in the bottom 40 percent of the income distribution spending more than 30% of household income on housing costs	Metro Level[1]	34.88	33.09	37.00	38.00	31.37	30.69	34.52	31.07
	Suburb Average[2]	33.47	31.55	36.16	34.93	30.12	31.93	34.60	30.57
	LGA Average[3]	34.96	32.27	37.61	37.49	31.08	30.69	27.79	30.91
% of households renting as a proportion of total	Metro Level[1]	28.39	28.74	34.16	32.83	29.41	31.64	43.07	28.52
	Suburb Average[2]	26.35	27.69	32.55	30.30	29.78	32.36	46.55	27.85
	LGA Average[3]	28.99	30.54	32.62	33.43	30.75	31.64	38.08	26.96

[1] The percentage for all residents within the Greater Capital City Statistical Area (GCCSA), as defined by the ABS; [2] The average of all suburb-level percentages within the study area; [3] The average of all LGA-level percentages within the study area.

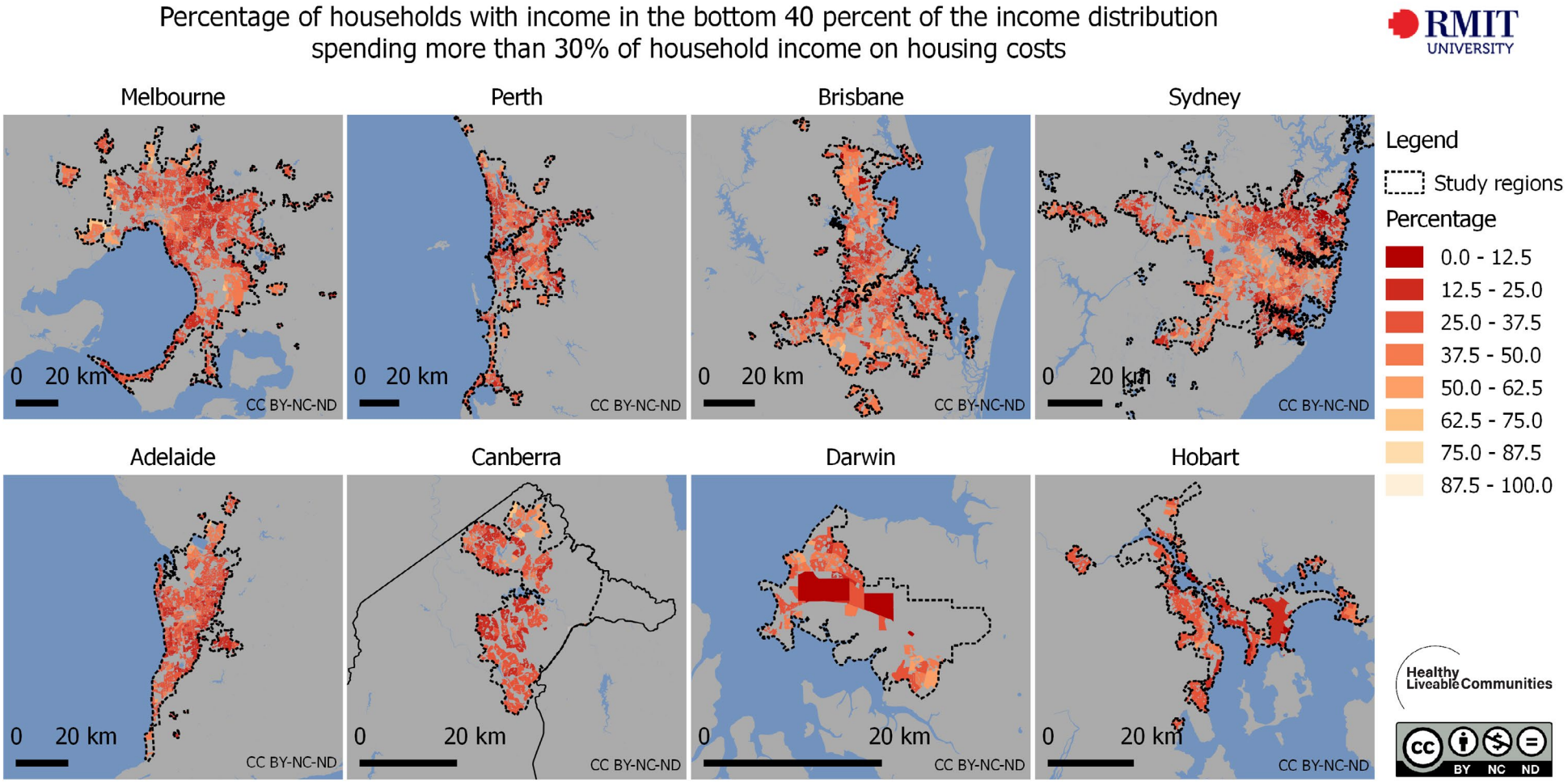


Figure 29: The 30/40 measure of housing affordability (by city and suburb)

Employment

9.1 Selected policy targets and indicators

Despite an extensive policy review for Melbourne, Perth, Brisbane and Sydney (see Appendix 1), no measurable spatial policy standards were identified for employment access or provision in local areas. Therefore, this section focuses on national liveability indicators only (see Table 8), which allow comparison between Australian cities by applying a consistent measure to all cities.

Four national liveability employment indicators were developed: one for access to local employment, and three for travel mode to work. Access to local employment was measured by the percentage of employed people living and working in the same area. This indicator was developed at two scales. The first was ABS Statistical Area (SA) 3 level, reflecting the scale tested in the Australian National Liveability Study [16]. An SA3 represents an area with a population generally between 30,000 and 130,000, characterised by a regional identity based on geographic and socio-economic similarities [113]. SA3s are built from aggregated whole Statistical Area 2s (SA2), where each SA2 represents a community that interacts both socially and economically, with an average population of about 10,000 [113].

In this study, access to employment was also calculated at the SA4 level. SA4s are the largest sub-state regions in the main structure of the ABS Australian Statistical Geography Standard. In metropolitan areas they tend to have populations between 300,000 and 500,000 [113]. The indicator therefore measured the percentage of employed people living in an SA2 who worked within (1) the same SA3 (in which the SA2 is contained), and (2) the same SA4. For completeness and comparability with other results, for each city we also calculated the average percentage of employed persons living and working in the same LGA across all LGAs, and the percentage of employed persons living and working in the same Greater Capital City Statistical Area (GCCSA).

The other three employment indicators related to travel mode to work for employed people over 15 years of age, as a measure of employment accessibility by transport mode. As already discussed, travel mode to work affects health, through its effect on physical activity levels, and by increasing motor-vehicle traffic, which is associated with air pollution, noise and traffic injuries [11]. Thus the travel mode to work indicators are also relevant to the public transport and walkability domains.

9.2 National liveability indicators

When measured at the SA3 scale, across all capital cities, only a minority of the working population works near home. In Darwin, Hobart and Perth, between 37% and 43% live and work in the same local area (e.g. work in the LGA containing the suburb the live in) (see Table 8); just over 30% do so in Sydney and Canberra; and just over 25% in Melbourne and Brisbane. However, when 'local' is broadened to the SA4, between 43% and 89% of the working population live and work in the same local metropolitan region, with a much higher proportion doing so in Canberra, Darwin and Hobart, compared with the other five capital cities. Notably, at the metropolitan-wide level, nearly one-tenth of the working population works outside the city.

The employment accessibility indicators (see Table 8) show that all Australian cities rely on private motor vehicles to transport the vast majority of people to work. At the metropolitan level, 71–87% of the population in all capital cities travel to work via private motor vehicles, with a greater proportion in Darwin (87%), Hobart (86%), Adelaide (86%) and Canberra (84%) than elsewhere.

A greater proportion of people travel to work by public transport in Sydney (23%), Melbourne (16%) and Brisbane (15%) at metropolitan scale, compared with other cities, with the lowest public transport use recorded in Darwin (5%). In most cities, public

transport use was second to private motor-vehicle use, followed by active transport. The exceptions were Hobart and Darwin, which both had higher rates of active transport compared with public transport (8% vs 7% and 9% vs 5% respectively).

Based on the 2011 Census figures, Darwin had the largest proportion of residents using active transport to get to work (9%), with prevalence in other capital cities ranging from 4% to 8%. Given that 26–43% of the working population in all capital cities live and work in the same local area (SA3), this suggests an opportunity to increase active transport journeys to work.

Table 8: National liveability indicators for employment

Indicator	Scale	City							
		Melbourne	***Perth***	***Brisbane***	***Sydney***	***Adelaide***	***Canberra***	***Darwin***	***Hobart***
% of employed persons living and working in same area	Metro-level[1]	91.58	88.08	88.85	91.08	90.23	93.48	88.43	90.46
	SA2 in SA3[2]	26.67	36.81	25.86	31.19	29.05	31.23	43.09	39.26
	SA2 in SA4	46.74	53.88	43.49	42.58	53.38	88.79	85.37	85.49
	LGA Average[3]	27.10	24.08	49.73	24.78	24.30	89.05	44.65	36.02
% of employed persons aged 15 and over using active transport to travel to work	Metro-level[4]	5.03	4.10	4.92	5.68	4.32	7.69	8.82	7.73
	Suburb Average[5]	5.09	4.37	4.91	5.92	4.93	8.71	10.64	6.98
	LGA Average[6]	5.63	6.07	3.33	6.02	6.42	7.69	11.53	5.59
% of employed persons aged 15 and over using public transport to travel to work	Metro-level[4]	16.38	12.75	15.20	23.41	10.17	7.86	4.65	6.59
	Suburb Average[5]	15.15	12.34	14.65	26.55	10.77	7.79	4.30	6.40
	LGA Average[6]	17.05	13.69	11.59	26.73	10.69	7.86	5.88	5.25
% of employed persons aged 15 and over using private vehicle/s to travel to work	Metro-level[4]	78.59	83.15	79.88	70.91	85.50	84.44	86.52	85.68
	Suburb Average[5]	79.76	83.28	80.44	71.76	84.30	83.50	85.05	86.62
	LGA Average[6]	77.33	80.24	85.08	67.53	82.89	84.44	82.59	89.16

[1] The percentage of employed persons living and working in the same GCCSA; [2]The average of all Statistical Area 2 (SA2) percentages within the study area, with these calculated as the percentage of employed persons in each SA2 working in the same encompassing Statistical Area 3; [3] The average of all LGA-level percentages of employed persons living and working in the same LGA [4] The percentage for all residents within the Greater Capital City Statistical Area (GCCSA), as defined by the ABS; [4]The average of all suburb-level percentages within the study area; [6] The average of all LGA-level percentages within the study area.

Figure 30 through Figure 33 show the spatial distribution of living and working in the same SA3 and the same SA4. Given the importance of accessible local employment to shifting the population into active travel modes, these figures are telling. In the inner areas of each city, residents are more likely to live and work in the same area, particularly at the broader metropolitan region (SA4) scale. Beyond inner-city areas, the percentage of residents working locally drops off rapidly, with many of those living in the middle suburbs commuting to the inner city for work. However, as distance from the city increases, the proportion of people working near home starts to rise again.

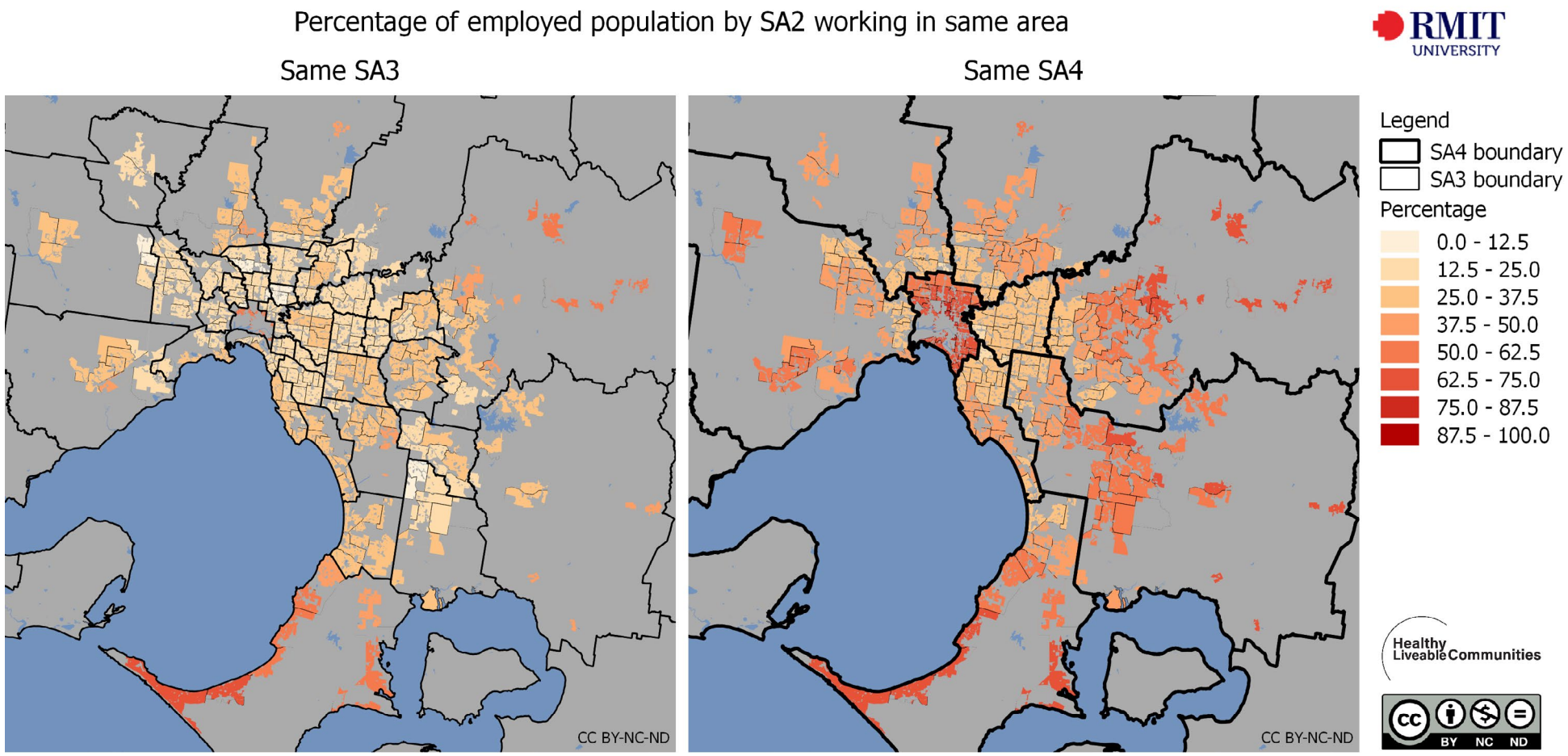


Figure 30: Melbourne: percentage of employed population (by SA2) working in the same SA3 (left) and same SA4 (right)

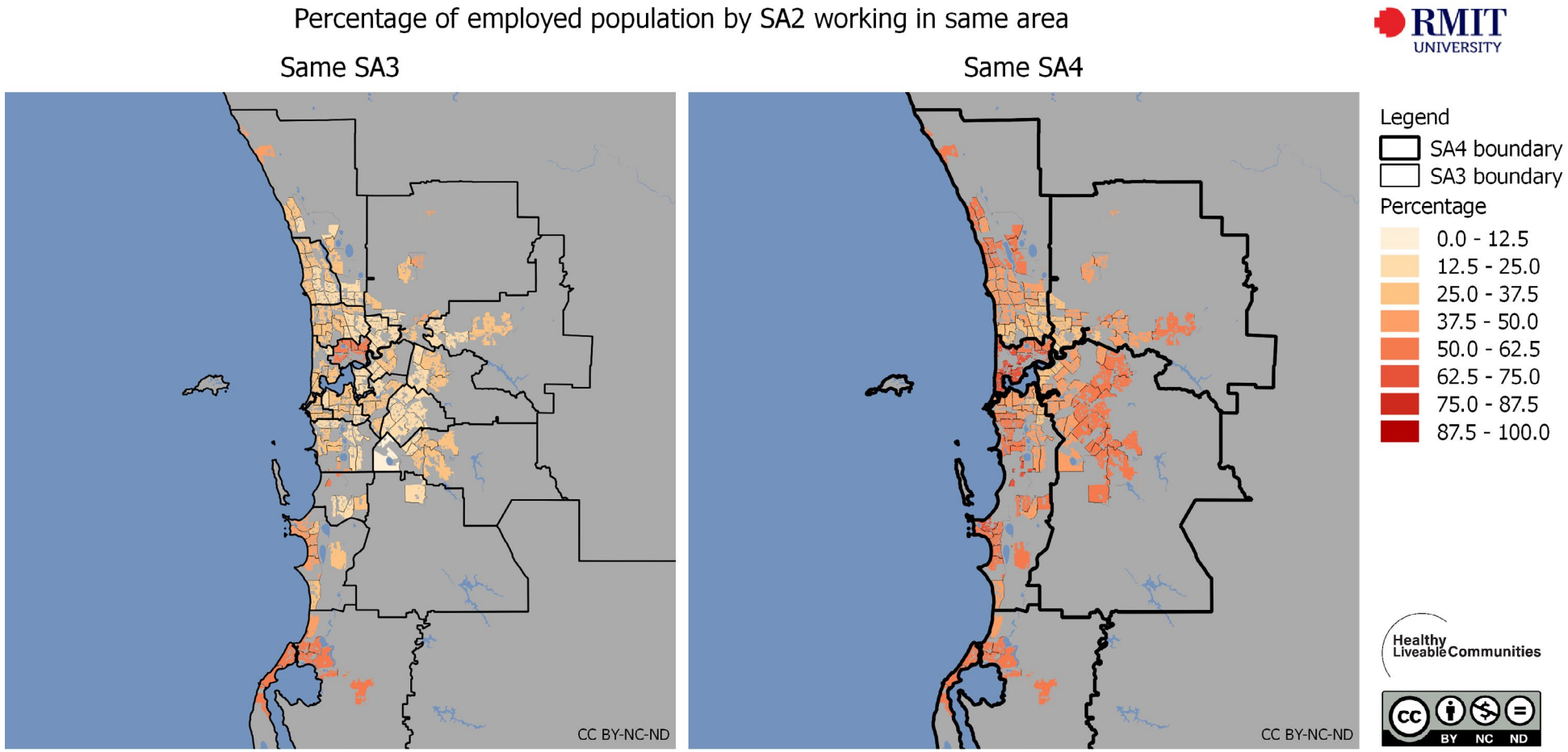


Figure 31: Perth: percentage of employed population (by SA2) working in the same SA3 (left) and same SA4 (right)

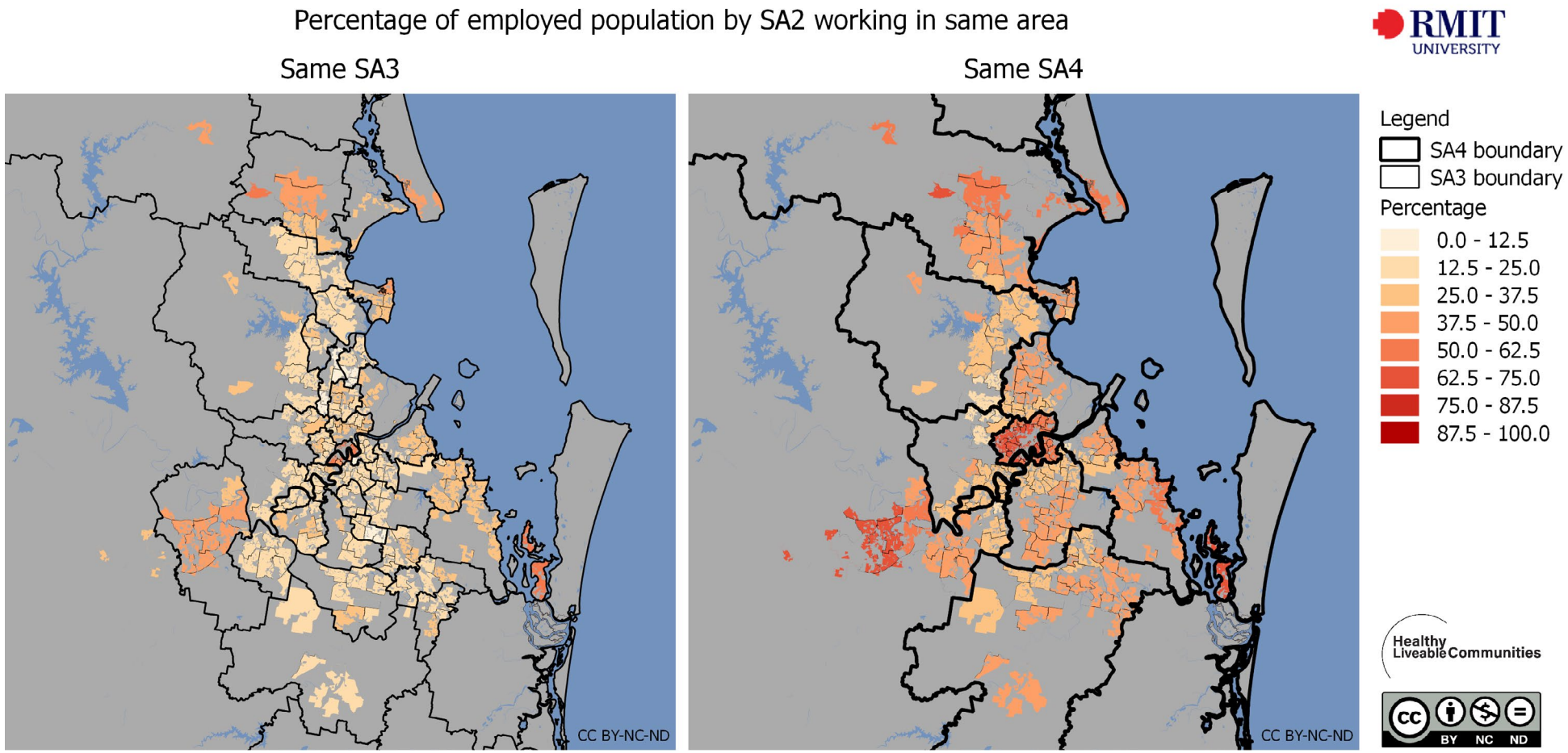


Figure 32: Brisbane: percentage of employed population (by SA2) working in the same SA3 (left) and same SA4 (right)

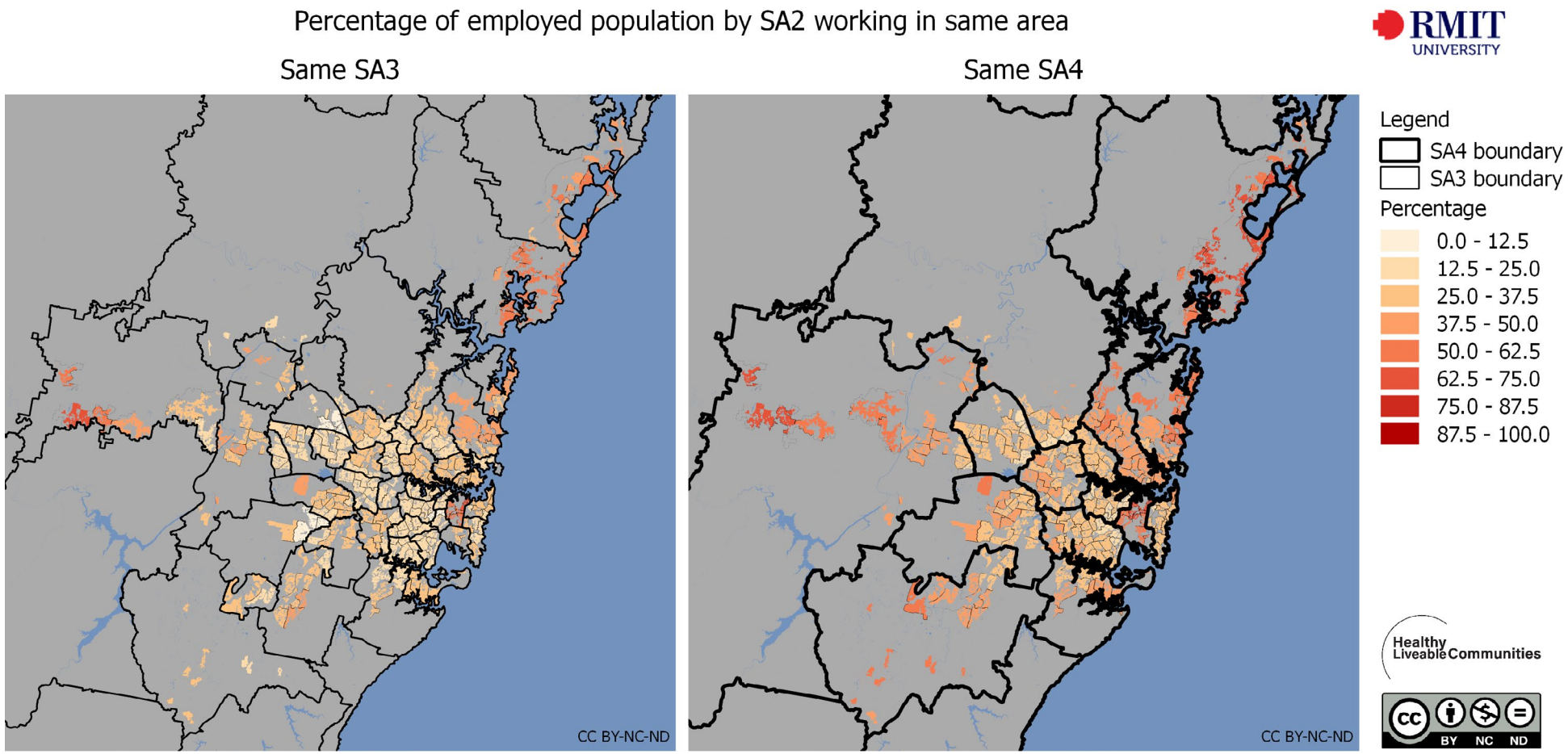


Figure 33: Sydney: percentage of employed population (by SA2) working in the same SA3 (left) and same SA4 (right)

Figure 34 and Figure 35 show the geographical variation in travel mode to work among employed people over 15 years of age, for each Australian city. This highlights the low use of public transport (Figure 34) and even lower use of active transport (Figure 35) across Australian cities. The geographical pattern of higher use of public transport in inner-city areas is most evident in Melbourne, Perth, Brisbane and Sydney. Similarly, the proportion of employed people using active transport to commute to work is shown to be generally higher in inner-city areas compared to outer-city areas in all cities, and is likely to be rising. This will become more evident using the 2016 Census data when it becomes available.

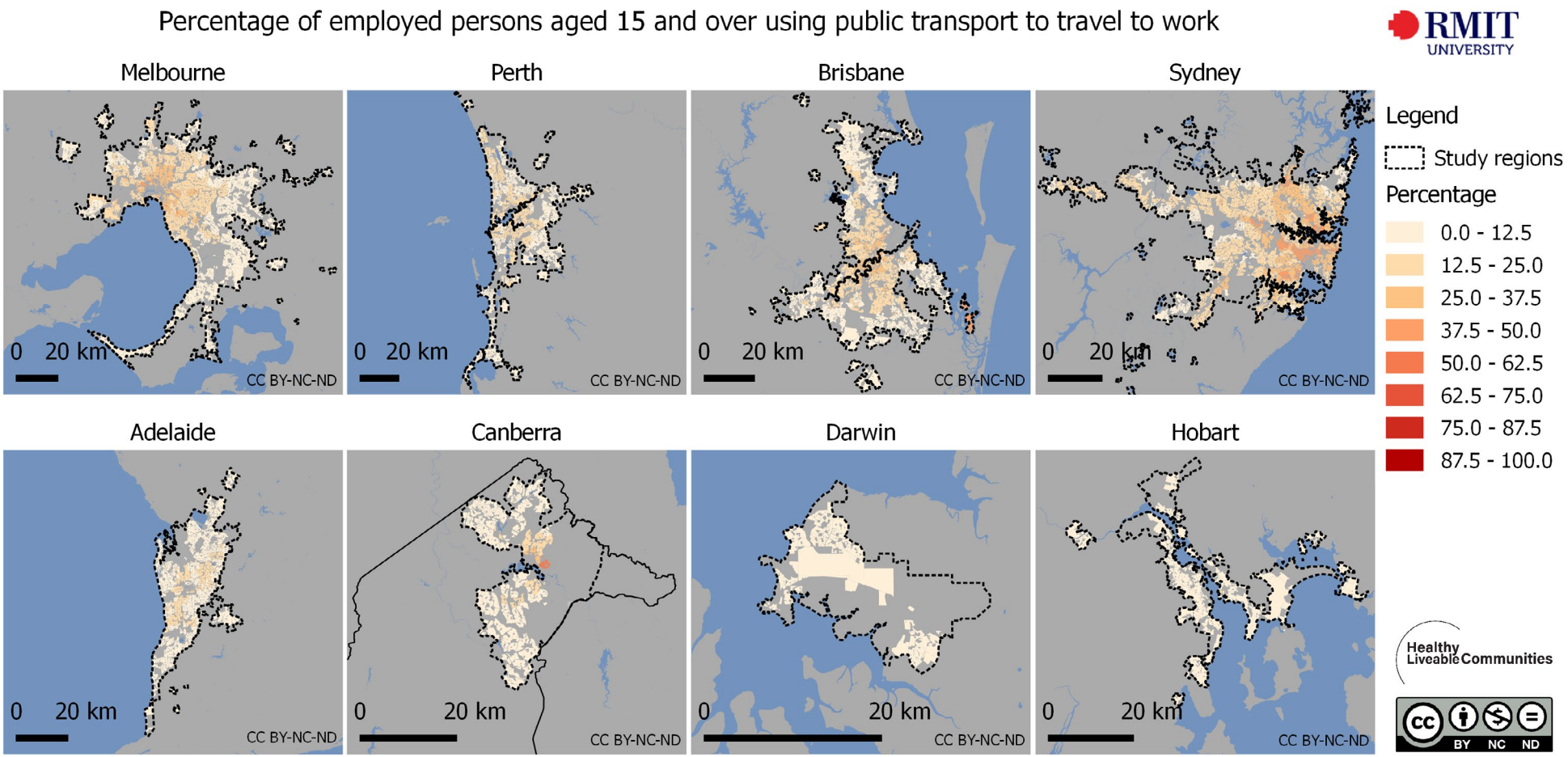


Figure 34: Percentage of employed persons aged 15 and over who travel to work by public transport

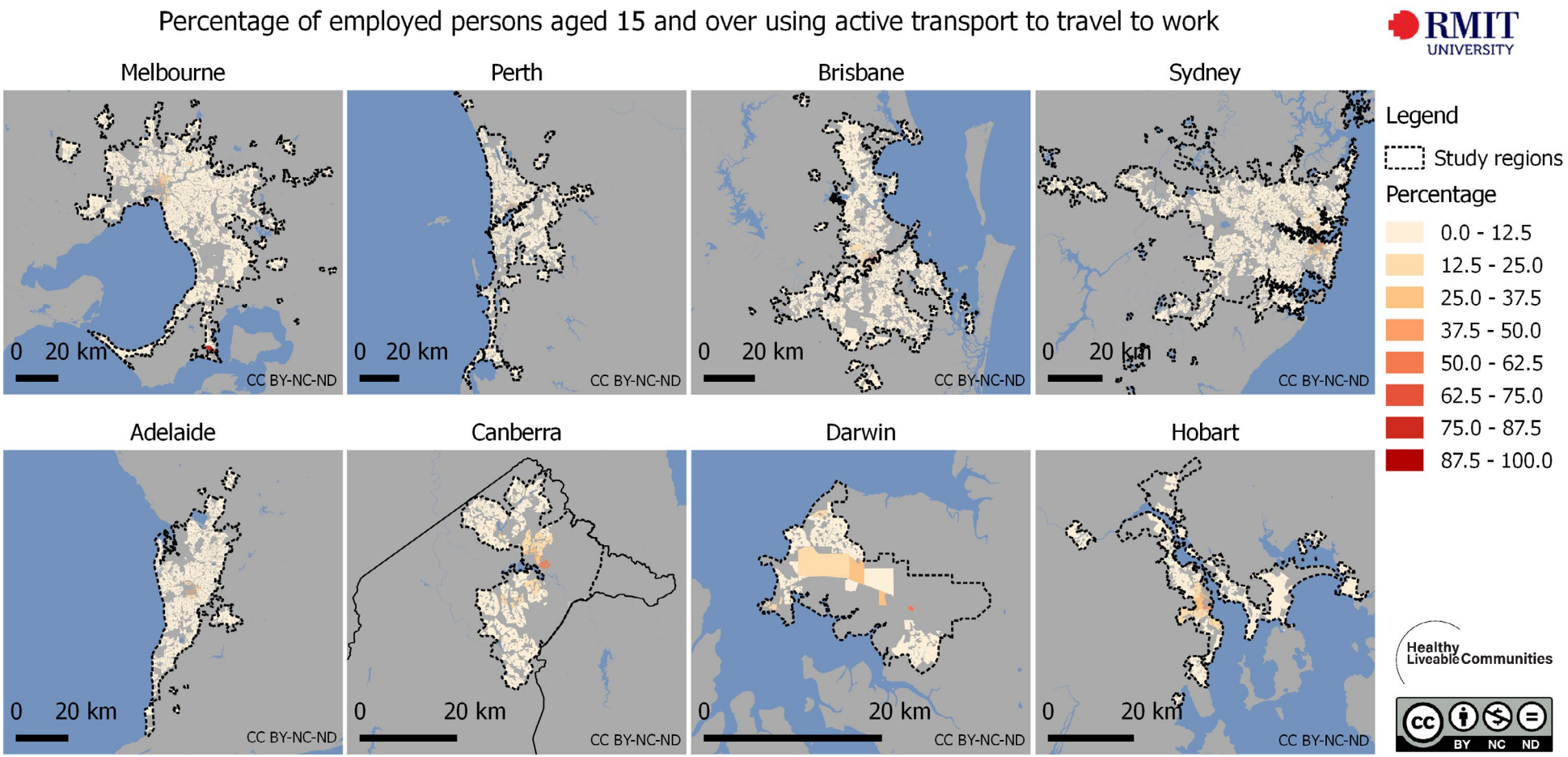


Figure 35: Percentage of employed persons aged 15 and over who travel to work by active transport

Food Environment

10.1 Selected policy targets and indicators

Our review found no measurable spatial policies in Western Australia, Victoria, New South Wales or Queensland that related directly to providing a healthy food environment. However, the Victorian Precinct Structure Planning Guidelines requirement for 80-90% of dwellings to be within 1 km of an activity centre with a supermarket served as an indirect measure of healthy food environment [114, 115]. This requirement focuses more on mixed land use than on providing a supportive food environment, so the level of implementation of this policy was discussed in the Walkability section (Section 5).

Hence, this section focuses on the national liveability indicators of food environments. The food environment can be characterised by outlets that offer consumers (i) healthy choices such as fresh food, including greengrocers, fishmongers, butchers and supermarkets; and (ii) less-healthy and unhealthy choices such as fast food including burgers, pizzas and fried chicken. The healthy food ratio has been shown to be associated with diet and obesity risk [58], with a recommended ratio of fresh food stores as a proportion of all food stores above 75% [32]. Healthy food access is not necessarily dependent on walkable distances, as people often travel by motor vehicle to shop for food. Hence, based on the Australian National Liveability Study food environment analysis, a healthy food ratio – the percentage of food outlets within 3200 m that are healthy food destinations – was calculated. This indicator was created for four cities only: Melbourne, Perth, Brisbane and Sydney (Table 9). The other national food environment indicator is informed by the Victorian policy context, measuring the proportion of dwellings within 1 km of a supermarket (an important source of healthy food) for all capital cities.

10.2 National liveability indicators

At the metropolitan level, all four cities had a very similar healthy food ratio of about 46%. That is, just over half the food outlets within 3200 m of residents' homes in Melbourne, Perth, Brisbane and Sydney are fast food outlets (see Table 9). Notably, there were 64 metropolitan suburbs nationally where all residents had neither a major chain supermarket nor a major fast food destination within 3200 m. Of these, 37 were in Melbourne, with many located in the rapidly growing outer-urban fringe. Although not shown in tables or figures, in Melbourne only 7 out of 403 suburbs (2%) had a healthy food ratio of 75% or more, where residents in these suburbs had higher access to healthy food choices than to fast food outlets. In Perth, it was 19 out of 298 suburbs (6%) and in Sydney 43 out of 562 suburbs (8%). A higher proportion of suburbs in Brisbane (11%) had a healthy food ratio of 75% or more (37 out of 337 suburbs). These findings are important because our previous research has shown modest increases in body mass index in people living in areas with lower (less than 75%) healthy food ratios [32, 116].

As shown in Table 9, at the metropolitan level, the percentage of residential dwellings within 1 km of a supermarket varied significantly between cities, from 17% in Darwin to 44% in Adelaide. Thus, more than half of residential dwellings in each Australian capital city are outside a comfortable walking distance to a supermarket, creating potential barriers to food access and active transport, as well as fostering motor-vehicle dependency. Similar findings are shown at the suburb and LGA level. In Darwin, the LGA average percentage of dwellings within 1 km of a major supermarket was only 8%.

Figure 36 shows the spatial distribution of the average food ratio across the four cities. Other than on the urban fringe, the food ratio is relatively homogenous across the metropolitan areas of all four cities, with the least variation occurring across Melbourne. Notably, in rapidly growing cities such as Melbourne and Brisbane, there were more suburban areas with poor access to either a supermarket or a fast food chain (37 suburbs in Melbourne, 17 suburbs in Brisbane).

Table 9: National liveability indicators for the food environment

Indicator	Scale	City							
		Melbourne	Perth	Brisbane	Sydney	Adelaide	Canberra	Darwin	Hobart
Food ratio[1]	Metro-level[2]	46.53	46.22	46.13	46.42	-	-	-	-
	Suburb Average[3]	46.31	46.58	48.60	47.59	-	-	-	-
	LGA Average[4]	47.30	47.27	48.99	48.98	-	-	-	-
% residential dwellings within 1km of a supermarket	Metro-level	39.78	34.40	36.55	40.77	44.36	40.00	16.80	39.80
	Suburb Average	38.73	31.93	32.05	39.42	42.69	41.27	13.00	31.86
	LGA Average	44.45	43.72	32.78	45.14	48.35	40.00	7.88	36.19

[1] Count of major supermarket chains within 3200m of each residence divided by combined count of major fast food chains and major supermarkets within 3200m. Where residents are without access to either fast food or a supermarket within 3200m a null value is recorded, and excluded from subsequent averages; [2] The average food ratio for all residences within the study area; [3] The average of the suburb-level food ratio averages across the study area; [4] The average of the LGA-level food ratio averages across the study area.

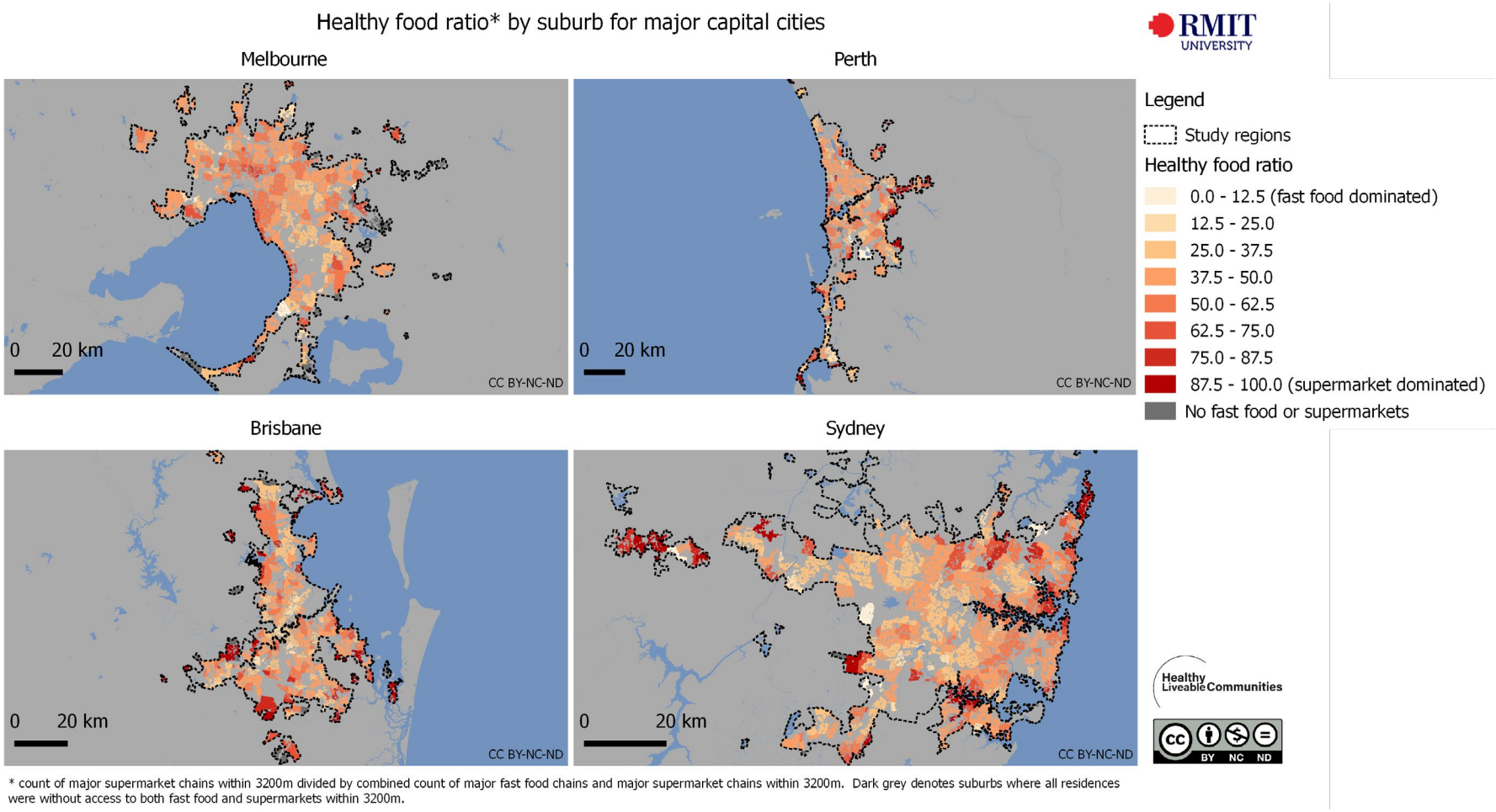


Figure 36: Healthy food ratio (by suburb) (a higher score suggests access to more healthy food outlets than fast food outlets)

Alcohol Environment

11.1 Selected policy targets and indicators

We reviewed state government policies for Victoria, Western Australia, Queensland and New South Wales, to identify policies and targets for access to alcohol. We found no measurable spatial policy standards for alcohol availability or accessibility, so this section focuses on national liveability indicators of the alcohol environment.

In our previous urban liveability research, we found that in Melbourne the density of off-licence alcohol outlets (liquor stores and supermarkets that sell alcohol) in disadvantaged areas was associated with poorer self-rated health. This reflects other Australian research, showing that the density of alcohol outlets is associated with harmful alcohol consumption [60] and alcohol-related violence [61], and that more alcohol outlets appear to be located in more disadvantaged areas [60]. Hence, the national liveability indicators included in this study measure the percentage of residences without access to on-licences (pubs, bars, licensed restaurants) within 400 m, and off-licences within 800 m. This is because previously we found that for those living in more disadvantaged areas, not having an off-licence outlet within 800 m and not having on-licences within 400 m appears to be protective of self-rated health [18]. Due to difficulties in obtaining alcohol data nationally, this indicator was created for only four cities: Melbourne, Perth, Brisbane and Sydney.

11.2 National liveability indicators

In Perth and Brisbane, the vast majority of residential addresses (90% and 86% respectively) are not within 400 m of an on-licence alcohol outlet, while in Melbourne and Sydney the figures are 80% and 77% respectively (see Table 10). Across Melbourne, Perth and Sydney, access to off-licence outlets within 800 m is more prevalent than on-licence outlets within 400 m. Only 52% dwellings in Melbourne, 44% in Sydney and 66% in Perth are not within 800 m of an off-licence alcohol outlet. Nevertheless, access to alcohol outlets is highly prevalent in Australian cities. While not shown in the tables or maps below, across all four cities studied, only 17% of suburbs (265 out of 1600) were found to have no residential addresses with access to an on-licence within 400 m – 42 of these were in Melbourne, compared with 90 in Sydney. Similarly, only 12.3% of suburbs (198 out of 1600) had no residential addresses with access to an off-licence within 800 m – with most of these suburbs (118) in Brisbane.

The results for access to off-licence outlets in Brisbane were markedly different from the other capital cities. It is not clear whether this reflects reality, or is caused by missing data on off-licence outlets in that city. Unlike in other states, there is only one liquor licence category that relates to off-licences in Queensland: commercial hotels. The licence for any major national bottle shop outlet is associated with a commercial hotel and its registered address, rather than the address of the bottle shop itself. A commercial hotel licence allows up to three detached shops to be operated away from the main premises [117]. By using liquor licensing data that has only registered addresses, it is likely that this under-represents the number of alcohol outlets available, with many of these detached shops missed from the analysis. This is a limitation, and alternative ways of collecting these data will be considered in the future.

Figure 37 and Figure 38 show the spatial distribution of alcohol outlets across the four capital cities. Compared with other parts of the city, outer suburbs were more likely to have no residential addresses with access to either an off-licence within 800 m or on-licence outlets within 400 m, especially in the latter case. In Melbourne and Sydney, far fewer inner-city suburbs were without access to an on-licence alcohol outlet within 400 m. Off-licence alcohol outlets were more evenly spread across Perth, Melbourne and Sydney, with more residences without access on the urban fringe. Far fewer residential addresses in the inner city and middle suburbs of Melbourne, Sydney and (to a lesser extent) Perth do not have access to an off-licence alcohol outlet within 800 m, compared with other parts of the city. Levels of access to both types of alcohol outlets are considerably lower in Brisbane than in other cities, irrespective of location.

Table 10: National liveability indicators for the alcohol environment

Indicator	Scale	City							
		Melbourne	***Perth***	***Brisbane***	***Sydney***	***Adelaide***	***Canberra***	***Darwin***	***Hobart***
Percentage of residences without access to an on-licence within 400m	Metro-level[1]	79.70	89.73	86.01	76.74	-	-	-	-
	Suburb Average[2]	77.43	88.52	85.14	73.86	-	-	-	-
	LGA Average[3]	74.21	82.11	90.53	69.61	-	-	-	-
Percentage of residences without access to an off-licence within 800m	Metro-level[1]	51.51	65.96	87.71	44.07	-	-	-	-
	Suburb Average[2]	50.95	65.53	86.69	42.27	-	-	-	-
	LGA Average[3]	46.37	55.26	90.01	36.65	-	-	-	-

[1] The average percentage of residences without access within the study area; [2] The average of the suburb-level percentage of residences without access across the study area'; [3] The average of the LGA-level percentage of residences without access across the study area

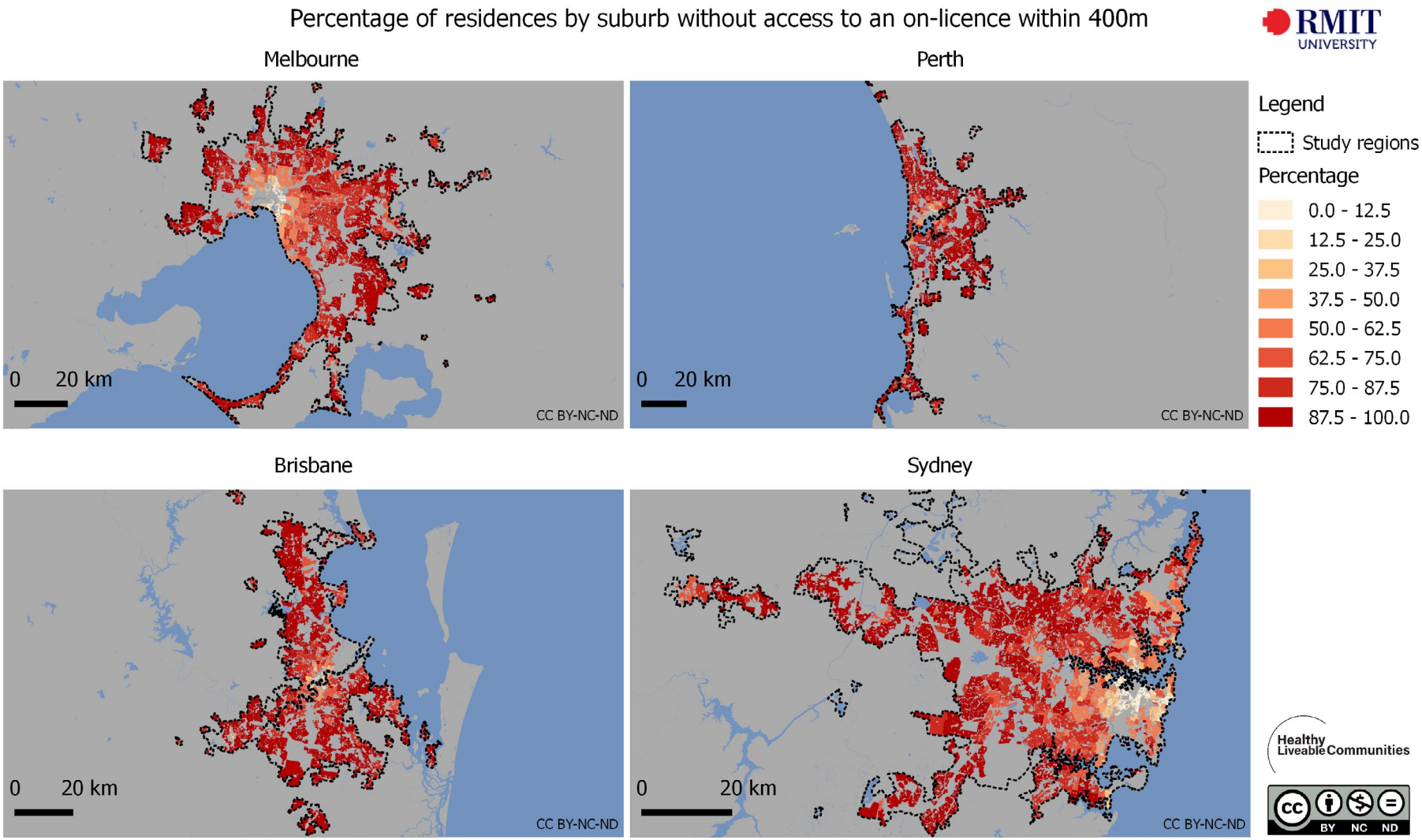


Figure 37: Percentage of residences (by suburb) without access to an on-licence within 400 m

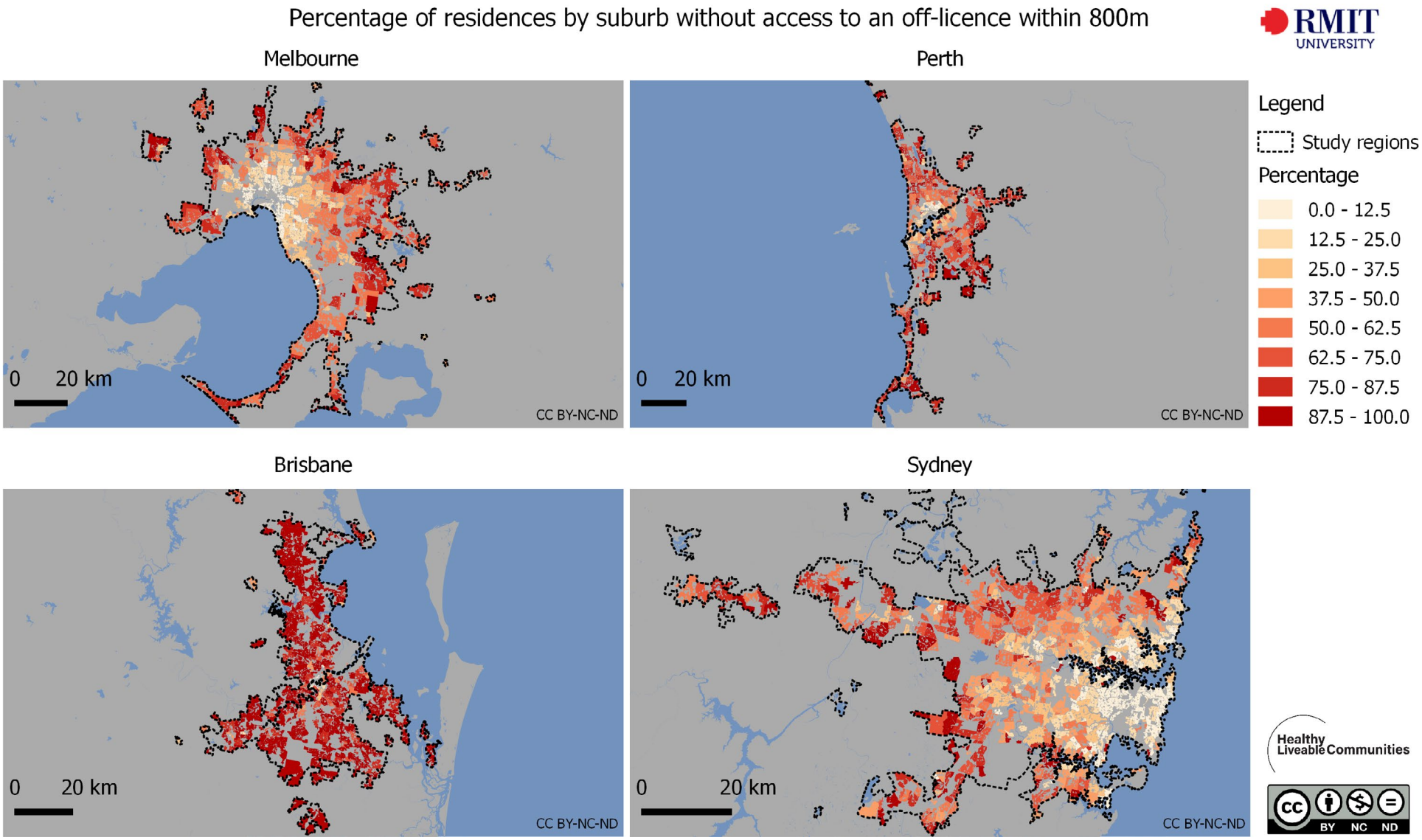


Figure 38: Percentage of residences (by suburb) without access to an off-license within 800 m

Discussion & Conclusions

This report presents indicators of liveability that could be used to benchmark and monitor Australian cities. Along with an online Urban Observatory of indicators currently under development (see http://cur.org.au/project/urban-observatory/ for more details) the aim of this report is to support Federal, state and local government decision-making and priority-setting, with the aim of promoting the health and wellbeing of Australians living in cities, and reducing inequities within and between cities and metropolitan regions. Variations within a city are likely to be of concern to those state government departments and planning authorities responsible for the whole metropolitan region (and to Brisbane City Council, due to its large geography). However, our results are reported at the suburb and LGA level, which will be relevant to local government, providing the ability to identify inequity of access at the sub-LGA level.

Not only could this evidence be used to inform local governments' own investments, it could also assist them and their communities to identify interventions requiring state and Federal government infrastructure investments. In this regard, although state government policy was the focus of this research, the findings are also relevant to the Federal government given its interest in creating smart liveable cities, its potential investments through city deals, as well as its National Cities Performance Framework [118].

The specific aims of the research presented in this report were to:

- identify state government urban planning policies and legislation and their targets that relate to important aspects of urban liveability;
- create and map urban liveability indicators based on state government policy documents, to assess the degree of policy implementation and spatial inequities in liveability across Sydney, Melbourne, Perth and Brisbane; and to
- map a set of evidence-based national liveability indicators from the Australian National Liveability Study found to be associated with chronic disease risk behaviours and/or health outcomes, for all Australian capital cities where data are available.

12.1. Do Australian cities have measurable policies designed to create liveable cities?

The review of state government policies in Western Australia, Victoria, New South Wales and Queensland involved more than 73 documents, with spatial standards found mainly in policy guidelines and regulations. Some sector-specific strategic policies were also sufficiently detailed to include spatial standards that could be measured and mapped. The final number of state-specific policy indicators included was limited, because only a small number of measurable spatial policies and targets were identified, and some could not be operationalised using a geographic information system (GIS).

Measurable spatial policies were identified for only three of the seven liveability domains: walkability, public transport, and public open space. No measurable spatial state government policies that could be operationalised in GIS were identified for local employment, housing affordability, promoting access to healthy food choices, or limiting access to alcohol outlets. In many cases simplifying assumptions needed to be made in order to operationalise the measures; e.g. interpreting 'most' as 50% and ignoring ambiguous qualifiers such as 'safe', 'potential', 'planned', 'generally' and 'typically'.

While the framing of a policy determines whether it can be measured spatially, the measure can of course only be produced if there is data available to support the analysis. The availability and quality of data across cities varies significantly; see Appendix 4 for further details. Even when high quality data were available, the inconsistent categorisation of data across states and territories was a significant barrier to comparing cities on a consistent basis. This problem was particularly acute for the public open space and alcohol environment domains. A final data challenge was the lack of high-quality

pedestrian network data. While street network data can be used as a proxy for a pedestrian network, the results for some areas will not reflect the 'on the ground' reality.

The policy review revealed a dynamic policy environment. For example, even since this study took place, a number of new policies have been developed, which may include additional, or more ambitious targets and standards than included in this review. For example, the latest version of the Plan Melbourne metropolitan strategic plan aims to reach densities of 20 dwellings per hectare 'in the future', replacing the previous state target measured in this study, of 15 dwellings per hectare in growth areas [67]. Nevertheless, the policy review also highlighted the diverse range of policy standards across the jurisdictions reviewed. The lack of consistency between states reflected different levels of policy ambition, and possibly lack of agreement among policy-makers and decision-makers about how land-use, transport and infrastructure planning could be used to make Australian communities more liveable.

Our findings suggest that evidence is not being used to inform policy standards across Australian cities. Indeed, in some cases, there appears to be a mismatch between the value placed on urban liveability and walkability [35] and what the evidence tells us will be the likely results of current inconsistent urban policy across Australian cities.

It is possible that policy-makers and decision-makers lack access to the type of evidence needed to create evidence-informed policy and standards [35]. This suggests that Australian universities can play an important role in providing policy-relevant quantitative evidence. For example, what levels of density encourage walking, cycling and public transport use and discourage driving [100]? What is the optimal proximity and size of public open space [119]? How many and what types of employment opportunities – and what ratio of jobs to housing – would encourage active transport, and reduce commute times?

12.2. Are Australian cities implementing state-government policies that will create liveable cities?

Where current policies did exist, we assessed levels of actual policy implementation [80]. Some of these policies were created after established areas were developed, so one could argue that ours was an unfair assessment. Nevertheless, the assessment of policy implementation is important when trying to answer the question: are we there yet? It revealed that, in both new and established cities, there is little evidence that Australian cities are meeting current policy targets for walkability, public transport and public open space across the entire metropolitan area, or within suburbs and LGAs. The meeting of targets is even less likely in most newly established areas on the urban fringe of cities – the very places for which contemporary guidelines are intended.

The only circumstance where policy targets were being reached was in cities that set unambitious targets. Although harder to achieve, more ambitious targets are needed and should be encouraged, as they will ensure that governments continue striving to maintain and improve liveability across entire cities. Notably, attainment of policy standards varies significantly between neighbourhoods, suburbs and LGAs within cities, with residents of outer-suburban areas, and of many middle-level suburban areas, substantially less well served that those in the inner city.

Because policies to create liveable cities were state-specific and varied significantly from state to state, it was not always possible to make comparisons between cities. In addition, we conducted policy analyses for only four cities: Melbourne, Perth, Brisbane and Sydney. To enable comparisons between all Australian capital cities, we calculated policy-relevant national liveability indicators that our previous research found were associated with health and wellbeing. This enabled comparisons both within and between cities, with findings representing the type of neighbourhoods likely to promote the health and wellbeing of residents.

As with policy indicators, we observed considerable variation between and within capital cities in the implementation of interventions that will create healthy, liveable communities. These differences are discussed in detail in the section that follows.

12.3. Key findings and discussion

Overall, no Australian city performed well on all indicators, with some cities performing

better for some policy implementation or national liveability indicators, and weaker on others. We identified geographical inequities in attaining policy standards for healthy, liveable communities, and areas of greatest disadvantage in access to jobs, housing, walkable environments, services and infrastructure. However, the fact that some new outer-suburban areas appear to be walkable (for example in Perth), underscores the role that well-implemented urban policy could play in achieving better results for Australian cities.

12.3.1 Walkability

The policy analysis in Melbourne, Perth, Brisbane and Sydney revealed a degree of mismatch between the aspiration of creating walkable communities and the policies required to achieve walkability. This was particularly evident when considering dwelling density. State policies in Melbourne, Sydney and Brisbane all included a density standard for suburban development of 15 dwellings per hectare, a low policy ambition that will perpetuate sprawling development on the urban fringe. Perth had a more ambitious target for new suburban development – 26 dwellings per hectare – while Brisbane had a 30 dwelling per hectare target for 'urban' development. These latter levels of density – even if low by international standards – are more consistent with the evidence on levels of density required to create more walkable neighbourhoods, with more shops, services and public transport [96].

Despite Australian governments setting only modest targets for dwelling density, there is little evidence that these policies are actually being implemented. Irrespective of whether density is measured as gross or net, average dwelling densities in all Australian cities are very low and, with the exception of Sydney, well below each state's respective suburban-density targets. Sydney came the closest to meeting its density policy target (15 dwellings per hectare), with average suburb-level densities of 12.9 and 19.7 dwellings per gross or net hectare, respectively. Applying the more lenient net density measure, 37% of Sydney suburbs achieved the state government's policy target of 15 dwellings per hectare, as did 21% of Melbourne suburbs.

While Perth had the most ambitious density target for suburban development of all cities studied (26 dwellings per hectare), this was achieved by only 2% of Perth suburbs. Similarly, only 2% of Brisbane suburbs appeared to achieve that city's 'urban' target of 30 dwellings per hectare; 13% met its suburban target of 15 dwellings.

It is plausible that these overall results mask successful implementation of policies in new residential development areas, which is where new density policies are meant to apply. However, there was little evidence of this in the spatial maps of density for Australian cities. Given the importance of dwelling density to the viability of shops, services, amenities and public transport, the perpetuation of low-density suburban development in Australian cities makes it very difficult to achieve the walkable 30-minute (or 20-minute in Melbourne) city.

All cities except Sydney had measurable spatial policy targets to increase street connectivity (block and/or lot size), but few had targets. Only Perth and Melbourne appeared to have measurable spatial policies and targets for increasing access to local destinations. However, only a minority of dwellings in those cities met their state government targets (less than 10% and 40% respectively). This is important, because local destinations are essential for walkable neighbourhoods [120].

The national health-related walkability indicators broadly aligned with the policy requirements in each state. The composite walkability index (which combined dwelling density, daily-living destinations and street connectivity) highlighted the spatial patterning of walkability across Australian cities, with few residents of outer-suburban areas enjoying the benefits of living in a walkable area. In each capital city, walkability is generally concentrated in the inner (and in some cases middle-level) suburbs.

Nevertheless, there were notable exceptions. For example, a small number of outer-suburban developments in Perth appeared to be highly walkable, as did some of Canberra's established outer-suburban areas, which were designed to include local neighbourhood activity centres. This clearly reflects the implementation of policy. For example, the Perth results are likely to reflect the Western Australian government's trial of the Liveable Neighbourhood Guidelines [101], which began in 1997. Indeed, Western Australia appeared to have the most comprehensive range of spatially measurable urban design policies designed to create walkable neighbourhoods. However, a major

evaluation of the Liveability Neighbourhood Guidelines found the policy to be only 46% implemented [80, 120]. Nevertheless, with every 10% increase in implementation of the policy, residents were significantly more likely to walk, to have better mental health and sense of community, and be less likely to be victims of crime [121]. These results show that well-designed and well-implemented policy make it possible to create more walkable neighbourhoods, even in outer-suburban areas of Australian cities. Comprehensive more ambitious policies designed to create walkable environments in the suburbs could also be considered in other states.

Walkable neighbourhoods are the foundation of a liveable city. While comprehensive and integrated urban design is critical to making outer suburban development more walkable, integrated regional planning is also needed to provide essential infrastructure and services, particularly public transport and accessible local employment that will create 'liveable' communities. Hence, our findings suggest at this stage, walkable communities may not necessarily be achieving their potential as 'liveable' communities. These findings are considered in the sections that follow.

12.3.2 Public transport

Policies in Melbourne, Perth, Brisbane and Sydney all included standards for proximity to public transport, although the level of policy ambition varied from requiring 60% to 100% of dwellings to have proximate access. Only New South Wales had a target for proximity and frequency of service: access to a bus stop within 400 m serviced every 30 minutes, or a train stop within 800 m serviced every 15 minutes. Perth exceeded its state public transport target of 60% of residential lots being located within a 400 m (road network) of a bus stop or 800 m of a train station, but the Western Australian government's target is both modest at 60%, and substantially lower than those of other states.

Melbourne's public transport policy target of 95% of dwellings being within 400 m of a bus, 600 m of a tram or 800 m of a train stop is more ambitious than Perth and Brisbane's, and was achieved by 69% of dwellings. However, only inner and middle-level suburbs met this standard, and few residents living on the urban fringe enjoyed this level of access. Overall, 61% of Brisbane residents had a public transport stop within 400 m, but this was below its target of 90%. As noted, policy targets in Sydney were the most ambitious of the cities reviewed: that 100% of dwellings have proximate and frequent public transport services. Perhaps unsurprisingly, only 38% of dwellings had levels of access consistent with this policy standard.

The Australian National Liveability Study found that a measure of public transport access that combined proximity (a public transport stop within 400 m) with frequency of service (every 30 minutes) was a stronger predictor of walking for transport than a measure of access alone [32]. Hence, the health-related national liveability public transport indicator measured the percentage of residential dwellings within 400 m walking distance of a public transport stop, with a service at least every 30 minutes on a normal weekday. This enabled direct comparison of all capital cities, unlike the indicators comparing implementation of state government policies.

When this more ambitious target was applied, around 36% of dwellings in Melbourne, Adelaide and Sydney were found to have this level of access. Only 18% of Perth dwellings, between 11% and 13% of dwellings in Brisbane, Canberra and Hobart; and only 4% of dwellings in Darwin enjoyed this level of access. Melbourne, Perth, Brisbane and Sydney showed a clear pattern of better access to proximate and frequent public transport in areas closer to the city. Fewer areas in smaller cities such as Canberra, Darwin and Hobart had access to public transport comparable to that of other larger Australian cities, and the spatial patterning of access was less obvious, even though in Adelaide and Hobart public transport access was also higher closer to the inner city.

While residents of some cities faced greater public transport access barriers than others, these results show that the vast majority of dwellings in capital cities in Australia did not have access to proximate and frequent public transport services during weekday work hours. While proximity targets are easier to achieve, Australian cities could consider following the lead of New South Wales, by adopting more ambitious public transport targets that combine proximity with frequency of services.

12.3.3 Public open space

Melbourne, Perth, Brisbane and Sydney all had state policies requiring access to public open space within 400 m – or a five-minute walk – and three of the four states also had policies requiring access to larger parks of specified sizes within longer walking distances. In Sydney and Perth, policy targets were expressed as 'most' dwellings having access (interpreted in this study to mean more than 50%), although Perth also required all dwellings to have access to public open space (of any size) within 300 m. In Brisbane the target is for 90% of residences, in Melbourne it is 95%.

Overall, 82% of dwellings in Melbourne had access to a public open space within 400 m, 89% of dwellings in Perth had access to a neighbourhood park greater than 1 ha within 800 m, and 98% of dwellings in Sydney had a 2 ha park within 2 km of dwellings. As New South Wales policies set the targets for access to smaller public open spaces as 'most' dwellings (interpreted as 50% or more), it was the only city to achieve the state governments target, where 59% of residences had access to public open space greater than 0.5 ha within 400 m. Other states had more ambitious targets, in the range of 90–100%, and fell short of achieving this level of access.

There was a close relationship between the national liveability indicators for public open space and the policies in each state, and, in Victoria, a direct overlap. The national liveability indicators for public open space that allowed direct comparison of cities focused on access to public open space within 400 m, and another focused on proximate access to public open space with an area greater than 1.5 ha. The latter indicator was based on (as yet unpublished) research in Melbourne, indicating that only access to larger public open space encouraged recreational walking [106]. These indicators could only be calculated for Melbourne, Perth, Brisbane and Sydney, as similar data for other cities were not readily available. For access to public open space of any size within 400 m, Sydney and Melbourne (both 82% of residences) performed better than Perth (78%) and Brisbane City Council (75%). However, when access to public open space over 1.5 ha was taken into account, Perth (63%) and Brisbane City Council (52%) performed better than both Melbourne (49%) and Sydney (43%) where parks tended to be smaller.

Using the Mesh Block data on parkland, it was possible to compare all capital cities. Suburbs in Perth, Sydney and Canberra on average comprised more than 20% parkland, while Melbourne, Brisbane and Adelaide suburbs averaged less than 15% parkland. Although these data could not be used to assess the implementation of current Australian POS policies, they provide an indication of the total amount of 'greenness' in an area, which has been shown to benefit both physical and mental health [122-127].

There is growing evidence of a range of health benefits associated with access to larger, proximate public open space, including encouraging recreational walking [46, 108, 109]. However, to bring the greatest health benefits, it may be preferable to provide access to fewer but larger higher-quality local public open spaces within closer walking distances of dwellings [46]. To inform policy standards, more research is required on optimal size and distance to public open space, particularly for different population groups (children through to older adults). This needs to take into account the densification of cites, as well as protecting biodiversity and mitigation against heat island effects.

12.3.4 Housing affordability

In the policy review conducted in Melbourne, Sydney, Perth and Brisbane, no state-specific spatial or measurable policy standards were identified for housing affordability, availability or quality. This finding revealed a gap in policy. Thus, this study assessed housing affordability using only the two national liveability indicators found to be associated with health and wellbeing: the 30/40 measure of housing affordability, and the proportion of households renting.

Using the 30/40 indicator (based on the 2011 Census) more than one-third of lower-income households in Sydney, Brisbane, Melbourne, Darwin and Perth appear to be experiencing housing affordability stress. Sydney had the highest percentage (38%) of residents with incomes in the bottom 40% of the income distribution paying more than 30% of their household income on housing costs, closely followed by Brisbane (37%). Fewer lower-income households in Canberra (31%) appeared to be encountering housing affordability stress based on the 30/40 indicator. The proportion of households renting varied significantly between cities, with Darwin having the highest proportion of renters (43%).

In Sydney and Brisbane, and to a lesser extent in Melbourne, housing affordability stress appeared to spread across large areas of the city. Low-density housing on the urban fringe is generally seen as the policy solution to housing affordability problems experienced in Australian cities. However, when the spatial distribution of housing affordability stress was examined, the suburbs with the highest levels of housing affordability stress were located towards the urban fringe. Given that outer suburbs have poor access to public transport and are less likely to be walkable [112], these are the suburbs most at risk of mortgage stress, given high household expenditure on private motor-vehicle transportation. Moreover, these figures may under-represent current housing affordability stress, as the indicator is based on 2011 Census data, awaiting the 2016 Census data to become available.

12.3.5 Employment

As was the case with housing affordability, no measurable spatial state-based policy standards were identified for employment access or provision in local areas. Two aspects of employment were assessed: access to local employment measured by the percentage of employed people living and working in the same area; and travel mode to work for employed people over 15 years of age, as a measure of employment accessibility by transport mode (private motor vehicle, public transport, or active transport).

Across all major capital cities, a minority of the working population worked near home (varying from 26% in Brisbane to 43% in Darwin). When 'local' was broadened to the local metropolitan region scale (SA4), this increased to between 43% and 89% of the working population living and working in the same local metropolitan region. A higher proportion of people living in smaller capital cities (Canberra, Darwin and Hobart) did so. Residents of inner-city areas were more likely to live and work in the same area; the percentage tended to be lower in the middle 'commuter' suburbs, then rose again towards the city edge.

Across all cities, the vast majority of people over 15 years of age travel to work by private motor vehicle as their main mode of transport. Travel to work by public transport varied from 5% in Darwin to 23% in Sydney. Darwin had the highest rate of residents using active transport to get to work (9%), with the prevalence in other cities ranging from 4% to 8%. As cities increase in size, there is a general increase in the proportion using public transport to travel to work, but a decrease in active travel, due to (typically) increasing commuting distances and/or times.

The dependency of the vast majority of people in Australian cities on private motor vehicles for transport to work reflects, in part, transport and land-use planning that reduces the accessibility of employment by public transport and active transport modes [11]. These results underscore the difficulties faced by Australian cities aiming to achieve the 30-minute (or 20-minute in Melbourne) city. However, given that 26–43% of the working population in all capital cities lives and works in the same local area (SA3), there does appear to be an opportunity to increase active travel modes by walking and cycling, particularly for trips under 2–4 km [128]. Patterns of commuting longer distances to work in the middle suburbs and some outer suburbs suggests the need for a more equitable distribution of local employment opportunities in these areas, particularly in major activity centres. As the policy review showed, there appear to be no measurable state government spatial policies or targets for local employment access or economic development to support local economies.

12.3.6 Food environment

We identified no measurable spatial policies for access to healthy food choices, with the exception of a Victorian state government policy that 80-90% of households should be within 1 km of an activity centre with a supermarket. As a result, only national liveability food environment indicators were calculated. The healthy food ratio indicator (measured by the percentage of food outlets within 3200 m that are healthy food destinations – specifically supermarkets) was limited to four cities (Melbourne, Perth, Brisbane and Sydney). However, healthy food access measured by the proportion of dwellings within 1 km of a supermarket was calculated for all Australian state capital cities.

Across Melbourne, Perth, Sydney and Brisbane, just over one-half of food outlets within 3200 m of residents' homes were found to be fast food destinations; the healthy food ratio

was remarkably similar between and within these cities. However, there were 64 suburbs nationally where all residents had no access to either a major fast food destination or major supermarket within 3200 m. Over half of these were in Melbourne, with many located on the rapidly growing outer-urban fringe.

While access to a supermarket within 1 km varied significantly between cities, well over one-half of residential dwellings in all Australian capital cities were outside this comfortable walking distance to a supermarket, creating potential barriers to food access. Compared with other cities, fewer residences across Darwin's metropolitan area had access to supermarkets within 1 km (16.8%).

There appear to be geographic inequities in access to healthy food choices – both within and between cities – and some evidence of the need to improve access to healthy food relative to unhealthy food. Setting and achieving targets for access to activity centres with a supermarket in urban policy across Australia, following the example of the Victorian Precinct Structure Planning Guidelines [114, 115] may help here.

12.3.7 Alcohol environment

No measurable spatial state government policy standards were found for alcohol availability or accessibility in Western Australia, Victoria, New South Wales or Queensland. Hence, based on previous research of what was protective of public health, the national liveability indicators measured the percentage of residences without access to an on-licence outlet within 400 m, and without access to an off-licence outlet within 800 m. Due to difficulties in obtaining alcohol data nationally, this indicator was created for only four cities: Melbourne, Perth, Brisbane and Sydney.

While in Perth and Brisbane the vast majority of residents (90% and 86% respectively) do not live within 400 m of an on-licence alcohol outlet, more than one in five residents of Melbourne and Sydney (20% and 23% respectively) do so. Access to off-licence outlets within 800 m is more prevalent than on-licence outlets within 400 m. Only 52% dwellings in Melbourne, 44% in Sydney and 66% in Perth do not have access to an off-licence outlet within 800 m.

Indeed, we found that access to alcohol outlets is highly prevalent in Australian cities. Across all four cities studied, only 16.5% of suburbs had no residential addresses with access to an on-licence premises within 400 m (42 in Melbourne compared with 90 in Sydney). Similarly, only 12.3% of suburbs had no residential addresses with access to an off-licence within 800 m – with most of these suburbs (118) in Brisbane. The results for access to off-licences outlets in Brisbane were markedly different to the other capital cities, and it is not clear whether this reflected reality, or was caused by missing data on off-licence outlets in that city. Unlike in other states, there is only one liquor licence category that relates to off-licences in Brisbane: commercial hotels. This is a limitation, and alternative ways of collecting these data will be considered in the future.

Given the health and social harms caused by alcohol, most notable was the lack of planning policy across Australian cities for the spatial distribution of alcohol outlets, and the high level of access, particularly to off-licence outlets.

12.4 Recommendations

Based on our research, we offer seven recommendations.

Recommendation 1: Evidence-informed integrated transport, land-use and infrastructure planning is needed to deliver affordable housing, public transport, accessible employment and amenities, and to create walkable neighbourhoods as the foundation of a liveable city.

There are considerable inconsistencies in current state government planning policies and lack of agreement about what policies and standards could be used to enhance the liveability of Australian cities. This suggests lack of policy agreement about how to create liveable cities, and insufficient use of evidence to inform policy standards and targets. For example, it will not be possible to achieve walkable, liveable communities in Australian suburbs, building at 15 dwellings per hectare yet this is the current standard in three of Australia's fastest growing cities (Melbourne, Sydney and Brisbane). To maintain and enhance the liveability of Australian cities, it is critical that standards and targets are informed by quantitative evidence. To achieve equity within and between cities, there is a

need for greater alignment between states to produce more consistent evidence-based policies aimed at maintaining and enhancing the liveability of all Australian cities; and that local urban design policies are supported by integrated regional planning to deliver the infrastructure and amenities required to create a liveable city.

Recommendation 2: Include measureable spatial standards in state government urban, transport and infrastructure policies and/or guidelines, including short-, medium-, and long-term targets as appropriate.

Despite an extensive policy review in four major Australian capital cities, we identified relatively few measurable spatial standards or targets related to walkability, public transport, public open space, and none for housing affordability, employment and food and alcohol environments. State government policies contain many aspirational visions, goals and actions, but lack of clear targets or standards to achieve those aspirations. This makes it difficult to measure the impact of policy change or to benchmark and monitor the attainment of the desired goals. In addition, it is important that more ambitious 'stretch' targets be identified, rather than modest less ambitious targets. Thus, we therefore recommend inclusion of standards and short, medium and long-term targets in urban, transport and infrastructure policy and guidelines.

Recommendation 3: Develop spatial indicators of Australian cities to benchmark and monitor the implementation of state-based policies designed to create liveable communities.

As we have demonstrated in this report, national liveability indicators could be used to assess, benchmark and monitor city planning policies aimed at creating liveable cities. Spatial indicators enable inequities in cities to be benchmarked and monitored, and areas requiring further investment to be identified. The indicators in this report are a starting point for setting relevant and measurable standards into state government policy.

Recommendation 4: Develop agreed standards for the collection and categorisation of state government data that could be used to benchmark and monitor the implementation of urban policies in Australian cities.

One of the challenges of creating indicators that allow Australian cities to be directly compared, is inconsistencies in the way that spatial data in Australia is being collected and categorised. There is an urgent need for agreed standards to be put in place for the collection and categorisation of state and local government spatial data, and a stronger focus is also needed on spatial data relevant to active modes of transport (walking and cycling).

Recommendation 5: Update liveability indicators at least every five years, to coincide with the ABS Census, and more frequently when possible.

As Australian Bureau of Statistics data becomes available, relevant indicators in this report will be updated. However, in order to benchmark and monitor the liveability indicators, it will be necessary to update these on a regular basis. We recommend a complete update every five years to coincide with the Census, and indicators that could respond to shorter cycles of change, should be updated even more regularly.

Recommendation 6: Expand the Federal government's National Cities Performance Framework, to include policy implementation indicators for access to public transport, walkability, public open space, employment and affordable housing.

The Federal government's National Cities Performance Framework includes many downstream indicators of the outcomes of policies, but also requires 'upstream' indicators of policies and investments likely to create the outcomes being sought. For example, it includes indicators of modes of transport to work, without measuring access to public transport (or frequency of services). At this stage, there are no indicators to measure 'walkability' or 'live and work in the same area' (or a measure of job/housing balance) despite the aspiration to create 30-minute liveable cities. We recommend that the Federal government's National Cities Performance Framework be expanded to include policy and policy implementation indicators related to access to public transport, walkability, and employment. Moreover, it would be preferable if these were spatial, to enable inequities across cities and areas for future investment to be identified.

Recommendation 7: Move towards metropolitan governance of cities, starting by ensuring that state and local government policies are consistent and evidence-informed, and specifically designed to create healthy liveable communities.

Achieving urban liveability requires metropolitan-wide governance and integrated planning across sectors and all levels of government. Metropolitan-wide governance is ideal to create healthy liveable cities, and it is important that local and state government policies are consistent and evidence-based.

12.5. Concluding comments

Although increasing the liveability of Australian cities is an objective common to all three levels of government, our study identified only a limited number of measurable spatial policy standards that could be used to assess progress towards achieving this laudable goal. Variation in quantifiable urban policy standards may reflect a lack of agreement or different interpretation among policy-makers and decision-makers about how land-use, transport and infrastructure planning could be used to improve liveability for Australian communities. Moreover, while most metropolitan strategic plans aspire to achieve walkable, liveable 30-minute (or 20-minute) cities, in most cities policy standards do not support these aspirations. In many cases the policy ambition is modest, and inconsistent with the growing body of quantitative evidence about how to achieve such targets.

Given projected population growth in Australia, there is an urgent need for greater alignment of state government policies designed to achieve healthy, liveable and walkable communities, and for these policies to be evidence-informed and to include measurable targets designed to improve the health and wellbeing of residents and ensure that the quality of urban life is maintained as our cities grow.

Overall, no Australian city performed well on all indicators of policy implementation or national liveability, with some cities performing better on some indicators and weaker on others. There is little evidence that any Australian city is achieving contemporary policy targets for walkability, public transport and public open space across its entire metropolitan area. Moreover, within each city we observed considerable variation between neighbourhoods, suburbs and LGAs in the degree to which they are meeting these goals.

Our research demonstrated that it is possible to create spatial indicators that will allow urban policies to be benchmarked and monitored over time, and for the level of implementation to be assessed. This is important because it could assist in monitoring progress and in determining the highest priorities for local, state and Federal investment. Moreover, if linked to desirable results (e.g. use of active and public transport, less time spent commuting, less traffic congestion, and better health), these indicators could provide an early warning system in the event of unintended outcomes that require policy adjustment.

Developing these types of indicators in Australia at present is difficult because of variations between the states in standards for collecting and attributing spatial data. Some of these difficulties are explained in Appendix 4. Australia-wide standards are needed for the collection of consistent spatial data that could be used for the purpose of creating environmentally and economically sustainable Australian cities that will encourage residents to lead more active and healthy lives.

We hope that the findings of this study will (re-)spark a national conversation about the need for:

- policy-relevant evidence, and development of evidence-informed policies across Australian cities, with the aim of maintaining the liveability of Australian cities – particularly as our population grows;
- consistent state government policies to create urban liveability and to ensure greater equity within and between Australian cities;
- integrated metropolitan governance in Australian cities; and
- urban policies that will shape cities that foster the good health and wellbeing of all residents.

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Appendix 1

Policies reviewed for each domain

A1.1 Victoria

Table 11: Policies reviewed in Victoria

Policies and Legislation	Policy level	Relevant liveability domains						
		Housing	*Employment*	*Public Open Space*	*Public Transport*	*Walkability*	*Alcohol*	*Food*
Planning and Environment Act 1987 [119]	Legislation	✓	✓	✓	✓	✓		
Infrastructure Victoria Act 2015 [120]	Legislation	✓	✓	✓	✓	✓		
Victorian Planning Provisions [121]	Regulations	✓	✓	✓	✓	✓	✓	✓
Plan Melbourne 2014 [68]	Strategic policy	✓	✓	✓	✓	✓		✓
Precinct Structure Planning Guidelines Part One and Two [106] [107]	Guidelines	✓	✓	✓	✓	✓		✓
Transport Integration Act 2010 [122]	Legislation				✓	✓		
Activity Centre Design Guidelines [123]	Guidelines	✓	✓	✓	✓	✓		
Linking People and Spaces: A Strategy for Melbourne's Open Space Network [124]	Strategic policy			✓				
Open Space Planning and Design Guide [125]	Guidelines			✓				

Subdivision Act 1988 [126]	Legislation	✓		✓				
Planning for Community Infrastructure in Growth Areas [127]	Guidelines			✓				
A Guide to Social Infrastructure Planning [65]	Guidelines			✓				
A Guide to Governing Shared Facilities [128]	Guidelines			✓				
Higher Density Residential Development Guidelines [129]	Guidelines	✓				✓		
Public Transport Guidelines for Land Use and Development [130]	Guidelines				✓	✓		
Cycling into the Future 2013-2023: Victoria's Cycling Strategy [131]	Strategic policy				✓	✓		
Liquor Control Reform Act 1998 [132]	Legislation						✓	
Victoria Government Gazette No. G 23 Thursday 7 June 2012 [133]	Legislation						✓	

A 1.2 Western Australia

Table 12: Policies reviewed in Western Australia

Policies and legislation	Policy level	Relevant liveability domain						
		Housing	*Employment*	*Public open space*	*Public transport*	*Walkability*	*Alcohol*	*Food*
Planning and Development Act 2005 [144]	Legislation	✓	✓	✓	✓	✓		
Planning and Development (Local Planning Scheme) Regulations 2015 [145]	Regulation	✓	✓	✓	✓	✓		
State Planning Strategy 2050 [146]	Strategic policy	✓	✓	✓	✓	✓		
Affordable Housing Strategy 2010–2020: Opening Doors to Affordable Housing [147]	Strategic policy	✓						
State planning policies (including State Planning Framework) [148]	Strategic policy	✓	✓	✓	✓	✓		
Directions 2031 and Beyond: Metropolitan Planning Beyond the Horizon [71]	Strategic policy	✓	✓	✓	✓	✓		
Public Transport for Perth in 2031 [149]	Strategic policy				✓			
Western Australian Bicycle Network Plan 2014–2031 [150]	Strategic policy				✓			
Public Transport Authority Strategic Plan 2013–17 [151]	Strategic policy				✓			
Classification Framework for Public Open Space [152]	Strategic policy			✓				
Community Use of School Facilities and Resources [153]	Strategic policy			✓				
Development Control and Operational Policies [154]	Guidelines	✓	✓	✓	✓	✓		
Liveable Neighbourhoods 2009 and 2015 (Draft) [90, 107][1]	Guidelines	✓	✓	✓	✓	✓		✓
Planning bulletins, fact sheets, manuals and guidelines [155]	Guidelines	✓	✓	✓	✓	✓		
Walk WA: A Walking Strategy for Western Australia 2007–2020 [156]	Strategic policy					✓		
Liquor Control Act 1988 [157]	Legislation						✓	
Liquor Control Regulations 1989 [158]	Regulation						✓	
Liquor Control Act 1988: Report of the Independent Review Committee [159]	Legislation						✓	

[1]Both versions of Liveable Neighbourhoods were reviewed, with policy standards selected from Liveable Neighbourhoods 2015 where possible. Policies from the 2009 version were selected where there was no relevant, measurable policy standard in the 2015 version.

A 1.3 Queensland

Table 13: Policies reviewed in Queensland

Policies and legislation	Policy level	Relevant liveability domain						
		Housing	*Employ-ment*	*Public open space*	*Public transport*	*Walkability*	*Alcohol*	*Food*
Sustainable Planning Act 2009 [160]	Legislation	✓	✓	✓	✓	✓		
Sustainable Planning Regulation 2009 [161]	Regulation	✓	✓	✓	✓	✓		
Transport Infrastructure Act 1994 [162]	Legislation				✓	✓		
State Planning Regulatory Provisions – Delivering Queensland Affordable Housing Strategy: Greenfield land supply in South East Queensland [163]	Regulation	✓						
Queensland Housing Affordability Strategy [164]	Strategic policy	✓						
State Planning Policy (SPP) [165]	Strategic/statutory policy	✓	✓	✓	✓	✓		✓
State Planning Policy guidance material [166]	Guidelines to implement SPP	✓	✓	✓	✓	✓		✓
Queensland Planning Provisions [167]	Statutory planning	✓	✓	✓	✓	✓		
State Infrastructure Plan Part A and B [168, 169]	Strategic policy	✓	✓	✓	✓	✓		
South East Queensland Regional Plan 2009–2031 [70]	Strategic policy	✓	✓	✓	✓	✓		
South East Queensland Regional Plan 2009–2031: State planning regulatory provisions [165]	Regulation	✓	✓	✓	✓	✓		
Shaping SEQ: Draft South East Queensland Regional Plan [166]	Strategic policy	✓	✓	✓	✓	✓		
Positively Green: Queensland Greenspace Strategy 2011–2020 [170]	Strategic policy			✓				
South East Queensland Infrastructure Plan and Program 2009–2026 [171]	Strategic policy				✓	✓		
Connecting SEQ 2031: An Integrated Regional Transport Plan for South East Queensland [172]	Strategic policy	✓	✓	✓	✓	✓		
Queensland Cycle Strategy 2011–2021 [173]	Strategic policy				✓	✓		
Priority Development Area guidelines and practice notes [174]	Guidelines	✓	✓	✓	✓	✓		
Liquor Act 1992 [175]	Legislation						✓	
Liquor Guideline 38: Community Impact Statement [176]	Guideline						✓	

A 1.4 New South Wales

Table 14: Policies reviewed in New South Wales

Policies and legislation	Policy level	Relevant liveability domain						
		Housing	*Employ-ment*	*Public open space*	*Public transport*	*Walkability*	*Alcohol*	*Food*
Environment Planning and Assessment Act 1979 [177]	Legislation	✓	✓	✓	✓	✓		
Environment Planning and Assessment Regulation [178]	Regulation	✓	✓	✓	✓	✓		
State Environment Planning Policies [179]	Regulation	✓	✓	✓	✓	✓		✓
Standard Instrument – Principal Local Environmental Plan [180]	Regulation	✓	✓	✓	✓	✓		
A Plan for Growing Sydney [69]	Strategic policy	✓	✓	✓	✓	✓		✓
First Things First: State Infrastructure Strategy 2012–32 [181] and State Infrastructure Strategy Update 2014 [182]	Strategic policy	✓	✓		✓	✓		
Long Term Transport Masterplan [183]	Strategic policies				✓	✓		
NSW Road Safety Strategy 2012–21 [184]					✓	✓		
Integrated Transport and Land Use: Improving Transport Choice – Guidelines for Planning and Development [104]					✓	✓		
Integrated Public Transport Service Planning Guidelines: Outer Metropolitan Area & Sydney Metropolitan Area [102, 103]					✓			
Housing Choice and Affordability in Growth Areas: Dwelling Density Guide [185]		✓				✓		
NSW 2021: A Plan to Make NSW Number One [186] and the Premier's Priorities [187]	Strategic policy	✓	✓		✓	✓		✓

Policies and legislation	Policy level	Relevant liveability domain						
		Housing	*Employ-ment*	*Public open space*	*Public transport*	*Walkability*	*Alcohol*	*Food*
Recreation and Open Space Planning Guidelines for Local Government [91]	Guidelines			✓				
Liquor Act 2007 [188]	Legislation						✓	
The Environment and Venue Assessment Tool (EVAT) [189]	Guideline/tool						✓	
NSW Government Response to the 'Statutory Review of the Liquor Act 2007 and the Gaming and Liquor Administration Act 2007' [190]	Policy						✓	
NSW Department of Trade and Investment, Office of Liquor, Gaming and Racing website [189]	Policy						✓	

Appendix 2

Included policy standards

A 2.1 Walkability

Table 15: Included policy standards for walkability

Source of policy requirement or indicator	Policy	Policy standards
Victorian State Government	Victorian Planning Provisions [131] Clause 56.06–7, Standard C20	Provide street blocks that are generally between 120 m and 240 m in length and generally between 60 m and 120 m in width, to facilitate pedestrian movement and control traffic speed.
Victorian State Government	Precinct Structure Planning Guidelines Part Two [115] Element 3, p. 26, S3	80–90% of households should be within 1 km of a town centre of sufficient size to allow for provision of a supermarket.
Victorian State Government	Precinct Structure Planning Guidelines Part One [114] Objective 2, p. 10	Generally, there is an average net density of 15 dwellings per developable hectare or more.
Western Australian State Government	Liveable Neighbourhoods 2009 [90] Element 3, R3	To facilitate lot diversity and an urban structure that is pedestrian friendly, street and lot layouts should provide for perimeter street blocks that are generally in the range of 70–120 m deep by 120–240 m long.
Western Australian State Government	State Planning Policy 4.2: Activity Centres for Perth and Peel [148]	Secondary activity centres and district activity centres should have a walkable catchment of 400 m, and neighbourhood centres should have a walkable catchment of 200 m.
Western Australian State Government	Liveable Neighbourhoods 2009 Element 7 Activity Centres R14	Neighbourhood centres should be located and distributed to provide a centre for most residents in a 400–500 m walk.

Western Australian State Government	Directions 2031 and Beyond: Metropolitan Planning Beyond the Horizon [71] p. 4	Sets a target of 15 dwellings per gross urban-zoned hectare of land in new development areas.
Western Australian State Government	Liveable Neighbourhoods 2015 [107] Element 1 (also see Directions 2013 and Beyond [71])	The current dwelling targets in greenfield areas for the Perth and Peel region is 15 dwellings per gross urban hectare and 26 dwellings per site hectare.
Western Australian State Government	Liveable Neighbourhoods 2015 [107] Element 4, R6.1	A range of residential lot sizes suitable for a variety of housing types and densities provided, preferably within each street block.[1]
Queensland State Government	Priority Development Area guidelines and practice notes [174] Neighbourhood planning and design: PDA guideline no. 5	Block sizes: • Length 100–200 m • Mid-block break providing a pedestrian link when blocks are over 130 m • Depth 40–80 m
Queensland State Government	Priority Development Area guidelines and practice notes [174] Neighbourhood planning and design: PDA guideline no. 5	• Suburban neighbourhood – average net residential density of at least 15 dwellings per hectare (unless prevented by topography or other constraints). • Urban neighbourhood – average net residential density of at least 30 dwellings per hectare. • Higher-density residential development is located in and around neighbourhood centres, along connector streets and within 400 m of transit nodes. Note: net residential density means the total number of dwellings divided by the combined area of residential lots, local parks, internal local roads and half the width of local roads bordering the site. Average net residential density means net residential density calculated for a whole neighbourhood.
NSW State Government	Integrated Transport and Land Use Guidelines [104] (also see Housing Choice and Affordability in Growth Areas: Dwelling Density Guide [185], which suggests a minimum 15 dwellings per hectare for growth areas)	A minimum gross neighbourhood residential density of 15 dwellings per hectare needs to be achieved to support reasonable bus services.

[1] The policy indicates that the provisions of small lots (less than 350 m2) is more likely to result in two-storey town housing and town-centre-style residential development, and the densities needed to support neighbourhood and town centres. Assigning typologies of size allowed for an assessment of the relative mix and share of the different lot sizes. All cadastre were coded into one of five size categories, based on the policy standards, previous measures used by The Planning Group WA [191] and consultation with the Department of Planning: less than 350 m^2; greater than 350 m^2, less than 550 m^2; greater than 550 m^2, less than 750 m^2; greater than 750 m^2, less than 950 m^2, greater than 950 m^2. For each development, the number of cadastre in each size category was computed as a percentage of the total number of cadastre. The presence of a greater number of lot-size bands assists in creating a more diverse range of housing stock and choice, supporting the policy objectives.

A 2.2 Public transport

Table 16: Included policy standards for public transport

Source of policy requirement or indicator	Policy	Policy standards
Victorian State Government	Precinct Structure Planning Guidelines Part Two Element 6, p. 44, S7	95% of dwellings are located not more than 400 m street-walking distance from the nearest existing or proposed bus stop.
Victorian State Government	Victorian Planning Provisions [131] Clause 56.04–1, Standard C7	95% of dwellings to be located no more than 400 m street-walking distance from the nearest existing or proposed bus stop, 600 m street-walking distance from the nearest existing or proposed tram stop, and 800 m street-walking distance from the nearest existing or proposed railway station.
Western Australian State Government	Liveable Neighbourhoods 2009 [90] Element 2 Movement Network, R37 Liveable Neighbourhoods 2015 [107] Element 1, p. 14 (also see Development Control Policy 1.6 [154])	At least 60% of dwellings should be in a safe 400 m walk from a neighbourhood or town centre, or an existing or potential bus stop, or in a safe 600 m walk from a railway station. Most people will consider walking up to 400 m to reach services and facilities, or 800 to a train station or higher-order centre.
Queensland State Government	Priority Development Area guidelines and practice notes [174] Neighbourhood planning and design: PDA guideline no. 5	90% of all dwellings are within 400 m of an existing or planned public transport stop.
NSW State Government	Integrated Transport and Land Use Guidelines [104][1]	Households should be within an 800–1000 m walk of an existing or programmed metropolitan railway station or equivalent mass-transit node, served at least every 15 minutes, or within a 400 m walk of a bus route, accessing a metropolitan railway station, or equivalent mass-transit node, served at least every 20–30 minutes.

[1] The more recent Integrated Public Transport Service Planning Guidelines [102, 103] were also reviewed, but their policy standards were found to be complex, and not able to be measured using existing data. Therefore, the policy standard from the 2001 Integrated Transport and Land Use Guidelines (still available at the time of analysis) was selected for inclusion.

A 2.3 Public open space

Table 17: Included policy standards for public open space

Source of policy requirement or indicator	Policy	Policy standards
Victorian State Government	Victorian Planning Provisions [131] Clause 56.05–2, Standard C13 (also see Precinct Structure Planning Guidelines Part Two [115], Element 5, p. 34, S1)	Local parks within 400 m safe walking distance of at least 95% of all dwellings. Where not designed to include active open space, local parks should be generally 1 ha in area and suitably dimensioned and designed to provide for their intended use and to allow easy adaptation in response to changing community preferences.
Western Australian State Government	Liveable Neighbourhoods 2015 [107] Element 1, Requirement 5.1	Public open space should be provided within 300 m (of safe walking distance) to all residential lots.[1]
Western Australian State Government	Classification Framework for Public Open Space [152]	Local parks:[2] access within 400 m or 5-minute walk; typical size 0.4 ha to 1 ha.
Western Australian State Government	Classification Framework for Public Open Space [152] (also see Liveable Neighbourhoods 2015 [107])	Neighbourhood open space:[2] access within 800 m or 10-minute walk; typical size 1 ha to 5 ha.
Western Australian State Government	Classification Framework for Public Open Space [152] (also see Liveable Neighbourhoods 2015 [107])	District open space:[2] within 2 km or 5-minute drive; typical size 5 ha to 15+ ha.[3]
Queensland State Government	Priority Development Area guidelines and practice notes [174] Park planning and design: PDA guideline no. 12	90% of dwellings within 400 m of a neighbourhood recreation park or other park providing equivalent informal recreation opportunities. Neighbourhood recreation park minimum area: 5000 m^2
Queensland State Government	Priority Development Area guidelines and practice notes [174] Park planning and design: PDA guideline no. 12	90% of dwellings within 2.5 km of a district recreation park. District recreation park minimum area: 5 ha.
NSW State Government	Recreation and Open Space Planning Guidelines for Local Government [91][4] Table 4. Default standards for open space planning in NSW	District parks within 2 km of most dwellings. District park size 2–5 ha.
NSW State Government	Recreation and Open Space Planning Guidelines for Local Government [91][4] Table 4. Default standards for open space planning in NSW	Local parks within 400 m of most dwellings.

[1] This is a proposed new standard for inclusion in the revised version of the Liveable Neighbourhoods policy. It was included to provide a benchmarking analysis of the current levels of access against this new standard.

[2] The parkland classification framework is being adopted by the Department of Planning in the proposed new version of Liveable Neighbourhoods. The size categories were similar to those previously outlined in the Liveable Neighbourhoods policy and so were used to benchmark current levels of POS against these new standards.

[3] For the purposes of analysis, the upper size threshold of the district-sized parks was classified as less than or equal to 20 ha. This was decided in collaboration with the Department of Sport and Recreation, as its size classification for regional open space started at 20 ha.

[4] This guideline may no longer be operational at the time of writing (September 2017), as it is no longer available online.

Appendix 3
Data sources and processing

A 3.1 Defining study areas – an example for Melbourne

The methods used to define study areas and map results are described in Section 4. But to further assist understanding we have provided a worked example for Melbourne in Figure 39. The first panels show the Greater Capital City Statistical Area (GCCSA) for Greater Melbourne in yellow, and the Statistical Division (SD) for Melbourne in orange. Overlaid upon one another, as in the next panel, the map shows that the SD is contained fully within the GCCSA, which stretches another 20 km further north. Also overlaid in this second panel, in red, are the metro urban and other urban areas of the state. A number of areas of red sit within the GCCSA, but outside the SD: Bacchus Marsh, Gisborne, Macedon, Riddells Creek, Romsey, Lancefield, Wallan and Heathcote Junction. This study determined residential addresses within the study region based on the SD definition of Melbourne rather than on the GCCSA definition. However, ABS results have been summarised at the metropolitan level using the GCCSA definition. A consequence of this is that Bacchus Marsh residences are not included in calculations for, say, access to public transport or access to public open space, but are included in metropolitan-level averages for housing affordability and employment. When calculations are updated for the 2016 Census data, we will endeavour to align all results to the GCCSA boundaries.

The final panel in Figure 39 shows the suburbs of the study region masked by the non-residential Mesh Blocks, leaving visible only those areas of Melbourne defined by the ABS as residential. While a similar but slightly different approach was taken to determine the in-scope residential addresses (see Section 4.3.2), Mesh Block masking is a convenient way of remedying the otherwise distorting effects of portraying a whole suburb result over a large area when only a small proportion of that area is residential. For Melbourne, the Mesh Block mask has the most visual impact for outer south-eastern (e.g. Dandenong South) and north-western (e.g. Laverton North, Campbellfield) suburbs. The major limitation of this approach is that Mesh Blocks have only a single category of land use, and therefore results are sometimes obscured for areas where there is a significant number of residential dwellings but the primary land use is not residential. An obvious example of this is the Melbourne central business district, which is home to a population of nearly 40,000 people, but classified primarily as commercial and therefore masked in the maps.

A 3.2 Walkability

The wide range of policy and national liveability indicators for walkability required a more diverse collection of datasets than did any other urban liveability domain. The foundation dataset for walkability is the one that reflects where people can walk: the walkable street network. We used the pedestrian-accessible street network dataset described in Section 4.3.5 as a proxy for a 'pedestrian' network. However, as noted in Section 4.3.5, a true pedestrian network would include footpaths and mid-block links, for which we were unable to obtain national data .

Block size

Calculating block lengths and widths is somewhat subjective, as the orientation of blocks varies, and blocks are often irregularly shaped. In this study we calculated block length and width equivalents using the following approach. Based on an example block that under Victorian policy is between 120 m and 240 m long, and between 60 m and 120 m wide, we converted the dimensions to an upper bound for the perimeter. The maximum perimeter of a regular-shaped complying block would be 240 m + 120 m + 240 m + 120 m = 720 m. Using cadastral data sourced from PSMA [92], we then identified all blocks within areas defined as residential, based on ABS Mesh Block classifications. The number of blocks that met the target was divided by the total number of blocks within each

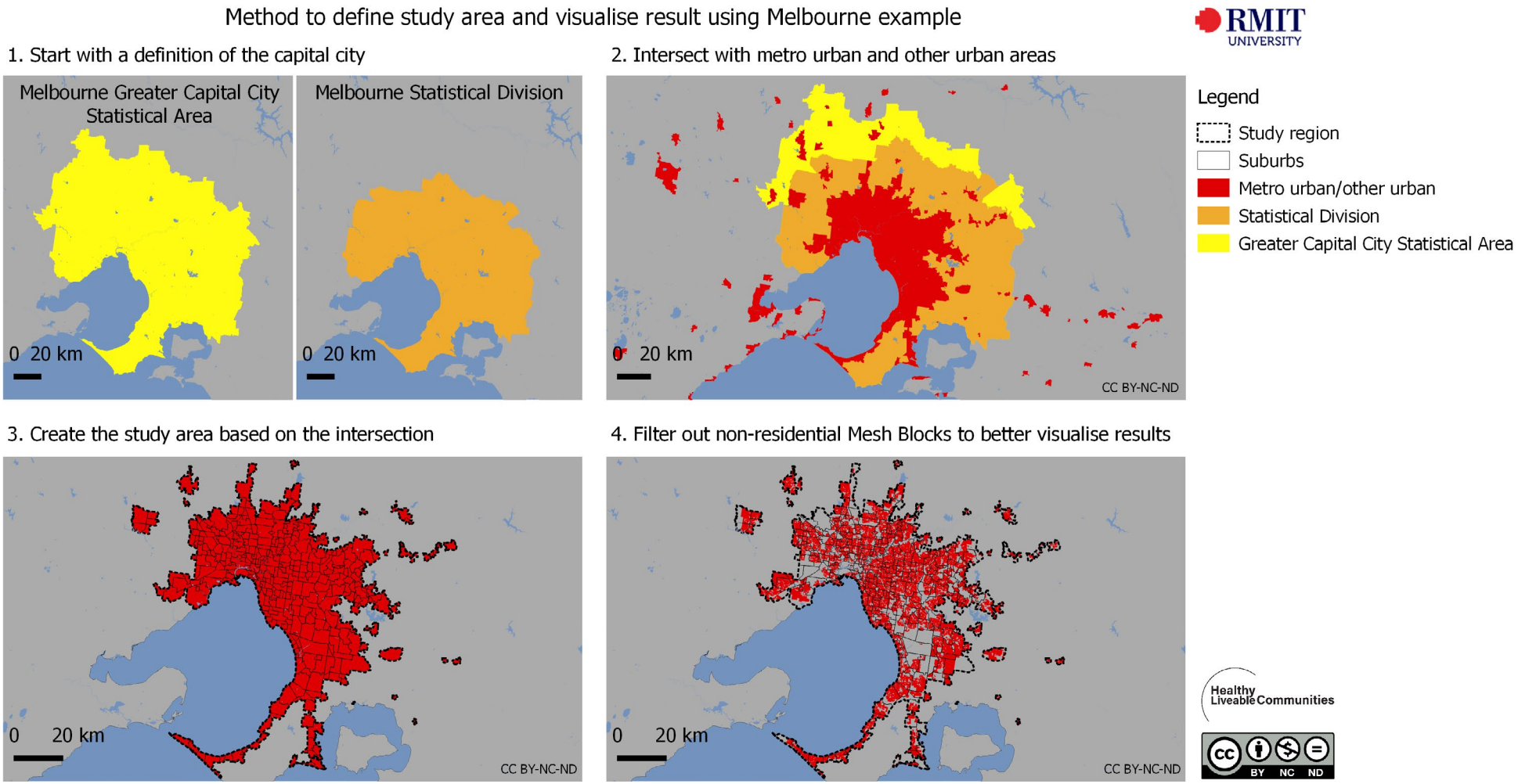

Figure 39: Method to define study area and visualise result using Melbourne example

aggregated reporting area: suburb, LGA and GCCSA.

Dwelling density

Calculating dwelling densities is computationally straightforward. For a given area (for instance, a suburb), the total number of dwellings (sourced from ABS data) is divided by the area in hectares. From state to state, the denominator in this calculation is generally further qualified: in Victoria the policy target is based on a 'developable hectare', in Western Australia a 'gross urban hectare' or 'site hectare', in Queensland the land is classed as either 'urban' or 'suburban' for density calculations, and in New South Wales it pertains to 'new residential release areas'. We were unable to source data allowing us to calculate densities for only the qualified areas to which the policy applied, so we calculated two density measures that allowed comparisons between cities. The first was a measure of gross density, where for each area the total number of dwellings based on ABS Mesh Block data was divided by the total area. The second measure was net density, where for each area the total number of dwellings in residential Mesh Blocks was divided by the total area of residential Mesh Blocks only.

Daily-living destinations

The destination types in the daily-living score included supermarkets, public transport stops, convenience stores and newsagents. The choice was based on previous empirical research showing that access to these destinations encourages more walking [100], and was used as an alternative to land-use mix commonly used in walkability indices, because we were unable to replicate this nationally [89]. In unpublished analyses, this variable produced similar results to the traditional land-use mix in the walkability index. We used business-listings data sourced from Acxiom Australia [192] to create the destinations in an origin–destination cost matrix, where each origin was a residential address within the study area. To compute the daily-living score for each residential address, one point was assigned for having any supermarket, any public transport shop and/or any convenience store, petrol station or newsagent within 1600 m.

Dwelling density and street connectivity

Of all the indicators calculated in this study, dwelling density and street connectivity were the most computationally intensive, as both relied on the creation of a spatial buffer for each residential address. The spatial buffer is calculated for each residential address by first determining the pedestrian-accessible street network within 1600 m. This set of streets is then buffered by 50 m to create the spatial buffers. The area of this spatial buffer is used as the denominator in both the dwelling density and street connectivity calculations. In the case of dwelling density, the numerator is the count of dwellings in the Mesh Blocks intersecting the buffer. In the case of street connectivity, the numerator is the count of intersections that connect three or more streets.

Composite walkability indicator

Once the daily-living score, dwelling density and street connectivity had been calculated, a composite walkability indicator was derived. For each city, results were first aggregated and averaged for the spatial areas for which the composite indicator was calculated, for example in this case the suburb level. For each suburb, the three individual measures were then converted to a standardised score reflecting how many standard deviations each result was from the mean (a z-score) and the z-scores for all three measures were added together to provide a suburb-level walkability z-score. For each city, the composite z-scores were then ordered from lowest to highest, and results converted to deciles.

Pedshed ratio

The final walkability indicator is the pedshed ratio: the buffered area of the 400 m street network distance from each residential address, divided by the radial 'crow flies' area within 400 m – that is, 50.2 ha. For each SA1, a generalised service area [193] with a cut-off distance of 400 m was calculated for the centroid of the SA1. This was then converted to a percentage by dividing by the 'crow flies' area of 50.2 ha.

A 3.3 Public transport

In each state or territory, the government department or authority responsible for planning public transport typically publishes data on public transport stops and timetables on their websites in a format known as the General Transit Feed Specification (GTFS) [194]. GTFS defines a common format for public transport schedules and associated geographic information, and was used to determine the stop locations by mode, and the frequency of services at each stop.

Where an indicator required calculation of stop frequency as well as stop access, stops were filtered out from the access calculation if they did not meet the required frequency threshold. Because service frequencies differ by time of day and day of the week (and in some cases by time of year – such as school holidays), we calculated frequencies between 7 am and 7 pm on a normal (non-school-holiday) weekday. Friday timetables were typically excluded from the analysis, because in many cities services operate on a different schedule on Fridays from other weekdays. We applied a strict interpretation of the filter criteria: if at a given stop there were no services before 7.30 am or after 6.30 pm, or if at any time during the day consecutive services were spaced more than 30 minutes apart, that particular stop was filtered out from the access calculation. Using the 30-minute service frequency, a minimum of 56% (in the case of Melbourne) and a maximum of 96% (in the case of Darwin) public transport stops were filtered out from the original dataset of public transport stops.

As outlined in Section 4.3.5, we used a pedestrian-accessible road network to determine distances between origins (residential addresses) and destinations (in this case, public transport stops). For Perth, this approach created a problem, because the Mandurah railway line runs along the median strip of the Kwinana Freeway for part of its route. As freeways are not walkable streets they are removed from the pedestrian-accessible street network, and this isolated the stations from the surrounding neighbourhoods when using our standard analysis approach. To deal with this, for Perth train stations we generated a road network service area extending 800 m from each train station and selected all residential addresses within this buffer to determine which residential addresses had access to train stations.

A 3.4 Public open space

We encountered significant difficulties in sourcing data suitable for analysing access to public open space across Australian cities. Although PSMA does provide a Greenspace layer as part of its Transport and Topography dataset [195], this does not contain many of the categories of POS that were included in our analysis. The PSMA Geoscape dataset [196], based on high-resolution satellite imagery, provides useful data on tree-cover, as does CSIRO's Urban Monitor [197], which is based on high-resolution aerial imagery. But for both these products, data were not yet available for all major Australian capital cities, and would in any case have required further processing to combine with land-ownership data in order to be of use for POS analysis. The ABS does, however, categorise Mesh Block land-use nationally, and for this study we used that data as a proxy for a national POS dataset.

Mesh Blocks are the smallest geographical area defined by the ABS, containing between 30 and 60 dwellings. Each Mesh Block is classified by the ABS according to the dominant land use: water, parkland, residential, industrial, commercial, education, hospital/medical, agricultural, transport, and other. All Mesh Blocks from the 2011 Census dataset classified as 'parkland' were extracted. The Mesh Blocks were used to represent a measure of the total amount of greenness in an aggregate area – either the suburb or the entire GCCSA. The parkland Mesh Blocks were tagged to the suburb and GCCSA in which they fell. For each suburb and GCCSA, the sum area of all Mesh Block parkland polygons present was calculated as a percentage of the gross area of that suburb or GCCSA. Mesh Blocks identified as 'agricultural' were not considered as parkland, because these areas are not generally accessible by the public for recreation or physical activity. Domestic gardens were also not included in the parkland category. These data allowed the calculation of two national liveability indicators that allowed states to be compared: the percentage of gross area that is parkland, and the proportion of suburbs with different percentages of parkland measured at the Mesh Block level.

For Melbourne, Perth, Brisbane and Sydney, both the policy implementation measures and the remaining national liveability indicators required a more precise dataset, where individual public open spaces could be located explicitly and their areas determined. This

required sourcing the best available data on POS in each state. POS data for Melbourne was sourced from the Victorian Environmental Assessment Council [198]. For Perth, a digital spatial database reflecting the spatial extent of all areas of green POS across the metropolitan Perth region for 2012 was obtained from the Centre for the Built Environment and Health at the University of Western Australia (Centre for the Built Environment and Health 2013). For Brisbane, a list of park locations and names [199] was downloaded from Brisbane City Council's online spatial data repository [200]. Parkland parcels were identified for each park-geocoded location, using cadastral data [201]. Each park was then manually checked using high-resolution ortho-imagery to verify the boundary extents, and modify them where needed. For Sydney, data were obtained from the Government Architect NSW through the NSW Department of Planning and Environment [202].

From each state dataset, the first consideration was what types of green space constitute public open space. The types of green space typically included in the POS-related planning policies were freely accessible green open spaces catering for a range of active, passive and social recreational and play needs. This included parks, gardens, reserves, and recreational and sporting areas (excluding golf courses, which are not free). Categories typically excluded from the definition of POS were national parks, state forests and bushland. Unfortunately, as outlined in Appendix 4 – public open space, because this taxonomy of POS varies across states, we could not accurately align definitions across states, so we made the closest approximation possible based on available categories.

The next consideration for each state dataset was the determination of a park's area. In some cases this was straightforward – for example, a rectangular reserve distinct from any other park. However, a number of more difficult scenarios arose. For example, if two 1 ha parks of different names were divided by a road they could reasonably be assumed to constitute two distinct public open spaces. But if both were classified as parks (rather than some other category) and the road was a minor road, they could be viewed as a single 2 ha park. In general, for this study we considered these parks as separate for the purpose of calculating areas for access. A further problem arose with linear parks, such as typically occur along waterways. Although these can often be large in area, only a small proportion of that overall area will be accessible within easy walking distance. For our calculations we used the total area of the linear park.

The final step in pre-processing each state dataset was to add points at intervals on the perimeter of each POS area to facilitate more accurate calculations of access distances. This approach was required to avoid measurement error that would result from using the centroid of public open spaces of varying shapes and sizes [203]. Instead of representing each POS by a single point at its geometric centre, we represented it by many points at regular intervals along its boundaries. For Melbourne and Sydney, intervals of 50 m were used; for Perth and Brisbane, 40 m intervals were used.

As outlined in Section 4.3.5, we used a pedestrian-accessible road network to determine distances between individual residential address origins and POS destinations. To calculate access to POS meeting specific area criteria (such as parks greater than or equal to 1.5 ha), we first filtered out any POS perimeter points attached to POS that did not meet criteria (e.g. perimeter points attached to POS less than 1.5 ha).

A 3.5 Housing affordability

The 30/40 measure of housing affordability was based on custom data provided by the ABS [78, 204]. The number of households in the first and second quintiles of income distribution, who were spending more than 30% of household income on housing costs, was divided by the total number of households in the first and second quintiles of the income distribution whose household costs could be determined. This proportion was calculated for suburbs and LGAs within the study area, and for each capital city GCCSA.

We used the ABS TableBuilder tool to extract national datasets for tenure by GCCSA, LGA and SSC (suburb) [205]. From this, the proportion of households renting was calculated.

A 3.6 Employment

The living and working in same area national liveability indicator was constructed from ABS data. The ABS TableBuilder tool was used to extract a national dataset comprising SA2

of usual residence and SA2 of place of work; LGA of usual residence and LGA of place of work; and GCCSA of usual residence and GCCSA of place of work [206]. A Python script was used to calculate the percentages for the various live and work in same area metrics, and results were linked to spatial boundaries also obtained from the ABS [113].

To determine method of travel to work (active transport, public transport or private vehicle), ABS data for method of travel to work (MTWP) were used [207]. The ABS TableBuilder tool was used to map the more than 200 MTWP permutations (e.g. 'car as driver, train') into one of the three categories (e.g. 'public transport') using customised aggregations. A consequence of this simplification into a single non-overlapping category was that active transport (i.e. 'walked', 'bicycle') in conjunction with any other mode was categorised based on that other mode. Similarly, journeys to work involving both a private vehicle and public transport were categorised as public transport.

A 3.7 Food environment

The food environment is highly dynamic, with destinations changing from year to year. Unlike the alcohol environment, however, there is no government licensing or regulation, and therefore no central record of destinations. Previous Australian studies of the food environment have used business-listings data, most notably from Sensis [208] or Acxiom [192]. The advantage of this is that it includes individual fast food destinations and supermarkets that are not part of any chain. However, business-listings data are subject to geocoding errors. To provide the most accurate picture of fast food and fresh food locations, we decided to source data directly from the websites of major chains only. As major chains manage closely the information on their websites and provide 'find a store' map services, their geocoded locations are much more likely to be accurate than those automatically geocoded from a raw address in generic business-listings data. Naturally, using major chain food environment data omitted some categories of fresh food such as greengrocers, butchers and fishmongers; it also excluded a proportion of fast food and takeaway destinations (e.g. a fish and chips shop in a local shopping strip). However, we felt that the improved spatial accuracy of destinations used in the food ratio warranted using major chain food environment data as a proxy for the overall food environment. Data were collected nationally, although food ratios were only calculated for major capital cities. The number of major fast food destinations and supermarkets is summarised by state/territory in Table 18.

For each residence in the study area of the four major capital cities, we calculated the number of major fast food outlets and supermarkets within a 3200 m pedestrian-accessible road network distance. From this the percentage of fast food destinations of the total (fast food destinations plus supermarkets) was calculated at residential address level. If neither fast food nor supermarkets was present within a 3200 m distance, a null value was recorded and this residential address was then excluded from subsequent averages.

A 3.8 Alcohol environment

Liquor licensing data was sourced from the government authority responsible for issuing licences in each state:

- the Victorian Commission for Gambling and Liquor Regulation (VCGLR)
- the Department of Racing, Gaming and Liquor WA
- the Office of Liquor and Gaming Regulation, Queensland
- Liquor & Gaming NSW.

Because liquor licence categories vary from state to state, the mapping in Table 19 was used to determine which locations were coded as on-licences and/or off-licences. Addresses from individual liquor licences were geocoded to a latitude and longitude. From each residential address, access to on-licences within 400 m and off-licences within 800m was determined using distances along the pedestrian-accessible street network.

Table 18: Number of food destinations (stores) by category, chain and state/territory, June 2017

Food category		State								
	Chain	*Vic*	*WA*	*Qld*	*NSW*	*SA*	*ACT*	*NT*	*Tas*	*Subtotal*
Major fast food chains	Domino's	112	72	168	210	39	12	8	12	633
	Hungry Jack's	99	60	98	90	48	5	5	8	413
	KFC	170	52	137	211	46	8	6	14	644
	McDonald's	253	86	223	315	53	6	8	16	960
	Red Rooster	75	68	119	79	6	2	8	0	357
	Subway	337	148	325	408	124	29	8	23	1402
	Subtotal	**1046**	**486**	**1070**	**1313**	**316**	**62**	**43**	**73**	**4409**
Major supermarket chains	ALDI	141	22	103	176	19	11	0	0	472
	Coles	208	94	166	252	56	13	7	16	799
	Foodworks	132	11	116	90	17	2	0	3	371
	IGA	302	256	260	362	75	23	9	81	1368
	Woolworths	246	96	234	293	70	18	12	32	1001
	Subtotal	**1029**	**479**	**879**	**1173**	**237**	**67**	**28**	**132**	**4011**

Table 19: Classification of liquor licences into on-licences and off-licences

Classification	Victoria	Western Australia	Queensland	New South Wales
On-licences	• General • Late night (general) • Full club • Late night (on-premise) • On-premise • Restaurant and café	• Hotel • Tavern • Hotel restricted • Tavern restricted • Small bar • Restaurant • Nightclub • Club	• Commercial hotel • Subsidiary on-premises • Bar • Industrial canteen • Commercial special facility • Community club • Nightclub	• Club • Hotel • General bar • On-premises • Small bar
Off-licences	• General • Late night (general) • Late night (packaged) • Packaged liquor	• Hotel • Tavern • Liquor Store	• Commercial hotel	• Hotel • Packaged liquor
Excluded	• BYO permit • Limited • Pre-retail • Restricted club • Wine and beer producers	• Wholesaler • Producer • Club restricted • Special	• Community other • Subsidiary off-premises • Producer/wholesaler • Wine producer • Wine merchant	• Producer/wholesaler • Limited – single or multiple functions • Limited – special event or trade fair

Appendix 4
Difficulties in creating consistent urban liveability indicators

A 4.1 Public transport data

Availability of the data needed to conduct analysis across the various domains considered in this report varied widely. For housing affordability and employment, sourcing appropriate nationwide ABS data was straightforward. But every other domain used at least one measure based on access from a residential address to a destination of some type, and sourcing data on these destination types was frequently difficult.

For public transport, although PSMA Australia Ltd provided national data on public transport stops [195], our analysis required additional information on service frequency. This involved sourcing timetable data in General Transit Feed Specification (GTFS) format [194] directly from state and territory public transport authorities. GTFS data is not available retrospectively, so we used 2017 timetable information. Further, the way in which the GTFS specification was implemented varied from city to city. For example, in some cities, train stations were modelled as a single stop, whereas in other cities they were modelled hierarchically, at both a station and individual platform level. So when assessing access to a frequent service, we had to take care to apply a consistent method across all cities and modes. And, as mentioned earlier, we were able to source data for existing stops only, not for planned or potential stops.

A 4.2 Walkability and pedestrian network data

The walkability access measure used public transport stop data but not service frequency, so by using retrospective Transport and Topography data from PSMA [195] we could match this temporally with the other destinations data (supermarkets, convenience stores, newsagents and petrol stations) sourced from Business Points Australia [192]. The remaining walkability indicators were built on PSMA street network data and ABS Mesh Block data and were therefore straightforward, albeit computationally intensive from a data sourcing and processing perspective.

A greater impediment to modelling walkability – and walking generally – was a lack of pedestrian network data. We used the PSMA Transport and Topography street network dataset [195] as the basis of a pedestrian walking network. While non-walkable roads such as freeways were excluded from this dataset before we calculated measures, walkable pedestrian links such as pedestrian overpasses and underpasses, mid-block links and rail crossings were also absent. As previous analysis has shown [209], omitting pedestrian links has a significant and variable effect on walking results. In contrast to the missing pedestrian links, footpaths are assumed to exist on all streets, despite data not being available. Although this is a reasonable general assumption, in some areas it will indicate walking access to destinations when this is not the practical reality. The final problem encountered when using a street network as a proxy for a pedestrian network was ‘snapping’ effects. To calculate the network distance between any two points, the points were first ‘snapped’ to the network (generally within a specific distance or tolerance). This can introduce errors, more in some planning designs than others. If a particular dwelling is snapped to the street behind the house because it is closer than the street in front, all results for this dwelling will be incorrect. This can be an even larger problem for destinations, and is compounded by the lack of pedestrian links. A suburban train station will be snapped to the network on only one side of the tracks; residential addresses on the other side of the tracks would be deemed to have poor access. A supermarket in a large shopping centre will be snapped to the street network, sometimes moving it by 100 m or more. Someone who has access to the supermarket’s actual location within 400 m may be deemed to be without access once it is snapped in this way. Further research is needed into how to solve such methodological problems, and more support is required to improve wide-scale availability of pedestrian data.

A 4.3 Public open space data, taxonomies and area calculations

Public open space destination data varied widely in quality, scale and taxonomy between states. The Perth and Brisbane data had both been extensively cleaned in previous studies before analysis was undertaken in this study. The Sydney and Melbourne data were used as-is (subject to the methods described in Appendix 3 – Public open space). As an example of the difficulties encountered when trying to define public open space consistently across states, Table 20 compares the categories in the datasets used for Sydney and Melbourne. The only category for which there is seemingly an overlap is parks and gardens. While other categories can be matched on name more loosely, for example 'sports' in Sydney may correspond to 'organised recreational area' in Melbourne, these too are approximations. Consider the case of public golf courses. These require users to pay green fees, so typically we would not include them in our definition of public open space. In the case of Sydney these can mostly be excluded by excluding the 'golf course' category, but there are exceptions: the Georges River Golf Course is owned by the NSW Office of Strategic Lands and appears under the 'CSEPA owned' category. In Melbourne, where golf courses are not categorised separately, public golf courses are necessarily included in the definition of public open space as they typically appear under the category 'organised recreational area'. This example highlights some of the inconsistencies encountered when aligning definitions of public open space between just two cities; the problem was compounded for each additional capital city included in the analysis.

The second major hurdle in analysing data on public open space is the consistent treatment of area calculations. As discussed in Appendix 3 – Public open space, discrete park polygons are joined as a contiguous area if they share the same name and category. The taxonomy used can therefore dictate the extent to which park areas are considered jointly or discretely when calculating access measures. The differences in taxonomies between states would mean that a hypothetical park of 2 ha nature reserve and a 1 ha picnic area, would be considered either as a single 2 ha park, two 1 ha parks, or even as a 1 ha park, depending on the city it is in.

Table 20: Taxonomies for public open space in Sydney and Melbourne

Sydney public open space categories	Melbourne public open space categories
Bushland	Civic square and promenade*
Cemetery	Natural and semi-natural area*
Civic*	Organised recreational area*
Community Purpose*	Parkland and garden*
CSEPA_CCM*	Protected area*
CSEPA_Owned*	Recreation corridor
CSEPA_ProposedAcquisition	Services and utilities area
Golf Course	
Heritage and Cultural*	
Operational	
Parks and Gardens*	
Special	
Sports*	
Undeveloped_Unspecified	
Waterfront	

* Included in the definition of public open space used for analysis in this study.

A 4.4 Food and alcohol data

Of all the data used in this study, it is perhaps the food and alcohol environment data that changes most quickly. With alcohol licence data needing to be newly sourced for some states, and retrospective licence data not being readily available, this forced a decision to use a current (2017) view of alcohol licenses. As noted in Section 11.2, the

licensee data for Queensland reflected only the main licensee location and not satellite sites. Licensee data needed to be geocoded to a location, a process that can introduce errors if locations are incorrectly assigned. We found that historic business-listings data geocoded by commercial providers also contains geocoding errors for a small but significant proportion of business listings. For this reason we similarly made a decision to source updated data on major supermarkets and fast food chains directly from their corporate websites, as this data was most likely to be correct. Again, this necessitated using current (2017) data rather than historic listings data.

Two consequences arise from mixing data from different time points: inaccurate results for those areas in which change has been greatest between the different time periods, and potential confusion in representing results. At the time this study commenced, 2016 Census data had not yet been released, and at the conclusion of the study 2016 Census data on employment was still pending. This led us to decide to baseline our analysis for the 2011 Census year and use other spatial data (such as G-NAF and Business Points Australia) [92, 192] from approximately the same period. As noted above, we needed to use updated data for some domains such as food and alcohol. In areas that have undergone rapid change over the last five years, such as planned suburbs on the urban fringes, this created a situation where our data contained, for example, a supermarket but no road network by which it could be accessed. When our results are updated with 2016 Census data (and updated PSMA data), these sorts of errors will be corrected. The results will then reflect in all cases the latest possible information, making interpretation more straightforward and intuitive.

A 4.5 Differences of scale between cities

A central challenge in this study has been how to compare cities as different in size and population as Sydney and Darwin. In 2011, Greater Sydney had a population of 4.4 million, and the study area stretched across 200 km. In contrast, Greater Darwin had a population of 0.12 million and a study area of 25 km. While the national liveability indicators provided a common baseline for comparing areas within and across cities, it is natural to expect large and small cities to have differences arising purely from their differences in scale. It is therefore more meaningful to compare, say, Sydney with Melbourne than Sydney with Darwin. This is not to say that there is no value in the latter comparison, but that there is more value in the former.

The differences in scale (both area and population) are even more apparent when comparing LGAs across Australia. The most populous city in the study had a population approximately 37 times that of the smallest. The most populous LGA had a population approximately 700 times that of the smallest. The three most populous LGAs in Australia are all in Queensland; two of them – Brisbane City Council (population 1,131,155 in the 2016 Census) and Moreton Bay Regional Council (population 425,309 in the 2016 Census) – were in the study region. Nationally, there are 12 LGAs with a population greater than Hobart's (222,356) and 52 LGAs greater than Darwin (136,831). Using 2011 Census data, Australia's average LGA population is approximately 100,000 persons, but averages vary significantly from state to state: Perth LGAs average 54,000 persons, Sydney 100,000, Melbourne 127,000, and Brisbane 400,000. Since the 2011 Census, local government mergers in New South Wales have created 19 new councils, with a further five merger proposals pending court decisions [210]. This will lead to an increase in the average size of LGAs nationally, especially in New South Wales. Two of these new super-councils (Canterbury-Bankstown and Central Coast) are now the fourth- and sixth-most populous nationally, based on 2016 Census data.

Appendix 5

Other related research

The Kids in the Community Study (KiCS)

KiCS is working to understand how different factors in our communities – physical environment, social environment, socio-economic factors, access to services, and governance – influence the way that children develop. The study involves researchers from the Murdoch Children's Research Institute, RMIT University, The University of New South Wales, Griffith University, The University of Western Australia, and the Australian National University. We know that the early childhood years have a profound and lasting influence on children's health and development. We also know that there are different factors in our communities that play a major role in the healthy development of children, particularly the resources available to families.

But we do not know exactly which community factors affect child development, and how we can modify those factors to help all children get the best start in life. The 'what' and the 'how' are what KiCS aims to answer. Based on this research, this project will be developing child urban liveability indicators. Although not considered in this particular report, for completeness it is included. In the future, national child urban liveability indicators based on this study will be developed.

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