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Transport development stages within Australian cities: An analytical understanding of SA2 density and mode shares

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Abstract

Australia is experiencing rapid urbanisation, with a projected population increase from 26 to 31 million by 2034, with two-thirds to be located in capital cities (ABS, 2023). This presents significant challenges for governments in trying to sustainably accommodate the additional population and provide them with high levels of liveability. Given the lead time for transport infrastructure and services, proactive and adaptable policy and planning that understands how localised urban areas tend to change is crucial to determine when, where and what is needed to best support these future communities and achieve desired outcomes.

To help address this challenge, an investigation into the three conceptual stages of the urban transport policy development cycle identified by Jones (2015) has been undertaken. This involved analysing census data to pair demographic densities and mode shares at SA2 level for Sydney, Melbourne, and Brisbane. Statistically informed and distinct relationships that align with the three stages in the current land use and transport system have been identified across these three cities.

In gaining this analytical basis, it is expected to help inform policy development and transport planning with desired travel behaviour outcomes within localised urban areas, as well as what resulting environments and supporting infrastructure are required. Its integration into current industry practices could help facilitate a more holistic and progressive local area focused approach, by providing:

- Dynamic precinct analysis: track mode share evolution
- Form-outcome connection: identify design elements to achieve desired outcomes
- Data-driven forecasting: predict demands based on comparable real-world data
- Progressive targeting: set evolving targets to coordinate responses.

Having a better understanding of what urban precinct outcomes likely occur should be at the core of the transport planning industry. Achieving this through a pragmatic data-driven approach should provide deeper insights and better equip decision makers to navigate the challenges of accommodating rapid urbanisation.

1 Introduction

Australia is embarking on an extraordinarily challenging period in accommodating population growth of 4-5 million people over the next 10 years (Australian Bureau of Statistics 2023), which is the equivalent size of present-day Melbourne or Sydney. This rate of population growth is expected to continue further thereafter, with the vast majority of these people (68%) expected to live within our capital cities (Australian Bureau of Statistics 2023). Where and how this growth will be supported within our capital cities is a multi-faceted matter, occurring across a spectrum of social, economic, and environmental factors.

The transport networks in these capital cities will be at the forefront of experiencing the impacts of this population growth, generally resulting in proportional increases in the amount of people they need to move each day. How and where the transport network needs to move them will

depend on a number of factors, such as the location, type and mix of land uses, as well as what transport facilities and services connect them.

Historically, low density residential development has been deployed at scale to accommodate population growth. In turn contributing to the urban sprawl in our capital cities which has influenced private car use to be the dominant method of travel. However, we have seen more inner city areas and activity centres achieve lower levels of private car use, with higher densities and mix of land uses, as well as a range of transport modes serving them.

These different urban environments are broadly consistent with the following three conceptual stages of the urban transport policy development cycle identified by Jones (2015).

Stage 1: Support traffic growth – Vehicle focus

- Low density and land use diversity
- Uncongested road network
- Private vehicles seen as the most cost effective, convenient, and prioritised mode.

Stage 2: Alternative modes – Personal movement focus

- Increasing densities, land use diversity (internal trips) and access demands
- Congested road network approaching 'peak car use'
- Non-private vehicle travel modes become more competitive and viable.

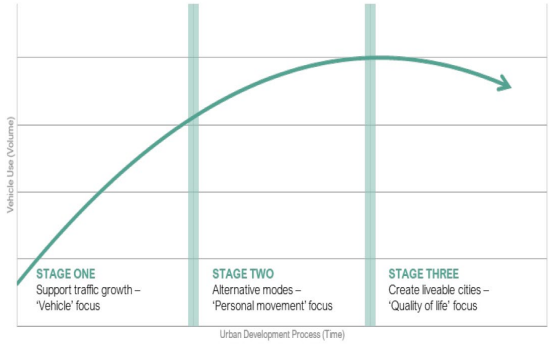
Stage 3: Create liveable cities – Activity / Quality of life focus

- High density, land use diversity and demands
- Actively suppress car use and reallocate road space to more space efficient modes
- Increasing placemaking, amenity and dwell based safety urban design features.

Presented in Figure 1 is a conceptual representation of the above three stages of the urban transport policy development cycle (Jones, 2015).

Conceptually the three stages seem to be understood across industry, and policy settings talk to the urban environmental attributes associated with each stage. However, there seems to be a meaningful gap in its application in determining how mode shares vary between them. This impacts on what user demands are trying to be accommodated, and the infrastructure and services to support them.

Figure 1: Three conceptual phases of the urban transport policy development cycle



This application gap is broadly discussed in Table 1, around the current two main different transport planning approaches of Predict and Provide and Vision and Validate, in considering urban environments and mode shares. Given the current implications and limitations, investigations of an analytical understanding for the three conceptual stages of urban development have been undertaken to help better understand how travel behaviour varies and what features contribute to these different urban environments within our capital cities.

The investigations have centred on the urban form 'ingredients' that impact mode shares, more communally known as the 5D's (Guzman et al, 2020), 1. Population density, 2. Land use diversity, 3. Distance to transit, 4. Destination accessibility and 5. Human centred design.

Table 1: Current Australian transport planning approaches

Approach	Activity	Process	Limitation	Implication
Predict and Provide	Transport Impact Assessments	Determine demands to be generated by a new development on the external transport network	Generation rates are based on historic survey data for the proposed land use type	Historic generation rates with limited consideration of how the broader precinct will change over time
	Strategic Modelling	4 – step demand modelling based on future land use forecasts and networks, typically only directly considers vehicles and public transport	Calibrated based on existing conditions and mode shift based on future comparable utility function.	Anchored based on the current travel mode shares, requires future networks to be fully planned and coded, with limited consideration of how urban form factors influence travel behaviour.
Vision and Validate	Activity Centre Planning	Setting of aspirational mode shares and urban design objectives	Emerging approach with limited empirical backing and standardised application / guidance	Limited understanding of what mode shares are typically achievable for a given precinct, how they transition over time and/or what combination of urban design elements influence / needed to support them.

In terms of the 5D urban form 'ingredients', population densities and land use diversity are considered to relate to the demand side of transport network outcomes, when the others (distance to transit, destination accessibility and human centred design) are about how the demands are being supported. All of the 5D's (and other matters) are believed to ultimately influence the actual transport network outcomes, but there is considered to be a lack of consideration at how they individually and collectively influence travel behaviour, especially at a more local urban area level, where much of our transport planning occurs.

Given the complexity of our urban environments and the availability of data to measure the above, initial investigations (as presented in this paper), have focused on demographic densities (and diversity to a lesser extent), as they are collected and able to be paired with journey to work mode shares through Australian Bureau of Statistics (ABS) Census data at an Statistical Area 2 (SA2) level for capital cities.

Previous research has occurred around the potential influence of population densities on mode shares. This has generally indicated that increasing densities does tend to reduce private car use (McIntosh, Trubka, Kenworthy, and Newman, 2014) but that there seems to be a number of inconsistencies when comparing the density and mode share outcomes between different global cities (Mees, 2009). This is in part due to the differing ways densities are calculated and over what areas of a city's urban footprint is included. Moreover, concern is raised on having a focus on trying to increase a given city's overall density as a means to reduce private car use, given the scale of change and timeframes this relates too. Rather, more focus is recommended to be given to policy settings that are able to cause change more rapidly and without the necessity for city shaping infrastructure (Mees, 2009).

A key limitation considered to exist with this previous research on population densities and mode shares is that they have only been considered at a city-wide level. Limited consideration seems to have been given to the distribution effects of demographic densities across the cities on mode shares. Unless there is a linear relationship between densities and mode shares, distribution effects would be expected to result in different city-wide mode shares for cities with the same city-wide densities. As such, it is considered beneficial to look at population densities and mode shares at a more local urban area level.

Recent research on how Melbourne's public transport capacity is keeping up with population growth at a city-wide level, but not locally in areas there has been high population growth (De Gruyter, Pemberton, and Keys, 2024) is an example of how this disconnect is currently playing out. Though an increased focus of local urban areas and how they develop should help better compare and/or inform our land use and transport policy settings needed to support them.

In this regard, it is also highlighted that it is well appreciated that densities alone cannot be expected to achieve a given mode share outcome. At a minimum, it has been noted density are one of the 5D urban form ingredients that influence travel behaviour. However, there are expected to be general outcomes that tend to occur within our current land use and transport system. Thus, it is the focus of this paper to see if there is some alignment with the three conceptual stages of the urban transport policy development cycle by Jones (2015).

As such, the purpose of this paper is to investigate if there is an analytical basis to the three conceptual stages of the urban transport policy development cycle identified by Jones (2015) by pairing demographic (resident and employment) densities against journey to work car mode share data at SA2 level across the urban areas of Melbourne, Sydney, and Brisbane.

2 Method

This section describes the datasets, data preparation, and data analysis utilised and/or performed for this study. The analysis was completed for the Greater Capital City areas of Melbourne, Sydney, and Brisbane; as well as collectively, here after referred to as the Eastern Seaboard. Each of the four areas were analysed three times, by looking at the place of Usual Residence (UR) (reflecting population density), Place of Work (POW) (reflecting employment density), and finally as a Combined (UR/POW) value. The data preparation was done using Structured Query Language (SQL) and analysis completed in R (v4.2.1, R Core Team 2022).

2.1 ABS datasets

This study utilised publicly available ABS datasets without modification from the 2021 Census of Population and Housing, including the following:

- 2021 population counts, i.e., persons by UR (ABS 2021a)
- 2021 employment counts, i.e., persons by POW (ABS 2021c)
- 2021 journey to work data, i.e., method of travel to work (ABS 2021b, 2021d)
- 2021 land use data, as defined by Mesh Block (MB) boundaries (ABS 2021e).

The ABS datasets were retrieved at the geographical level of SA2, as classified by the Australian Statistical Geography Standard (ASGS) Edition 3. The land use data was retrieved at MB level, which defines the smallest geographic areas that ABS supply data for, noting these collectively form the larger ASGS regions. It is at MB level that land use is broadly classified. All datasets were pre-processed where necessary, in preparation for further analysis. This is described below under Data Preparation and Analysis. It is important to note that the 2021 Census of Population and Housing occurred during the period of COVID-19 travel restrictions, which will likely have had some impact on the data collected.

2.2 Data preparation

2.2.1 Densities

The ABS land use data (provided at MB level) was used to better understand the amount of relevant space used within the larger SA2s, and therefore calculate more appropriate and comparative densities. The area used to determine density was therefore calculated by applying weights to those land uses applicable to the respective densities, i.e., those likely to accommodate residents and/or support employment. The following summarises the process used to calculate the densities at SA2 level for UR, POW, and combined UR/POW:

1. Prepare the MB weights for UR, POW, and UR/POW. The MB land use categories with non-zero weights are show in Table 2 (all other category weights were zero).

2. Multiply the MB area by the weight for each analysis and then sum the weighted areas to SA2 (all calculations from here on out are performed at SA2 level).
3. Divide the population count by the respective weighed area in square kilometres. If the SA2 had a weighted area equal to zero, the density was recorded as zero. Note that the population for the UR/POW scenario is the sum of both UR and POW.

Table 2: Mesh block land use category weightings

Category[1]	UR	POW	UR/POW
Commercial	0.1	1.0	1.0
Education	0.1	1.0	1.0
Hospital/Medical	0.1	1.0	1.0
Industrial	0.1	1.0	1.0
Residential	1.0	0.1	1.0
1. Excluded categories: ANTARCTICA, MIGRATOTY, NOUSUALRESIDNECE, OFFSHORE, Other, Outside Australia, Parkland, Primary Production, SHIPPING, Transport.			

2.2.2 Car mode shares

The ABS journey to work data provides counts by method of travel to work (in this case, using a 6-category classification schema). This was used to calculate car mode shares at SA2 level for UR, POW, and combined UR/POW, as per the following process:

1. Calculate the total number of trips by summing the count of trips for ‘Active Transport’, ‘Other Mode’, ‘Public Transport’, and ‘Vehicles’.
2. Divide the count of ‘Vehicle’ trips by the total number of trips.

For the UR/POW scenario each mode was summed with the respective mode from both UR and POW before applying the above formulation. Note that the counts of ‘Not stated’, ‘Worked at home or did not work’, and ‘Not applicable’ were excluded from the total for calculating mode shares, as they do not produce trips on the transport network.

2.3 Analysis

Using the prepared data, three distinct responses (stages) of car mode share versus log (density) were observed. Linear regression was used to calculate this relationship for each of the three stages, noting the following exclusions were applied:

- For UR – any SA2 with a person count less than 500 was removed from the analysis
- For POW and UR/POW – any SA2 with zero-density or a zero-person count was removed from the analysis.

Note that there were 11 SA2s that had persons recorded as working and/or living in them but did not have any area being considered either employment or residential, and were therefore excluded. For each stage, a subset of the data was independently selected from the full dataset for the purpose of calculating the linear regression lines, as described below:

- For Stage 1 – the subset data included all the data up to the point where Stage 2 data started to affect the regression slope.
- For Stage 2 – the subset data used to calculate the regression was chosen to be mostly homogeneous, not affected by obvious Stage 3 data nor any roll off towards Stage 1. This meant that there was a gap between the data used to calculate Stage 1 and Stage 2 and an overlap between the data used to calculate Stage 2 and Stage 3.
- For Stage 3 – the subset included all data from where Stage 2 data stopped affecting the regression slope onwards.

Also not used in the calculation of the regression were SA2s that were considered outliers. These were SA2s with car mode share more than 2.5 standard deviations (σ) away from the final respective regression line. To determine these SA2s, the standardised residuals were

checked and any SA2 with car mode share that was more than 2.5 σ away from the regression line were removed from that subset of data. This was done iteratively until there were no more outliers. Stage 1 was the most affected by this step.

In the gap between the subsets for Stage 1 and Stage 2, data points were also considered outliers if they were more than 2.5 σ from both the final Stage 1 and Stage 2 regression lines.

Plots of the slope and σ for a range of subsets, differing by the cut off limits for the density, as shown in Figure 2, were used to inform the final choice of the limits for each stage's subset.

All the three types of density (UR, POW, and UR/POW) had SA2s that were considered outliers and removed from the data used to calculate the regression model for each stage. These outliers tend to be areas characterised as defence, greenfield, industrial, islands, and areas that have major public transport services passing through to service other areas.

Figure 2: Typical slope and σ graphs used to calculate data subgroup stage limits

3 Results

3.1 Population density

The Eastern Seaboard dataset shows that each of the three cities are following similar patterns with respect to population (UR) density versus car mode share, as presented in Figure 3.

Figure 3: Population (UR) densities frequencies and car mode shares

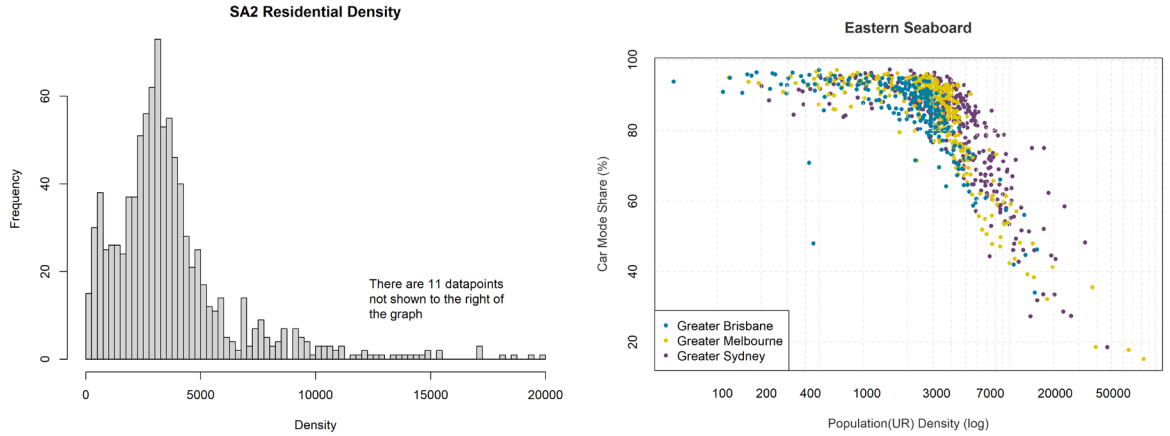
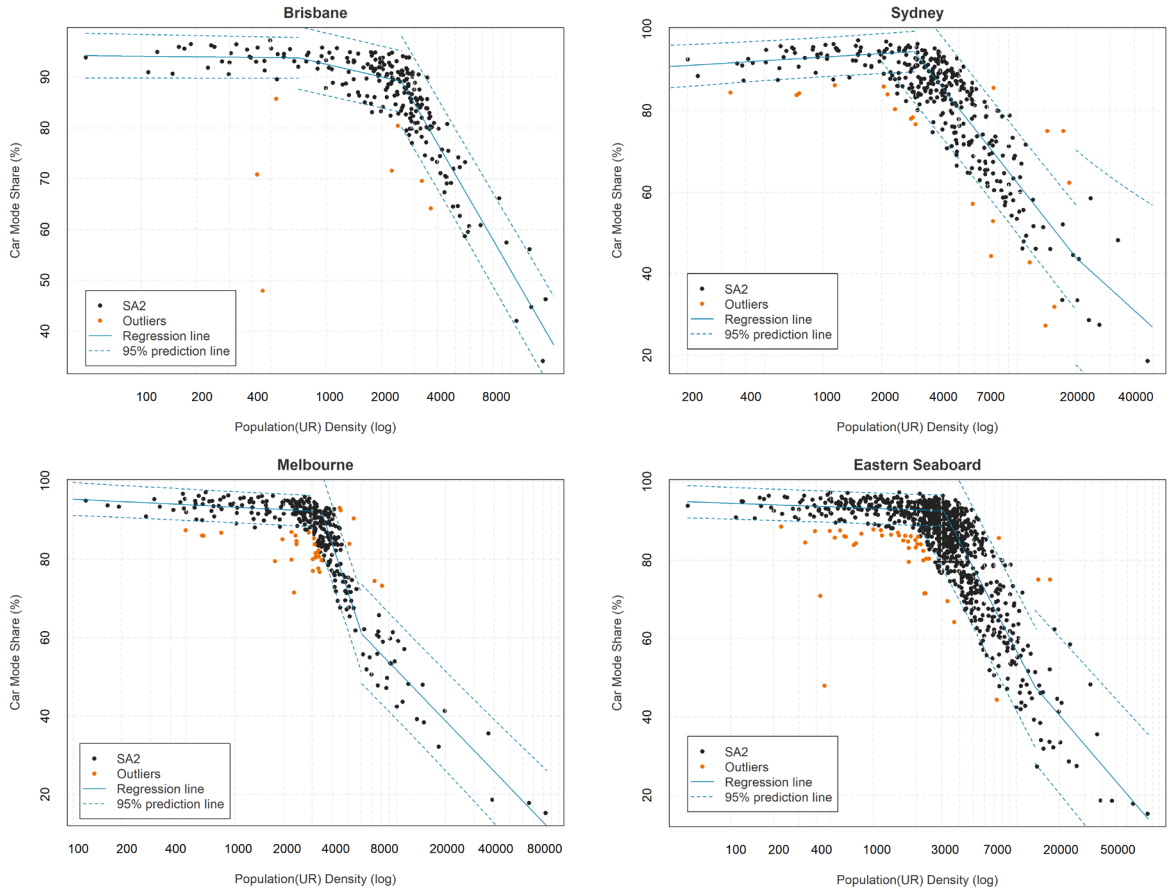


Figure 4 shows the regression analysis results for each capital city and the Eastern Seaboard.

Figure 4: Population (UR) regression analysis for capital cities and the Eastern Seaboard



For a given population density, Brisbane tends to show higher car mode share for the lower end of Stage 1, then tending to lower car mode share to the upper end of Stage 1 and most of Stage 2. In terms of Stage 3 in Brisbane, there is insufficient data at an SA2 level that could be used to confirm its existence.

Melbourne and Sydney are more alike, but Melbourne has less variability, and Sydney still tending higher car mode share than either Brisbane or Melbourne. The rate of change increases as the city goes from Stage 1 to Stage 2, and decreases as the city moves from Stage 2 to Stage 3.

With Brisbane not clearly evidencing a separate Stage 3, a separate regression was calculated across what would have been the gap between the subsets of Stage 1 and Stage 2. The two outliers with densities under 500 and mode share under 75% are the Bay Islands. The only access to the mainland for both is by ferry.

Sydney's, Stage 2 was the longest of the three cities, with densities up to 20,000. Melbourne had the shortest and sharpest Stage 2, spanning densities of only 3,400 to 5,900.

It is also noted that the three conceptual stages of the urban transport policy development cycle have similar mode share to population density traits as the three urban fabrics (Newman et al, 2016), whereby 'automobile urban fabric' seem consistent with Stage 1, 'transit urban fabric' with Stage 2, and 'walking urban fabric' with Stage 3.

3.2 Employment density

The Eastern Seaboard dataset shows that each of the three cities are following similar patterns with respect to population (POW) density versus car mode share, as presented in Figure 5.

Figure 6 shows the regression analysis results for each capital city and the Eastern Seaboard.

Figure 5: Population (POW) densities frequencies and car mode shares

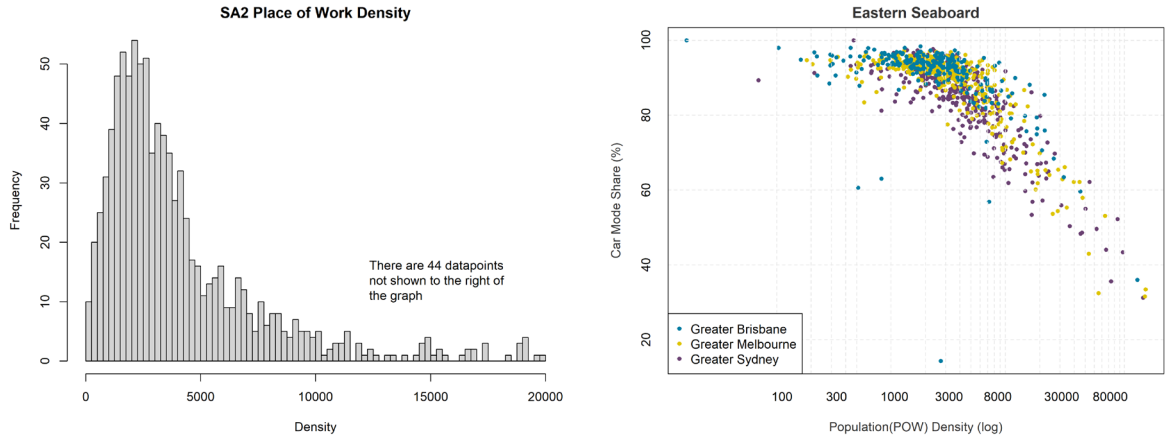
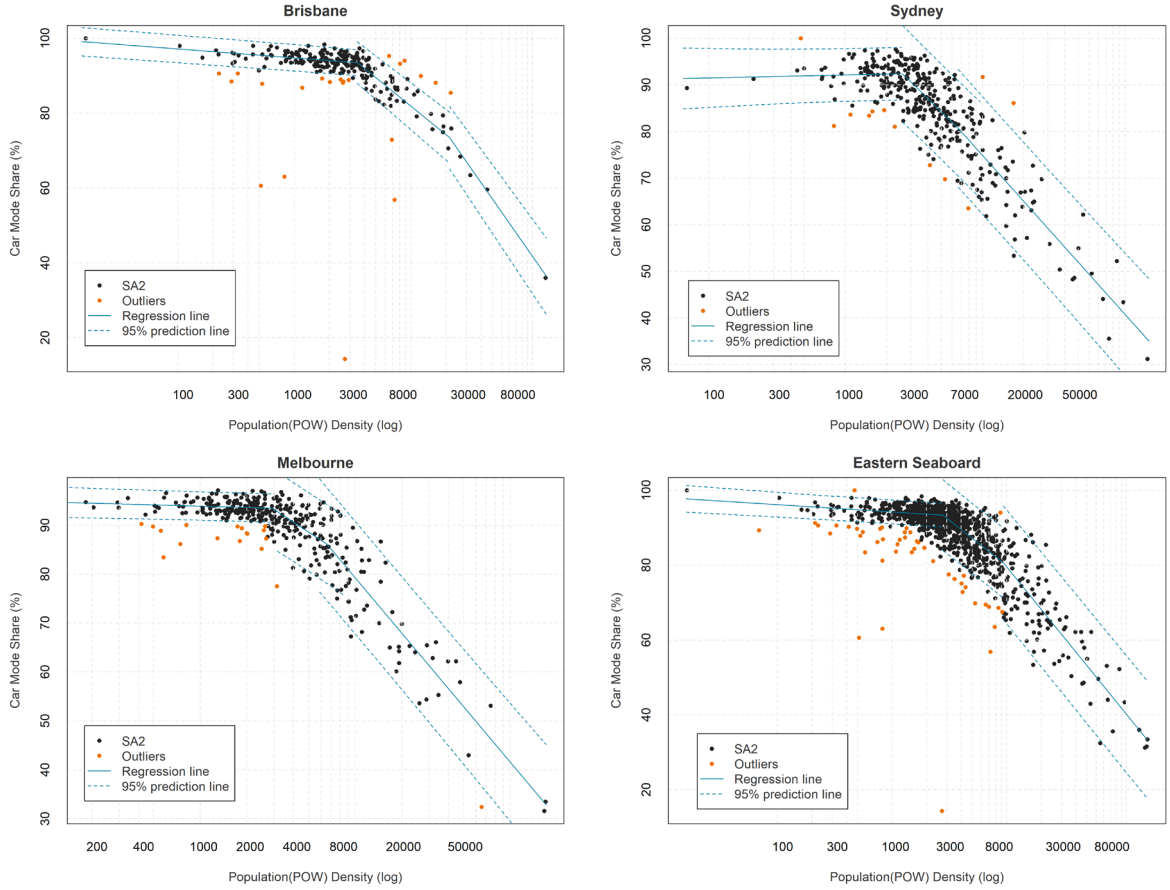


Figure 6: Population (POW) regression analysis for capital cities and the Eastern Seaboard



Unlike the UR analysis, the rate of change of car mode share increases as the cities move to the next higher stage.

For a given employment density, Brisbane tends to have higher car mode share across all stages. Melbourne and Sydney are more alike but, again, Melbourne has less variability, with Sydney tending lower car mode share than either Brisbane or Melbourne.

Brisbane has the longest Stage 3. Syndey might not have a separate Stage 2; the slopes of Stage 2 and Stage 3 are very similar. Both Melbourne and Sydney have a short second stage.

3.3 Combined density

The Eastern Seaboard dataset shows that the three cities are following similar patterns with respect to combined (UR/POW) density versus car mode share, as presented in Figure 7.

Figure 7: Combined (UR/POW) densities frequencies and car mode shares

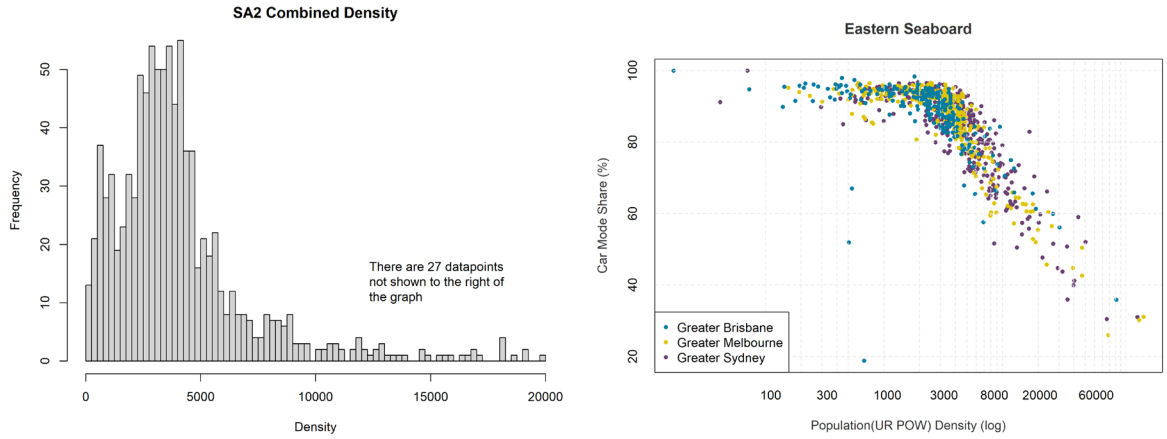
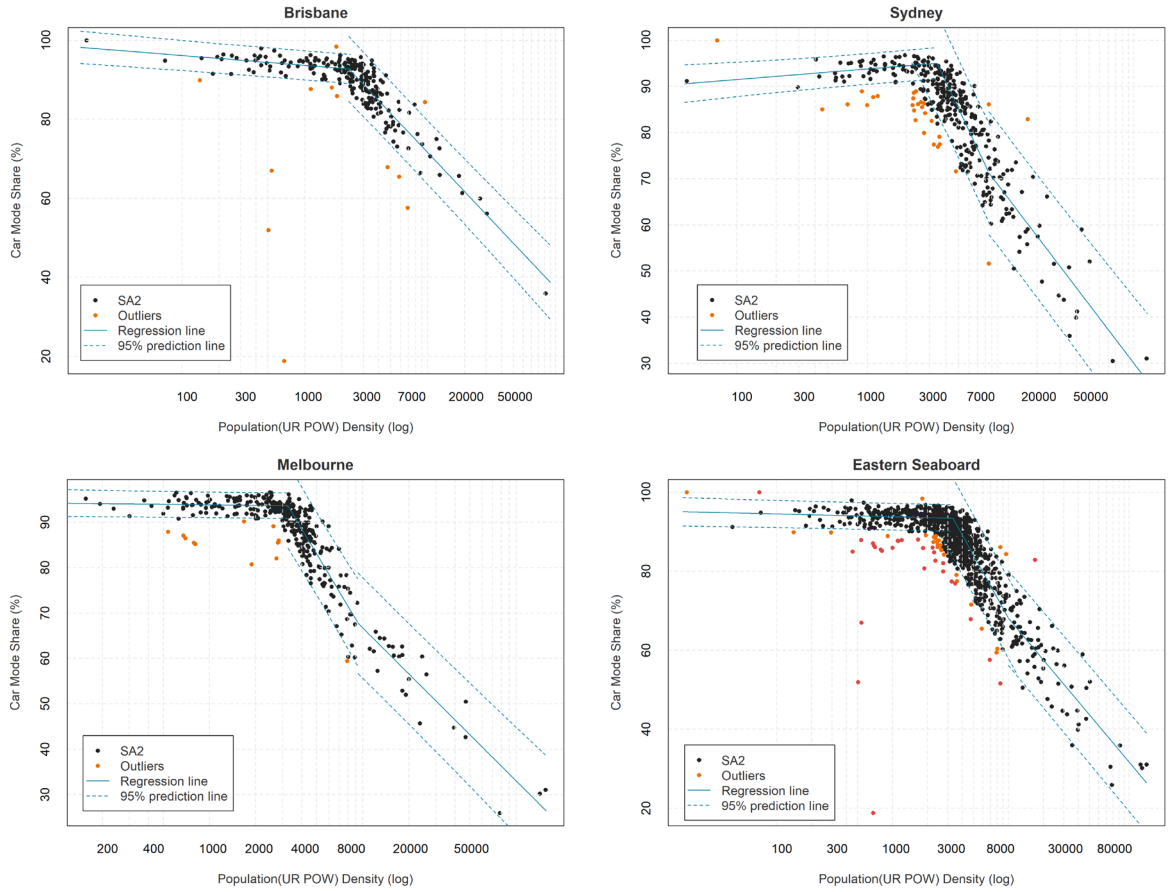


Figure 8 shows the regression analysis results for each capital city and the Eastern Seaboard.

For a given combined density, Stage 1 has each city roughly equally distributed. Brisbane tends to have a lower car mode share across Stage 2. Melbourne and Sydney are more alike but, again, Melbourne has less variability, with Sydney tending to have a lower car mode share than either Brisbane or Sydney.

In terms of Stage 3 in Brisbane there is insufficient data at an SA2 level to confirm its existence. Melbourne has the most obvious change point between Stage 2 and Stage 3. Syndey's change between Stage 2 and Stage 3 is much less pronounced than Melbourne.

Figure 8: Combined (UR/POW) regression analysis for capital cities and the Eastern Seaboard



3.4 Three stages of urban development

The completed analysis identifies statistical relationships between the population densities and car mode shares that reflect the three stages of the urban transport policy development cycle identified by Jones (2015) for Australia's three largest capital cities at SA2 level.

In considering each of the three stages, the following high-level insights can be drawn:

Stage 1: Support traffic growth - Vehicle focus

1. The typical travel mode share level for cars is greater than 90% for respective SA2s in Brisbane, Sydney and Melbourne.
2. With respect to the relationship with associated population densities, it was in the order of up to 2,500 – 3,000 persons per sq.km in all cities.
3. On the trip attraction side for employment densities, up to approximately 2,000 jobs per sq.km were associated with Stage 1 for all three major Eastern Seaboard cities.
4. Combining both population and employment density for each respective SA2 found that Stage 1 for Brisbane was approximately up to 2,000 persons per sq.km, while Sydney and Melbourne's were up to approximately 3,000 persons per sq.km.

Stage 2: Alternative modes - Personal movement focus

1. For all three cities there is a distinct strategic inflection point in terms of the trend line gradient having a higher rate of change as density increases which is the commencement of Stage 2.
2. For Stage 2 level population densities typically between 2,000-8,000 persons per sq.km, car travel mode shares reduce from ~90% to approximately 40% in Brisbane with no discernible Stage 3, while to approximately 60% in Melbourne and Sydney.
3. From a trip attraction perspective with regard to SA2 employment densities, the length of Stage 2 is shorter ranging between 2,000-4,000 jobs per sq.km for Melbourne and Sydney while for Brisbane, as there was not a discernible Stage 3, it ranges between 3,000-30,000 jobs per sq.km
4. In combination, employment and population highlight the lack of a discernible Stage 3 for Brisbane, while for Sydney and Melbourne, Stage 2 ranges between densities of approximately 3,000-10,000 persons per sq.km.

Stage 3: Create liveable cities - Activity / Quality of life focus

1. While there is insufficient data for Brisbane at an SA2 level to confirm a Stage 3 trend line with respect to population densities, a Stage 3 trend line is apparent for Melbourne and Sydney for SA2s with population densities of more than 20,000 persons per sq.km (Sydney) and more than 8,000 persons per sq.km (Melbourne). This results in car travel mode shares ranging between approximately 20-60%.
2. For SA2 employment densities, the Stage 3 was not discernible in Brisbane, and approximately 5,000 jobs per sq.km for Melbourne and Sydney.
3. Combining the trip generating population densities and trip attracting employment densities finds that Stage 3 occurs for SA2's with densities of more than 8,000 persons per sq/km in Melbourne and Sydney, while Stage 3 doesn't appear for Brisbane.

4 Discussion

The completed analysis has identified relationships between the various demographic densities and car mode shares across the SA2's that make up our largest three capital cities (Melbourne, Sydney, and Brisbane). While there is variability and differences between each capital city, likely related to the many other influences on travel behaviour like the other 5D urban form ingredients, the identified relationship trend lines seem to reflect the three stages of the urban transport policy development cycle identified by Jones (2015).

Even given the initial and narrow nature of the completed analysis around densities and mode shares at an SA2 level, the findings have the ability to provide an improved analytical understanding of how travel behaviour within local urban areas across our largest capital cities will likely change as they accommodate significant population growth in the coming decades. It could also be used to help inform land use policy and what development patterns should be encouraged to achieve desired outcomes, such as sustainability and liveability.

In a simplistic sense, if we only locate future population growth at Stage 1 densities, we will have very high car dependence. Rather, we should be considering matters such as what happens if we move more SA2's into Stages 2 and 3, should we be providing improved transport infrastructure and services in SA2s above the trend lines, and/or support increased densities in areas below the trend lines.

In this regard, the analysis is considered to have provided various insights that should be further investigated through future research topics, such as those in Table 2.

Table 2: Findings and applications derived from completed analysis

Topic	Finding	Application
Conceptual description associated with each stage	Identification of the three stages has generally been mathematically based and hasn't confirmed that the associated SA2s reflect the conceptual description associated with each stage.	This isn't expected to necessary reduce the applicability of the trend lines, rather may require the description associated with each stage to be modified
City size	Brisbane, which is the smallest of the three capital cities analysed, did not have enough data points at an SA2 level to fully demonstrate Stage 3 data points, and Stage 2 was at a higher level.	Overall city size may affect what stages are being achieved at a SA2 level, have different points of inflection, and/or gradients of the Stage 2 and 3 trend lines. As such, if or how this differs with smaller or larger cities should be investigated.
Census year	A single Census data with COVID-19 restrictions in many parts of Australia was assessed. Working from home trips were removed to try to minimise the impact of these restrictions and focus on those trips that used the available transport networks.	The results are expected to reflect the land use and transport policy settings and associated urban environmental systems in place at the time. There is potential that the identified points of inflection and trend lines will differ between Census data sets given changing policy settings, working from home behaviours and/or transport network changes, which would likely provide further valuable insights.
International applications	Analysis was only done for Australia's three largest capital cities, so reflects their land use and transport policy settings and associated urban environmental systems at the time of the 2021 Census data assessed.	This analysis could be applied to other cities around the world to gain insights around the influence of different urban policy settings and ecosystem arrangements.
Specific SA2's	A single Census data set for Australia's three largest capital cities was completed.	Tracking specific SA2s over the years could help better understand the impacts of the changes that occur over the three stages of the urban transport development cycle.
Other trip types and modes	The analysis has only considered Journey to Work car mode shares.	Other trip types and modes could also be investigated through other Census years, data sets and/or across comparable SA2's from a stage, density and/or mode share perspective.
5D supply side factors	Consideration has only been given to the transport network demand	The other 5D urban form factors that influence mode shares generally relate to

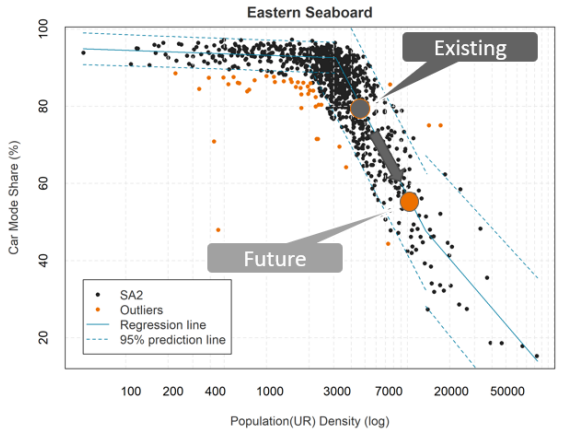
Topic	Finding	Application
	side (population densities and land use diversity) of the 5D urban form factors influencing travel behaviour.	how the demands are being supported and could be investigated in a similar manner to help better understand their level of influence.
Area size	SA2's were the adopted area size for the analysis, which based on initial testing of various SA sizes was found to provide the clearest relationship.	There is considered to be benefit in undertaking this analysis for smaller areas to better investigate activity centres smaller in size than SA2's and help understand the level variability and reasons of different outcomes.
Outliers	Various outliers of 2.5 σ from both the final Stage 1 and Stage 2 regression lines were identified.	Further consideration could be given to understand the characteristics of those SA2's that have been considered outliers and how they can be replicated or avoided for positive outcomes.
Other relevant research	Urban form factors and travel behaviour are multifaceted and complex interactions. While this analysis is considered to provide some helpful insights in this regard, further and broader considerations should be pursued.	A wider lens can be applied to compare the findings of this analysis to other relevant works, for example, how does this study compare to the recent 'four types of commuter' paper (Hayward, D; Dewbery, S; Shelton, P and Wilson, H 2023) and the relationships / influences between both.

In terms of how the completed analysis can be applied in practice, there are considered to be three main transport planning and engineering activities that would benefit from integrating this concept and process into its current practices. These are discussed below, along with a broader approach to addressing the current limitations that exist in these spaces.

Transport impact assessments (TIAs)

The identified relationship between precinct level population densities and car mode shares could help with understanding how people likely access a given development, now and into the future. This could be done by understanding the current and future (post development and background growth) population densities within the SA2 where a given development is located; and based on the identified relationship, determine what the future car mode share level of change might be, as shown in Figure 9.

Figure 9: Estimating future mode shares



Based on the anticipated future population density and car mode share, other comparable SA2's associated with the future state could be benchmarked against to determine the other non-car mode shares. Once all access mode shares have been determined, then a trip based assessment could be undertaken, such as those undertaken in the United Kingdom (UK) and as being proposed through the recently released draft Guide to Transport Impact Assessment by Transport for New South Wales (TfNSW).

This approach is also able to be linked to what car parking provision should be provided, ensuring the number of car parking spaces doesn't undermine the targeted modes shares.

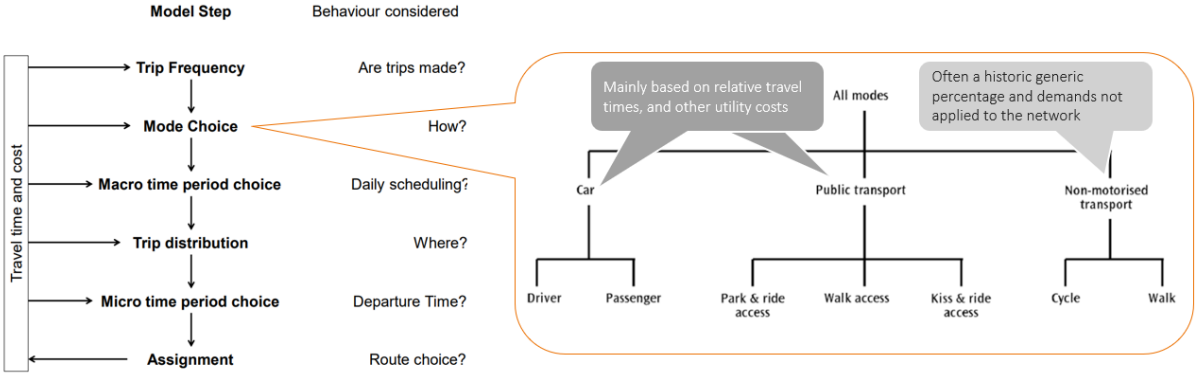
Where a specific proposed development is a lot denser and/or has much better access via other transport modes than across the SA2 on average, then consideration of the general

range of mode share outcomes that are achieved at the associated population density could be considered, and a car mode share towards its lower range adopted.

Strategic modelling

As part of the 4-step strategic modelling process outlined in Figure 10, the mode choice step could utilise the above understanding of how precinct level car mode shares will change with increasing population densities, as current mode shift considerations within strategic models have limited consideration of urban form factors. While it's full integration into strategic models would be some time away, it could at least be used in the interim to inform scenarios to be considered or sense check results and manually manipulate parameters on a per project basis to help provide more likely future modal network demand outcomes, so as to not continue to reinforce current travel behaviours.

Figure 10: Current 4-Step strategic modelling process



A key benefit of this developed process is that it reflects typical mode share changes as population numbers increase at a SA2 level, as it is based on other exiting SA2 sized areas with given transport network arrangements in place that support the associated modal demands. As such, it would help reduce the need to develop much broader network level arrangements within the strategic models for each mode to consider a given study area.

This would help focus efforts on developing what transport arrangements a given study area needs within and accessing it, rather than future uncommitted hypothetical network wide arrangements needed to inform modelling outcomes.

Activity centre planning

There is considered to be an ability to apply the analytical insights from the analysis presented in this paper to support the planning of growing centres. This is on the basis it provides an understanding of how they will tend to develop and identify comparable centres to benchmark themselves against to help identify the 'ingredients' needed to support the level of development and/or targeted aspirational urban form outcomes.

In summary, the application of this analytical process to activity centre planning is expected to enable the following:

- Provide a likely trajectory for how mode shares evolve over time in a precinct.
- Help predict what the future travel demands accessing the precinct will be based on real-world data from comparable precincts.
- Help identify urban form factors that will help achieve desired travel outcomes (based on the comparable precincts and considering the 5D's).
- Enable the setting of progressive targets aligned with development phases and/or time horizons, enabling coordinated responses in achieving desired outcomes.

While the above should not stop highly aspirational mode shares being set for centres, it should help reflect how likely they are to be achieved within our current planning systems, identify comparable existing centres to benchmark against, and what demand and supply side ingredients are needed to achieve the aspirational outcomes.

5 Conclusion

The analysis of SA2 level population densities and travel mode shares of the three largest cities on Australia's Eastern Seaboard identified distinct patterns and trends that demonstrate a degree of consistency with Professor Peter Jones' conceptual three stages of the urban transport policy development cycle. These patterns and trends have the potential to help guide more effective and sustainable urban development planning in terms of travel mode shares, trip generation and what urban form ingredients are needed to support them.

The key high-level insights the analysis provides for each of the three stages are as follows:

Stage 1: Support traffic growth - Vehicle focus

1. Car mode share is generally greater than 90% for respective SA2s in all cities.
2. Comprises population densities of up to ~2,500 – 3,000 persons per sq.km in all cities.
3. Comprises employment densities of up to ~2,000 persons per sq.km in all cities.
4. Comprises combined densities of up to ~2,000 persons per sq.km for Brisbane; and 3,000 persons per sq.km for Sydney and Melbourne.

Stage 2: Alternative modes - Personal movement focus

1. For all cities there is a distinct inflection point in terms of the trend line gradient having a higher rate of change as density increases, which is the beginning of Stage 2.
2. Population densities are typically 2,000 – 8,000 persons per sq.km in all cities; with car mode shares reducing from ~90% to ~40% in Brisbane, and to ~60% in Melbourne and Sydney.
3. Employment densities are typically 2,000 – 4,000 jobs per sq.km for Melbourne and Sydney (smaller range), and 3,000 – 30,000 jobs per sq.km for Brisbane (larger range).
4. Combined densities are typically 3,000 – 10,000 persons per sq.km for Melbourne and Sydney; whilst there is a lack of a discernible end of Stage 2 for Brisbane.

Stage 3: Create liveable cities - Activity / Quality of life focus

1. While there is insufficient data for Brisbane at an SA2 level to confirm a Stage 3 trend line, a Stage 3 trend line is apparent for Melbourne and Sydney.
2. Comprises population densities greater than ~8,000 persons per sq.km for Melbourne, and ~20,000 persons per sq.km for Sydney; with car mode share ranging from ~20% to ~60%.
3. Comprises employment densities greater than ~5,000 jobs per sq.km for Melbourne and Sydney.
4. Comprises combined densities greater than ~8,000 persons per sq,km for Melbourne and Sydney.

The above analysis has been limited based on the available data with various other potential areas of research recommended to be undertaken. However, the findings still are considered to provide useful insights to how precinct level urban transport development occurs within our current land use and transport environment. Having a clear and agreed understanding of how urban centres will likely change over time should be at the core of the transport planning industry, as well as what 'ingredients' are needed to achieve desired outcomes.

It is also noted that the three stages have similar traits as the three urban fabrics (Newman et al, 2016), whereby 'automobile urban fabric' seem consistent with Stage 1, 'transit urban fabric' with Stage 2, and 'walking urban fabric' with Stage 3.

Its integration into current traditional industry practices could help facilitate a more holistic and progressive precinct level approach, by providing:

- Dynamic precinct analysis (track mode share evolution)
- Form-outcome connection (identify design elements to achieve desired outcomes)
- Data-driven forecasting (predict demands based on comparable real-world data)
- Progressive targeting (set evolving targets to coordinate responses).

Achieving this through a pragmatic data-driven approach will provide deeper insights and better equip decision makers to navigate the challenges of rapid urbanisation.

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