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Trip chaining accessibility measurement by public transport in Melbourne

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1 Introduction

Accessibility is often defined as how easy it is for a location to be reached or to reach other locations (Dalvi and Martin, 1976). It results from the interaction between an area's transportation system and the land use system (Geurs and van Wee, 2004). Accessibility models are often used to measure the impact of transportation infrastructure or land use changes. Accessibility modelling is also commonly used in equity-focused research to demonstrate whether disadvantaged groups have lower access to opportunities than others (Ermagun and Tilahun, 2020, Cui et al., 2022).

Currently, accessibility modelling generally considers a simple trip to only one type of destination (Klumpenhouwer and Huang, 2021). Yet in reality people's journeys often involve more than one destination, which is known as 'trip chaining' (McGuckin et al., 2005). The knowledge gap related to trip chaining in accessibility modelling impacts the validity of the resulting model. If a trip is only assumed to be a simple trip, the results of the accessibility calculation will tend to be overestimated. The absence of consideration of trip chaining could make an area appear to have high accessibility when it does not.

This study was conducted to answer the question of how to combine trip chaining in accessibility modelling. This study proposes a methodology for calculating accessibility for multiple destinations in one trip chain, called 'Trip Chaining Accessibility'. It modifies the measurement of cumulative probability by adding parameters that can capture a series of trips. The trip chain we have chosen to model is "home – school – work," as this is among the most common trip chain type and is more likely to be undertaken by women than men (Rahmah et al., 2024). The primary mode of transportation that is the focus of this study is public transportation, which ideally serves all levels of society (Currie and Delbosc, 2011).

2 Research approach

This section will be divided into two main parts. The first part explains how the work is distributed. Then, the discussion part of the accessibility calculation process for direct trips and trip chains.

2.1 Job opportunities

The distribution of the number of jobs is obtained from 2 types of data, both of which come from ABS (Australian Bureau of Statistics) in 2016. The number of jobs data is derived from the OD matrix of work trips from the 2016 census. Meanwhile, the workplace area comes from land use data in 2016. The year was chosen because the census data was considered the most stable before the COVID-19 pandemic.

The number of jobs comes from the number of trips to the workplace by various modes of transportation. It is assumed that each trip represents one job. Land use data is obtained at the depth of the mesh block level. From the various types of land use, a selection process is used to select land uses that are considered suitable for the workplace (such as: Commercial, Education, Hospital/Medical, Industrial, Primary Production, and others/ agricultural and mixed-use). Both data were then analysed spatially using ArcGIS Pro. The analysis output is the number of jobs for each SA1 area.

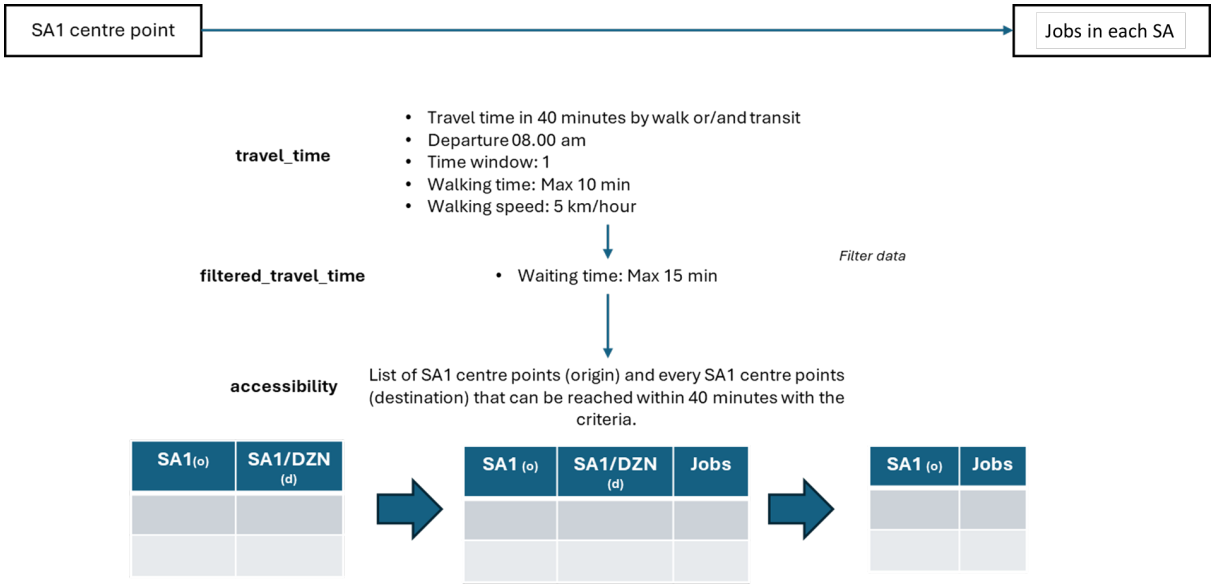
2.2 Accessibility measurement

Accessibility calculation is done using the cumulative opportunity method. In this study, accessibility calculations are done using the R5R Package, while the transit data input is focused on metropolitan transit. The data comes from GTFS (General Transit Feed Specification) data from September 2024, assuming there were no major changes in transit from 2016 to 2024 (Keys et al., 2024).

For each accessibility measure, the departure time is 8:00 a.m., which is considered a regular time to leave for work in the office, with a shift starting around 9 a.m. The total travel time is 40 minutes (average travel time based on VISTA 2012 – 2019).

2.2.1 Direct trip/ simple trip

Figure 2: Direct trip accessibility calculation



In the direct trip calculation, the origin and destination of the trip are represented by the midpoint of each SA1. The following are some of the calculation parameters used in the calculation:

- Transport mode: walking and transit (metropolitan only)
- Total travel time: 40 min
- Max walking time: 10 min
- Max waiting time: 15 min
- Walking speed: 5km/hour (reference: Google Maps)

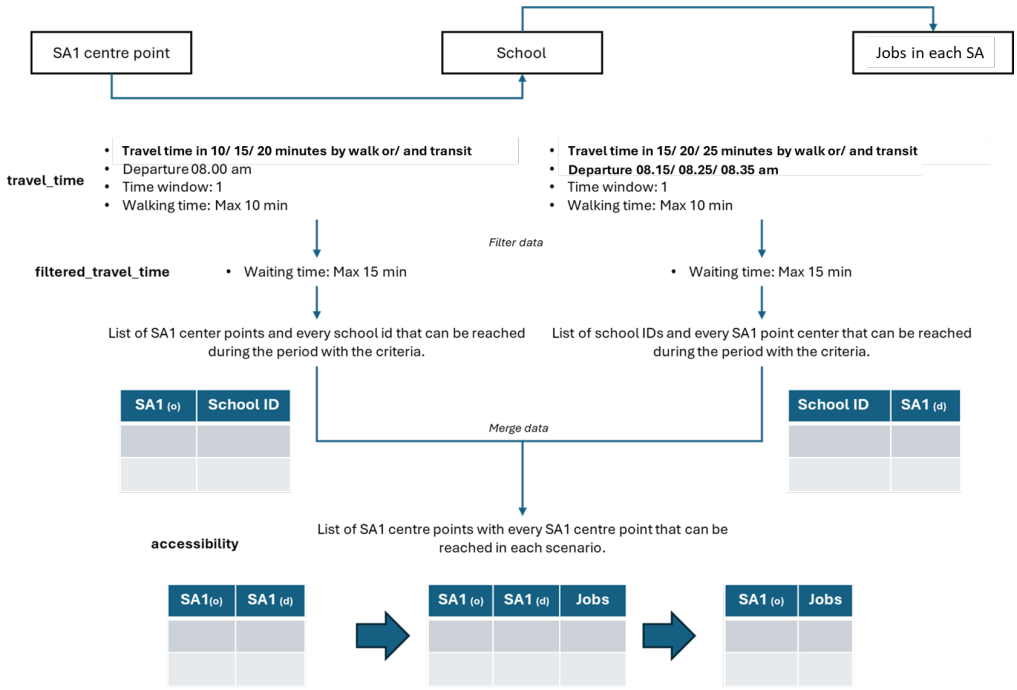
The results of this calculation will show the number of jobs that can be reached within 40 minutes using public transport from each SA1.

2.2.2 Trip chaining/ multi-destinations trip

In this study, trip chaining is a trip with two main destinations: the workplace and primary school. In this study, we consider all of the type of primary school. The primary school data are sourced from the Department of Education (www.education.vic.gov.au).

The calculation of trip chaining is divided into two stages. The first stage is calculated from home to primary school. The aim is to see which facilities can be reached from home within a certain period. The second calculation is carried out with the trip's origin in the form of selected schools (results from stage 1) to all workplaces that can be reached within the remaining travel time.

Figure 3: Step-by-step calculation process for trip chaining



Trip-chaining accessibility shows the number of jobs reachable after dropping children off at school. To avoid double-counting, a filtering process follows the second-stage calculation since workplaces may be accessible from multiple facilities with similar travel times. Like direct-trip accessibility, it employs the cumulative opportunity method; however, here the destination is the school's location rather than the SA1 midpoint. A 5-minute drop-off duration—representing the average time at the school gate—is included and affects the start time of the second trip.

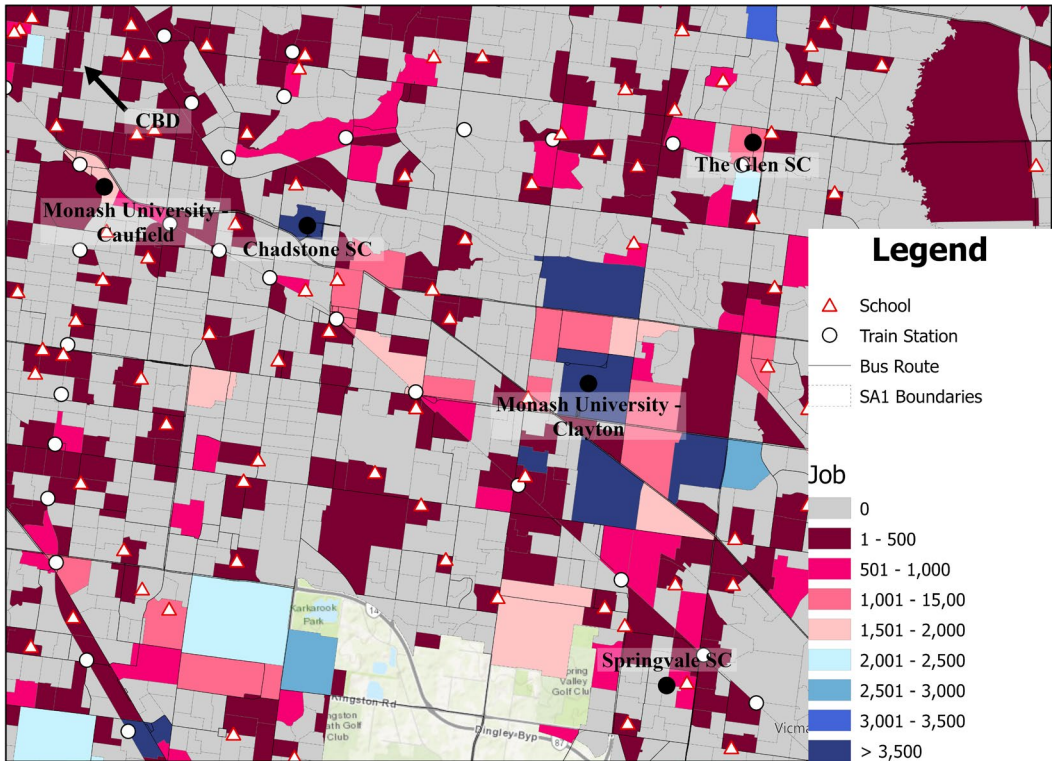
Three scenarios are analysed, differing in travel composition to facilities and workplaces to reflect daily variations and the effect of facility location on mothers' accessibility:

- 10 minutes to the facility + 25 minutes to the workplace,
- 15 minutes + 20 minutes, and
- 20 minutes + 15 minutes.

3 Job distribution

In the urban area of Melbourne, approximately 30,000 jobs are distributed unevenly across each SA1, as shown in Figure 4 for area around Monash University and Figure B for Greater Melbourne Area. Of the 9,971 SA1 areas, approximately 71.9% have no jobs, with a few zones spread near the CBD and mainly in the suburbs. Areas without jobs are more likely to be residential or large green spaces. Some areas in the Central Business District (CBD) have significant employment numbers, with some zones having more than 3,500 jobs. In the suburbs, particularly those dominated by industrial areas, employment numbers range from 2,000 to more than 3,000 jobs per zone.

Figure 4: Job distribution (around Monash University)



4 Job accessibility

Figure 5 illustrates the variation in accessibility across four different scenarios. In the direct-trip condition, people living in the CBD can reach more than 35,000 job opportunities, while those residing near stations outside the CBD can access around 25,000. Accessibility declines with increasing distance from the CBD, and approximately 6.5% of SA1s lack access to workplaces within a 40-minute public transport trip, primarily due to limited walking access within a 10-minute radius.

The remaining three maps depict trip-chaining accessibility (school + workplace). In the 10+25-minute scenario, most outer areas lose access to workplaces, although the CBD still retains around 25,000 jobs, and nearby stations have about 5,000. As school drop-off time increases, accessibility decreases markedly: with a 15-minute school trip, about 50% of areas lose access, rising to 55% for 20-minute trips. The most significant decline occurs between 10 and 15 minutes, where Inner Melbourne's accessibility drops from roughly 25,000 to fewer than 15,000 jobs.

Figure 6 compares direct and chained trips. Most suburban areas experience reduced accessibility, often losing more than 10,000 reachable jobs, as parents detour to schools. A few peripheral green areas show slight gains, while around four SA1s in the east and west remain unchanged.

Figure 5: Accessibility for direct trips vs chained trips (around Monash University)

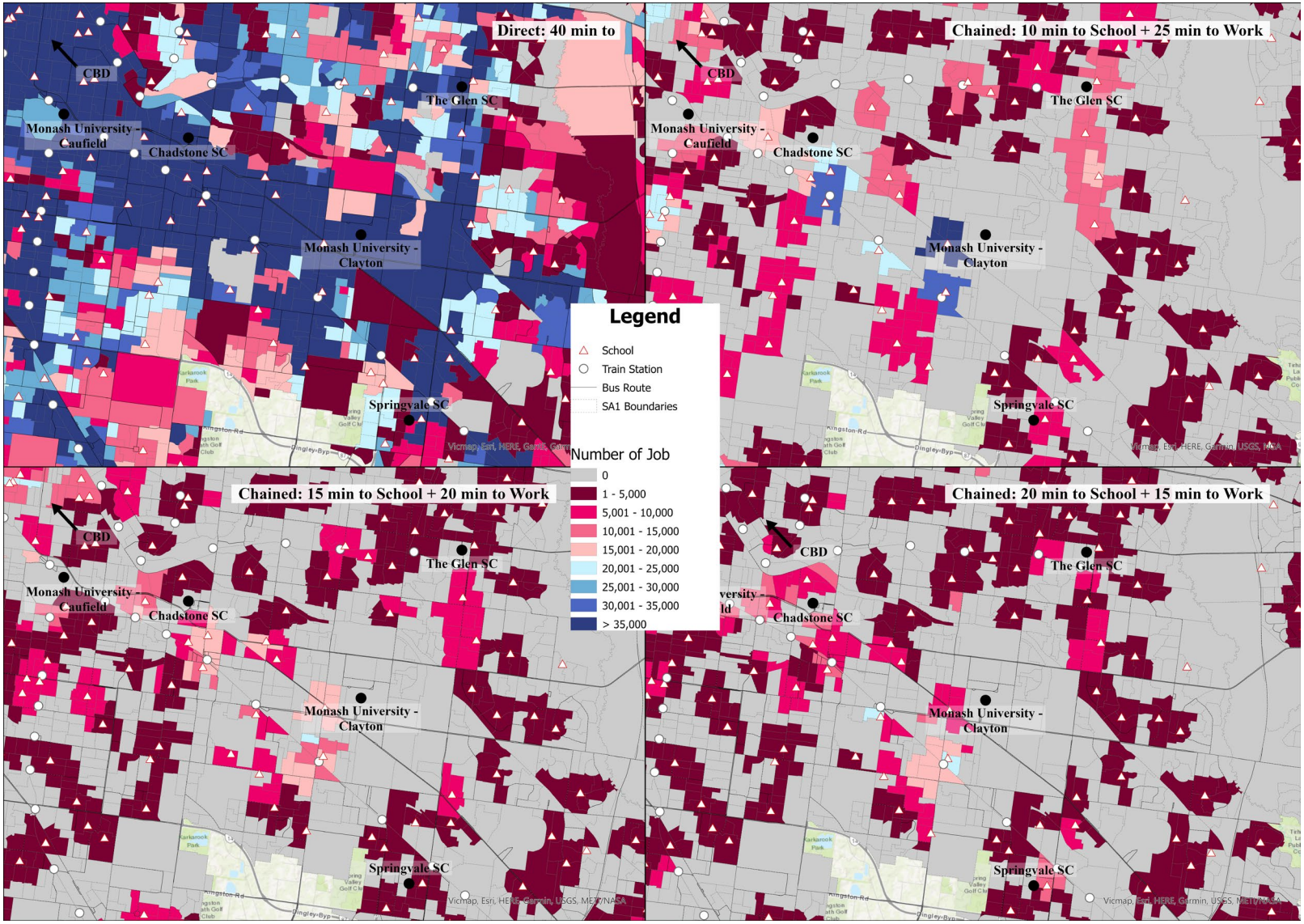
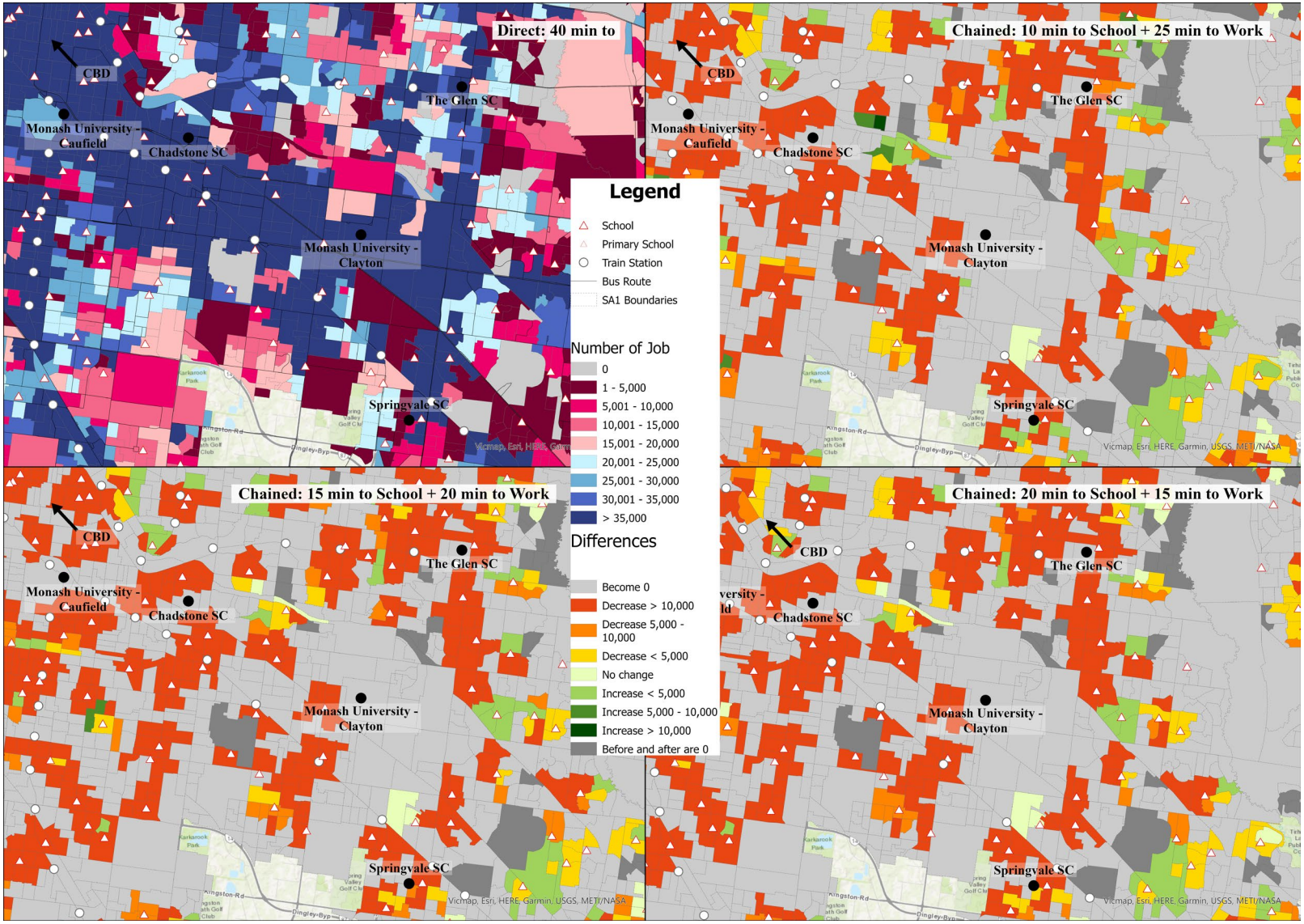


Figure 6: Change in accessibility between direct and chained drips (around Monash University)



In this study, we introduce a new approach to measuring public transport accessibility that incorporates trip-chaining behaviour. This framework offers a more realistic perspective on everyday travel, particularly for parents who frequently make additional stops—such as dropping off their children at school—before commuting to work. Although the case study for this research is Monash, Melbourne, the analytical concept can be adapted to other regions, particularly those seeking to evaluate how trip-chaining scenarios impact public transport accessibility. This concept can also provide valuable insights for policymakers in providing more equitable public transport for all community groups.

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