6 Evaluating Transit-Oriented Development Using a Sustainability Framework: Lessons from Perth's Network City

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Planners and urban designers across the globe are promoting transit-oriented development (TOD) to encourage sustainable precincts around public transport stations. TODs are compact, mixed-use developments that facilitate walking, bicycling, and use of public transport through its urban design. This chapter presents a method to evaluate the sustainability of TODs based on six aspects of outcomes, including 1. Travel Behaviour, 2. The Local Economy, 3. The Natural Environment, 4. The Built Environment, 5. The Social Environment, and 6. The Policy Context. Data were collected in five rail precincts across Perth, Western Australia. The major goal of the study was to determine which indicators were possible to collect and establish baseline data.

Introduction

Transit-oriented development is gaining popularity as a tool to achieve sustainable development, particularly in Western Australia. *Hope for the Future: The Western Australian State Sustainability Strategy* (2003) discusses the need to manage urban and regional growth, revitalise declining centres and suburbs, and integrate land use with balanced transport to reduce automobile dependence. TOD seeks to accomplish these goals, creating compact, mixed-use, pedestrian-friendly precincts around major public transport stations. This chapter presents a tool to measure the outcomes of TOD using a sustainability framework.

Sustainable development seeks to create an urban environment which maximises economic development and social equity, whilst minimising negative externalities upon the natural environment (see Figure 6.1). From a land use and transport perspective, this means reducing automobile de-

pendence through mixed use and compact cities with an array of travel alternatives focused on walking, bicycling, and public transport (Newman and Kenworthy, 1999, Banister et al., 2006).

Figure 6.1. Theoretical Model of Sustainable Development

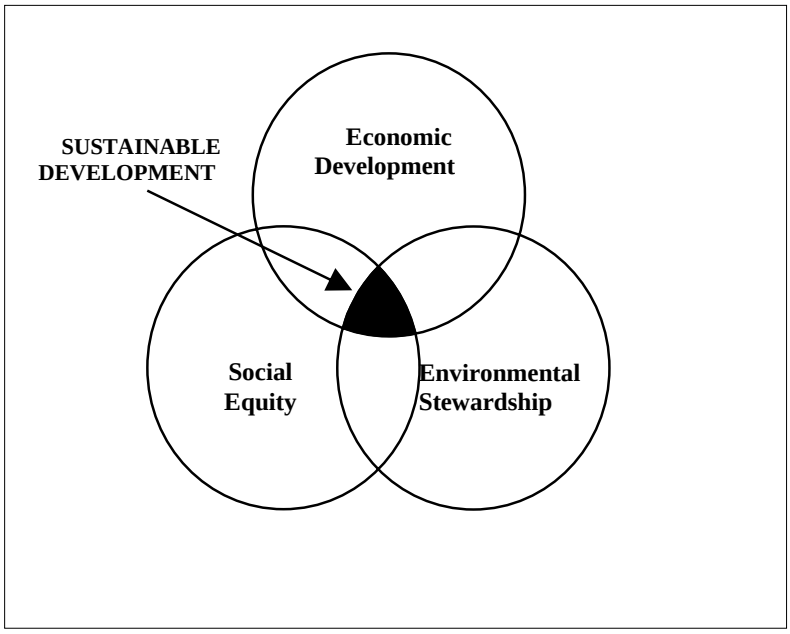
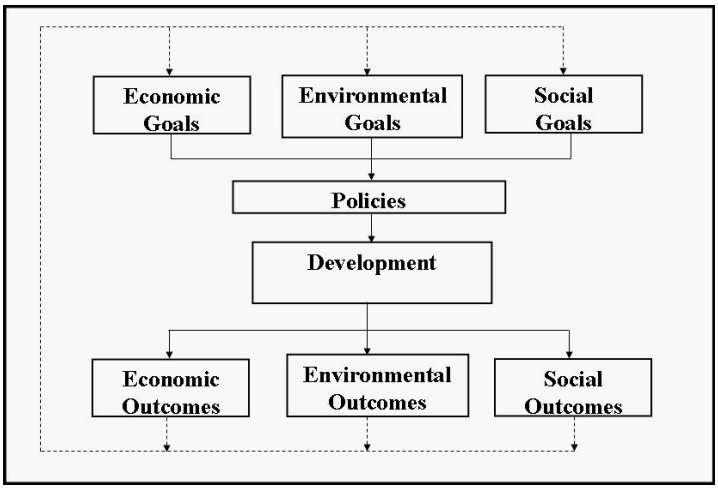


Figure 6.2 presents a framework which illustrates how sustainability is related to land use and transport policies and thus development outcomes. Inherent in all land use and transport policies are economic, environmental, and social goals. Policies take the form of land use and zoning regulations, parking requirements, design guidelines, and transportation system priorities. The policies shape the built environment leading to economic, environmental and social outcomes. The tool presented in this paper identifies indicators that can be used to measure outcomes so policy makers can continually monitor and update policies to foster more sustainable developments.

When instituting a system for measuring land use and transport outcomes, it becomes difficult to categorize indicators using the three basic categories of sustainable development (economic, environmental, and social) since many indicators cross boundaries. This method evaluates six aspects of TOD outcomes, including 1. Travel Behaviour, 2. The Local

Economy, 3. The Natural Environment, 4. The Built Environment, 5. The Social Environment, and 6. The Policy Context.

Figure 6.2. Framework for Evaluating Sustainable Development Policies



Background

Measuring Success and TOD Outcomes

Success is subjective. One TOD may yield a high transit mode share but lacks social diversity. Another might be deficient in shopping and entertainment choices but provides affordable housing on reclaimed brownfields. Moreover, a myriad of goals for TOD obfuscates success. A recent study found that planners in Perth felt TOD was important towards increasing transit ridership, spurring economic development, increasing housing choice, relieving traffic congestion, reducing sprawl, creating a diverse community, improving neighbourhood quality, and increasing political support for transit (Renne, 2005a). With so many goals for TOD, measuring success becomes a matter of perspective.

The evaluation of TOD should be both cross-sectional and longitudinal. Indicators of performance can compare the TOD with regional and subregional averages, since TODs function as part of a larger whole. This approach is better than a matched-pair analysis, which is sometimes sug-

gested for comparing TODs to similar developments not built near a transit node. The problem with matched-pair analysis is that it is often impossible to find two developments that exhibit similar characteristics for comparison purposes and when a comparison is made it is usually only one or two-dimensional. After creating baseline data, future TOD outcome analyses should compare longitudinally to determine if a TOD is becoming more sustainable over time.

A Focus on Travel Behaviour, Vehicle Ownership, Property Values, and Markets

Past studies have focused mainly on just a few aspects of success – travel behaviour, vehicle ownership, property values and understanding markets. Several studies have looked at commuting in TODs. A 2003 study of TODs across California found that residents were up to five times more likely to commute via transit compared to non-TOD areas (Lund et al., 2004). In the San Francisco Bay Area, Cervero (1994) found that, "[o]n average, residents living near stations were five times as likely to commute by rail transit as the average worker living in the same city, and in some cases as much as seven times as likely" (Cervero, 1994, p. 177). Another study of 103 TODs across twelve regions in America found that, on average, residents were 2 – 2.5 times more likely to commute on transit compared to the average resident of the region (Renne, 2005b).

Studies which investigate non-commute trips in TODs have been less conclusive on travel behaviour impacts (Boarnet and Crane, 2001), although Chatman (2006) found that residents and employees near rail stations have a higher non-auto share of commuting and non-work travel. He attributed the effects based mainly upon the level of convenience (or inconvenience) in using an automobile. His study also found higher shares of non-auto use closer to job centres.

TOD households exhibit lower automobile ownership in comparison to regional averages. One study found that American households near train stations owned 0.9 cars per household compared to 1.6 cars per household across regions (Center for Transit-Oriented Development, 2004). My study of 103 TODs found that 37 percent of TOD households owned two or more cars compared to 55 percent of regional households (Renne, 2005b).

In looking at property value, a number of hedonic price studies found a premium on land value closer to rail stations (Cervero et al., 2004, Califor-

nia Department of Transportation, 2002b). A report published by the City of Cleveland summarizes a number of these studies (see Table 6.1). A study in the Santa Clara Valley of California found that commercial parcels located within a quarter mile of a light rail station was worth 24 percent more (an additional $4.10 per s.f.) due to the station. Residential parcels experienced a 28 percent premium due to the station (an additional $9.20 per s.f.) (Cervero and Duncan, 2002b, Cervero and Duncan, 2002a)

Table 6.1. Summary of Studies on Land Value Near Train Stations

Location	Increase in Property Value	Decrease in Property Value	No Effect in Property Value
Commuter/Rapid Rail			
Commercial Property	4	0	1
Residential Property	6	0	1
Light Rail			
Commercial Property	2	0	0
Residential Property	6	1	1
Total	18	1	3

Source: City of Cleveland, 2001

Finally, some studies have looked at the market for TOD and necessary elements of local markets for a TOD to thrive. Huang (1996) studied the land-use impacts of rail systems on real estate development and concludes that "zoning incentives, attractive station sites with available land, and strong local economies are necessary for development to occur around transit stations" (p. 28). Bertolini contends that several factors have led to an increased number of station-area urban developments. This includes the expansion of high-speed rail systems across Europe and Asia and light rail systems across the United States, an increased process of the privatisation of railway companies, a decreased presence of manufacturing in cities, and the goal to make urban areas competitive to attract new residents (Bertolini, 2007).

The building of a new train line does not automatically yield TODs around stations. Loukaitou-Sideris and Banerjee (2000) examined why TOD failed to materialize along the Blue Line in Los Angeles, despite impressive growth in transit ridership. They propose eleven missing antecedents for economic development, including: 1. the corridor's industrial 'back-door' location of Los Angeles, 2. missing density gradients near stations, 3. inaccessible stations, 4. pedestrian-unfriendly station locations, 5. lack of an urban design framework for station locations, 6. landscape dep-

ravation and the 'broken window syndrome,' 7. relatively high land costs, 8. antiquated zoning and regulatory barriers, 9. lack of institutional commitment, 10. absence of critical mass, and 11. lack of community involvement and participation (p. 119 – 122).

When a number of factors coexist, including a healthy local real estate market, community and institutional support, and transit and road network accessibility, changing demographics are supporting TODs. A number of studies indicate that the supply of transit accessible, mixed-use neighbourhoods is much lower than the demand to live in such locations (Levine and Inam, 2004, Center for Transit-Oriented Development, 2004, Urban Land Institute and PriceWaterhouseCoopers, 2005). Levine (2006) argues that zoning policies are artificially restricting smart growth developments, such as TODs.

Transit Oriented Development in America: Experiences, Challenges, and Prospects (Cervero et al., 2004) was the seminal report on TOD in the United States, sponsored by the Federal Transit Administration. This study, which reviewed the literature, surveyed and interviewed a number of stakeholder groups, and conducted case studies across ten regions concluded that "[t]he literature is replete with platitudes that have been heaped on the TOD concept; however, relatively few serious studies have been carried out that assign benefits to TOD in any quantitative or monetary sense. For the most part, anecdotes and story lines are relied on instead" (p. 119). The study went on to note that transit ridership impacts and land value gains were the areas with the most amount of quantitative research.

Studies in Measuring TOD Success Holistically

Some studies have attempted to study TOD success from a holistic vantage. The *Statewide Transit-Oriented Development Study: Factors for Success in California* (California Department of Transportation, 2002a, 2002b) reported on ten areas of major benefits, including: 1. TOD can provide mobility choices, 2. TOD can increase public safety, 3. TOD can increase transit ridership, 4. TOD can reduce rates of vehicle miles travelled (VMT), 5. TOD can increase households' disposable income, 6. TOD reduces air pollution and energy comsumption rates, 7. TOD can preserve resource lands and open space, 8. TOD can play a role in economic development, 9. TOD can decrease infrastructure costs, and 10. TOD can contribute to more affordable housing (pp. executive summary 4 – 6). In addition to providing data within the final reports which addresses each of these areas, the State of California also launched an online TOD Search-

able Database (http://transitorienteddevelopment.dot.ca.gov/). This database provides data about: land uses, mapping, implementation processes, financing, facilities, zoning, design features, pedestrian access, transit services, photos, travel benefits, local contacts, and other variables for 21 TODs across California. While the database is valuable, most of the data appear to date back to the early 2000s, thus the database is in need of an update.

Wells and Renne (2003) proposed a set of indicators to evaluate the success of the New Jersey Transit Village Initiative, a state program that facilitates TODs, otherwise known as Transit Villages. We recommended an evaluation framework based upon economic activity, environmental and transportation activity, institutional changes, and community perceptions using data most readably available for economic activity, travel behaviour, and public perception. Table 6.2 illustrates the indicators suggested for each of the categories. In attempt to collect the data, it was found that much of the data were missing and difficult to obtain. Subsequent efforts in working with local and state government in New Jersey met with some difficulty in collecting data as many of the variables were unavailable or only available in paper format located within municipal libraries. It became a time consuming effort to collect the data so designated Transit Villages were encouraged to collect and report data to the State for analysis by researchers at Rutgers University. This led to a series of reports as part of the Transit Village Monitoring Research program (available at: http://www.policy.rutgers.edu/vtc/tod/tod_ projects.html).

Our findings in New Jersey prompted a national study, called *Transit-Oriented Development: Developing a Strategy to Measure Success* (2005) to determine what local, county, state departments of transportation and transit agencies across the United States reported as benefits and measures of TOD. Our study revealed 56 indicators, which we categorized as: travel behavior, economic performance, environmental performance, the built environment, and social benefits. Our findings revealed that that half of agencies surveyed had access to five or fewer indicators to measure these criteria. While we sought to determine which indicators were most useful and easiest indicators to collect (see Tables 6.3 & 6.4), the project did not include actual data collection for each of the indicators.

Table 6.2. Recommended Indicators to Evaluate TOD as Part of the Evaluation of the New Jersey Transit Village Initiative

Economic Activity	Environmental and Transportation Activity	Institutional Changes	Community Perception
Public Investment	**Pedestrian**		**Residential Survey**

• Municipal funds
• State funds
  o Grants
  o Loans
• Federal funds
  o Grants
  o Loans
• Tax abatements
• Total public investment (calculated from indicators above)
 	
Private Investment, Commercial
• New or substantially rehabilitated retail/office space[1]
• Estimated private investment[2]
• Estimated new property taxes generated[3]
 	
Private Investment, Residential
• New or substantially rehabilitated housing units[1]
• Estimated private investment[2]
• Estimated new property taxes generated[3]
• Number of new studios / one bedroom
• Number of new two bedrooms
• Number of new three or more bedrooms
• Number of new units for sale
• Number of new units for rent
	• Length of improved streetscape
	• Number of improved intersections/street crossings for pedestrian safety
	• Length of façade improvement
	• Pedestrian activity counts
	
	Parking
	• Number of new spaces for shoppers only
	• Number of new spaces for commuters only
	• Number of spaces that are shared
	• Number of new bicycle racks or lockers provided
	
	Traffic Flow
	• Number of new shuttle or jitney services provided to and from the transit station
	• Number of traffic control or flow improvements
	
	Land Use
	• Amount of brownfield properties remediated under a [Department of Environmental Protection] approved plan
	• Number/size of vacant buildings rehabilitated or replaced
	• Number/amount of underutilized/vacant lots reclaimed for
		• New TOD ordinances
		• New TOD or smart growth designations
			• How would you rate your town/neighborhood as a place to live?
			• Do you feel the downtown (or transit station area) is more or less attractive now compared to (number) years ago?
			• Is it more or less pleasant to walk around the downtown (or transit station area) now compared to (number) years ago?
			• Does the downtown (or transit station area) seem more or less safe now compared to (number) years ago?
			• Does the downtown (or transit station area) offer better or worse shopping now compared to (number) years ago?
			• Does the downtown (or transit station area) offer more or less restaurant options now compared to (number) years ago?
			• Does the downtown (or

Source: Wells and Renne, 2003

Table 6.3. Indicators Rated Very Useful for TOD by at Least 50% of the Respondents

Indicator	Percentage as 'Very Useful'	Category
Qualitative rating of streetscape (i.e., pedestrian orientation/human scale)	77	Built environment
Pedestrian activity counts	77	Travel behavior
Number of transit boardings	**70**	**Travel behavior**
Population / housing density	67	Built environment
Estimated increase in property value	63	Economic
Public perception (administered survey)	63	Social diversity / quality
Number of bus, ferry, shuttle, or jitney services connecting to transit station	**63**	**Travel behavior**
Number / square feet of mixed-use structures	**60**	**Built environment**
Number of improved intersections / street crossings for pedestrian safety	**60**	**Built environment**
Estimated amount of private investment	57	Economic
Number of parking spaces for residents	53	Travel behavior
Number of shared parking spaces	53	Travel behavior
Number of convenience/service retail establishments (i.e., dry cleaners, video rental)	**53**	**Economic**
Employment density (i.e., number of jobs per acre / square mile)	53	Economic / built environment
Estimated amount of private investment by type of land use	52	Economic

Note: Bold indicators were also reported as easy to collect
Source: Renne and Wells, 2005 p.19.

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We recommended the following indicators as the most essential for a TOD evaluation framework: 1. transit ridership, 2. population and housing density, 3. quality of streetscape design, 4. quantity of mixed-use structures, 5. pedestrian activity and pedestrian safety 6. increase in property value/tax revenue, 7. public perception—resident and merchant surveys, 8. mode connections at the transit station, 9. parking configuration—for commuters, for residents, and shared parking.

Methodology

This study was commissioned jointly by the State of Western Australia's Department for Planning and Infrastructure (DPI) and the Public Transport Authority (PTA). DPI and PTA are both members of a state TOD Committee. Other members of the TOD Committee include the Main Roads department, the East Perth Redevelopment Authority, the Midland Redevelopment Authority, the Department of Housing and Works, and the Western Australia Local Government Association. The TOD Committee coordinates and prioritizes capital infrastructure planning to encourage TOD. The Committee recently developed a TOD Assessment Tool, which helps in prioritizing when stations should receive capital investments. They work closely with local government and have ranked all stations with respect to partnership potential, strategic significance of location, potential for maximising transit ridership, development opportunities, and socio-economic benefits.

As the TOD Committee funnels state resources into creating TODs, they would like a way to track progress. This tool was commissioned to be flexible so progress could be measured across a variety of benefit types.

Table 6.4. Indicators of TOD Rated Very Easy to Collect by at Least 50% of the Respondents

Indicator	Percentage as 'Very Easy to Collect'	Category
Number of bus, ferry, shuttle or jitney services connecting to transit station	**79**	**Travel behavior**
Number of bicycle racks or lockers	72	Travel behavior
New or improved cultural/artistic institutions or establishments	71	Social diversity/quality
Mileage of bicycle lanes	71	Travel behavior
Amount of improved public park area / public space	68	Built environment
Number of subsidized housing units	64	Economic
Number of neighborhood institutions (i.e., local clubs or organizations)	64	Social diversity/quality
Number/amount of underutilized lots reclaimed for construction or green/recreation space	63	Built environment
Number of parking spaces for commuters	62	Travel behavior
Number of traffic flow improvements (i.e., traffic-calming devices)	61	Travel behavior
Number/acreage of brownfield properties remediated	61	Built environment
Number of affordable housings units	61	Social diversity/quality
Number of transit boardings	**61**	**Travel behavior**
Number of improved intersections / street crossings for pedestrian safety	**59**	**Built environment**
Number/size of vacant buildings rehabilitated or replaced	57	Built environment
Estimated amount of new property taxes generated	57	Economic
Amount of crime	57	Social diversity/quality
Number of convenience/service retail establishments (i.e., dry cleaning, video rental)	**57**	**Economic**
Length of facade improvement	57	Built environment
Number / square feet of mixed-use structures	**54**	**Built environment**
Length of improved streetscape	54	Built environment
Number of substantially rehabilitated housing units	50	Economic

Note: **Bold** indicators were also reported as most important to collect (Table 6.3)
Source: Renne and Wells, 2005, p. 20

The goal of the study was to develop a method for measuring the performance of TODs in Perth against selected economic, environmental, social, and other performance criteria, and to establish the structure for a database required to undertake on-going periodic performance measurement. Therefore, while collecting data was an important part of the study, the most important part of the project was to test which data were available for collection. Therefore, this study has established a baseline that future analyses can be measured against.

The scope of the project began by identifying five transit precincts for analysis. The selection team, which included researchers and planners from DPI and PTA sought to select five stations which were representative of the different types of stations across Perth. The five stations selected were: 1. Mosman Park – a relatively compact, mixed-use and mixed-income established suburb; 2. Subiaco – an awarding winning textbook TOD build in the early 2000s, which has been so successful that property values have priced out most working class residents; 3. Maylands – a working class suburb close to Downtown Perth with an underutilized mainstreet and commercial centre; 4. Joondalup – an awarding wining New Urbanist town built in the early 1990s, which some argue has not taken full advantage of the train station within the urban fabric; 5. Glendalough – a station surrounded by automobile-oriented land uses that is hostile towards pedestrians.

The next step was to identify appropriate data categories, indicators, and data sources. The project team then embarked on collecting the data, working with local and state government to collect as much secondary data as possible before a primary data collection effort. Since our data collection effort sought to identify performance within the approximate 800-meter station precinct, some of the secondary data sources did not allow for an analysis at such a small geographic scale.

Our primary data collection effort took the form of site visits and a TOD Household Survey. The site visits sought to collect indicators from field observation whereas the Household Survey aimed to collect data from households living within the study areas. 2,503 households were randomly selected across the study area. Because Joondalup only had 364 households within the station precinct, we selected all of these households. In the remaining precincts 535 households (534 households in Glendalough) were randomly selected and sent surveys. For each selected household a letter was mailed from the government stating that they were chosen to participate in a study and that they would soon be receiving a question-

naire that was important for the future of planning in Perth. The first round of questionnaires was mailed within a week after this initial letter. To generate the highest response rate possible, each packet contained an introductory letter, an eight page questionnaire, and a postcard to return separately to ensure complete anonymity for the responses. After two weeks, the households that did not return postcards were sent a second round of questionnaires.

In total, 332 surveys were returned as bad addresses resulting in 2,171 surveys sent to valid households. The Household Survey resulted in 848 completed questionnaires or a response rate of 39.1 percent of households with valid addresses. This response rate falls in line with another household TOD mail survey using a similar methodology. A household mail questionnaire of three TODs in New Jersey recently resulted in a response rate of 40 percent (Renne and Wells, 2003).

It is important to note the limitations of this study's methodology. Many of the indicators draw from secondary data sources; therefore the data may be biased based on the methodologies used within the original collection of data depending upon the source. As for the primary data collection, the TOD Household Survey may be biased similar to any mail survey. Those that have the strongest opinions are perhaps more likely to complete the questionnaire. Moreover, since we surveyed only households that live within 800 meters of a train station, the habits of the population might be skewed compared to the general population due to a self-selection process of living near a rail station. Despite these limitations, the collection of these data represent one of the first attempts to amass such a broad set of indicators to measure the success of TOD based on a sustainability framework. There is no doubt that problems within the data exist but this study's goal was more to test a method for measuring TOD success than to collect the data. The best way to test a methodology for measuring TOD success is to actually collect data, which serves as a baseline to track future growth.

Results

The team identified indicators for six categories, including: 1. Travel Behaviour, 2. The Local Economy, 3. The Natural Environment, 4. The Built Environment, 5. The Social Environment, and 6. The Policy Context. This section presents the results of identifying and collecting indicators within

each category. While a number of indicators are reported as possible measures to track TOD success, for the sake of brevity, this section only presents the results of selected measures from a larger set of data collected.

Travel Behaviour

Table 6.5 lists the potential measures, indicators, and possible data sources for measuring travel behaviour of residents living in TODs, while Table 6.6 reports information collected from secondary data sources. Three cells pertaining to vehicle kilometres travelled (see reverse coloured cells) are identified because the data seems questionable. This data comes from the Perth and Regional Travel Survey (PARTS) which surveyed 14,651 households across the region. The percent of the sample living within the station area precincts ranged from a high of 0.54 percent (79 households) in Mosman Park to a low of 0.055 percent (8 households) in Joondalup. The questionable data could be due to the small sample size in these locations.

As discussed above, The TOD Household Survey provided a much larger sample across the station area precincts. The questionnaire asked residents how they use public transport (see Table 6.7), how long it takes them to walk to the nearest train station (see Table 6.8), how they travel for shopping and commute trips (Table 6.9). This data reveals that automobiles are used for roughly 70 percent of all shopping and commute trips. Of the remaining 30 percent, residents in these five station areas are more likely to use public transport for commuting and more likely to walk or ride a bike for shopping. The survey also collected the number of vehicles, bicycles, and licensed drivers within the household (results not reported here). We also asked a number of opinion questions related to transportation, as reported in Table 6.10.

Table 6.5. Potential Travel Behaviour Measures, Indicators, and Possible Data Sources[1]

Measure	Indicator	Possible Data Sources
Vehicle Use/ Modal Split	Vehicle kilometres travelled (VKT) per household	Travelsmart, PARTS, Survey
	Number of trips per day, by mode, per household	Travelsmart, PARTS, Survey
	Method of journey to work (residents)	ABS, Survey
	Method of journey to work (employees)	ABS, Survey
	Method of other journey (visitors)	Survey
Trip Lengths	Average daily commuting time and distance (residents)	Travelsmart, PARTS, Survey
	Average daily commuting time and distance (employees)	Travelsmart, PARTS, Survey
Transit Quality	Number of high frequency, line haul and local public transport services available	PTA
	Integration of services both spatially and timetable	PTA, DPI
Vehicle Ownership	Number of vehicles per household	ABS
Pedestrian Accessibility	Ped Shed	DPI

Table 6.6. Secondary Travel Behaviour Data

[1] Travelsmart – a State Government Program in Western Australia that works to reduce automobile dependence; PARTS – Perth and Regional Travel Survey; Survey – The household TOD survey conducted for this project; ABS – Australian Bureau of Statistics census data; PTA – Public Transport Authority; DPI – Department for Planning and Infrastructure

TOD Performance Indicators	Mosman Park Station	Town of Mosman Park	Subiaco Station	City of Subiaco	Maylands Station	City of Bayswater	Glendalough Station	City of Stirling	Joondalup Station	City of Joondalup	Perth Metro Area
Average VKT per household (per day)	11.87	17.57	66.62	31.10	13.47	18.41	48.48	21.40	164.32	23.45	26.38
Mode Share of Daily Household Trips (all trips)											
% trips by private vehicle (driver or pass) inc truck, mbike, taxi	68.91	80.52	79.39	75.34	74.49	86.21	91.02	86.18	92.68	85.80	83.88
% trips by public transport (all modes)	5.88	4.68	5.64	5.18	7.65	0.95	3.91	2.90	3.05	2.39	3.87
% trips walking, cycling, other	25.21	14.81	16.16	19.49	17.86	10.12	4.69	10.85	3.96	11.75	12.17
Method of Journey to Work (residents)											
% trips by private vehicle (driver or pass) inc truck, mbike, taxi	63.16	32.00	78.87	74.30	78.26	87.50	95.24	88.95	90.00	89.30	86.51
% trips by public transport (all modes)	10.53	40.00	18.31	15.08	17.39	7.29	3.17	8.51	6.67	7.79	9.26
% trips walking, cycling, other	10.53	28.00	2.82	10.61	4.35	5.21	1.59	2.54	3.33	2.91	4.23
Method of Journey to Work (employees)											
% trips by private vehicle (driver or pass) inc truck, mbike, taxi	64.29	80.00	82.93	78.11	66.67	87.50	91.89	89.19	91.18	89.86	86.51
% trips by public transport (all modes)	21.43	4.00	12.20	12.94	27.78	7.55	5.41	7.88	5.88	6.69	9.26
% trips walking, cycling, other	14.29	16.00	4.88	8.96	5.56	4.69	2.70	2.75	2.94	3.23	4.21
Method of other Journey (visitors)											
% trips by private vehicle (driver or pass) inc truck, mbike, taxi	70.09	81.52	78.32	74.65	77.53	86.04	89.73	85.74	93.52	85.17	83.53
% trips by public transport (all modes)	4.02	4.08	4.07	4.54	3.93	3.08	3.78	2.29	2.73	1.87	3.10
% trips walking, cycling, other	25.89	14.40	17.62	20.81	18.54	10.89	5.95	11.93	3.55	12.88	13.33
Trip lengths (residents)	9.723	2.810	11.341	10.257	9.601	11.240	13.254	11.952	8.273	15.443	14.404
Trip lengths (employees)	9.274	6.680	12.318	11.276	8.654	11.381	13.297	11.842	9.487	15.210	14.404
Number of services available (train and bus) total services	256		632		286		502		700		
#trips, bus services not co-ordinated with trains	76		132		0		0		0		
#trips, bus services not serving station	36		332		122		78		0		
Number of vehicles per household	1.139	1.275	1.286	1.223	1.353	1.562	1.429	1.573	0.875	1.880	1.694
Ped Shed (walkable catchment/total catchment)	77%		67%		67%		67%		67%		
Passengers boarding (Average Weekday Boardings (AWB)	677		2504		1418		1791		2444		68416

Note: Data from multi secondary sources. Shaded cells represent questionable data.

Table 6.7. Frequency of Public Transport Usage from the TOD Household Survey

How often do you use public transport such as bus or a train?	**Percent**
5 days per week or more	32.1
1 to 4 day(s) per week	25.1
1-3 day(s) per month	24.3
Less Often	18.3
Never	0.3
N = 742	

Table 6.8. Walking Distance to the Nearest Train Station from the TOD Household Survey

Approximately how long does it take you to walk to nearest train station?	**Percent**
Less than 5 minutes	19.7
5-10 minutes	61.0
10-20 minutes	17.0
More than 20 minutes	1.9
Don't know	0.4
N = 839	

Table 6.9. Mode Choice for Shopping and Commute Trips from the TOD Household Survey

Mode	**Shopping Trips**	**Commute Trips – Survey Respondent**	**Commute Trips – Survey's Partner** (if available)
	(Percent)		
Automobile	69.5	63.5	69.6
Public Transport	3.6	22.5	11.6
Walk and Bicycle	24.7	5.7	6.5
Motorcycle and Taxi	2.1	4.2	5.7
	N = 827	N = 614	N = 352

Table 6.10. Transportation Opinion Questions from the TOD Household Survey

Transportation Perception Question	Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
	(Percent)				
I feel safe walking around my neighbourhood at night	7.8	17.2	18.5	34.2	22.1
My neighbourhood is well served with public transport	1.0	2.4	3.5	22.6	70.5
Traffic is not a major issue in the area	14.8	21.6	17.6	28.2	17.8
The neighbourhood is easy to walk around	1.8	4.1	7.2	33.5	53.3
Footpaths are in good condition	4.3	9.9	13.8	34.4	37.7
It is easy to cross the street	7.7	11.8	14.7	34.4	31.4
I feel safe from traffic while walking	4.3	11.4	13.0	37.1	34.2
Drivers give way to pedestrians crossing the road	16.6	21.9	26.2	26.8	8.5
I can easily walk to the train station from my house	1.8	3.8	3.7	17.3	73.4
Hills along the route area barrier to walking to the train station	57.2	16.7	14.5	6.0	5.5
One of the main reasons I live here is to be close to the train station	17.4	11.4	27.8	22.2	21.2

The Local Economy

The potential measures, indicators, and possible data sources for economic variables are reported in Table 6.11. The economic indicators focus on the range and success of local business, the amount, affordability, and tenure

of housing, property values, taxes, and percent of income spent on housing and transportation.

Table 6.11. Potential Local Economy Measures, Indicators, and Possible Data Sources

Measure	Indicator	Possible Data Sources
Range of Businesses	Number of retail, commercial and industrial businesses (possibly on GIS)	DPI, Local Government
	Suitability of local retail for residents (Index of Retail Variation)	DPI, Site Visit
Business Success	Rate/ Number of vacant buildings/units (retail, commercial, industrial)	REIWA, Site Visit, DPI
	Number of jobs in area (by, categories, FT/PT)	DPI, ABS
	Number of people in home-based employment	Survey
Range of Housing	Number of residential units (houses/flats/apartments)	ABS, Local Government, DPI
	Number of rental and owner-occupied residences	ABS, Local Government, DPI
	Number of affordable housing units (to be defined) Range of 1, 2 and 3+ bedroom	ABS, Local Government, DHW, Real Estate Agents
Financial Base	Property value (over time)	Valuer General, REIWA, DPI
	Percentage of income spent on housing and transport	ABS, PARTS, Survey
	Taxes collected by local government ($)	Local Government

Note: Survey – The household TOD survey conducted for this project; ABS – Australian Bureau of Statistics census data; PTA – Public Transport Authority; DPI – Department for Planning and Infrastructure, DHW – Department of Housing and Works; REIWA – Real Estate Institute of Western Australia

The number of jobs (by type) for each station area is presented in Table 6.12. The bulk of the jobs across the areas are in retail, office, services, health care, and entertainment. These are exactly the type of jobs that are compatible with TOD, as opposed to heavy industry jobs. Vacancy rates, reported by DPI are shown in Figure 6.3. DPI also reports the number of

vacant buildings, but the data reported here is based on floor space to capture both buildings that are totally and partially vacant.

Table 6.12. Number of Jobs, by Type, for Each Station Precinct

Number of jobs in the area (by type)	Station Area Precinct				
	Mosman Park	Subiaco	May-lands	Glenda-lough	Joonda-lup
Primary/Rural	988	851	1,035	424	45
Manufacturing/Processing/Fabrication	1,517	1,661	2,401	2,448	249
Storage/Distribution	2,503	2,279	3,428	2,251	233
Service Industry	1,003	980	1,033	952	224
Shop/Retail	1,685	3,464	3,066	1,664	2,220
Other Retail	2,443	2,380	3,592	2,097	718
Office/Business	2,282	5,029	3,207	3,593	1,581
Health/Welfare/Community Services	2,368	4,770	2,835	1,506	392
Entertainment/Recreation/Culture	4,484	4,777	5,890	2,728	578
Utilities/Communications	4	83	25	41	10
Total	19,276	26,274	26,512	17,704	6,250

Source: Department for Planning and Infrastructure

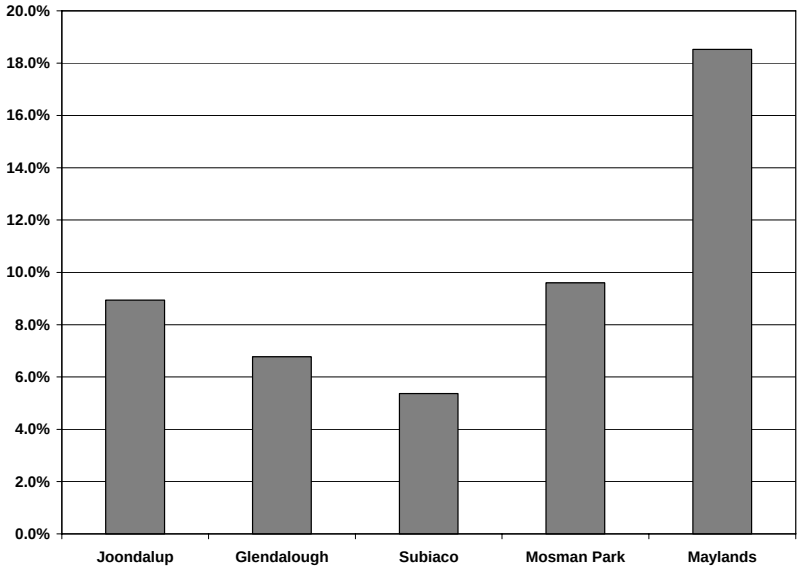
Table 6.13 reports housing tenure for each station precinct and Figure 6.4 presents the weekly payment towards rent or mortgage. The average amount spend on petrol, based on the TOD Household Survey, was $46.94 AUD per week, whereas the average spent on parking and public transport was $14.44 AUD and $14.39 AUD, respectively.

Table 6.13. Housing Tenure for Each Station Precinct

Housing Tenure	Station Area Precinct				
	Mosman Park	Subiaco	Maylands	Glenda-lough	Joonda-lup
Fully Owned	32%	26%	21%	23%	24%
Being Purchased	15%	22%	21%	23%	8%
Rented	45%	42%	48%	45%	64%
Other	8%	10%	10%	9%	4%

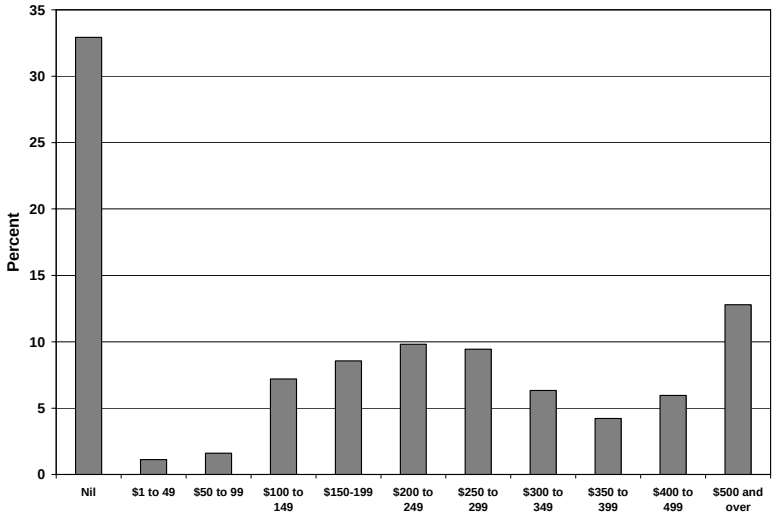
Source: Australian Bureau of Statistics

Figure 6.3. Vacancy Rate (Vacant Floorspace/Total Floorspace)



Source: Department for Planning and Infrastructure

Figure 6.4. Weekly Payments for Rent or Mortgage from TOD Household Survey



The Natural and Built Environment

An ideal TOD includes compact development and mixed land uses while still provided green and natural space. The potential measures, indicators and possible data source are listed in Table 6.14 and 6.15.

Table 6.14. Potential Natural Environment Measures, Indicators, and Possible Data Sources

Measure	**Indicator**	**Possible Data Sources**
Air Quality and Pollution	Estimate emissions based on VKT	Survey, PARTS, Travelsmart
Energy use (people)	Estimate car fuel use based on VKT	Survey, PARTS, Travelsmart
Noise	Average and Peak noise levels	Local Government
Stormwater Retention	Volume of water	Local Government

Note: Travelsmart – a State Government Program in Western Australia that works to reduce automobile dependence; PARTS – Perth and Regional Travel Survey; Survey – The household TOD survey conducted for this project

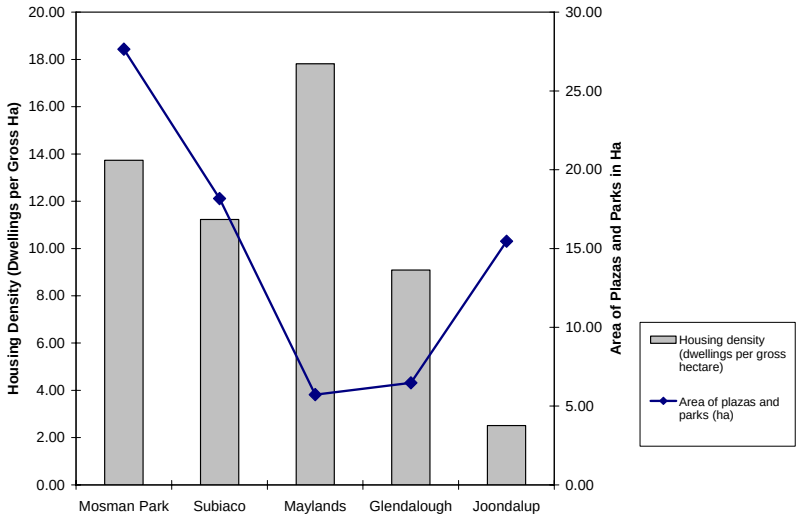
Table 6.15. Potential Built Environment Measures, Indicators, and Possible Data Sources

Measure	Indicator	Possible Data Sources
Vibrancy	Resident population (density)	DPI, ABS
	Pedestrian counts	Site visit
	Area/number of vacant land parcels	Site visit, Local Government, DPI
Attractiveness	Subjective measure of façade quality	Site visit, Survey
	Subjective measure of streetscape quality (inc. pedestrian amenity)	Site visit, Survey
	Number of heritage buildings preserved	Local Govt, State Heritage Register
	Public Art	Site visit, Local Govt
Safe and inviting area	Quality of lighting	Site visit
	Security at railway station	PTA
	Facilities (incl. retail) at railway station	DPI, PTA, Site visit
	CPTED (Crime Prevention Through Environmental Design) Building Frontages - SAFE assessment (measures to be determined)	
Mixture of uses	Number of mixed use buildings	DPI, Local Govt., Site Visit
	Housing/Population density	DPI, Local Govt., Site Visit, ABS
Space for people rather than cars	Area of plazas and parks	Local Govt., Site Visit, DPI
	Area/number of auto-oriented land uses	Local Govt., Site Visit
	Area/number of pedestrian-oriented land uses	Local Govt., Site Visit
	Bicycle parking spaces	Site Visit, DPI
	Bicycle traffic volume	Site Visit
	Presence of Principal Shared Paths (PSP) and on-street bicycle lanes	DPI
	Number of traffic calming features	Local Govt., Site Visit
	Auto traffic speed and volume	Main Roads, Local govt.

Note: Survey – The household TOD survey conducted for this project; ABS – Australian Bureau of Statistics census data; PTA – Public Transport Authority; DPI – Department for Planning and Infrastructure

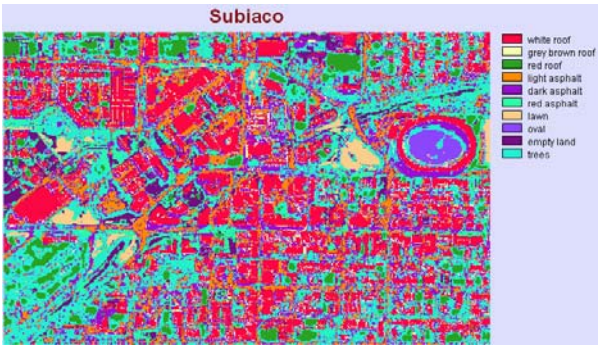
Figure 6.5 reports housing density and the amount of public space, which is a vital component for creating a successful built environment.

Figure 6.5. Housing Density and Area of Plazas and Parks



An analysis of land use by remote sensing depicts the amount and variety for different types of land uses (see Figures 6.6 – 6.10). Table 6.16 shows the comparison of land uses across the five station precincts.

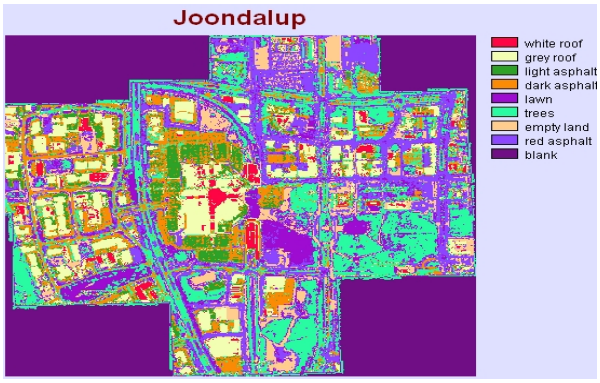
Figure 6.6. Land Uses Within the Subiaco Rail Precinct



Land Use Type	
Buildings	28%
Asphalt	41%
Greenspace	3%
Trees	21%
Empty land	7%

Map Source: Map Created by Les Chandra
Table Source: Department for Planning and Infrastructure

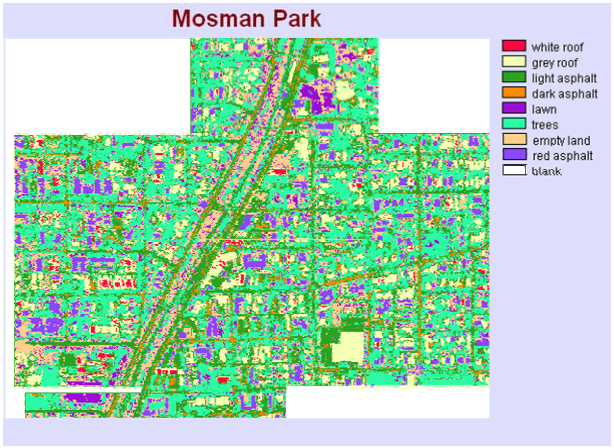
Figure 6.7. Land Uses Within the Joondalup Rail Precinct



Land use type	
Buildings	16%
Asphalt	33%
Greenspace	18%
Trees	25%
Empty land	8%

Map Source: Map Created by Les Chandra
Table Source: Department for Planning and Infrastructure

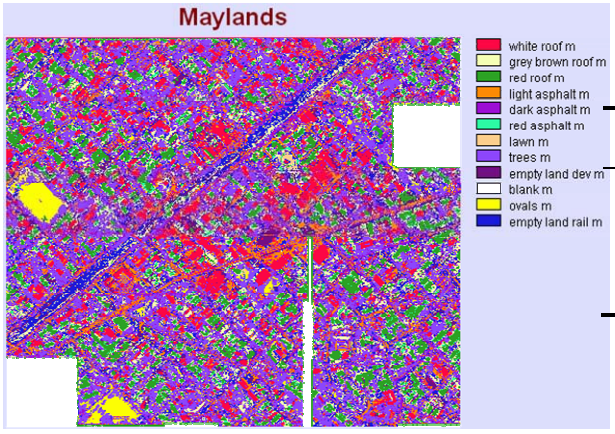
Figure 6.8. Land Uses Within the Mosman Park Rail Precinct



Land Use Type	
Buildings	13%
Asphalt	32%
Greenspace	4%
Trees	35%
Empty land	16%

Map Source: Map Created by Les Chandra
Table Source: Department for Planning and Infrastructure

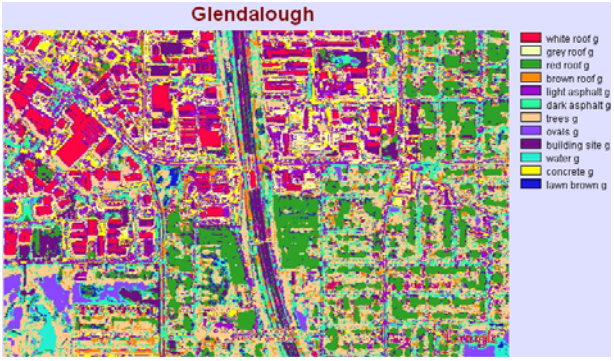
Figure 6.9. Land Uses Within the Maylands Rail Precinct



Land Use Type	
Buildings	32%
Asphalt	21%
Greenspace	4%
Trees	26%
Empty land	16%

Map Source: Map Created by Les Chandra
Table Source: Department for Planning and Infrastructure

Figure 6.10. Land Uses Within the Glendalough Rail Precinct



Land Use Type	
Buildings	30%
Asphalt	35%
Greenspace	5%
Trees	20%
Unused land	10%

Map Source: Map Created by Les Chandra
Table Source: Department for Planning and Infrastructure

Table 6.16. Land Use Comparison Across Rail Station Precincts

	Glenda-lough	**Joonda-lup**	**Maylands**	**Mosman Park**	**Subiaco**
	(Percent)				
Buildings	30	16	32	13	28
Asphalt	35	33	21	32	41
Greenspace	5	18	4	4	3
Trees	20	25	26	35	21
Unused land	10	8	16	16	7

Source: Department for Planning and Infrastructure

The TOD Household Survey also asked a number of detailed questions about the quality of the natural and built environment. Some of the data, including the quality of the footpaths, perceptions of safety, and other indicators related to transportation as it relates to the environments were reported in Table 6.10. Other data, which asked detailed questions about the respondent's ideal neighbourhood and the types of land uses that were important to them were asked on the questionnaire but not reported here for the sake of brevity.

The Social Environment

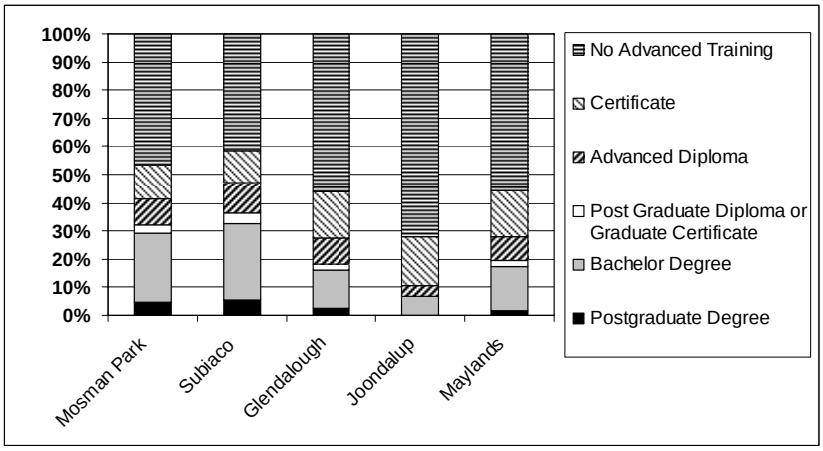
Potential measures, indicators and possible data sources of the social environment are reported in Table 6.17. Figures 6.11 and 6.12 present data on educational attainment and income distribution of the population. Some of the data on safety and security were reported in Table 6.10. We also collected data on age and gender, as well as the perception of neighbourhood quality. Table 6.18 reports quality of life indicators collected thorough the TOD Household Survey.

Table 6.17. Potential Social Environment Measures, Indicators, and Possible Data Sources

Measure	Indicator	Possible Data Sources
Safety and Security	Public perception of: neighbourhood, crime, pedestrian and bicycle safety	Survey
	Recorded incidents of crime, pedestrian and cycle accidents	Police, Local Govt.
Ownership	Public perception of community	Survey
	Perceived quality of retail environment	Survey
	Community support for further (re)development	Survey
Residential diversity	Breakdown of population by age, education, ethnicity and income level and household formation (size)	ABS
Opportunities for advancement	Number of libraries, theatres, galleries etc	Site Visit, Local Govt
	Number of other community facilities	Site Visit, Local Govt
	Perceived quality of community facilities	Survey
	Number of festivals and events	Local govt
	Perceived quality of events	Survey
	Educational Opportunities	Site visit

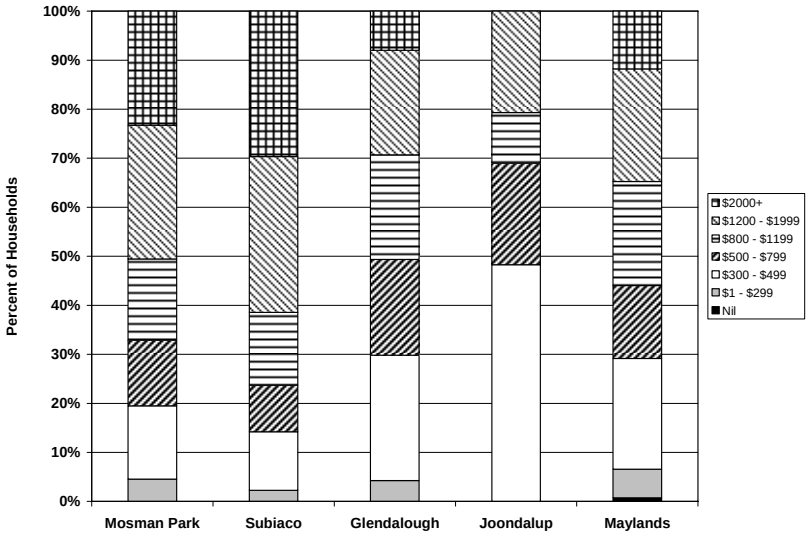
Note: Survey – The household TOD survey conducted for this project; ABS – Australian Bureau of Statistics census data

Figure 6.11. Educational Attainment of Residents Living Within the Rail Precincts



Source: Australian Bureau of Statistics

Figure 6.12. Weekly Income of Households Living Within the Rail Precincts



Source: Australian Bureau of Statistics

Table 6.18. Quality of Life Indicators from the TOD Household Survey

Quality of Life Perception Question	Strongly Disagree	Slightly Disagree	Neutral	Slightly Agree	Strongly Agree
	(Percent)				
My neighbourhood is a good place to live	0.9	2.1	6.2	24.0	66.9
My neighbourhood is a better place to live than other parts of Perth.	1.7	2.6	15.3	28.1	52.3
My neighbourhood is clean and well maintained	2.9	7.3	12.3	37.8	39.7
My neighbourhood is a low crime area, compared to other parts of Perth	3.3	12.5	28.1	34.4	21.6
The neighbourhood centre is an attractive place that is nice to be in	4.6	10.0	21.6	30.1	33.6
I can do all my weekly shopping in the neighbourhood centre	5.0	8.4	6.8	26.5	53.3
I can do my day-to-day shopping in the neighbourhood centre	2.2	4.1	5.6	25.3	62.7
There is a strong community feeling in my neighbourhood	6.0	13.7	35.8	29.8	14.7
The area is quiet and free from traffic and other noise pollution	19.3	24.4	17.5	26.4	12.5
The neighbourhood is well provided with community facilities	5.1	8.9	20.0	35.4	30.6
There are many opportunities for recreation in my neighbourhood	4.5	9.0	18.0	33.9	34.6

The Policy Context

The locations selected in this study vary to a certain degree with respect to TOD potential. Glendalough is the most automobile dependent and is fairly built-out. The potential for changing Glendalough into a TOD is pretty low. Subiaco is a mostly completed TOD. It also has little room for

change. Other station precincts, such as Mayland, Mosman Park, and Joondalup may have more development potential. Of the five rail precincts, Joondalup and Subiaco were developed under heavy public institutional and financial support, however, Joondalup was not planned with a focus on the train station. Table 6.19 reports the public's support for future growth and development in the train station precinct.

Table 6.19. Public Support for Future Growth and Development from the TOD Household Survey

Opinions on Future Development	Strongly Oppose	Slightly Oppose	Neutral	Slightly support	Strongly support
	(Percent)				
There should be more shopping/retail development in the train station precinct	11.8	12.1	26.7	23.2	26.2
There should be more commercial/office development in the train station precinct	16.5	17.7	34.5	19.2	12.0
There should be more flats/apartments/ townhouses built in the train station precinct	23.8	20.1	28.2	16.3	11.6

Interpretation and Policy Recommendations

In recent years, TOD has been proposed as a means to encourage sustainable development. The problem is that few, if any studies have attempted to move beyond a discussion of sustainability to the collection and analysis of a holistic set of indicators measuring TOD success. This study attempts to provide indicators of TOD that use a sustainability framework, but the problem is that a multi-dimensional analysis, such as this, quickly becomes increasingly complex due to the vast number of indicators. Analyzing the data is difficult without having a particular objective or defined set of goals, but sustainable development calls for the simultaneous improvement of the economy, environment, and social arenas. Complex optimization models are possible to identify a possible solution space TOD sustainability, but can we expect neighbourhood groups and governments who operate within a political process to rely on such an analysis? In my opinion, the role of this type of analysis is to empower communities to make their

own decisions. This section suggests policy recommendations for using this sort of TOD outcome analysis and how it can inform policy.

1. *Understand that most decisions are ultimately political* – Planners need to understand that no matter how much data experts analyze, decisions are mostly made based on political factors. The importance of data is to confirm or reject assumptions that local communities make based on gut feelings. Data can assist to refine goals and objectives and ultimately create better policies to produce more sustainable outcomes (see Figure 6.2).
2. *Define the goals of TOD* – Each community needs to define their own goals for TOD. If multiple goals exist, they should be ranked. Some communities might encourage TOD primarily from a mobility perspective while others see it as a driver of economic development. Other communities might use TOD as a way to encourage location efficient affordable housing. Without specific prioritized goals for TOD, it becomes very difficult to define success.
3. *Establish baseline data across sustainability dimensions* – This paper attempts to create multiple dimensions to evaluate TOD success. Baseline data is needed to track future changes to ensure that goals are not achieved at the expense of some other unintended negative externality. Collecting data from both primary (ie. the TOD Household Survey) and secondary sources (ie. census) is often necessary. Secondary sources do not provide the coverage and scope of data needed to fully evaluate TOD from a sustainability perspective. It is also important to ensure that at least some of the data collected can be compared to regional or sub-regional averages.
4. *Collect data at regular intervals to track success* – Once the baseline data has been established, the only way to determine success is to collect the same data, using the same methodologies, at regular intervals. Change within the TOD could be compared to change within the region (or sub-region) to determine if the TOD is becoming more or less sustainable in comparison to the average.
5. *Analysis of data should include local and regional stakeholders* – A mechanism needs to be established for local and regional stakeholders to discuss and debate the outcomes of the analysis. Local planners need to seek the input of the community and regional planners need to work collaboratively across agencies and layers of government to ensure political coordination. The TOD Committee in Western Australia provides such a forum for Perth.

Again, the goal for this study was not to create the definitive methodology to measure TOD success using a sustainability framework. The goal was to start a dialogue. Future studies should analyze which indicators are best, how many are needed, and how to best analyze the data once it has been collected. The terms sustainable development and transit oriented development have become quite popular with planners across most urbanized areas, especially in Australia and North America. The problem is most studies focus too heavily on only one aspect of TOD success. This attempt admittedly has flaws as well, namely, what do you do when you have all of the data? How do you make decisions? Perhaps this tension is not so bad because it ensures that we are moving towards building cities based on a blend of political and data-driven analyses.

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