Human settlements

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In the following text, there are hyperlinks to indicator documents which informed the particular statement or comment to which they are linked. It should be noted that, at different points in the commentary, different words might trigger links to the same indicator document. The links are entirely context dependent. In some cases, hyperlinks are made to indicator documents which are now populated but for which data were unavailable to the commentary authors at the time of writing the commentaries

Introduction

Human settlements need to be considered from two perspectives in state of the environment reporting.

Firstly, they constitute an environment in their own right—the built environment—delivering amenity and liveability to resident and visitor populations. Australia’s built environment was assessed as contributing 40 per cent of the nation’s total asset base of $3500 billion in 2001; by way of contrast, Australia’s natural environment (land, minerals, oil and gas, timber) constitute one third (ABS 2003a, p. 875). Furthermore, Australia’s human capital has been assessed as being three times that of its physical, or built capital (Wei 2004) and it is increasing its contribution to the national asset base, in absolute and relative terms.

Secondly, human settlements are a source of pressure on the rest of the (natural) environment. Settlement-based activities draw down resources such as energy, water, and materials; they convert land into production and consumption landscapes; and they generate wastes and emissions to air, land and water. Understanding how human and built capital interacts with natural capital is fundamental to the planning and management of sustainable human settlements.
An extended urban metabolism model was developed for state of the environment reporting on human settlements in Australia as a means of capturing this dual feature of human settlement (Figure 1). Its key elements are described in Newton (2003) and they contribute significantly to the structuring of this commentary.

**Figure 1: Extended urban metabolism of human settlements**

External pressures on human settlements

External processes can significantly shape the future state of human settlements. They include flows of population, financial capital and trade, and an increasing spectrum of environmental risks.

**Population dynamics**

Natural increase and migration are the two factors driving aggregate population change. In recent years, both have contributed in relatively equal proportion to national population increases. Migration, however, constitutes the major driving force in the growth and decline of individual urban centres.

**International migration**

There has been a huge increase in total movements over the period 1993 to 2004: this is a significant contributor to increases in total consumption.
Permanently arriving is significant from a human settlements perspective because they tend to gravitate to the capital cities—especially Sydney and Melbourne. This has put significant pressure on Sydney, in particular, and on its housing market, leading to calls by the New South Wales Government for significant cuts in international migration (McDonald and Temple 2003).

A response by commonwealth and state governments has been to devise policies to encourage immigration to rural and regional Australia through new visa classes that give special consideration to applicants (ranging from humanitarian and refugee to employee-sponsored skilled migrants) who are prepared to locate in urban centres other than the major capitals. Recent data suggest that the policy is having an effect: in 2004, two-thirds of immigrants to Australia settled in capital cities, compared with some 80 per cent during the 1990s. Notwithstanding, Sydney and Melbourne combined continue to attract half of all permanent immigrants.

The most striking changes over the course of the past decade have been in relation to temporary migration, driven by two key categories: students and temporary business entrants (the 457 visa, see Khoo et al. 2003). In both of these categories, destinations favour the cities: the educational institutions that attract foreign students are primarily located there, as are the high-skilled jobs (McDonald and Temple 2004). Initial locations chosen by immigrants are significant, since surveys (Richardson et al. 2002) suggest that once in Australia, migrants tend to stay in their place of first settlement.

**Internal Migration**

The movement of people within and between states and territories is an important determinant of population increase and decline in Australia’s settlements. During 2002–03, for example, approximately 400 000 people were estimated to have moved interstate (ABS 2004a). Overall, the three east coast states generate four-fifths of the nation’s population growth. Recent increases in sunbelt migration to Queensland are generally attributable to quality-of-life drivers, employment opportunities (linked to south-eastern Queensland growth opportunities), and a major loss of population from New South Wales due to cost-of-living effects in Sydney (especially housing).

Smart growth policies need to be a core element of urban planning in these jurisdictions.

**Tourism**

International and domestic visitors bring with them massive benefits to local economies and employment but, depending on the destinations chosen for holidaying, an additional layer of population is added to pressures and costs on infrastructure, services and the environment. For example, in 2004, international visitor numbers (131 million visitor days) equated to 364 000 permanent residents.

International and domestic visitor survey data provide insights that run counter to the popular conception that Australia relies on its natural assets (flora, fauna and landscapes) as the key drawcard for international tourism. Tourists’ revealed preferences—where they actually visited while in Australia—suggest that it is
Australia’s cities that are the principal attractions. Cities like Melbourne and Sydney now feature a year-round calendar of sporting, arts and entertainment events that are proving increasingly attractive drawcards for tourism (ABS 2002 c, p. 19). Capital city and contiguous regions continue to dominate domestic tourism as destinations, capturing three-quarters of total visitor nights.

Australia is devoid of studies that attempt to assess the triple-bottom-line impacts of tourism—partly because tourism does not constitute an industry in the traditional sense (as defined by ANZIC—the Australian and New Zealand Industrial Classification). This is because tourism is an amalgam of parts of many industries (for example, transport and accommodation) that supply goods and services to tourists. Where studies have been undertaken, the environmental impacts have been significant (Foran 2003 reports that nearly one-quarter of New Zealand’s natural energy and greenhouse gas emissions were related to tourism activities). Governments are responding in many ways, as reflected in the *Steps to Sustainable Tourism* programme (DEH 2004b).

**Population futures**

The projected increase in Australia’s population to 26.4 million in 2051 reflects a ‘business-as-usual’ view of Australia’s population future; it occupies a middle ground between environmentally-favoured lower targets and industry-favoured higher targets (Foran and Poldy 2002). The most recent summit on Australia’s population future (Vizard et al. 2003) captures the mix of drivers for the various scenarios and preferred views of different interest groups. Industry generally argues for higher migrant intake targets from the perspectives of labour supply (current concerns relate to the tightness of labour markets and the availability of skilled workers) and the size of the domestic market (consumption). Some commentators see this as a suggestion that governments have failed to develop policies to encourage higher levels of fertility (that is, family policy designed to ‘grow our own population’), and to address potential skill shortages through enhanced training policies and programmes (Birrell 2003).

All of the capital cities will experience larger percentage growth than the rest of their states, resulting in further concentration of Australia’s population within the capital cities. Sydney and Melbourne will remain the two largest cities, followed by Brisbane, Perth, Adelaide, Canberra, Darwin and Hobart (see Appendix 1.

**Settlement futures**

Recent data suggest that the big cities in Australia continue to act as the key magnets for population, through natural increase, internal migration, international migration and tourism. Other classes of settlement that are attractors of population are the high amenity coastal regions—especially those located within the boundaries of the capital cities—and the larger regional centres (both coastal and inland). Smaller centres in the more climatically marginal farming regions, and those associated with mining, are the most vulnerable economically (fly-in-fly out schemes are a response to this reality in the case of mining).
**Large cities**

Australia’s large cities provide an increasing diversity of urban environments in which to live, ranging from the inner cities, to the suburbs, and to the peri-urban fringe and beyond. Intra-urban mobility is the process that continues to redistribute approximately 15 per cent of the population within cities each year.

**Inner city growth**

Until the 1990s, most of the inner suburbs of Australia’s cities were associated with consistent population loss. The process of re-urbanisation that was identified by Newman et al. (1996) has subsequently intensified as the supply of inner-city dwellings has increased to meet (and run ahead of, according to some commentators) demands from a group of consumers that includes students and single and dual person households at both ends of the family lifecycle, although most are in the 20–30 year bracket (DoI 1998). Despite high rates of growth in percentage terms for the inner suburbs, the absolute levels of growth remain modest, except for the east coast capitals.

Although inner cities continue to gain population, the flows of people to the suburbs has been dominant. Residential densities are highest in the inner suburbs, but they are increasing across middle suburbia. Reasons include the ‘compact city’ policies of state governments and the relatively recent process of infill housing. Despite the list of environmental and other benefits associated with higher density development (this report) there are growing challenges identified recently by Birrell et al. (2005) and Searle (2003)—infrastructure and land capacity constraints, underlying market demand, social isolation, and destruction of neighbourhood character. In addition, there is debate about the long-term sustainability of these recent levels of high rise growth. It is viewed by some as a response to long pent-up demand for inner-city apartment living; but it is not a recipe that can be applied en masse to the middle-ring suburban (activity) centres of Sydney and Melbourne under current ‘compact city’ state planning strategies (Salt 2004; Birrell et al. 2005).

**Suburban growth**

‘[Inner city living is] fine for a component of the community, but it is not as pivotal to grass roots Australian values as is the quest for space, for independence, for privacy and for low density living…’ (Salt 2004, p. 6)

It is the middle and outer suburbs that continue to accommodate the majority of Australia’s urban population growth. These data, and the research by O’Connor (1999), indicate that suburbs offer opportunities for matching both housing and jobs. Transport indicators suggest that this match is far from optimal and it is possibly becoming more difficult to satisfy—as revealed by continued high growth in car usage.
**Peri-urban growth and mega-metro regions**

With continued growth of the major capital cities, their peri-urban extensions are beginning to merge with their surrounding second-tier urban centres and provincial regional centres, forming what have been termed mega-metropolitan regions (O’Connor and Stimson 1996, Forster 2004). Four principal mega-metropolitan regions have emerged in Australia (see Appendix 2):

- South East Queensland (Sunshine Coast to Gold Coast – Coolangatta)
- Sydney mega-metro (Newcastle to Wollongong)
- Port Phillip Region (Bellarine to Mornington peninsulas)
- Perth Corridor (Wanneroo to Mandurah)

Useful as they may be as demographic absorbers (Willis and Fry 2001), mega-metropolitan regions, by virtue of their sheer size, create complex and multi-faceted planning and governance challenges on scales never experienced before in Australia. They represent regions where there is greatest pressure to convert native bushland and productive farming and horticulture land to urban use (there appears to be no mechanism in Australia for monitoring the loss of quality agricultural land and the loss of biodiversity to urban uses). They also provide opportunities for a new class of resource-based industries that are capable of delivering more sustainable metropolitan areas through eco-industrial clusters (refer to ‘Waste’ section). Long-term planning strategies have been developed for each of the mega-metropolitan regions in an attempt to achieve more sustainable outcomes than would be possible under laissez-faire alternatives (see, for example, Melbourne 2030 [Dol 2002] and the Draft South East Queensland Regional Plan [OUD 2004]).

**Coastal high amenity regions**

Next to Australia’s cities, the regions that experience the most sustained growth over the past 20 years have been the high amenity coastal regions (the so-called ‘sea change’ areas), which mostly extend far enough inland to pick up many of the high amenity ‘hill change areas’ as well. Examples include the Blue Mountains and Southern Highlands (New South Wales), Gold Coast Hinterland, Victoria’s goldfield towns and Yarra Valley (Burnley and Murphy 2004).

O’Connor’s (2001) analysis of coastal population growth between 1976 and 2000 separates growth in metropolitan areas from that in other coastal regions outside of the cities. The data revealed that the coastal municipalities of cities had experienced a three-fold increase in population from 1976 to 2000, compared with an increase of 70 per cent in the non-metropolitan coastal regions. More recent data indicate that coastal municipalities within capital cities continue to grow faster than their counterparts
outside the capitals (Table 1). ‘Coastal city’ has emerged as the most sought after residential address in Australia. ABS (2005b) indicates that the largest growth outside capital cities also occurred in coastal Australia.

Table 1: Size and density changes in estimated resident population of coastal areas in Australia, 1996–2004\textsuperscript{a,b}

<table>
<thead>
<tr>
<th>Coastal areas (as defined by Statistical Local Areas)\textsuperscript{a}</th>
<th>Estimated resident population (’000s)</th>
<th>Population change (%)</th>
<th>Population density (persons/km\textsuperscript{2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>All coastal areas</td>
<td>2 163.1</td>
<td>7 482.0</td>
<td>7 971.7</td>
</tr>
<tr>
<td>Coastal areas excluding capital cities</td>
<td>2 149.2</td>
<td>2 977.7</td>
<td>3 193.4</td>
</tr>
<tr>
<td>Coastal areas within capital cities</td>
<td>13.8</td>
<td>4 504.4</td>
<td>4 778.3</td>
</tr>
<tr>
<td>Australia</td>
<td>7 705.3</td>
<td>18 310.7</td>
<td>19 413.2</td>
</tr>
</tbody>
</table>

Notes:
- a. Coastal areas are all Statistical Local Areas (SLAs) with a boundary adjoining the sea, including those with boundaries adjoining harbours and rivers, such as Leichhardt (A) in Sydney harbour and South Perth (C) on the Swan River in Perth. Note that many SLAs extend inland for large distances (for example, East Pilbara Shire in Western Australia has a coastline of roughly 80 kilometres and an area of over 350,000 square kilometres)
- b. Based on 2004 Australian Standard Geographic Classification (ASGC) boundaries
- c. Average annual growth rate
- p. Provisional numbers

Rural and resource settlements

The persistent, long-term movement of labour out of agriculture presents continuing threats to the social and economic viability of rural service centres. Figure 2 dramatically illustrates the difference in population fortunes between the ‘bleeding bush’ and the ‘booming beach’ (Salt 2004). During the past two decades, the number of farmers has declined (at an average rate of 2.2 per cent each year) and fewer younger people have been entering agriculture as a vocation. Greater farm losses have been offset by increased dependence on off-farm income. Beer and Keane (2000) have clearly modelled the vicious cycle of rural settlement dynamics: employment loss \(\rightarrow\) services loss \(\rightarrow\) disincentive for in-migration \(\rightarrow\) disincentive for business \(\rightarrow\) employment and population loss… It is a scenario that is broadly evident across Australia, especially in the smaller rural service centres.

National Institute of Economic and Industry Research analyses (Shepherd 2003, p. 161) indicate how widespread the population loss has been across rural municipalities between 1991 and 2001. Sixty-three
per cent of all rural municipalities lost population during this period. This is a major contrast to all other regional groupings, with only the resource-based centres—the other group of settlements associated with extractive industry—also losing population. The Australian Natural Resources Atlas (NLWRA 2000a) forecasts a decline of between 30 and 55 per cent in farmer numbers to 2020 and a further increase in median farmer age, peaking in 2011. The regions that are experiencing the greatest threat are the dryland (wheat and sheep) farming regions (Hugo 2002). It is these regions that have been identified as highly vulnerable under future climate change scenarios of reduced rainfall (Fisher 2005).

The larger rural regional and provincial centres in most states and territories, however continued to gain population (ABS 2005b, p. 6) by serving a larger market catchment and by providing a higher order and broader range of goods and services, and employment.

Figure 2: Projected population change across Australia from 2002 to 2011

Environmental risk to human settlements

Climate change

Reports on the impact of global climate change on Australia (Pitock 2003; Pearman 2005; Allen Consulting Group 2005) indicate that many Australian ecosystems, regions and industries are vulnerable to climate change in the coming decades (see ‘Climate change’). Key impacts on human settlement implications include:
• Climate variability, involving lower rainfall and more frequent and intense droughts, would mean less secure water supplies, accentuate competition between users, threaten allocations for environmental flows, and lower water yields for many catchments linked to urban centres. This will have implications for their future economic viability (for example, Goulburn). Implications for agriculture (dryland as well as irrigated farmland) and the long-term viability of associated service towns are key issues for assessment. Water quality is also likely to be affected through reduced runoff, increased temperature and higher salinity.

• The increased risk of bushfire to human settlements would also align with the lower rainfall – higher temperature scenario.

• Urban infrastructure damage could be expected under increased return periods for cyclones and storm surges and episodes of heavy rainfall and flooding in certain regions, accentuated by an absence of planning and design guidelines in jurisdictions that are not accustomed to such extreme events.

• Climate changes are also expected to enhance the spread of some disease vectors, increasing the potential for disease outbreaks such as dengue fever and Ross River virus (see Australia State of the Environment 2001 (SoE2001))

_Urban salinity_

Salinity not only adversely affects the environment and economy of rural Australia; it is also causing damage to the nation’s urban infrastructure—its housing, roads and bridges (NLWRA 2000b).

_Natural hazards—extreme events_

Natural hazards that impact on Australia’s urban communities include extreme events such as cyclones, severe winds, storm surges, flooding and landslides; severe thunderstorms and hailstorms; earthquakes and tsunamis; and bushfires (Natural Disasters Organisation 1992). Natural hazards cannot be averted, but loss can be minimised by understanding the potential risks in each region and developing appropriate mitigation strategies (Allen Consulting Group 2005, such as in relation to appropriateness of building codes in particular jurisdictions). Geoscience Australia, through its Natural Risk Assessment project, has undertaken extensive assessments of South East Queensland and Perth in this regard (Granger and Hayne 2000). Macquarie University, through its Risk Frontiers programme, has estimated the risks of building damage by natural hazards to develop a nationwide ‘rating of postcodes’. A more detailed description of risk maps for Australia’s major cities are found in SoE2001.
Settlement induced pressures on built and natural environments

Resource consumption

Human settlements are key centres for the consumption of material resources. The convergence of road, rail, air, water, electricity and gas networks are evidence of this. There are three major sectors of material resource consumers in each urban centre:

- the built environment, where many thousands of individual material products are assembled as buildings and infrastructures
- the manufacturing industries and their feedstocks that generate products for export and local use
- households and their consumptive behaviours.

Each is the subject of increasing study concerning the resource use efficiencies. For built environments, the focus is on issues relating to the scale and form of settlement (such as density, compactness and infrastructure effectiveness); for manufacturing industries, the focus is on energy and water intensities, material reuse, recycling and re-manufacturing and the environmental signatures for manufactured products and materials (ecolabelling); for households the focus is on the potential for behaviour and lifestyle change to reduce the demand on natural resources.

A stocks and flows perspective

The first comprehensive materials stocks and flows study undertaken in Australia revealed a total material flow of about 180 tonnes per person per year (Foran and Poldy 2002), a figure that is more than twice that of any other OECD country. This high figure is due to Australia’s significant and continuing reliance on a minerals export industry and the fact that mining overburden and waste is included in the total (refer to Newton et al. 2001, pp. 39–41).

For this report, Lennox and Turner (2005) have attempted to measure material stocks and flows for three urban regions in Australia for 1991 and 2001: Goulburn, the mid-north coast of New South Wales and South East Queensland. As a result of unreliable and missing data for 1991, and the data problems associated with smaller regions, only a 2001 material flows profile of South East Queensland is available (Figure 3). The key insights provided by this study are as follows:

- A relatively small proportion of total material flow into each urban centre (of the order of ten per cent across all three regions) is incorporated annually into the stocks of the settlement (that is, buildings and other infrastructure). What constitutes an optimum level of resource investment in the built environment stock is yet to be established, although the consequences of under-investment are lack of
infrastructure capacity, a poorly maintained built environment, and inflated property prices when
demand for housing exceeds supply. Nett addition to stocks was highest for South East Queensland
(2.3 tonnes per person) and lowest for Goulburn (one tonne per person), reflecting their respective
levels of population growth.

- Australia’s urban regions are now highly interconnected with respect to material flows, which is seen
  in the growth of freight traffic.

**Figure 3: Resource stocks and flows – inputs to and outputs from South East Queensland**

Source: Lennox and Turner 2004
Energy

Energy use is a major environmental issue for Australia as a result of the contribution that it makes to the global generation of greenhouse gases through exports of fossil fuels—coal, oil and natural gas—as well as Australia’s continuing reliance on fossil fuels at a domestic level.

Primary energy consumption is forecast to increase by 48 per cent to reach 7544 petajoules by the year 2019; this is an average rate of increase of 2.2 per cent per year. It is significantly above the expected rate of population increase, and it is driven by the continued growth in per capita consumption and economic growth (Table 2). This is despite a forecast reduction in energy per gross domestic product, which reflects an expectation of a decline in energy intensity that is due to increasing energy efficiencies (Productivity Commission 2005), new energy technologies (ABARE 2005), and a shift in the structure of the economy towards less energy intensive sectors.

Table 2: Energy use in Australia

<table>
<thead>
<tr>
<th>Year</th>
<th>Energy consumption (PJ)</th>
<th>Estimated Resident Population (000)</th>
<th>GDP* $m</th>
<th>Energy use per capita (GJ per capita)</th>
<th>Energy use per unit GDP (GJ per $m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-98</td>
<td>4777.6</td>
<td>18711.3</td>
<td>633353.0</td>
<td>255.3</td>
<td>7543.3</td>
</tr>
<tr>
<td>1998-99</td>
<td>4884.7</td>
<td>18925.9</td>
<td>666921.0</td>
<td>258.1</td>
<td>7324.3</td>
</tr>
<tr>
<td>1999-00</td>
<td>4971.0</td>
<td>19153.4</td>
<td>692264.0</td>
<td>259.5</td>
<td>7180.8</td>
</tr>
<tr>
<td>2000-01</td>
<td>5034.1</td>
<td>19413.2</td>
<td>706109.0</td>
<td>259.3</td>
<td>7129.4</td>
</tr>
<tr>
<td>2001-02</td>
<td>5110.8</td>
<td>19641.0</td>
<td>733647.0</td>
<td>260.2</td>
<td>6966.3</td>
</tr>
<tr>
<td>2002-03</td>
<td>5215.1</td>
<td>19872.6</td>
<td>756170.0</td>
<td>262.4</td>
<td>6896.7</td>
</tr>
<tr>
<td>2003-04</td>
<td>5345.7</td>
<td>20111.3</td>
<td>783593.0</td>
<td>265.8</td>
<td>6822.0</td>
</tr>
</tbody>
</table>

* Reference Year 2002-2003


A projected switch—albeit small—to renewables and natural gas over the next 15 years is expected to be one cause of lower greenhouse gas emissions than would be expected under a business-as-usual projection. Key factors in the sluggish growth in this key area are a combination of the relative cost of renewables compared with fossil fuels, the Australian Government’s relatively modest 2020 mandatory renewable energy target, and the set of barriers associated with the transition of Australia’s different industrial sectors to renewables (such as better uptake in the residential sector versus air or surface transport).

Electricity generation is a leading consumer of energy in Australia. Its continuing high growth rates reflect the relatively low cost of electricity; the average price of electricity was 9.18 cents per kilowatt hour during 1994–95 to 2003–04 (ESAA 2002, 2005). There is scope for the greater energy efficiencies that need to be sought (Productivity Commission 2005), especially in energy conversion.
Energy conversion industries (such as electricity generation) provide energy inputs to other industries, and this is reflected in tables of final energy consumption (also see Figure 4). Transport emerges as the dominant sector, with over 40 per cent of final energy consumption. This is significant, and it is approximately 25 per cent above that of the European Union, Japan and United States (Awano 2003). By way of contrast, energy consumption by buildings has been significantly lower in Australia, which is in part a reflection of lower demands for space heating due to a relatively benign climate. Increasing demand for air conditioners may alter this.

**Figure 4: Australia’s energy consumption by sector 1991–92 and 2001–02**

<table>
<thead>
<tr>
<th>Sector</th>
<th>1991–92</th>
<th>2001–02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>58.7</td>
<td>80.2</td>
</tr>
<tr>
<td>Mining</td>
<td>90.2</td>
<td>76.2</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>260.9</td>
<td>176.2</td>
</tr>
<tr>
<td>Electricity generation</td>
<td>1033.9</td>
<td>1144.5</td>
</tr>
<tr>
<td>Construction</td>
<td>1092.9</td>
<td>1092.9</td>
</tr>
<tr>
<td>Transport</td>
<td>159.9</td>
<td>159.9</td>
</tr>
<tr>
<td>Commercial</td>
<td>303.0</td>
<td>303.0</td>
</tr>
<tr>
<td>Residential</td>
<td>1265.6</td>
<td>1265.6</td>
</tr>
<tr>
<td>Other</td>
<td>82.8</td>
<td>77.1</td>
</tr>
</tbody>
</table>

Source: Donaldson (2004, Table B1)

**Energy and the built environment**

Many of the issues regarding energy consumption are sectoral in nature, as is indicated above. A more challenging question continues to centre on identifying spatial or settlement-related factors that are linked to energy use.

**Rural-urban variation**

An analysis of household expenditure data by Lenzen (1999) revealed that people in rural areas used about 20 per cent less energy than people in metropolitan areas, which is largely explained by differences in household incomes and spending power. Patterns of energy consumption in Sydney were also strongly correlated with income. Moreover, there was no evidence that per capita energy requirements saturate or plateau over the income range used in the study (Lenzen, et al. 2004).
Urban form variation

A study undertaken by Newton (1997, p. 2000) for AATSE (1997, pp. 177–78) indicated that compact cities represent the most fuel efficient of all urban forms, with over 40 per cent less transport fuel consumption than a dispersed form. The urban consolidation policies now operating in Australia’s capital cities are encouraging less sprawl and more compact styles of development, but they are the subject of debate about the perceived benefits in areas other than resource consumption.

Building form variation

The increased construction of more medium and high density forms of housing in Australia’s cities over the past 10–15 years raises questions of the relative energy efficiencies of different forms of housing (Miller and Ambrose 2005; Newton et al. 2000; Holloway and Bunker, 2002; Troy et al. 2002). Results from the Miller and Ambrose study in South East Queensland revealed that medium-density housing performed two to three times better than detached housing in terms of operating energy; high rise was not quite as energy efficient as medium density due to the general lack of cross-ventilation.

Energy efficiency remains a key policy interest (Productivity Commission 2005). Recent initiatives that have attempted to reduce the amount of residential energy use include the introduction of more energy efficient appliances, and energy-focused programmes relating to building design. The latter include minimum operating energy performance requirements (Building Code of Australia 2004) and state and territory government building energy rating schemes. The impact of insulation would appear to be greatest on energy efficiency, with little change emerging for water heating, space heating and lighting. Meanwhile, the growth in installation of air conditioners is rapidly accelerating, reflecting the continued inadequacy of housing design for Australia’s climate and occupant preferences for thermal comfort (Tucker et al. 2002).

Water

The manner in which each urban region in Australia addresses its water security arrangements—how future demand is managed in the context of available supply options—tends to be specific to the unique biophysical and socio-economic circumstances of each region. A high level national perspective is, however, attempted in the sections that follow.

Urban water supply

Growth of human settlement in Australia called for a more reliable supply of water than was available from often highly variable river flows (McMahon et al. 1992). The construction of dams allowed for the diversion and storage of river flow and the creation of a more reliable water resource. It also ushered in the ‘linear’ model of urban water systems that has continued up until the present—distribution of water from central storage areas to consumers and discharge of wastewater (with varying levels of treatment) to receiving waters.
Australia now has over 80 major dams (with capacities over 100 gigalitres), most of which were constructed after the second world war—a period of major population and industrial growth (ABS 2004c). As the environmental consequences of reducing river flow have become known, only one major dam has been constructed since 1991. In April 2005, the Queensland Government allocated $150 million to build the 100 000 megalitre Wyaralong dam, west of the Gold Coast, to satisfy the water needs of an expected extra one million residents in the region.

With the exception of Perth, which has the largest potable groundwater supply of all Australian cities (supplying 60 per cent of present needs), water from aquifers currently do not feature significantly as a key source of drinking water in Australia’s cities; but this is likely to change as surface water becomes scarcer.

Currently, there are three networks that provide water services to urban communities—the drinking (or potable) water supply system, the sewerage (or wastewater) system, and the drainage and stormwater system.

Mains water accounts for 98 per cent of water provided to the capital cities; it is less important for other urban settlements, with mains providing only 86 per cent of their water. For both, the method of supply has been relatively fixed for some time. This is to a large extent due to the capital-intensive nature of these systems, with a long (100+ years) asset life. It is also due to the fact that satisfaction with water quality is relatively high, and has been increasing. The Australian Drinking Water Guidelines should continue to drive improvements in this area.

In 2001–02, nine per cent of Australia’s sewage effluent was being recycled for reuse, with higher rates of reuse in rural Australia (Radeliffe 2003, p. 212). Apart from Adelaide, the level of water recycling and reuse is currently very low across all capital cities, being well below the national average and virtually completely absent from the domestic sector because of the need for an additional ‘pipe’ into the system. Capture, treatment and use of stormwater—the realisation of ‘city as catchment’—is even less well developed.

**Demand for water**

After irrigated agriculture, households constitute the second largest water-using sector in the economy. The amount of water used varies substantially across the capital cities, reflecting the variable operation of a mix of factors that include consumption-based pricing, demand management through a range of conservation measures (appliances and household behaviour), and water restrictions. The reductions in urban water consumption over the last 20 years have been significant in some cities but nationally the trend indicates increased per capita and per household water use. For example, in the seven years to 2000–01, water use increased from 95 to 115 kilolitres per person (an average annual rate of three per cent).

In considering the consumption of water by Australian households, it is important to recognise its various uses. The available data at national, state and capital city levels clearly indicate that between one-third
and perhaps as much as 60 per cent of household water consumption in some urban centres is used outside the house, primarily on gardens—a significant contrast to the United Kingdom, which averages three per cent (WSAA 2003). This represents the area with the most significant potential for reduction in use. Perth’s domestic water use study indicated that usage of water by households living in multi-storey dwellings consistently averaged 250 litres per day. This is half that of the lowest daily usage of low income households in detached dwellings, and one-tenth of the highest daily usage by high income households (Water Corporation 2003).

The reduction in water use in toilets has been significant over the past ten years due to the introduction of dual flush toilets; the next major gains are likely to involve the use of recycled water for flushing and, ultimately, the waterless toilet. Of particular note in the Perth study is that the water savings achieved through the regulation of dual flush toilets (as well as other water conservation and labelling schemes) have been ‘lost’ to increased washing machine use. This is a classic example of the rebound effect that bedevils many areas of environmental conservation and efficiency.

**Future demand and supply**

Residents of Australian cities have responded positively to water demand management measures. In all cities, water consumption has either stabilised or declined from the peaks achieved around the early 1980s.

The key issue for the future is whether each city has a sustainable yield that is capable of meeting projected increases in population and industry. Calculations by the Water Services Association of Australia (unpublished data) and summarised in the Data Reporting System suggest that water consumption in all capitals, with the exception of Canberra, will have exceeded their sustainable yield by 2030.

These projections could be further exacerbated if current climate change scenarios for Australia materialise (Hennessy 2003). Decreased rainfall in the south-west of Western Australia has seen the total annual inflow to Perth dams decline from an average of 338 gigalitres in 1911–74 to 177 gigalitres in 1975–96, with only 120 gigalitres of inflow in 1997–2003. Rainfall has also declined in much of south-eastern Australia, with near-record low water levels in dams in much of the region during the prevailing 2002–05 drought.

**The challenge of urban water systems**

**Unaccounted-for-water**

While Australia compares favourably with overseas countries, a loss of 142 litres per property per day from leakages represents a challenge to the Australian water industry. Responses will emerge from improved monitoring and pipe maintenance systems (Burn et al. 2004).

**Efficient water use**
Voluntary water conservation rating and labelling schemes pioneered by Standards Australia and the Waters Services Association of Australia are now being superseded by state, territory and Australian government mandatory labelling schemes to ensure all key water using appliances are labelled.

**Water pricing**

Water pricing has been the cornerstone of demand management (WSAA 2003), as property-based pricing has given way to consumption-based pricing. The impact of pricing on demand has been significant across Australia’s cities. Clearly, the various household uses of water will have different price elasticities, with indoor water use being more inelastic than outdoor use. Is this perhaps a basis for dual metering?

**Integrated urban water management**

The various components of the urban water cycle have always been considered independently: potable water is extracted from a catchment to meet water demands; wastewater is collected, treated and discharged; and stormwater is collected and discharged. What is now apparent to water authorities is the unsustainability of this system, and that the interdependencies between the elements of the urban water cycle need to be recognised and harnessed. Integrated urban water management has been proposed by CSIRO (2002) as a more holistic approach to providing water, wastewater and stormwater to urban communities. For Australia’s major capitals, stormwater and wastewater—mostly disposed to receiving waters—represent a ‘resource’ to be tapped as they currently generate a volume that is 1.5 times in excess of present water use.

Capturing all parts of the water cycle involves consideration of:

- stormwater and treated wastewater diversion to aquifers (Dillon et al. 2004)
- increasing reuse of wastewater—currently less than ten per cent of Australia’s sewage effluent is being recycled. While applications to agriculture and manufacturing have increased significantly in recent years, gaining acceptance for household use remains a major challenge because of the need for proven technologies and monitoring systems, assurances of public health, and consumer acceptance
- water sensitive urban development takes into account the whole water cycle, from an urban perspective, to make best use of currently under-utilised resources (stormwater and wastewater) while minimising environmental impacts. Water sensitive urban designs are increasing, primarily in greenfield developments, but also in some infill projects such as Rouse Hill, Epping North, Mawson Lakes, and Roachdale (Coombes et al. 2000; Gold Coast Water 2003; Mitchell et al. 2002; Gardner and Sharma 2004).

**The challenge of healthy waterways: from catchment to coast**

Australian settlement is heavily concentrated around its coastline, rivers and estuaries and the range of activities associated with urban development have contributed to degradation of all water systems.
Waste

Improving the ecological sustainability of Australia’s human settlements involves minimising waste outputs by using a mix of processes that are applicable in the domestic and industrial sectors.

The volume of solid waste disposed to landfill across Australia remains high, at around one tonne per person per year (ABS 2003b, p. 641). Between 1996–07 and 2002–03, New South Wales, Queensland, South Australia and the ACT reduced the amounts of waste they generated; Victoria and Western Australia have experienced increases.

Across the three main categories of solid waste disposed to landfill, municipal waste tends to be the highest (40 per cent), followed by commercial and industrial waste (37 per cent). There is a range of hazardous wastes disposed across Australia. Those disposed by households reveal a pattern of disposal that is comparable between residents of capital cities and the rest of Australia (Table 3). Of particular concern, however, is the extent to which hazardous household wastes are currently disposed of in combination with municipal garbage.

Table 3: Solid landfill waste quantities in Australia by states and territories for 2002–03

<table>
<thead>
<tr>
<th>Sector</th>
<th>Amount of waste to landfill (’000 tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NSW</td>
</tr>
<tr>
<td>Domestic and municipal</td>
<td>1657</td>
</tr>
<tr>
<td>Commercial and industrial</td>
<td>2358</td>
</tr>
<tr>
<td>Construction and demolition</td>
<td>1193</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
</tr>
<tr>
<td>Total (b)</td>
<td>5208</td>
</tr>
</tbody>
</table>

See the Data Reporting System for caveats
Source: ABS (2004g, p. 15)

Resources from waste: recycling in Australia

Australia’s rate of recycling of solid waste has been estimated at 36 per cent, ranging from a high of 58 per cent in the ACT (Canberra) to a low of 18 per cent in Tasmania.

Household involvement in the recycling process is high and now almost universal within Australia’s cities. Recycling by households is lower in areas outside the capital cities, due to logistics and the costs associated with collection and transport from rural areas to processing plants. Reuse of waste, by way of contrast, is higher among non-metropolitan households (space for storage and home workshops may be a factor here).

Recycling is restricted to a relatively narrow band of products and materials. The data on which this assessment is based are almost a decade old, and they reveal an apparent inertia in Australia to initiatives
that attempt to make key transitions in Australia’s economy—cradle-to-cradle manufacturing, regional eco-industrial development, product stewardship, and creating wealth from waste. Providing data that relate to household recycling behaviour is no substitute for detailed information on waste streams and diversion rates. This becomes particularly apparent when Australia’s performance in recycling is put in international context.

Waste to energy

An international comparison of solid waste disposal methods (Batten 2002) reveals that landfill accommodates 96 per cent of Australia’s waste; this compares poorly with 70 per cent in the United States (where 16 per cent is incinerated) and 50 per cent in Sweden (where 45 per cent is incinerated). Technological improvements have made incineration cleaner and the process could be used to generate electricity, reducing Australia’s use of fossil fuels. Arguments against high temperature incineration—especially for hazardous wastes—are that such facilities reinforce the behaviour of waste creation and may also impede the development and introduction of new substitute products (Beder 1990).

When municipal waste is dumped in landfill, much of the organic component is naturally converted by bacteria to methane. In the year 2000, almost 15 million tonnes of methane was emitted to the atmosphere—contributing three per cent of Australia’s net greenhouse gas emissions (AGO 2002 cited in ABS 2003b, p. 145). It is estimated that approximately 80 per cent of Australia’s municipal solid waste could be used for the production of energy. This represents a source of approximately 50 gigajoules annually, excluding the total potential from existing landfill sites (ABS 2003b, Aquatech 1997). Despite this potential, Australia is one of the few developed nations that does not have a well-established waste-to-energy industry. This is due, in large part, to (low) pricing of landfill disposal and electricity.

The scope for eco-industrial development in Australia

Despite developments in resource recovery, millions of tonnes of materials continue to be disposed to landfill, accounting for the majority of waste that is generated in Australia. This linear pattern of resource flows, based on single-use and then disposal is unsustainable in the long term and it generates unwanted social, environmental and economic impacts.

Some approaches that are employed to address these impacts (to a greater or lesser extent) include:

- **product stewardship**—manufacturers take back their products at the end of their life; or governments impose an added tax on products at the point-of-sale to cover costs for end-of-life-management of materials (it makes the manufacturer rather than the consumer the responsible body)

- **government procurement guidelines**—such as those emerging in the USA; such guidelines list products that meet prescribed levels of recycled content
• landfill pricing—ensuring that pricing of disposal to landfill does not undermine initiatives that are related to recycling, product stewardship and cradle-to-cradle manufacturing initiatives (as well as capturing funds that can be used for repairing contaminated sites and groundwater)

• industry sector initiatives—to elevate current industry performance through voluntary waste minimisation programmes (see, for example, Environment Australia 1998)

• eco-efficient design—new design tools are applied to provide automated assessments of building performance at the concept stage in relation to cost and environmental impact (Tucker et al. 2005)

• Cradle-to-cradle design and manufacture—manufacturers create products whose materials are perpetually circulated in closed loops. Maintaining materials in closed loops maximises material value without damaging ecosystems (McDonough and Braungart 2002)

• Eco-industrial complexes—represent a larger scale and more systemic response to utilisation of waste streams than that of cradle-to-cradle or closed loop manufacturing, as these are typically limited to an individual company or product line. It is an open-loop system, which seeks to capitalise on multiple waste streams to manufacture a different ‘new’ product. Examples of eco-industrial development in Australia include Werribee (Melbourne) and Shelton Park (Perth).

**Urban systems and processes**

Since 2001, most state governments have released strategic plans for their capital cities that represent blueprints for development and that are loosely directed towards achieving a range of triple-bottom-line performance outcomes. Key among these for the faster-growing cities of Brisbane, Sydney, Melbourne and Perth are policies designed to minimise the sprawl of outer suburbia and to encourage higher density residential development around key activity centres and routes served by public transport. In addition there are a range of sector-specific government policies that require implementation within cities and that can directly as well as indirectly shape the form and function of cities. These relate to targets for water use and water quality, energy use, wastewater recycling, solid waste disposal to landfill, protecting catchments, and green wedges public transport usage, and others.

**Issues of urban form and density**

Between 1996 and 2001 levels of population density have increased in all capital cities, but most noticeably in the larger cities and, within that, predominantly in the inner city municipalities (the cities of Melbourne, Sydney, and Perth) where high rise development dominates (see Table 4).
Table 4: Selected occupied private dwellings* Australia, 2001

<table>
<thead>
<tr>
<th>Population centre (grouped by size)</th>
<th>Separate houses</th>
<th></th>
<th></th>
<th>High density housing</th>
<th></th>
<th></th>
<th>Total Dwellings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cities</td>
<td>72.4</td>
<td>16.1</td>
<td>26.7</td>
<td>36.2</td>
<td>4 453.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>63.7</td>
<td>10.2</td>
<td>35.5</td>
<td>36.5</td>
<td>1 438.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melbourne</td>
<td>74.5</td>
<td>13.9</td>
<td>24.7</td>
<td>36.0</td>
<td>1 243.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brisbane</td>
<td>80.6</td>
<td>25.9</td>
<td>18.3</td>
<td>73.5</td>
<td>601.1</td>
<td></td>
<td></td>
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<tr>
<td>Adelaide</td>
<td>75.5</td>
<td>13.5</td>
<td>24.0</td>
<td>13.9</td>
<td>430.2</td>
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<tr>
<td>Perth</td>
<td>77.9</td>
<td>26.1</td>
<td>21.5</td>
<td>30.5</td>
<td>511.2</td>
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<tr>
<td>Hobart</td>
<td>83.1</td>
<td>15.4</td>
<td>16.2</td>
<td>8.2</td>
<td>76.1</td>
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<tr>
<td>Darwin</td>
<td>62.6</td>
<td>32.8</td>
<td>29.8</td>
<td>55.4</td>
<td>38.2</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Canberra</td>
<td>76.9</td>
<td>18.0</td>
<td>22.8</td>
<td>49.6</td>
<td>114.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other large cities</td>
<td>76.8</td>
<td>40.0</td>
<td>20.8</td>
<td>71.5</td>
<td>1 257.9</td>
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<tr>
<td>Country areas</td>
<td>86.5</td>
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<td>8.5</td>
<td>-0.1</td>
<td>1 361.0</td>
<td></td>
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<tr>
<td>Australia</td>
<td>75.9</td>
<td>17.5</td>
<td>22.2</td>
<td>37.2</td>
<td>7 072.2</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

* Dwellings where the dwelling structure was not stated were excluded prior to the calculation of percentages; # - includes Other dwellings; Source: ABS (1991; 2001), cited in: ABS (2003e, p. 176)

A transition to higher levels of residential density within cities is seen as a means of achieving a number of key environmental objectives. Higher densities of urban development are associated with:

- reductions in per capita demand for land (Rees 1996, p. 2)

- reductions in the rate of loss of biodiversity as a result of lower rates of conversion of green space to residential use

- reductions in levels of operating energy in housing by approximately half (Miller and Ambrose 2005); also significant reductions in lifecycle energy use and greenhouse gas emissions are also observed (Newton et al. 2000)
• reductions in water consumption due to less outdoor water use (such as for gardens and swimming pools)

• reductions in the volume of building materials consumed (medium-density housing has two-thirds the material intensity of detached single family housing (Deilmann et al. 2001)

• reductions in solid and municipal waste generation (Matsunaga and Themelis 2002)

• improved human health as a result of decreased less car use and greater pedestrian activity (Sturm and Cohen 2003).

• reductions in the amounts of energy consumed and greenhouse gases emitted in travel (Newton 1997; Newman and Kenworthy 1999).

Despite these quantified environmental benefits of higher density residential development (versus detached housing), there continues to be debate in Australia over what are seen to be state and territory government ‘town cramming’ policies. Forster (2004, pp. 169–74) provides a recent summary of this debate. The most recent challenges to consolidation strategies have come from Birrell et al. (2005), who question the extent of demand for higher density forms of living—especially among generation X households entering the family formation phase and baby boomer households, the first several million of whom are about to turn 60 and their residential preferences are not known (particularly in relation to foregoing space). A second key area of criticism involves the negative impact that current residential infill policies and practices have had on neighbourhood character and amenity (see Lewis 1999). Key challenges here relate to inadequate regulation and guidelines, an absence of timely and rigorous assessment of development proposals, and continued separation of the planning and building (design) functions in government.

**New industrial landscapes and the mega-metropolitan region**

Australia’s current system of settlement reflects a century-long wave of transitions that have been accelerating over the past 50 years. Artefacts from each era are represented to some degree in the nation’s contemporary capital cities: the historical walking city around the port and central business district, the radial spokes of the transit city and its remnant manufacturing districts, the auto city highways and low density suburbs, and the emergent mega-metropolitan regions. The driving force of these transitions is grounded in technological change and the manner in which technical innovation is employed by society to create new industries, shape new urban infrastructures, produce new products and services for consumption, and generate new kinds of jobs (see Appendix 3; Milani 2000, Vellinga and Herb 2003, Florida 2002).

Industry-of-employment data reveal recent elements of these transitions (Appendix 4). What the analyses of the data reveal for the mega-metropolitan regions is maintenance in absolute levels of employment in extractive industries, but a slight decline as a proportion of total workforce; slight numerical growth in
manufacturing jobs, but a slight diminution of employment share. In other words, both extractive industries and manufacturing sectors continue to be significant contributors to the wider Australian economy. Growth in distributive and social services employment as a share of total has been negligible. Most growth is occurring in the producer services (information-centred) and personal services (consumption-centred) industries.

In twenty-first century Australia, the cities, and in particular the mega-metropolitan regions, are the major contributors to the nation’s economic activity. Capital cities generate about two-thirds of all economic activity: Sydney produces 23 percent of activity, Melbourne 18 per cent, then Brisbane and Perth at about seven per cent each and Adelaide at five per cent (Allen Consulting Group 2002;). Three-quarters of Australia’s economic activity emanates from the eight capital cities plus Geelong, Newcastle and Wollongong: these are classed by ABS (2004d) as ‘metropolitan Australia’. Australia’s regional centres are facing challenges in competing with the cities for the ‘new economy’ jobs. From 1995–06 to 2000–01, small business in capital cities increased by 6.4 per cent, but declined by one per cent in other parts of Australia (ABS 2004f). This exerts a circular and cumulative effect in the respective housing and retail (personal services) markets (Birrell and O’Connor 2000).

Figure 5: Percentage change in employment in four Mega-metro regions by industry sector (Singlemans Classification) 1991-2001

Source: Australian Bureau of Statistics (2003cd Table 15).
Consumption landscapes

Consumption is at the heart of modern capitalist economies, in which the market strives to convince a population that they must advance beyond a satisfaction of the ‘needs’ stage of materialism to a satisfaction of ‘wants’, the definition of which, in a sense, can be open-ended. Postwar suburbanisation was a highly successful attempt to tap into the needs of a growing population that had had demand for basic housing and civil infrastructure and transport suppressed as a result of the Depression and the Second World War (Forster 2004).

This sector of urban consumption continues to be stimulated in the early twenty-first century by advertising for larger houses, more appliances, and more cars, as well as a raft of personal products and services associated with leisure, entertainment, travel and other ‘wants’ (Australia is the tenth ranked country globally in terms of its annual spending on advertising). Hamilton et al. (2005) found that a significant proportion of current consumption is also found to be wasteful and the richer the household, the more is spent on wasted goods and services.

As already discussed in relation to water and energy (and, in later sections, for transport and housing), consumption increases with income. Forecasts of a doubling of living standards in Australia over the next 50 years (Guest and McDonald 2002, p. 13), together with an extra 6.5 million residents, suggest a formula for continued growth in total consumption, unless there is a shift to what Hamilton (2003) terms a post-growth society, with greater focus on rethinking and re-distributing work, reducing consumption, and reducing wastefulness (Milani 2000).

The trends of the past five to ten years indicate that, during a period of relatively high employment and sustained high consumer confidence, per capita household consumption expenditure has increased by 25 per cent from $19 000 per person in 1995–06 to $24 000 in 2003–04. During this period, Australians’ attitudes to environmental issues have nose-dived. In 1992, three-quarters of the population indicated an interest in or concern for environmental problems; by 2004 the figure was 57 per cent. This is perhaps indicative perhaps of a shift towards a society that is more materialistic and less concerned with sustainability (ABS 2003b).

Liveability of human settlements

The liveability of human settlements can be defined by performance in three key areas: environmental quality, neighbourhood amenity, and individual wellbeing.

Environmental quality

The environmental quality (capital) of cities includes those environmental resources that are contained within the boundaries of an urban centre and from which residents gain benefit. As such, they are distinct from the natural resources (capital) imported into the region to support the economic functioning of the settlement and its residents. They include urban air quality, water quality of urban creeks, rivers, bays and
Neighbourhood amenity

It is at the ‘neighbourhood’ scale, where a range of housing (design) and subdivision and infrastructure (planning) factors intersect (Figure 6), and where success in the creation of liveable and sustainable communities can be assessed for a set of key performance indicators. Where housing and neighbourhoods can be planned and designed in tandem, the maximum potential for innovation and achieving desirable triple-bottom-line outcomes is likely to be obtained; examples include using energy efficient dwellings to generate electricity and sell surplus back to the grid, and building water-smart housing, which relies on water sensitive urban design of the subdivision to derive maximum benefit. In the Australian greenfield urban development context, master planned communities are seen to offer the greatest prospect for achieving more sustainable residential development (Delfin Lend Lease 2002). The opportunity for simultaneously incorporating the range of environmental factors listed in (Figure 6) in a more integrated and comprehensive manner in master planned communities has been examined in a study by Blair et al. (2004). That study found that master planned communities, for the most part, delivered superior planning and design outcomes than would be possible under a traditional regulatory subdivision. New subdivision planning, however, continues to be dominated by financial yield over environmental performance, primarily because environment is under-priced (Miller and Ambrose 2005).
Housing

Demand for housing

McDonald (2001) has projected that there will be need for an additional 1.15 million new dwellings between 2002 and 2011 to accommodate the demand that will result from the increased number of households in Australia. Much of this demand will have to be satisfied in the capital cities; for example, Melbourne South will require 10 000 new dwellings per year; Melbourne West 8 000 per year; Melbourne East 4 000 per year; Inner Melbourne 3 000 per year. McDonald also forecasts that two-thirds of these new dwellings will be detached houses.

As of 2001, only Sydney represented Australian urban centres with a percentage of detached houses less than the projected level (Table 5); most were at or above the national average of 75 per cent. The rate of growth of medium-density and high-rise housing is, however, more than double than that of separate housing; and all the medium and high density housing is concentrated in the larger urban centres and the inner suburbs, where demand for housing is strongest and land prices are the highest.
Table 5: Selected Occupied Private Dwellings - 2001

<table>
<thead>
<tr>
<th></th>
<th>Separate Houses</th>
<th>High density housing</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage of dwellings (%)</td>
<td>Change in number of dwellings (%)</td>
<td>Percentage of dwellings (%)</td>
<td>Change in number of dwellings (%)</td>
<td>Total Dwellings* ('000)</td>
</tr>
<tr>
<td>Capital cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sydney</td>
<td>63.7</td>
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<td>22.8</td>
<td>49.6</td>
<td>114.7</td>
</tr>
<tr>
<td>Large Population Centres</td>
<td>76.8</td>
<td>40.0</td>
<td>20.8</td>
<td>71.5</td>
<td>1 257.9</td>
</tr>
<tr>
<td>Country Areas</td>
<td>86.5</td>
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<td>8.5</td>
<td>-0.1</td>
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<tr>
<td>Australia</td>
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<td>17.5</td>
<td>22.2</td>
<td>37.2</td>
<td>7 072.2</td>
</tr>
</tbody>
</table>

* Dwellings where the dwelling structure was not stated were excluded prior to the calculation of percentages; 
# includes Other dwellings

**Housing consumption**

Demand for housing—the acquisition of residential property for domestic or investment needs—has intensified over the past decade, and this is seen in house price statistics. The drivers of this trend include the continuing strong preference by approximately 90 per cent of Australians for owning their own home (Wulff et al. 2004), which is closely interlinked to preferences for separate house and land. The attractiveness of housing as a form of investment from a taxation and long-term capital growth perspective (zero capital gains tax on owner-occupied houses; negative gearing for rental investments) has also been key to maintaining high levels of demand, despite challenges of affordability.
The demand for more space within new dwellings has increased over the past decade, with average floor areas of new houses in capital cities consistently about 20 square metres greater than those in houses in the rest of the state (ABS 2002a) over a 20-year period. In this same 20-year period, household size has continued to contract to about 2.5 people per household. Recent studies of residential mobility (Wulff et al. 2004, p. 68) have concluded that ‘… too much space is hardly ever viewed as a problem by a household. Overcrowding nearly always leads to a residential move but a surplus of space tends not be considered a problem because adjusting to surplus space is far easier than to a shortage of space.’ Overcrowding is largely restricted to the rental sector in Australia, which also experiences the greatest churn of household movement.

While demand for more space inside the dwelling has been increasing, the allotment sizes for new housing in the capital cities have been decreasing. The exception has been Brisbane, where sites have increased in size between 1999–00 and 2003–04. New, detached housing now occupies a high proportion of the allotment.

Housing condition

The most recent survey of housing quality (ABS 1999) found that over half (57 per cent) of all occupied dwellings were in need of repairs, although less than eight per cent were considered in need of essential or urgent attention.

With regular maintenance, dwellings can have lifetimes that extend well over 100 years, which is an important target from the perspective of sustainability. The growth in major structural problems with age, however, and the shift in the cost ratio of dwelling: land from around 4:1 in the 1960s to 1:4 over the past five to ten years in major cities in Australia has increased the likelihood of demolition and re-build rather than re-life of property. This has a consequential impact of increasing construction and demolition on the associated waste streams.

Housing and neighbourhood character: the challenge of infill housing

A convergence of forces has led to a relatively new phenomenon in urban residential development in Australia’s major capital cities: that of infill housing. These forces can be identified as: an ageing of housing stock and inflation of land prices relative to dwelling costs; a set of government policies that encourage urban consolidation and higher density residential development; and the opportunistic property owner—someone who creates a dual occupancy on their hitherto single-dwelling allotment, or sells to an investor–developer who subsequently redevelops the property at two or three times the residential density. One of the few in-depth studies of this phenomenon estimated that the contribution of infill to Melbourne’s total new dwelling stock is around 35 per cent (Birrell et al. 2005). Notwithstanding the environmental benefits mentioned under ‘Urban form and density’, there has been an inability of development guidelines such as Rescode (Victoria) and BASIX (New South Wales) to come to terms with qualitative ‘design’ issues that can destroy the aesthetics of a streetscape and neighbourhood character (difficult to define, but readily apparent once constructed), increase traffic congestion, and diminish
residential amenity (such as privacy, wind flow and ventilation, environmental noise, and shading). This is reflected in the increase in planning appeals (see Newton et al. 2001), the emergence of save-our-suburbs groups (Lewis 1999), and urging by the Royal Australian Institute of Architects for appointment of a Chief Architect for Australia.

**Indoor air quality**

Indoor air quality is a component of a key factor that affects individual health and wellbeing—indoor environmental quality. The Australian population spends an average over 90 per cent of its time indoors—at home, at school, at work, in transit, and in retail and entertainment centres. The result is that most people experience extended exposure to a range of pollutants such as tobacco smoke, *Legionella*, dust mites, volatile organic compounds, small particle pollution, and ozone. All of these have been linked to a spectrum of illnesses that includes respiratory disease (including asthma), headaches and dizziness, fatigue, nausea, pneumonia, allergies, and skin rashes (US EPA 1994). Combined, these all signal the importance of this environmental factor.

Significant background information on indoor air quality in Australia is available in Brown (1997) and Newton et al. (2001), but there continues to be a lack of national standards for this category of air pollution, apart from those that apply to workplaces. Trends in indoor air quality in Australia are summarised in Table 6; some pollutants are declining (for example, asbestos fibres and tobacco smoke), and others are increasing (for example, dust mites and volatile organic compounds), and many classes of pollutant still lack sufficient information. Part of the reason for this continuing situation is that the responsibility for indoor air quality is not centralised in one authority in Australia and as such is poorly coordinated. Avenues for improving indoor air quality include:

- eliminating sources of polluting emissions (new building products)
- improving ventilation in buildings (increased air tightness of buildings and low rates of mechanical ventilation were introduced in the 1980s to assist energy performance but this has negatively impacted on indoor air quality)
- improving regulations that involve introducing guidelines and standards (NHMRC and NOHSC), and eco-labelling of materials, furnishings and appliances
- improving workplace and community education, using materials of the type being developed by the Commonwealth air toxics programme.
<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Indoor Concentration Range</th>
<th>Major Source</th>
<th>Control</th>
<th>Trend over Recent Decades</th>
<th>Basis of Trend Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asbestos fibres</td>
<td>&lt;0.002 f/ml</td>
<td>Friable asbestos products</td>
<td>Risk management, Removal</td>
<td>Declining</td>
<td>Asbestos products use declined to zero since 1980s</td>
</tr>
<tr>
<td>Radon: Conventional dwellings</td>
<td>99.9% &lt; goal of 200 Bq/m³</td>
<td>Soil under building</td>
<td>Siting of building</td>
<td>No change</td>
<td>Cities located in areas w/o radon problem</td>
</tr>
<tr>
<td>Radon: Earth-constructed dwellings</td>
<td>~9% &gt; goal of 200 Bq/m³</td>
<td>Background radiation of earth walls</td>
<td>Material selection</td>
<td>Unknown</td>
<td>-</td>
</tr>
<tr>
<td>Environmental tobacco smoke (ETS)</td>
<td>High in recreational buildings</td>
<td>Cigarette smoke</td>
<td>Prohibition of smoking, designated smoking area</td>
<td>Declining</td>
<td>Population who smoke approx. halved; smoking prohibited in most buildings</td>
</tr>
<tr>
<td>Respirable particulate matter</td>
<td>Poorly characterised</td>
<td>ETS, cooking, fuel combustion</td>
<td>Poorly characterised</td>
<td>Unknown</td>
<td>-</td>
</tr>
<tr>
<td><em>Legionella</em> spp.</td>
<td>30% of population exposed</td>
<td>Water cooling towers</td>
<td>Maintneance, site selection</td>
<td>Variable</td>
<td>Outbreaks in Vic decreased markedly last two years with new regs/register</td>
</tr>
<tr>
<td>House dust mites</td>
<td>10–40 µg/g Der p 1 [this is the main type of mite protein that caused the allergic reaction in humans] allergen in house dust</td>
<td>Allergen build-up in bedding, carpet, furniture</td>
<td>Removal of habitats, humidity control</td>
<td>High, possibly increased</td>
<td>Greater use of carpets, plush furniture and low ventilation</td>
</tr>
<tr>
<td>Microbial species</td>
<td>100s to 18000</td>
<td>Moist or damp surfaces</td>
<td>Control moisture and</td>
<td>Unknown</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>CFU/m³</td>
<td>mould</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>-------------------------</td>
<td>------------------------------</td>
<td>------------------------------</td>
<td>------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Formaldehyde:</strong></td>
<td>&lt;goal of 100 ppb&lt;br&gt;(1–3 day average)</td>
<td>Reconstituted wood-based products</td>
<td>Source emission control, ventilation</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td>conventional buildings</td>
<td></td>
<td></td>
<td></td>
<td>Product emissions reducing but more product used</td>
<td></td>
</tr>
<tr>
<td><strong>Formaldehyde:</strong></td>
<td>100–1000 ppb, exceeding goal</td>
<td>Reconstituted wood-based products</td>
<td>Source emission control, ventilation</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>mobile buildings</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td><strong>Volatile organic compounds (VOC):</strong></td>
<td>Total &lt;goal of 500µg/m³&lt;br&gt;Total 2000-20 000µg/m³</td>
<td>'Wet' synthetic materials (adhesives, paints), office equipment, printed matter, furniture</td>
<td>Source emission control, ventilation</td>
<td>Increasing</td>
<td></td>
</tr>
<tr>
<td>established buildings</td>
<td></td>
<td></td>
<td></td>
<td>Increasing new homes and renovation</td>
<td></td>
</tr>
<tr>
<td>new buildings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pesticides</strong></td>
<td>Limited data, median &lt;5µg/m³</td>
<td>Major sources unknown</td>
<td>Floor structure, clean-up, inspection</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Nitrogen dioxide</strong></td>
<td>Up to 1000 ppb</td>
<td>Unflued gas heaters and stoves</td>
<td>Source emission control, flued appliances</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td><strong>Carbon monoxide</strong></td>
<td>~10% &gt; goal of 9 ppm</td>
<td>Unflued gas heaters and stoves</td>
<td>Source emission control, flued appliances</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td><strong>Carbon dioxide</strong></td>
<td>Poorly characterised</td>
<td>Exhaled air</td>
<td>Ventilation to standards</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Probably increased in buildings from 1980s due to reduced ventilation standards</td>
<td></td>
</tr>
<tr>
<td><strong>Ozone</strong></td>
<td>Poorly characterised</td>
<td>Office equipment, ozone deodorisers</td>
<td>Source emission control, ventilation</td>
<td>Probably decreasing</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Emission from office equipment decreased in 1990s</td>
<td></td>
</tr>
</tbody>
</table>

1. Goals specifically referred to are National Health and Medical Research Council goals.

Source: Brown (2004 pp. 6–8)
Transport, mobility and accessibility

The sustained increase in personal mobility, whether in terms of transport communications, has been one of the key transitions of post-1950s Australia (Figure 7).

Figure 7: Change in the number of passengers on urban public transport from 1945 to 2005

![Urban Passenger Transport Task](image)


Private passenger vehicle travel represents three quarters of total road travel, but the rate of growth in the share of road travel is greatest in the category of light commercial vehicles (seven per cent per annum), which service intra-urban freight needs. Growth in the volume of freight that is transported by road, both urban and ex-urban, has also continued at rates more closely aligned to rates of economic growth than population growth.

Transport and triple-bottom-line negatives

The negative environmental, human health and economic impacts of Australia’s transport system are seen in increasing energy use and greenhouse gas emissions, urban air pollution, and traffic congestion. Transport contributes approximately 15 per cent of Australia’s total greenhouse gas emissions (ABS 2003c) as a result of its fossil fuel use. The demands of road transport have been largely responsible for an increase in fossil fuel use in Australia by more than 25 per cent in the decade 1991–2001.

Urban traffic congestion is likely to remain an intractable problem for Australia’s biggest cities. The bulk of city traffic is now dominated by non-work activities, such as social and recreational, ferrying children, shopping and personal business.

There is now a greater dispersion of trip origins and destinations. The central business district has long ceased to be the dominant employment destination of cities, with the suburbanisation of jobs into areas not well-served by public transport. Only 13 per cent of Sydney’s jobs are in the central business district (Warren Centre 2000). The reality of more balanced and self-contained residential communities, with a
measure of overlap of housing markets and labour characteristic of the early post-war metropolitan era, has diminished at the suburb level (Birrell et al. 1999, p. 54), but warrants attention at the ‘city of cities’ scale (Warren Centre, 2000).

Vehicles kilometres travelled per person per trip increases with distance from the central business district in the large cities, reflecting poorer access to public transport, employment and services.

It is estimated (ATA 2003) that the freight task will double over the next decade, increasing in volume from 375 billion tonne kilometres (btkm) in 1999–2000 to 648 btkm in 2020, at an average annual growth rate of 2.8 per cent.

Projections of car traffic for Australia’s capital cities to 2020 suggests volumes one-third higher than that in 2002, and 40 per cent higher when growth in light commercial vehicle traffic is included (25 per cent higher for non-metropolitan Australia). When these projections on traffic volumes are linked to data on current road capacity, the costs of congestion and associated costs to the national economy if nothing is done are forecast to be as high as about $30 billion per year by 2015 (BTRE 2000, p. 2).

Towards a solution

There is a range of responses that have been developed to address the negative externalities associated with increased automobile dependence in Australia. They fall into three main categories:

Integrated land use and transport planning

All of Australia’s major cities have strategic land use and transport plans that seek better integration of housing, employment, services and transport. A key objective of this integration is reduced levels of urban congestion and increased levels of public transport usage. The Warren Centre’s (2000) ‘city of cities’ concept has merit as a strategy for big city planning in that it harnesses anthropogenic and market realities (Marchetti 1992) of a 30-minute (on average) daily commute as an organising principle for cities through history. The shortcomings of this approach rest with the long lead times required to achieve the expected benefits.

Transport supply side innovation

Recent innovations include the introduction of more fuel-efficient vehicles. For example, Australian vehicle manufacturers have committed to a voluntary fuel consumption target for new passenger cars of 6.8 litres per 100 kilometres by 2010. This is an improvement of 18 per cent over the 2001 rate (AAA 2003). Hybrid vehicles are beginning to appear on the market, and they offer a fuel consumption of three litres per 100 kilometres (Winkel et al. 2001). The problem is that it will take more than a decade before new vehicle replacements begin to make a difference to the performance of the total vehicle fleet.

Other supply-side innovations relate to a variety of road and traffic systems (Australian Transport Statistics May 2004 ) and increased investment in public transport infrastructure and services to encourage
a shift in mode choice. This will require redressing the current imbalance in funding: new transport infrastructure investment on road ($5.3 billion) is three times greater than on rail ($1.8 billion) (Australian Transport Statistics May 2004, p.10). It will also require public transport planning to satisfactorily address the findings from surveys that have sought to understand reasons for low patronage of public transport.

**Transport demand side innovation**

The key initiatives here are road pricing, Intelligent Transport Systems and Smart Cars that provide driver information and guidance systems to improve efficiency on the road network (For example, see the SmartUK website), and use of the internet as a substitute for a range of trips; Corpuz and Peachman 2003).

**Individual Wellbeing**

Wellbeing is a concept that is firmly centred on the individual in terms of key issues such as employment, economic resources, and health; but is also affected by contextual factors that include family and social networks, neighbourhood amenity, and access to services on the basis of proximity and affordability (OECD 1976; ABS 2001b; Eckersley 1998).

**Income and consumption**

Over the past decade, household debt (as a share of household income) has reached historically high levels, indicating that consumption aspirations have ‘overtaken’ disposable income. Between September 1993 and December 2001, the aggregate debt to income ratio rose by 51 per cent (La Cava and Simon 2003).

The economic context for this period has been growth in employment and a decline in unemployment. By March 2005, Australia’s unemployment rate was 5.1 per cent, the lowest level since late 1976. Also important, are the growth in national economy, high levels of consumer confidence, growth in Australian investment markets, and growth in housing prices.

All have combined to provide the economic environment that has encouraged growth in individual and household consumption (Dvornak and Kohler 2003).

**Locational disadvantage**

Average wage and salary incomes for people in metropolitan Australia are higher than those paid to employees in non-metropolitan areas, and the difference is widening (ABS 2003f): from a 15 per cent differential in 1995–06 to 19 per cent in 2000–01.

The knowledge economy is also not uniformly represented across Australia. There continues to be metropolitan–non-metropolitan differences in access to and use of computers and the internet—the basic tools of the information economy—as well as significant spatial concentrations of information and
knowledge workers within cities linked to high income – high amenity suburbs (Newton 1991; Gipps et al. 1996; Florida 2002; Reich 1991).

There is also an increasing divergence of incomes between areas within metropolitan and suburban areas. In an analysis of employee income statistics between 1990 and 2000, Borland et al. (2001) have warned that one consequence of the income gap that widened during the 1980s and continued through the 1990s could be the development of ‘ghettos’, where welfare recipients concentrate spatially as a result of housing markets (cheap housing) and where the likelihood of finding work is small. The concern is that an intergenerational pattern of welfare dependency could be reinforced by a combination of poor family and neighbourhood experiences in relation to employment. The research pioneered in Australia by Maher (1995) and Gregory and Hunter (1995) requires more attention in the context of the long-term consequences of place-based inequality. Research by Birrell et al. (1999) points to a growth in the number of suburbs (in Melbourne) where ratios of poor to better-off people are increasing. The high rates of residential mobility observed among households in such areas may also reflect their housing tenure status (rental)—a housing-related social justice issue in its own right (Wulff and Newton 1996).

Birrell et al. (1999) suggest that the public policy responses for such areas need to be focused more on welfare, housing, educational and training needs of the residents and their neighbourhood amenity rather than local job creation, which would most likely translate into employment for better qualified ‘outsiders’.

**Human health**

The key human health indicators of life expectancy, mortality, subjective health, disability, illness, disease and injury need to be understood within a complex matrix of determinants (AIHW 2004) that include environmental, social and urban settings as well as the biomedical.

Newton et al. (2001) remains the most comprehensive national report to date on health from a human settlements perspective. Key findings from that report and AIHW (2004) reveal the following geographic variations in health outcomes across Australia:

Death rates are on average 1.1 times higher in regional Australia and 1.4 higher in very remote regions than in major cities. There a number of contributing causes to higher rates of mortality in areas outside cities, (see Table 7).

**Table 7: Leading Causes of ‘Excess’ Deaths in Areas Outside Major Cities – Australia 1997-1999**

<table>
<thead>
<tr>
<th>Specific cause of death</th>
<th>Annual ‘excess’ deaths</th>
<th>Per cent of total ‘excess’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischaemic heart disease</td>
<td>755</td>
<td>23</td>
</tr>
<tr>
<td>‘Other’ circulatory diseases*</td>
<td>518</td>
<td>16</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>374</td>
<td>11</td>
</tr>
<tr>
<td>Cause</td>
<td>Deaths</td>
<td>Excess Deaths</td>
</tr>
<tr>
<td>------------------------------</td>
<td>--------</td>
<td>---------------</td>
</tr>
<tr>
<td>Motor vehicle accidents</td>
<td>368</td>
<td>11</td>
</tr>
<tr>
<td>Diabetes&lt;sup&gt;b&lt;/sup&gt;</td>
<td>191</td>
<td>6</td>
</tr>
<tr>
<td>Suicide</td>
<td>184</td>
<td>6</td>
</tr>
<tr>
<td>‘Other’ injuries&lt;sup&gt;c&lt;/sup&gt;</td>
<td>214</td>
<td>6</td>
</tr>
<tr>
<td>Prostate cancer</td>
<td>131</td>
<td>4</td>
</tr>
<tr>
<td>Colorectal cancer</td>
<td>112</td>
<td>4</td>
</tr>
<tr>
<td>Lung cancer&lt;sup&gt;d&lt;/sup&gt;</td>
<td>52</td>
<td>2</td>
</tr>
<tr>
<td>All other causes</td>
<td>399</td>
<td>12</td>
</tr>
<tr>
<td>All causes</td>
<td>3 303</td>
<td>100</td>
</tr>
</tbody>
</table>

<sup>a</sup> excludes stroke or rheumatic heart disease.
<sup>b</sup> There were 360 ‘excess’ deaths for which diabetes was a contributing factor (associated cause). In 191 of these, diabetes was recorded as the principal cause of death. The principal causes of the remaining 169 are distributed among the remaining categories in the table. In 11% of all ‘excess’ deaths, diabetes was implicated as an associated cause of death.
<sup>c</sup> ‘Other’ injuries include all injuries except motor vehicle accidents, suicide, homicide and accidental shooting.
<sup>d</sup> There were 52 excess deaths due to lung cancer overall (this was made up of 112 ‘excess’ deaths of those younger than 70 years outside Major Cities and 60 fewer than expected for those who were 70 years and older). While it accounted for 2% of all ‘excess’ deaths, lung cancer accounted for 6% of ‘excess’ deaths of people younger than 65 years.

Source: AIHW National Mortality Database cited in AIHW (2003, p.10.)

The most significant contributor to loss of ‘healthy’ life in Australia is mental disorder (over 300 000 Disability adjusted life years (DALY)) years of life lost among the Australian population in 1996 for this condition (Mathers et al. 1999, p.14) and appears to be more highly concentrated in urban and rural compared to remote settings—although this may reflect shortages of mental health professionals in more sparsely settled regions.

Hospital visitation (separation) rates continue to be significantly higher in the more remote rural and sparsely settled regions. These higher rates for people living outside the major cities may be due to greater need (poorer health) or to different admission practices. For example, admission in regional and remote areas may be more likely because of the greater need for precaution as a result of the greater distances and restricted access to other medical services. The lower rates of admission to private hospitals reflect the lower levels of physical and financial access to these hospitals in regional and remote areas (most private hospitals are in the larger centres).
Conclusions

Population, economy and environment: the need for transition to a green economy

The twin drivers of economic and population (consumption) growth have both been influential forces in urban development since SoE2001; they are forecast to continue at similar levels through the next state of the environment reporting period to 2011 (Macfarlane 2005, Trainer 2003). It is apparent that, to date, Australia has been unable to find the formula for decoupling its economic growth from the significant demands it continues to make on resource consumption and environmental impact. This key transition to decouple economic growth from resource consumption will require new technologies that significantly dematerialise current industrial processes (that is, they are less energy and water intensive), enable eco-efficient design of the built environment as well as creation of eco-industrial systems that utilise wastes as resources—this means new engines are needed for the green economy. At the same time, adaptive management by government and industry will be required to orchestrate this transition, including change in the behaviour of the population towards more sustainable outcomes (see Table 8, which mirrors the structure of the extended urban metabolism model of urban development shown in Figure 1).

Table 8: Elements of an urban sustainability framework

<table>
<thead>
<tr>
<th>Direction</th>
<th>Objective</th>
<th>Interim Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using resources more efficiently</td>
<td>Reduced ecological footprint</td>
<td>Water usage</td>
</tr>
<tr>
<td></td>
<td>Increased use of renewables</td>
<td>Energy usage</td>
</tr>
<tr>
<td></td>
<td>Increased water, energy and materials efficiency</td>
<td>Waste generation</td>
</tr>
<tr>
<td></td>
<td>Reduced climate impact</td>
<td>Land consumption and conversion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Renewables</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Biodiversity</td>
</tr>
<tr>
<td>Sustainable urban and industrial planning, design, management</td>
<td>More liveable cities</td>
<td>Dwelling performance and rating</td>
</tr>
<tr>
<td></td>
<td>Efficient transport systems</td>
<td>Commercial building performance and rating</td>
</tr>
<tr>
<td></td>
<td>Buildings designed for climate, lifestyle, occupant health and productivity</td>
<td>Eco-labelling of construction materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic congestion</td>
</tr>
<tr>
<td>Maintaining and restoring urban environmental quality</td>
<td>Clean air</td>
<td>Air quality</td>
</tr>
<tr>
<td></td>
<td>Healthy marine and coastal areas</td>
<td>Water quality</td>
</tr>
<tr>
<td></td>
<td>Healthy soil</td>
<td>Urban salinity</td>
</tr>
<tr>
<td></td>
<td>Healthy waterways</td>
<td></td>
</tr>
</tbody>
</table>
Maintain and enhance biodiversity  
Increase green space  
Reduce environmental noise

Using wastes as resources

| Using wastes as resources | Less waste and increased resource efficiency | Quantity of solid and liquid waste generated reduced and the amount recovered for reuse, recycling and energy generation increased  
New eco-industrial clusters that utilise waster streams | New eco-industrial products

Enhancing human well-being

| Enhancing human well-being | Enhance social and human capital | Health target  
Good physical and mental health | Income distribution target  
Access to services

Source: Newton (2005, Table no. or page no.)

**Settlement transitions**

There are four transitions of note underway:

- all the capital cities continue to be key population magnets, but Sydney, Melbourne, Brisbane and Perth are accelerating physical as well as functional transitions to *mega-metropolitan region* status—a system of cities; key challenges relate to strategic planning for smart growth and redevelopment that have clear sustainability targets (see Appendix 3)
- there is a trend towards *higher density urban development* as high rise, medium density, infill and smaller-lot greenfield development; key challenges involve achieving positive social and aesthetic outcomes to balance the environmental benefits
- the development of a *contiguous urbanised east coast seaboard* stretching from the Sunshine Coast (in Northern Queensland) to the Surf Coast (in Victoria)
- a raft of *small rural towns and Indigenous communities are currently non-viable* due to rural depopulation and welfare dependency; key challenges relate to their sustainability for national cultural significance.

**Settlements and environmental resilience**

Assessing the extent to which Australian settlements are subject to a range of natural and human-induced hazards has not yet been the subject of state of the environment reporting, despite the costs to local and national economies and human lives. Three global hazards of recent times—climate change, biological
invasions, and terrorism—raise key questions related to the robustness of Australia’s settlements to such shocks, structurally and operationally.

**Infrastructure transitions for human settlements**

The infrastructures upon which Australia’s settlements have developed are unlikely to sustain future urban populations and economies beyond the next generation at current quality of life levels. The transitions envisaged are from linear, centralised systems that are wasteful of water, energy and material resources to closed-loop, distributed systems that attempt to maximise collection, recovery, reuse and recycling of each resource. Specifically, the required transitions are towards:

- integrated urban water systems based on utilisation of stormwater and wastewater
- green energy systems based on distributed renewable energy and a hydrogen economy
- zero waste economies based around eco-industrial development (utilising solid and liquid waste streams as resources) and cradle-to-cradle manufacturing
- sustainable subdivisions, integrating housing and neighbourhood innovation across ten key liveability dimensions
- minimal traffic congestion by utilising intelligent transport systems, road pricing, spreading peak travel, and broadband communications.

**The ultimate transition: changing individual attitudes and behaviour to consumption**

The ecological footprints of Australia’s settlements are increasing at a faster rate than population growth alone would dictate, and are due primarily to continued growth in rates of per capita resource consumption. Consumption was identified in *Australia State of the Environment 2001* as a key environmental challenge, and this is still the case in relation to:

- gross material flows: 20–25 tonnes per person per annum
- energy use: 260 gigajoules per person per annum
- water use: 115 kilolitres per person per annum
- travel: 8000 kilometres per person per annum car travel
- housing: 235 square metres per dwelling
• greenhouse gas generation: 27.5 tonnes per person per annum

• waste generation: approx one tonne per person per annum.

Over the past decade, the wealth of individual Australians as measured by gross domestic product per capita has continued to rise (Figure 8). Consumption aspirations have, however, risen faster for many sections of the population and this is reflected in the rapid growth in personal debt, which has been in advance of gross domestic product per capita since the late 1990s. The challenge for all Australians is to encourage a transition in attitude among the population from viewing Australia as a Norman Lindsay (1918) ‘magic pudding’ (which is able to endlessly supply needs) to that of adopting a lifestyle that is less materialistic and consumptive.

Figure 8: The cross-over of materialism and environmental concern

Source: Newton (2005)
Appendix 1: Population change in the mega-metropolitan regions

Sydney Mega Metro Region
Appendix 2: Definition of mega-metropolitan regions

As defined for use in the human settlement commentary for the Australian State of the Environment Committee

**Sydney Mega-Metro Region (1)**
All Sydney Statistical Division (05)
Newcastle (1005)
Wollongong (1505)

**Port Phillip Region (2)**
All Melbourne Statistical Division (05)
Greater Geelong City Part A (1005)
Greater Geelong City Part B (1010 2757, 1010 6080)
Greater Geelong Part C (1015 2758)
Bacchus Marsh (2010 5151)
South Loddon (3520)
Mitchell South (4020 4854)
Murrundindi West (4020 5622)
Bass Coast Phillip Is (5520 0741)
Bass Coast Bal (5520 0744)

**South East Queensland (3)**
Brisbane City (0505)
Gold Coast City Part A (0510)
Beaudesert Part A (0515)
Caboolture Part A (0520)
Ipswich (part in BSD) (0525)
Logan City (0530)
Pine Rivers Shire (0540)
Redcliffe City (0545)
Redland Shire (0550)
Gold Coast City Part B (1005)
Sunshine Coast (1015)
Moreton (SD Bal) (1020)

**Perth Corridor (5)**
Central Metropolitan (0505)
East Metropolitan (0510)
North Metropolitan (0515)
South West Metro (0520)
South East Metro (0525)
Mandurah (1001)
### Population size and population change 1991-1996-2001 (based on estimated resident population figures)


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**Total Perth Corridor**

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# Appendix 3: Key transitions

## Key Transitions

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<td>Fuel from Coal; Steam Porter</td>
<td>Liquid Fossil Fuels; Internal Combustion Engine</td>
<td>Distributed, Renewable Energy; Maglev; Hydrogen Economy</td>
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<td>Analog Comms; Centralised Telematics</td>
<td>Digital (mixed mode); Mobile Communications</td>
<td>High Bandwidth, Wireless Internet; Telepresence</td>
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<td>Industrial to Services Economy</td>
<td>Services to Information Economy</td>
<td>Emergence of Green Economy</td>
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<td>Diverted Water; Linear System; centralised and separate water and sewerage systems; discharge of waste to environment</td>
<td>Integrated Urban Water System; City as Catchment; Closed Loop</td>
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Source: Newton 2005
## Appendix 4: Definition of Singleman's industry classes

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References


ABARE—see Australian Bureau of Agricultural and Resource Economics

ABS—see Australian Bureau of Statistics


Australian Bureau of Statistics 2002c, Attendance at cultural venues and events. Cat. No. 4114.0. ABS, Canberra.


Burnley, I and Murphy, P 2004, *Sea Change, Movement from Metropolitan to Arcadian Australia*, University of NSW Press, Sydney.


Fisher, B 2005, ‘Predicting the impacts of climate change on agriculture, a case study of the Australian broadacre industry’, presentation to ABARE Outlook Conference.


Granger, K and Hayne, M 2000, *Natural Hazards and the Risks They Pose to South-East Queensland*, AGSO in conjunction with Bureau of Meteorology, Commonwealth of Australia, Canberra.


Holloway, D and Bunker, R 2002, ‘*How Do we Use Energy in our Houses – to Suit Building or Behaviour*’, Issues Paper 13, Urban Frontiers Program, University of Western Sydney.


Warren Centre 2000, *Sustainable Transport in Sustainable Cities*, University of Sydney.


