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Population Distribution, Migration and Climate Change in Australia: An Exploration

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INTRODUCTION

In Australia the body of knowledge of likely scenarios of climate change impact over the next few decades has increased significantly in both its robustness and level of detail. The Climate Commission's (2011) report on *The Critical Decade: Climate Science, Risks and Responses* summarises the evidence and projection scenarios which are based on them and indicates the certainty and urgency of the reality of climate change in Australia. There has been less advance, however, in tracing the complex interrelationships between these scenarios on the one hand and socioeconomic and demographic change at a regional level on the other.

It is undeniable that Australia is experiencing long term changes in climate involving higher surface air and sea-surface temperatures, more hot extremes and fewer cold extremes and increased sea levels. While there is some uncertainty about the rate of change, it seems clear that these changes will continue. The effects of climate change are not distributed evenly across the continent and will be felt more in some areas than others. Just as the impact of climate change is felt more by some members in the community than others, there are differences between areas and communities in the extent and nature of climate change. The purpose of this paper is to relate anticipated spatial variations in climate change impacts to the distribution of the Australian population and examine the implications for future patterns of population distribution and internal migration.

While there is strong scientific consensus about climate change and a growing body of evidence about its future effects, there remains a degree of uncertainty, not so much about the reality of climate change but rather its precise nature, severity and location.

At the outset some comments are made on Australia's contemporary demography and some of its linkages to environment. It is argued that environmental constraints have historically been an important factor in Australian population growth and distribution. The

historical debate on population and environment is briefly summarised. There is an examination of the contemporary population distribution in Australia. It is demonstrated that there has been a great deal of stability in the structure of population distribution over the last century. The processes impinging upon population distribution are then addressed. The evidence on the likely spatial distribution of climate change impacts is then examined. The characteristics of population in areas most likely to experience major impacts from climate change are then analysed. The final sections of the paper discuss some of the potential influences of climate change on national population distribution.

HISTORICAL TRENDS IN AUSTRALIAN POPULATION GROWTH

There is considerable debate about the size of the population of Australia prior to European settlement. The Indigenous population in 1788 was generally estimated to be approximately 300,000 but some commentators have suggested that it was around 500,000 and even may have been as high as 750,000 (Butlin, 1983). Table 1 traces the decline in

Table 1: Australia: Estimates of Indigenous Population, 1788-2010
Source: ABS Historical Statistics; ABS, 2011a

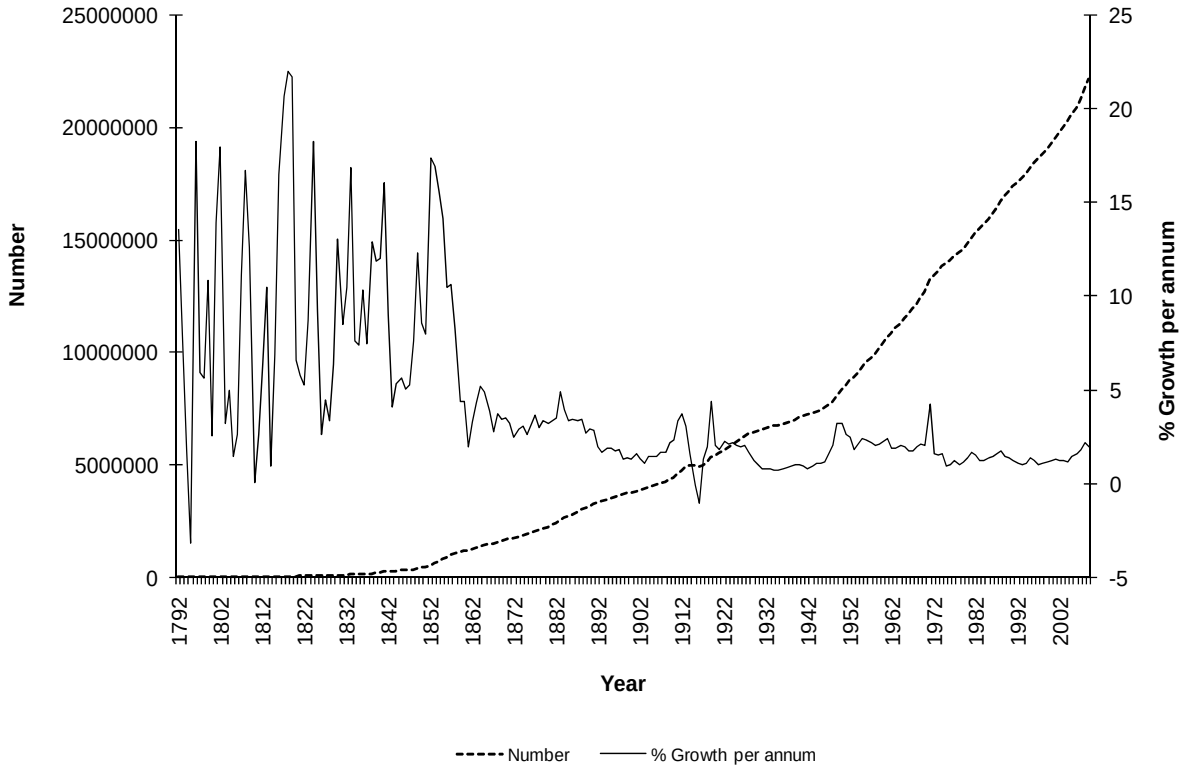
Year	Indigenous Population	Year	Indigenous Population
1788	314,500	1961	117,495
1861	180,402	1966	132,219
1871	155,285	1971	115,953
1881	131,666	1976	160,915
1891	110,919	1981	159,897
1901	94,564	1986	227,593
1911	83,588	1991	265,371
1921	75,604	1996	352,970
1933	73,828	2001	410,003
1947	87,000	2006	517,043
1954	100,048	2010	563,101

numbers associated with the decimation and deprivation the group experienced. It was not until the 1940s that their numbers began again to increase and even now the numbers are below those that were likely to be living in Australia on the eve of European settlement.

The official census data on the Australian population (which until 1966 excluded the Indigenous population) are depicted in Figure 1. It will be noted that it took 80 years of European settlement to reach the nation's first million. However, with the rapid influx associated with the Victorian gold rush and the expansion of the agricultural frontier the second million took less than two decades and the third less than a decade. Thereafter there were fluctuations with downturns in economic depressions (1890s and 1930s) and wars (1913-19 and 1939-45) and increases during periods of economic growth.

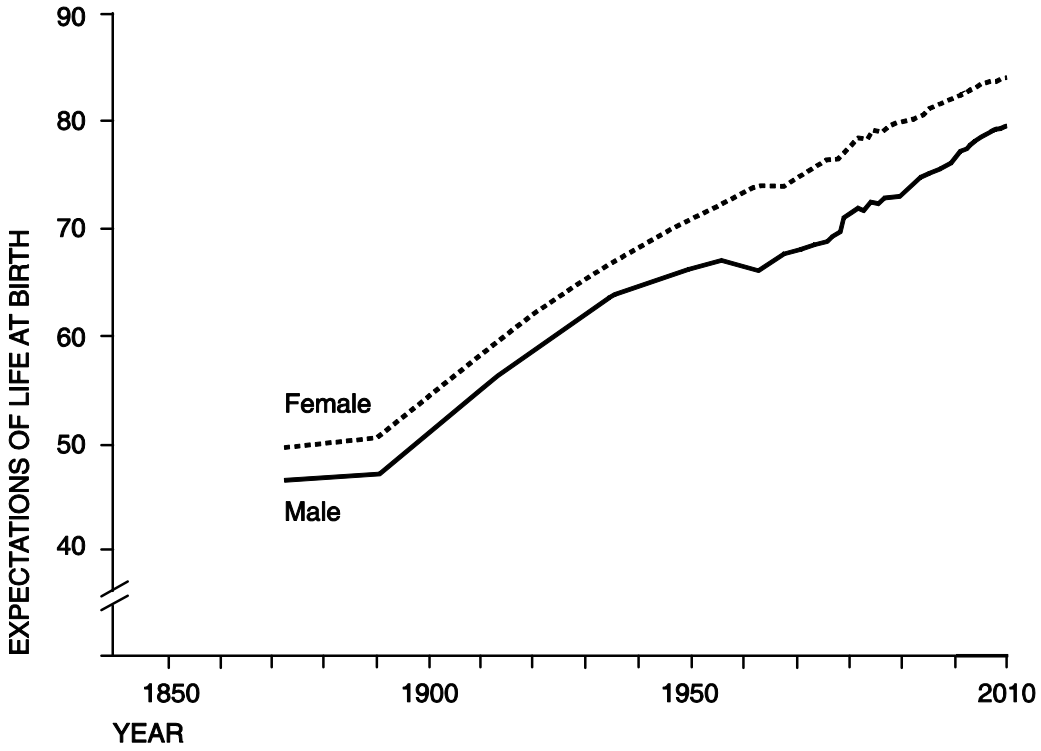
Figure 1: Australia: Growth of the Population, Year Ending 31 December, 1792-2009

Source: ABS Australian Historical Statistics, and ABS Estimated Resident Population Data



The striking feature of Figure 1 is the exceptional nature of the post-World War II period in Australia's demographic history. The population has more than trebled and has grown consistently. While there have been periods of relatively slow growth during economic downturns there have not been the extended periods of very slow growth that characterised the first one and a half centuries of European settlement. Australia's population growth rate reached 2.2 percent in 2008-09 which was the highest rate since the 1960s and was twice the rate at which the world's population was increasing at that time (ABS, 2011a, 14). Subsequently, the growth rate has fallen to 1.4 percent per annum (2010-11) but still is very high not only by high income country standards but globally as well (ABS, 2012).

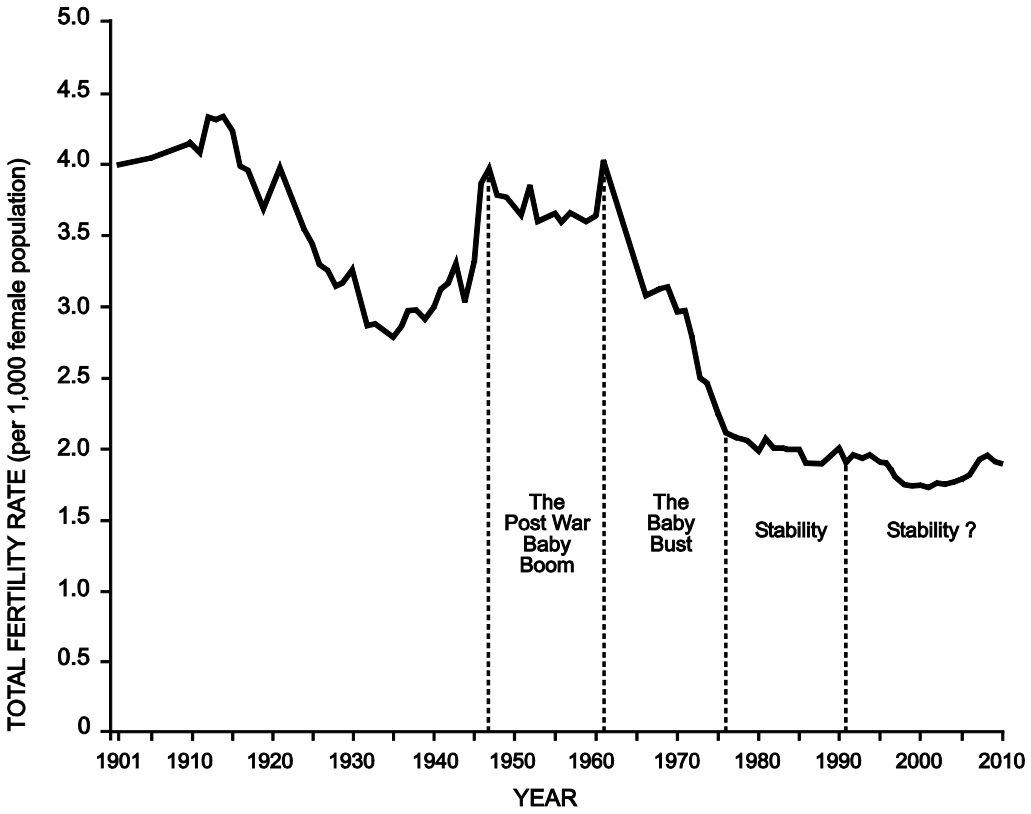
Figure 2: Australia: Life Expectancy at Birth, 1870-2010
Source: ABS, various issues of Australian Life Tables



Like other countries, Australia has experienced a demographic transition from a high fertility, high mortality regime to the present low fertility, low mortality situation. Figure 2

depicts the substantial improvement in life expectancy which has added 13 years of extra life to the average Australian since World War II. The decline in fertility has taken a different trajectory as is shown in Figure 3 where the long term decline trend was punctuated by the post-war baby boom which has had profound implications for the contemporary and future Australian population (Swan, 2010). Australia's fertility remains at relatively high levels by high income country standards and has helped to keep natural increase positive and substantial whereas in several OECD countries deaths now outnumber births.

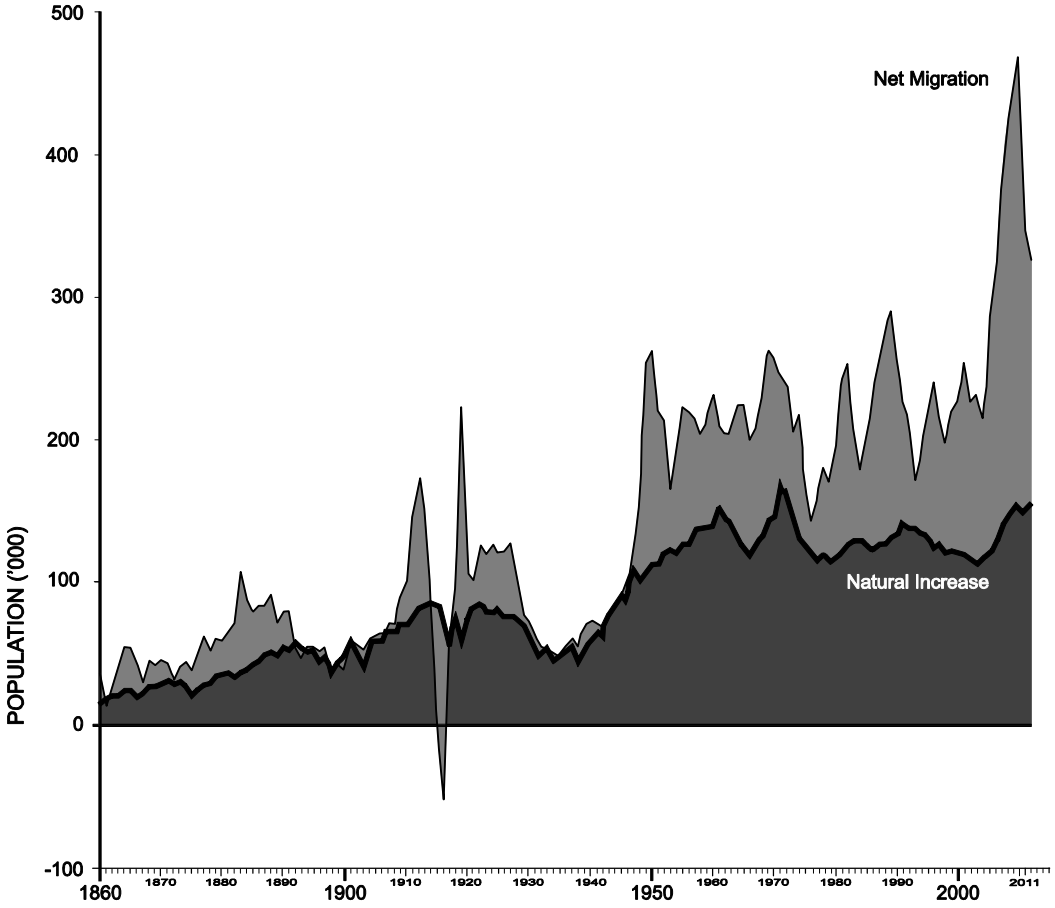
Figure 3: Total Fertility Rate Australia, 1860-2010
Source: Hugo, 2001; ABS, Annual Publications on Fertility



Australia's population growth has been, and is being, shaped by international migration, more than any other middle sized or large nation. Currently half of Australia's population are permanent or temporary immigrants or their Australia-born children (Hugo,

2010). Figure 4 depicts the levels of net migration and natural increase since 1860 and some striking trends are in evidence. Again, the distinct nature of the postwar period during which net migration has consistently been at a high level is striking although fluctuations with the economic situation are apparent. Without the effect of postwar migration the Australian population would be some 9 million persons less than at present.

Figure 4: Australia: Natural Increase and Net Migration, 1860-2011
Source: Australian Bureau of Statistics; Borrie, 1994



THE CONTEMPORARY DEMOGRAPHIC SITUATION AND OUTLOOK

In recent years Australia has experienced rapid population growth reaching 2.1 percent per annum in 2008-09 but falling to 1.6 percent in 2009-10 and 1.4 percent in

2010-11. This is almost twice the rate at which the global population is increasing and the fastest growth experienced by Australia since 1969. There has been a great deal of discussion about Australia's future population which has been to some extent polarised around arguments for a 'big Australia' (Ridout, 2010) and stabilising population as quickly as possible (Carr, 2010). An alternative argument (Hugo, 2010), however, suggests that while Australia needs population growth in the short to medium term to counterbalance the retirement of baby boomers from the workforce and meet a net annual increase in the number of jobs of around 200,000 per year, in the longer term it would be desirable to work toward a demographically stable population.

Despite these varying positions the standard set of population projections for Australia produced by the Australian Bureau of Statistics (2008a) which are based largely on a continuation of the trends of the 2005-08 period over the next 40 years.

There has been a great deal of debate in Australia over more than 100 years (Hugo, 2010) on the population-environment relationship. This was exacerbated in the lead-up to, and period subsequent to, the Federal Election of 2010. This debate, however, has often been over-simplistic and failed to appreciate the complexity of the population-environment relationship. Undoubtedly there is a relationship between population and environmental impact (The Millennium Ecosystem Report, 2005). However, it is not simply *numbers* of people in a country which shape that impact, it also involves:

- their per capita resource use;
- the technology they use in exploiting the environment;
- the way in which they are distributed across the natural space.

Nevertheless, numbers are important and there is considerable national focus and anticipated patterns of population growth in Australia. This attention has come from Australia currently having one of the fastest growing populations, not just in high income

countries (more than three times faster than the average) but also compared with all other Asia-Pacific countries growing at almost twice the rate of the world's population as a whole (Hugo, 2010).

The Australian Bureau of Statistics produces new national population projections every three years and the latest were published in 2008 (ABS, 2008a). Table 2 below shows the three main scenarios of future growth which are included in the ABS projections. Each scenario is based upon a set of assumptions relating to fertility, mortality and net overseas migration (NOM). In fact there is relatively little variation in the assumptions used regarding the fertility and mortality dimensions. Mortality has declined substantially in Australia increasing life expectancy at birth by over 13 years since World War II. More tellingly the life expectancy of an Australian aged 50 years has increased 9 years since 1970. The projections include two mortality assumptions, both suggesting that life expectancy will increase.

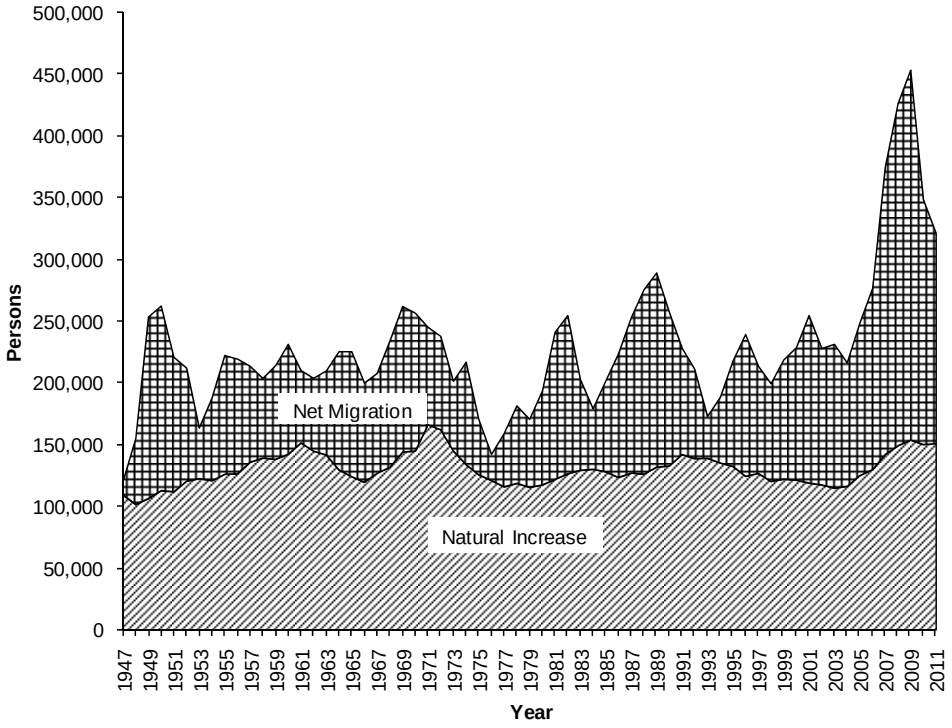
Table 2: Australia: Main Projection Series
Source: ABS, 2008a

	ASSUMPTIONS				PROJECTED POPULATION AT 30 JUNE	
			Life expectancy at birth(a)			
	Total fertility rate(b)	*Net overseas migration*(c)	*Males*	*Females*	*2056*	*2101*
	babies per woman	persons	years	years	million	million
Series A	2.0	220 000	93.9	96.1	42.5	62.2
Series B	1.8	180 000	85.0	88.0	35.5	44.7
Series C	1.6	140 000	85.0	88.0	30.9	33.7

(a) From 2056.
(b) From 2021.
(c) From 2010–11 in Series A and C. From 2007–08 in Series B.

The fertility assumptions vary between a Total Fertility Rate[1] of 2.0 in 2021 to one of 1.6. The cause of future fertility will be very important in shaping population growth but it seems likely at present that the Australian TFR will be around 1.9 for the foreseeable future.

Figure 5: Australia: Total Population Growth Showing the Natural Increase and Net Migration Components, 1947-2011
Source: ABS 1997 and ABS *Australian Demographic Statistics*, various issues



The main element in the assumptions which will fluctuate relates to net migration. Figure 5 shows that over the period since World War II it is net overseas migration which has been the major volatile element in population growth. Moreover, it is the component of growth which is most amenable to policy intervention. The issue of NOM has become contested in Australia, including during the last elections. The ABS modified the methodology for measuring NOM in 2006 to take greater account of non-permanent

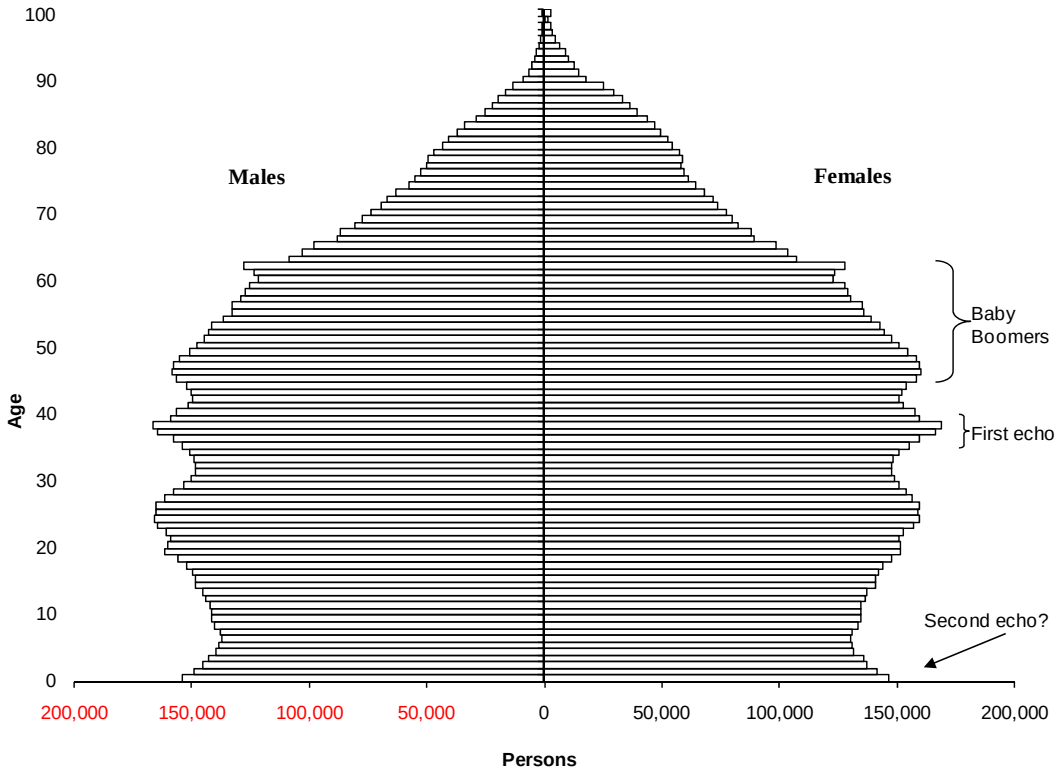
[1] TFR – Total Fertility Rate: The number of children, on average, a woman would bear if she were to have a childbearing experience identical with the experience of a cross-section of women of different age groups in a given year. It can be used as an estimate of the average number of children per completed family.

migration. While it can be seen from Figure 5 that there has been wide variation in NOM in the past there is some agreement in Australia that a NOM of around 180,000 is likely over the next few years at least (DIAC, 2011).

The future population that could be anticipated under the three scenarios is presented in Table 2 and it can be seen that the total population in 2056 will vary between 42.5 million (Series A) and 30.9 million (Series C) and the Series B figure of 35.5 million being considered the most likely.

The key issue for national development, however, is not so much the numbers but the composition of the population. In particular, the issue of ageing is of the utmost significance. Figure 6 depicts the current age structure of Australia. Of particular importance to note is the post World War II baby boom generation born between 1946 and 1966. It will be noted in Figure 6 that this period of high fertility has created a significant bulge in the age pyramid.

Figure 6: Australia: Age-Sex Structure of the Population, June 2009
Source: ABS Estimated Resident Population data



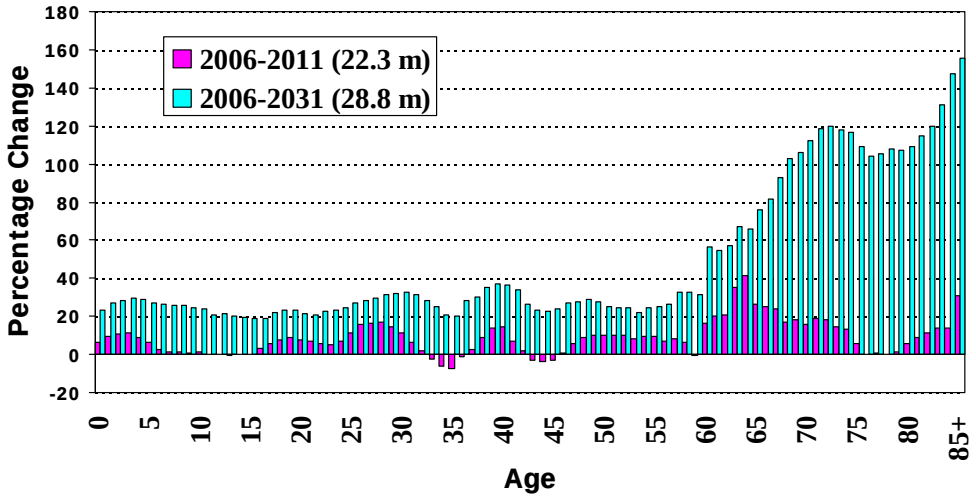
Baby boomers make up 28 percent of the Australian population but 41 percent of the current workforce. The fact that they are on the verge of entering the retirement years means that Australia, like other high income countries, faces a considerable challenge because:

- The numbers aged 65 years and over will double in the next two decades producing considerable pressure on aged care and health services.
- Their proportion of the total population will also increase substantially, leading to:
  - problems in maintaining the size of the workforce, let alone cope with the workforce growing by a net 200,000 per annum at the moment;
  - ageing within the workforce which will lead to reduced productivity;
  - a decline in the ratio of workers to aged dependents causing difficulty in funding aged care services and health services.

Accordingly, many would argue that Australia needs to maintain population growth in the short to medium term to cope with that ageing.

The ageing factor is well demonstrated in Figure 7 which indicates that the bulk of net population growth in Australia over the next quarter century will be in the older age groups, even under a quite optimistic growth scenario.

Figure 7: **Structural Ageing: Australia: Change by Age: 2006-11; 2031 (Series B)**
Source: ABS 2008 Projections



POPULATION AND THE ENVIRONMENT IN AUSTRALIA

Environment has played an important role in shaping Australia's population development. However, it was not until the 1920s that there was a substantial public discourse on this issue. Until then the dominant philosophy was to expand Australia's population to facilitate development (Hugo, 2011) and this philosophy gathered strength over the years. Powell (1984, 86) demonstrates that Brady's (1914) work '*Australia Unlimited*' was representative of the prolific booster literature of the time. It proclaimed a mix of imperialist, nationalist, racist and expansionist sentiments underpinned by a faith in the nation's unlimited resources. These optimistic views were embraced by many in government, the media and in industry. However, as Borrie (1994, 202) points out, in the 1920s this optimism was increasingly being countered by commentators who questioned the ability of Australia to absorb unlimited population growth. While there were many such commentators, the geographer Griffith Taylor was the most outspoken and controversial. Such was the virulence of opposition to his views, Griffith Taylor felt compelled to leave Australia for North America.

During the early decades of the postwar era, however, the period of the 'Long Boom' in Australia in the first quarter century following World War II saw a revival of the philosophy of population growth as being integral to national growth (Borrie, 1994, 231). There was little questioning of the environmental consequences. In the earlier growth discourse the focus was on the extension of the agricultural frontier often into marginal lands which was strongly opposed by geographers like Griffith Taylor. In the Long Boom, however, the engine of growth was manufacturing and the bulk of immigrants were absorbed in Australia's largest cities.

After three decades of quiescence, however, the 1970s saw a revival of concern about population and environment in Australia. The National Population Inquiry (1975, 213)

recognised that while the concerns about carrying capacity which were dominant in the interwar period, there began in the 1970s a new questioning of the pressures that population growth was putting on the environment. The discussion intensified in the 1980s (Birrell, Hill and Nevill [eds.], 1994; Day and Rowland [eds.], 1988) and the 1990s also saw a number of major investigations into population and environment. The first was the Inquiry into *Population Issues and Australia's Future: Environment, Economy and Society* undertaken by the Population Issues Committee of the National Population Council (1991a and b). The Council was asked by the Prime Minister to 'examine all pertinent matters – including the impact of population increase on the economy, environment, human service delivery, infrastructure, social equity and international obligations' (NPI, 1991a, v). The report produced by the Committee argued that Australia was at a crossroads with respect to its population and called for the development of a population policy which seeks to influence and respond to population change so as to advance economic progress, ecological integrity, social justice and responsible international involvement. The report advocated strongly for a more holistic approach to considerations of population which balanced economic, environment and social considerations. It argued that environmental considerations made it necessary to adopt a precautionary approach to population and to move toward a more sustainable future. It made a number of suggestions about how Australia could move toward the development of a comprehensive population policy which was both proactive and responsive. Unfortunately the report was presented to Prime Minister Hawke immediately before he was replaced by Prime Minister Keating and hence had little impact. Two other key documents from the 1990s were reports from the Australian Academy of Sciences (1995) and the Commonwealth House of Representatives Standing Committee on Long Term Strategies Inquiry Into Australia's Carrying Capacity (Cocks, 1996).

The last decade has seen a strengthening of the debate (ATSE, 2000, 2007; Vizard, Martin and Watts, 2004; Hamilton, 2002; Foran and Poldy, 2002; Hugo, 2010; Carr, 2010; Ridout, 2010; Sobels *et al.*, 2010). The recent population debate in Australia has had a number of distinctive features:

- Population has been seen as synonymous with immigration and the other dimensions of population change are ignored.
- Environmental impacts are a much more important element in the immigration/population debate in Australia than elsewhere in North America or Europe.
- The debate has been a strongly polarised one between continued rapid population growth on the one hand and little or no growth on the other.
- The sides in the debate are not drawn along traditional lines. There are both anti-growth and pro-growth elements on both sides of politics.
- There is strong continuity with the past in that issues of the size of the future population and optimum population dominate public discussion.
- Another element of continuity is the revival of interest in population distribution issues, regional development and decentralisation.
- The debate has generally been populist in nature and too often characterised by misinformation, self-interest and bigotry.
- While the debate has been overwhelmingly on numbers, population growth and the role of immigration there also have been some discussions regarding fertility. The Federal Government introduced a baby bonus and a number of family friendly initiatives in an effort to forestall further fertility decline (Heard, 2010).

CONTEMPORARY POPULATION DISTRIBUTION

The Australian population debate has been dominated by the numbers issue – How many Australians? A Big Australia vs a Small Australia? What is Australia's Carrying Capacity? What is Australia's Optimal Population? This dichotomisation and simplification is unfortunate for a number of reasons:

- Australia's population issues extend beyond numbers and one could argue that changing age composition is in fact a bigger challenge. There are many demographic issues which must be incorporated into the national population strategy beyond the size of the national population.
- The strategies which will produce the most desirable, sustainable outcomes for Australia lie between the Big Australia and Small Australia positions. Policies must be shaped by the evidence on economic, environmental and social outcomes and impacts and balancing those impacts in the light of the most robust empirical evidence.
- There is not going to be any single magic number. Possible population scenarios for short, medium and long term planning need to be developed and constantly monitored and modified in response to change.

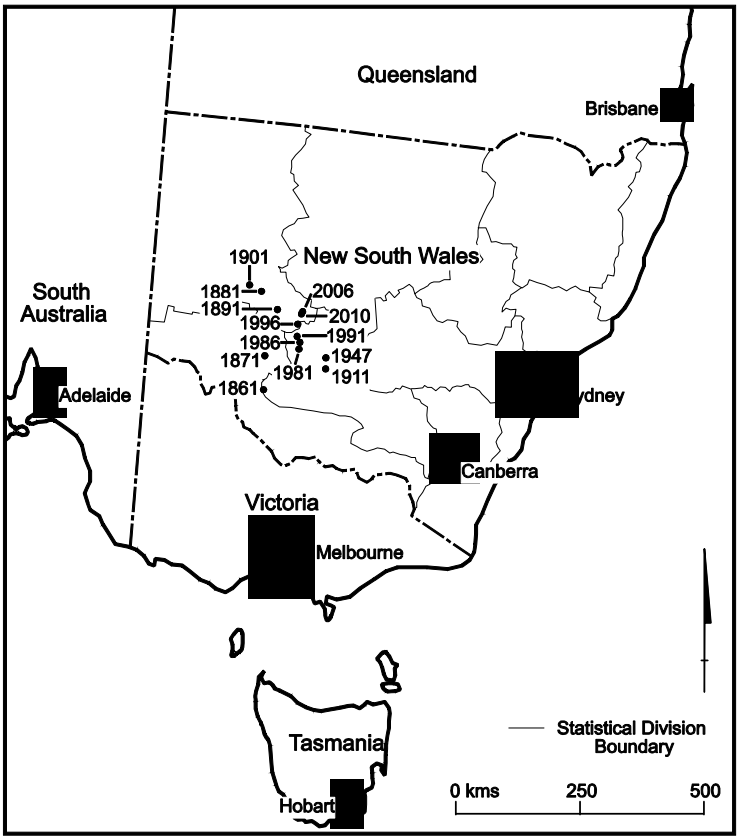
The distribution of Australia's population and its linkages to environment is an important but neglected issue. In discussing the national population distribution there is a striking paradox. On the one hand Australians are the most mobile society in the contemporary world. The 2006 census indicated that 16.8 percent of Australians had moved their permanent place of residence in the last year, the highest rate of residential mobility of any country. Moreover, 23.9 percent of the Australian population was born in another country, the highest proportion for any middle sized or large country. In addition, at any one

time there are almost one million foreigners in Australia on some form of temporary visa. Hence the Australian population is one of, if not the most, residentially mobile in the world.

Nevertheless, in the last few decades the Australian settlement system has been characterised by stability. In the 1920s Griffith Taylor argued that (Powell, 1984, 87):

> '… the contemporary margins of settlement in Australia *already* closely approximated the limits which had been set by the very nature of the physical environment: whether people, plants or animals were considered, the appropriate environmental controls could be ignored only at a cost'.

Figure 8: Australia: Centre of Gravity of Population, 1861-2010
Source: Calculated from ABS Historical Statistics

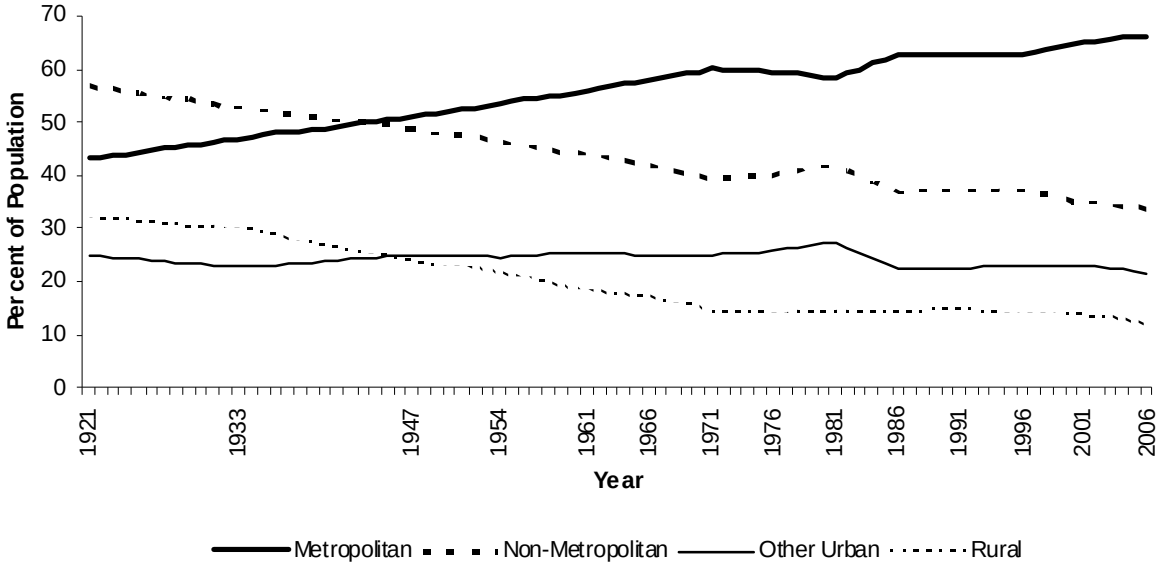


There is much to support his argument that the fundamental structure of Australian settlement was already established by the second half of the nineteenth century. Figure 8 shows the

centre of gravity of the Australian population since 1861 and indicates that it has moved very little. Despite massive population growth the basic structure of the distribution of the population has remained fairly stable. This is in contrast to the United States where there has been significant westward and southward movement in the centre of gravity of the population distribution (Plane and Rogerson, 1994).

There is also a degree of stability in the proportions of the national population living in metropolitan, other urban and rural areas. Figure 9 indicates that there has been little change over the last few decades in the proportions of the national population living in the three main section of state categories identified by the ABS.

Figure 9: Australia: Changing Distribution of the Population Between Urban and Rural Sectors, 1921-2006
Source: Australian Censuses, 1921-2006



This stability in the basic structure of Australia's population distribution and settlement system over an extended period needs to be *borne in mind in any discussion of the impacts of climate change on the national population distribution.*

Australia has a very distinctive population distribution which is characterised by the following:

- 87 percent live in urban areas
- 64 percent live in capital cities
- 81 percent live within 50 km of the coast
- 0.8 percent of the population live in the 70.5 percent of the land area of the continent with a population density of less than 0.1 persons per km^2
- 76 percent of the people live in the 0.33 percent of the land area within 100 persons or more per km^2

The strong spatial concentration of the Australian population is depicted in Figure 10. This indicates a strong clustering in the east coast, southeast and southwest regions. Australia is one of the least densely populated countries in the world (2 persons per km^2) but it also has one of the most spatially concentrated populations. In 2006 some 81 percent of the population lived within 50 kilometres of the coast. This uneven distribution has long been a point of debate in Australia (Rowland, 1982, 23-24) and raises a number of important policy issues in both the closely and sparsely settled areas. In the former, issues such as negative environmental impacts, overcrowding, and diseconomies in service provision abound while in the latter, questions of economic and social viability and lack of access to services loom large. These issues gain a particular significance in a context of climate change.

The density of population is one of the lowest in the world with Western Sahara, French Guinea, Namibia, Mongolia, Faulkland Islands and Greenland being the only nations with fewer people per square kilometre. The density is only a tenth that of all more developed countries (23 persons per km^2) and a twentieth that of less developed countries (58 persons per km^2). The distribution of population in non-metropolitan areas as depicted in Figure 11 shows that there is a sharp decline in population density as one moves inland from

the east, southeast and southwestern coasts of the continent. The majority of the continent, however, has fewer than one person per square kilometre. Table 3 shows the stark comparison between the percentages of population and land in each of the population density categories depicted in Figure 10. Only 0.8 percent of the population live in an area which has less than 0.1 person per square kilometre and this covers 70 percent of the continent. On the other hand, 76 percent of Australians live in areas with 100 or more people per square kilometre but this covers around 0.3 percent of the area.

Figure 10: Australia: Distribution of the Total Population, 2006
Source: ABS, 2008b, 192

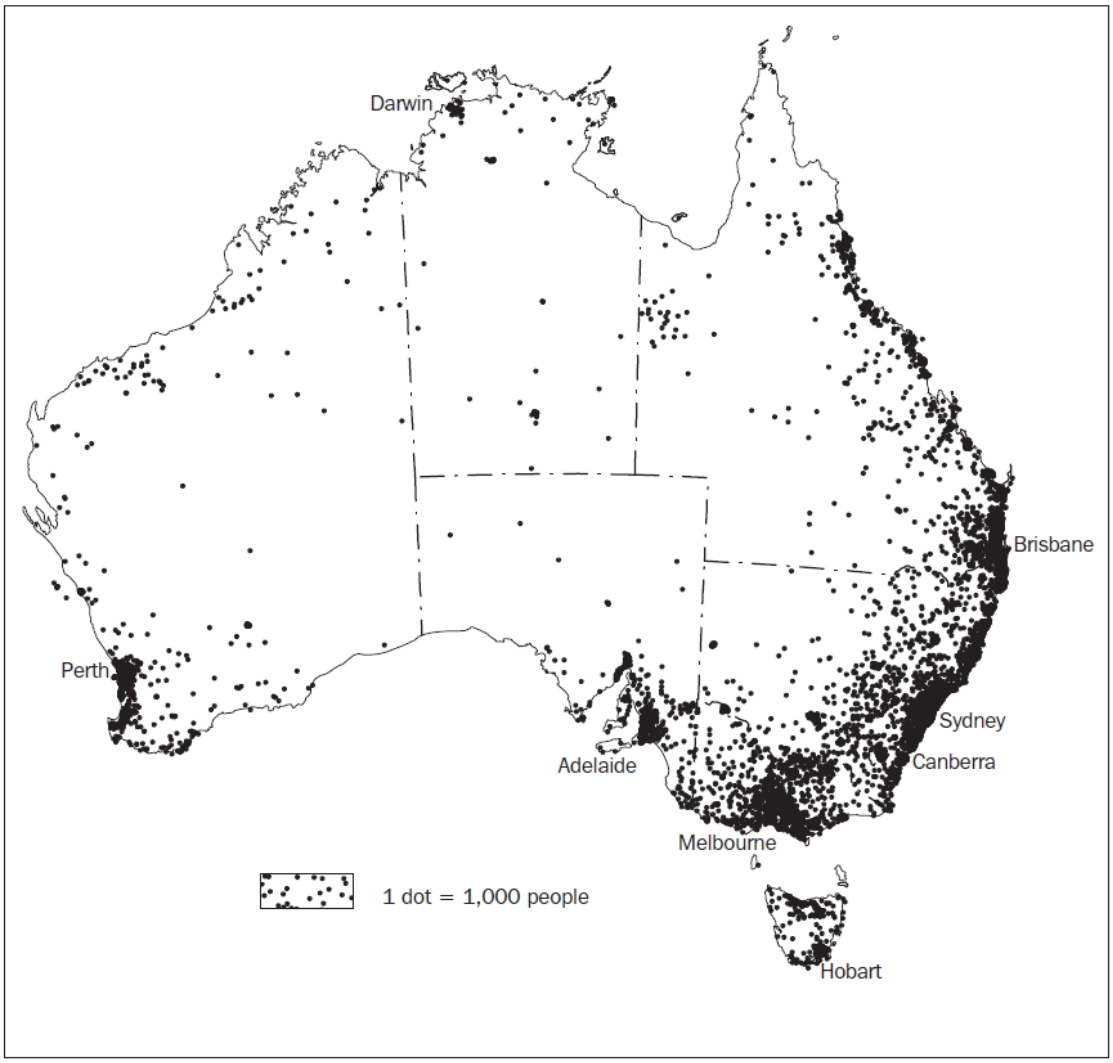


Figure 11: Population Density, 2011
Source: ABS, 2011b

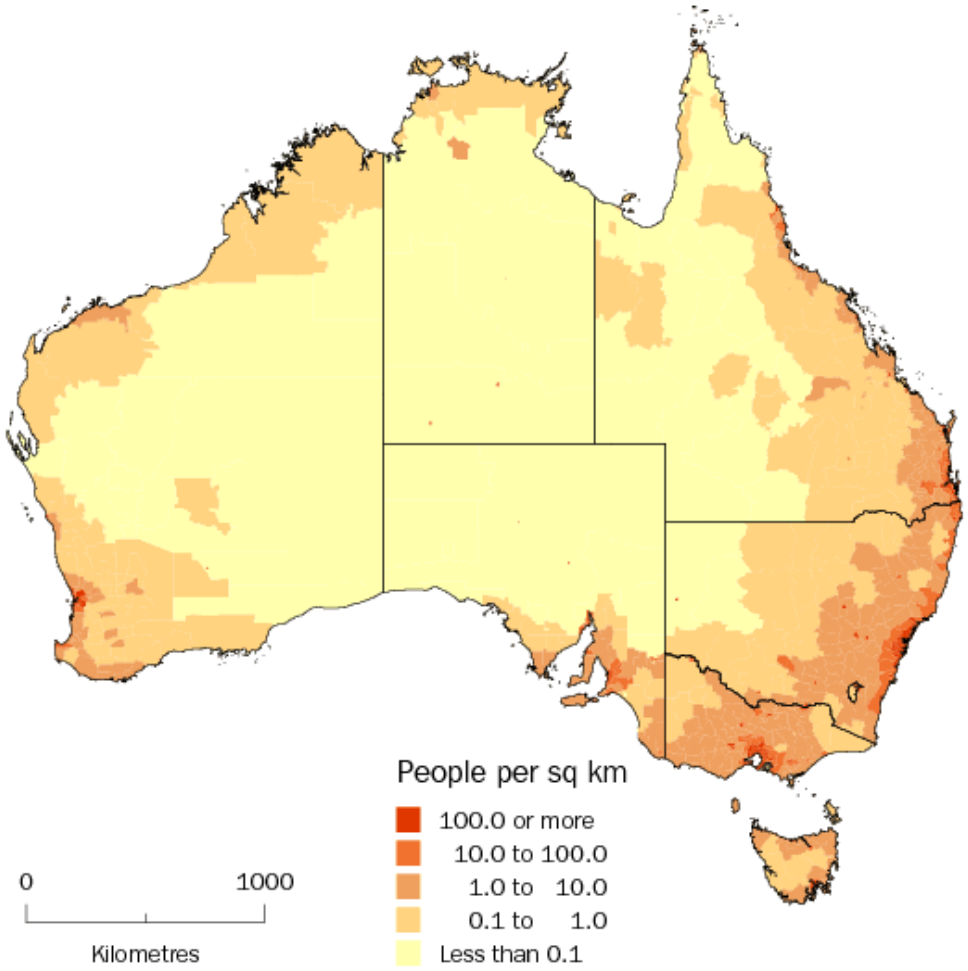


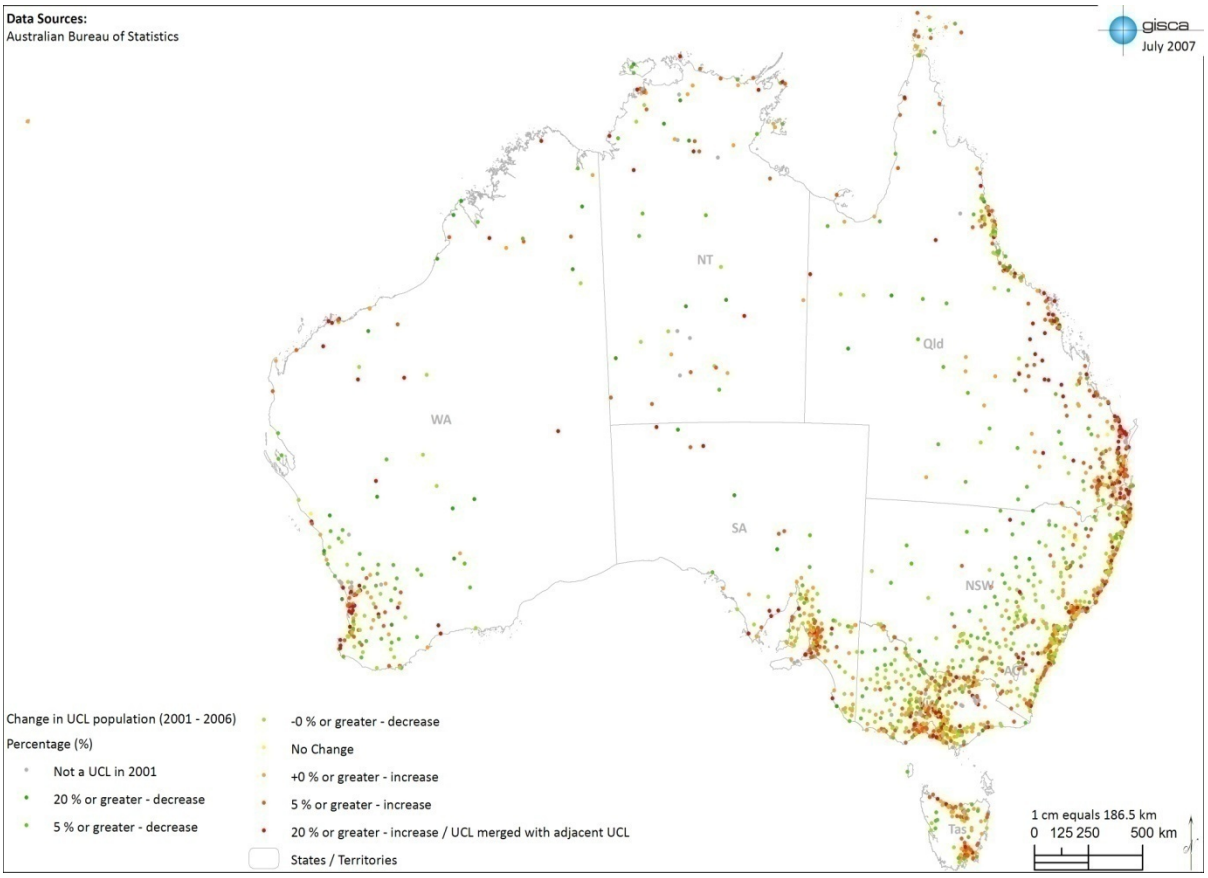
Table 3: Population Density 2006

Density Category Persons per km2	Percent of Population	Population	Per cent of land
Less than 0.1	0.31	62,156	84.00
0.1 to less than 1.0	1.60	316,388	12.04
1.0 to less than 10.0	3.61	714,689	3.29
10.0 to less than 100.0	4.55	901,824	0.43
100.0+	89.93	17,818,752	0.24

Notes:
Population and area data sourced from ABS census 2006 CD file

The overall pattern of stability within the Australian settlement system belies a great deal of dynamism and change at local and regional levels. As was indicated earlier, Australia's population has higher levels of international and internal migration than any other country. Although there has been little change in the proportions of the national population living within metropolitan and non-metropolitan Australia, there have been substantial shifts within these sectors. Figure 12, for example, shows that the urban centres and country towns which experienced growth over the 2001-06 period are concentrated in coastal areas and areas around major cities. On the other hand, those losing population tend to be located inland. It has been argued by some (e.g. Holmes, 1994) that there are two regional Australias – the coastal areas challenged by dynamism and growth, and inland Australia experiencing

Figure 12: Australia: Population Change in Country Towns, 2001-06
Source: Australian Censuses of 2001 and 2006



stability or decline. Certainly there is considerable variation across regional Australia in economic and demographic development. This is evident in Table 4 which examines the rate of population change in Australian remoteness areas. There is a pattern of higher population growth levels in more accessible areas although the impact of the mining boom is evident in the recent increase in growth in very remote areas.

Table 4: Australia: Population Change by Remoteness Area, 1996-2010
Source: Australian Bureau of Statistics

Remoteness Area Category	Population Change 1996-2006 ('000)	Growth Rate (%) pa			
		1996-2001	2001-06	2008-09	2009-10
Major Cities of Australia	2069.2	1.8	1.4	2.2	1.8
Inner Regional Australia	330.2	0.3	1.4	2.1	1.8
Outer Regional Australia	9.3	-0.7	0.8	1.7	1.2
Remote Australia	-12.2	-0.7	0.0	0.9	0.8
Very Remote Australia	-5.7	-0.5	-0.2	1.2	1.1
Total	2390.8	1.2	1.3	2.1	1.7

RECENT POPULATION DYNAMICS INFLUENCING POPULATION DISTRIBUTION

For several of the most recent intercensal periods growth of the population living outside of Capital City Statistical Divisions has been greater than that within the metropolitan areas (Table 5). Net international migration gain has been the most significant driver of metropolitan population growth. Table 6 shows that the international migration contribution varied between 69 percent of net growth in Sydney to 20 percent of that in Brisbane. Net internal migration gains from within Australia were responsible for 31.6 percent of Brisbane's growth and 3 percent of Perth's but there were net outmigrations from the other capitals, especially Sydney (a net internal migration loss of 121,000).

Table 5: Australia: Distribution of Overseas-Born Between Capital Cities and Rest of State, 2001 and 2006
Source: ABS Censuses

	2001		2006		Growth Rate
	Number	%	Number	%	2001-06
Major Capital Cities	3,307,577	81.1	3,557,486	80.6	1.47
Rest of States	771,574	18.9	857,873	19.4	2.14
Total	4,079,151	100.0	4,415,359	100.0	1.60

Table 6: Estimated Components of Population Change in Mainland State Capital City Statistical Divisions, 2001-06 (in '000s)
Source: Hugo and Harris, 2011

		Natural Increase	Net International Migration	Net Internal Migration	Population Change
Sydney	'000s	159	84	-121	122
	Percent	130.3	68.9	-99.2	100
Melbourne	'000s	121	124	-19	266
	Percent	53.5	54.9	-8.4	100
Brisbane	'000s	66	27	43	136
	Percent	48.5	19.9	31.6	100
Perth	'000s	49	53	3	105
	Percent	46.7	50.5	2.9	100
Adelaide	'000s	21	22	-10	33
	Percent	63.6	66.7	-30.3	100

Table 7 estimates the components of population change in all statistical divisions across Australia over the 2001-06 period. In this table, net migration is the combined result of internal and international migration. It is interesting that over the period only eight of Australia's SDs experienced an absolute decline in population. These were remote, northwestern and western NSW, south central and northwest in Queensland, northern in South Australia and Kimberley in Western Australia. Only Wimmera in Victoria located in the more closely settled wheat-sheep belt is an exception to this pattern.

Table 7: Australia: Statistical Divisions by Total Population, Net Migration (International and Internal) Estimates and Natural Increase, 2001-06

Source: Calculated from 2001 and 2006 Census Population Data

Statistical Division	2001 Census	2006 Census	Population Change 2001-2006	Net Migration		Natural Increase	
				Number	% of Population Change	Number	% of Population Change
Sydney	3949989	4119191	169202	-9278	-5.5	178480	105.5
Hunter	562409	589240	26831	6262*	23.3	20569	76.7
Illawarra	380687	394211	13524	110	0.8	13414	99.2
Richmond-Tweed	205162	219329	14167	8338*	58.9	5829	41.1
Mid-North Coast	266825	284674	17849	11109*	62.2	6740	37.8
Northern	170659	172396	1737	-5267	-303.2	7004	403.2
North Western	112022	111231	-791	-6149	777.4	5358	-677.4
Central West	167666	170897	3231	-3661	-113.3	6892	213.3
South Eastern	183026	197942	14916	8110*	54.4	6806	45.6
Murrumbidgee	143410	147292	3882	-2982	-76.8	6864	176.8
Murray	105941	110523	4582	583	12.7	3999	87.3
Far West	22585	22030	-555	-1242	223.8	687	-123.8
Melbourne	3357888	3592593	234705	87696	37.4	147009	62.6
Barwon	243375	259012	15637	6403*	40.9	9234	59.1
Western District	95488	98855	3367	29	0.9	3338	99.1
Central Highlands	134555	142219	7664	2452*	32	5212	68
Wimmera	48656	48441	-215	-1337	621.9	1122	-521.9
Mallee	85770	88601	2831	-432	-15.3	3263	115.3
Loddon	158233	168843	10610	4395*	41.4	6215	58.6
Goulburn	184008	195239	11231	3770*	33.6	7461	66.4
Ovens-Murray	88104	92587	4483	940	21	3543	79
East Gippsland	76927	80117	3190	989	31	2201	69
Gippsland	152722	159483	6761	1427	21.1	5334	78.9
Brisbane	1581803	1763133	181330	98357	54.2	82973	45.8
Gold Coast	413729	482318	68589	50888*	74.2	17701	25.8
Sunshine Coast	235220	276263	41043	31947*	77.8	9096	22.2
West Moreton	62740	68630	5890	3137*	53.3	2753	46.7
Wide Bay-Burnett	225228	254658	29430	20716*	70.4	8714	29.6
Darling Downs	202405	213756	11351	4673*	41.2	6678	58.8
South West	24854	24780	-74	-1507	2036.5	1433	-1936.5
Fitzroy	171485	188406	16921	6863*	40.6	10058	59.4
Central West	11677	10851	-826	-1384	167.6	558	-67.6
Mackay	130140	150171	20031	12118*	60.5	7913	39.5
Northern	181569	196672	15103	5100*	33.8	10003	66.2
Far North	211823	231049	19226	6482*	33.7	12744	66.3
North West	32535	30938	-1597	-4060	254.2	2463	-154.2
Adelaide	1070837	1105839	35002	3644	10.4	31358	89.6
Outer Adelaide	108670	123700	15030	10737*	71.4	4293	28.6
Yorke and Lower North	42252	43878	1626	845*	52	781	48
Murray Lands	65195	66805	1610	-569	-35.3	2179	135.3
South East	59456	62219	2763	169	6.1	2594	93.9
Eyre	32190	33343	1153	-206	-17.9	1359	117.9
Northern	76146	75927	-219	-3378	1542.5	3159	-1442.5
Perth	1332002	1445077	113075	52653	46.6	60422	53.4
South West	180269	207343	27074	18587*	68.7	8487	31.3
Lower Great Southern	49548	52592	3044	870*	28.6	2174	71.4
Upper Great Southern	17564	17714	150	-675	-450	825	550
Midlands	49903	50411	508	-1718	-338.2	2226	438.2
South Eastern	51307	51894	587	-2930	-499.1	3517	599.1
Central	56766	57428	662	-2320	-350.5	2982	450.5
Pilbara	37137	41004	3867	456	11.8	3411	88.2
Kimberley	30340	29297	-1043	-3388	324.8	2345	-224.8
Greater Hobart	191128	200523	9395	3073	32.7	6322	67.3
Southern	33036	34927	1891	593	31.4	1298	68.6
Northern	128397	133930	5533	1537*	27.8	3996	72.2
Mersey-Lyell	101786	106131	4345	1030*	23.7	3315	76.3
Darwin	99320	105992	6672	579	8.7	6093	91.3
Northern Territory - Bal	83791	84910	1119	-5279	-471.8	6398	571.8
Canberra	307834	323056	15222	29	0.2	15193	99.8

* Non-metropolitan net migration sinks

With respect to components of growth it is possible to identify a relatively small number of *sinks* of significant net migration gain in the non-metropolitan sectors of each state. These are marked with an asterisk in Table 7. It is striking that Queensland has more than a third of these. In fact of the 14 non-metropolitan SDs which recorded a net migration gain 5,000 or more in 2001-06 half were in Queensland.

Examination of internal migration data from the 2006 census allows us to identify the number of persons who moved into and out of each statistical division between 2001 and 2006 and these are shown in Appendix A. From this it is possible to identify the statistical divisions which act as *sources*, and which experience net migration loss, and SDs which act as sinks which experience net migration gain. Table 8 shows the top ten sinks and sources based on net migration between 2001 and 2006. Of the top ten sinks, four are located in each of Queensland and New South Wales, and one in each of South Australia and Western Australia. In Queensland, the Gold Coast, Sunshine Coast and Wide Bay-Burnett SDs shared

Table 8: Australia Statistical Divisions: Major Sinks and Sources of Net Internal Migration, 2001-06

Source: ABS 2006 Population Census

Net Gains		Net Losses	
Sinks		Sources	
Statistical Division	Net Migration	Statistical Division	Net Migration
Brisbane (Q)	42,750	Sydney (NSW)	121,012
Gold Coast (Q)	29,312	Melbourne (V)	18,709
Sunshine Coast (Q)	20,561	Adelaide (SA)	9,611
Wide Bay-Burnett (Q)	15,798	North West (Q)	6,506
Southwest (WA)	10,805	Balance (NT)	4,443
Mid North Coast (NSW)	10,254	South Eastern (WA)	3,725
Hunter (NSW)	9,656	Northwest (NSW)	3,439
Outer Adelaide (SA)	7,454	Northern (SA)	3,089
South Eastern (NSW)	6,501	Northern (NSW)	3,033
Richmond Tweed (NSW)	6,143	Murrumbidgee (NSW)	2,849

a net gain of some 66,000 persons between 2001 and 2006. Mackay experienced a net gain of 5,000 movers during the period, and while attractive living opportunities may account for some of the influx, agriculture and mining activity in the hinterland is clearly an additional factor accounting for the net gains. In New South Wales, the four main sink SDs gained around 32,000 persons in the five years to 2006. Three of these Statistical divisions – Richmond-Tweed, Mid-North Coast and Hunter are to the north of the Sydney SD, while South Eastern SD is to the south. Each of these SDs is in the coastal zone and have attracted substantial numbers of Sydney people leaving the increasingly congested environment of Sydney for more attractive environments of the north and south coast regions. The other areas of growth are in the peri-urban areas of Perth and Adelaide. On the other hand the major sources suffering significant net outmigration losses were the capital cities of Sydney, Melbourne and Adelaide. Hence the overall net flow of resident population from capital cities to non-metropolitan areas is one of the most striking trends in Australian internal migration.

The spatial patterning of internal migration between states during the 2001-06 intercensal period is shown in Figure 13. It is noticeable that there is considerable complexity and reciprocity in the system. While there are dominant flows in the northeast and west there are also flows in the opposing direction. There are significant flows to, and from, the capital cities. The largest flows are along the east coast. It is important to realise that the internal migration system in Australia, especially between states, is relatively inefficient with significant flows both in and out. This is evident in Figure 14 which shows the net migration reached by statistical divisions over the 2001-06 period. Clearly, net migration gains are concentrated along the eastern and southwestern seaboards and around the major capitals. It is unlikely that the 2011 census will show any major changes except for an increase of net gains in the mining areas of remote Australia. However, even with the

massive growth of mining activity in the last 5 years the dominance of fly in-fly out processes will mean that the permanent population added to those areas will be relatively small. The pattern of interstate migration over the 2006-09 period as reflected in the population estimates made by the Australian Bureau of Statistics is shown in Figure 15. This suggests a continuation of patterns observed at the 2006 census.

Figure 13: Australia: Major Internal Migration Flows Between States
Source: ABS 2006 Census of Population and Housing

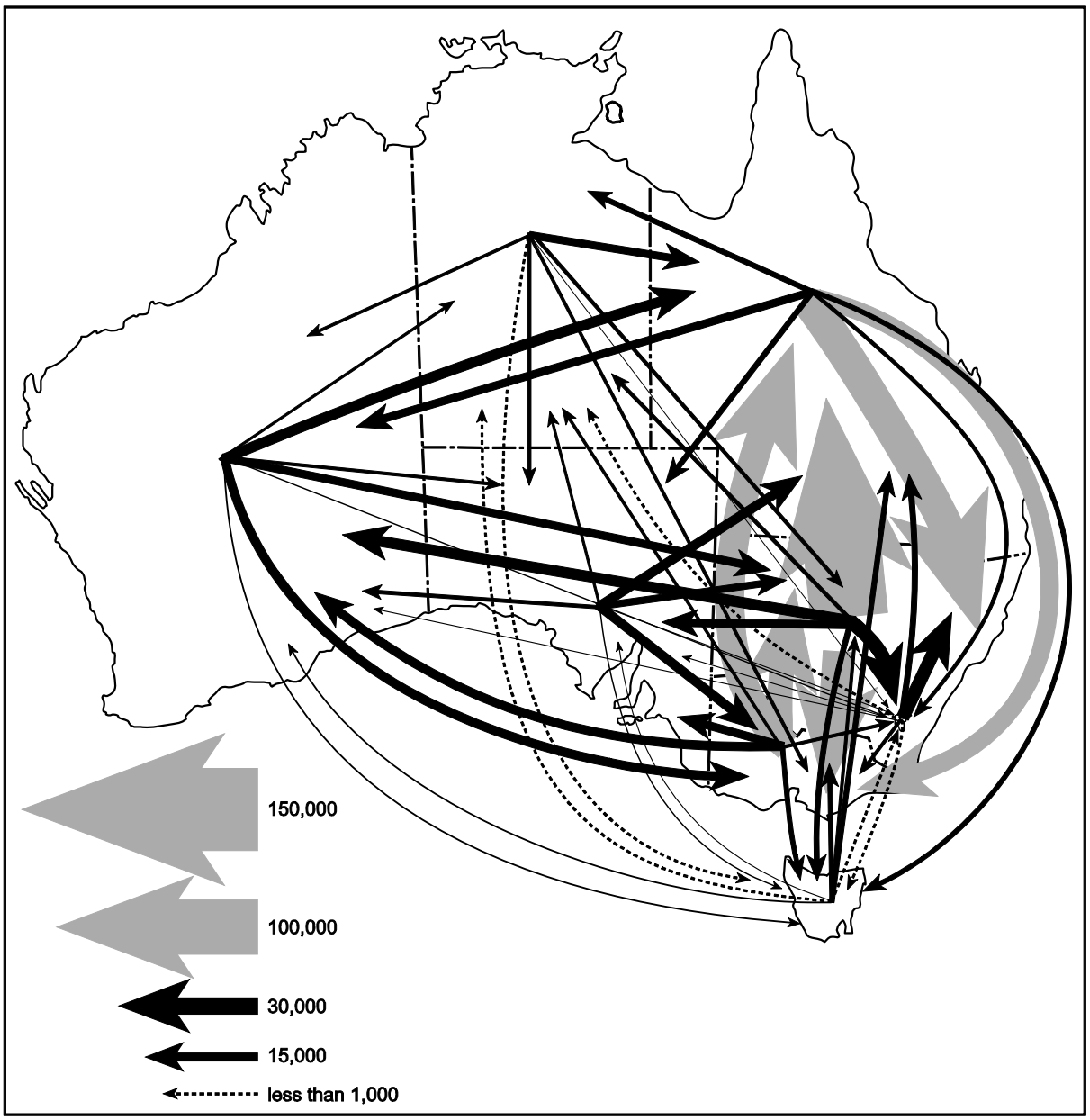


Figure 14: Australia by Statistical Divisions: Net Migration Between Statistical Divisions, 2001-06
Source: ABS 2006 Census

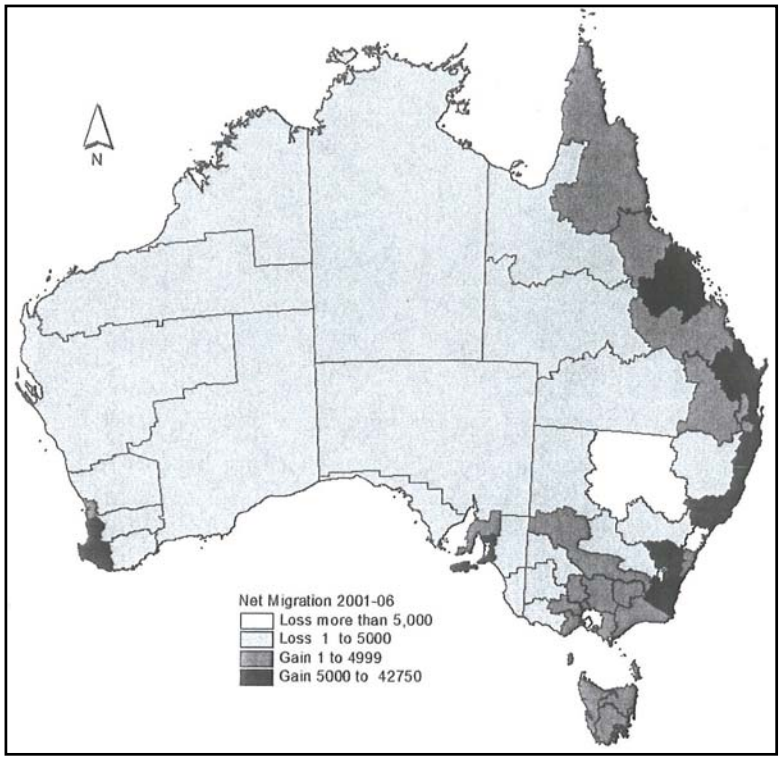
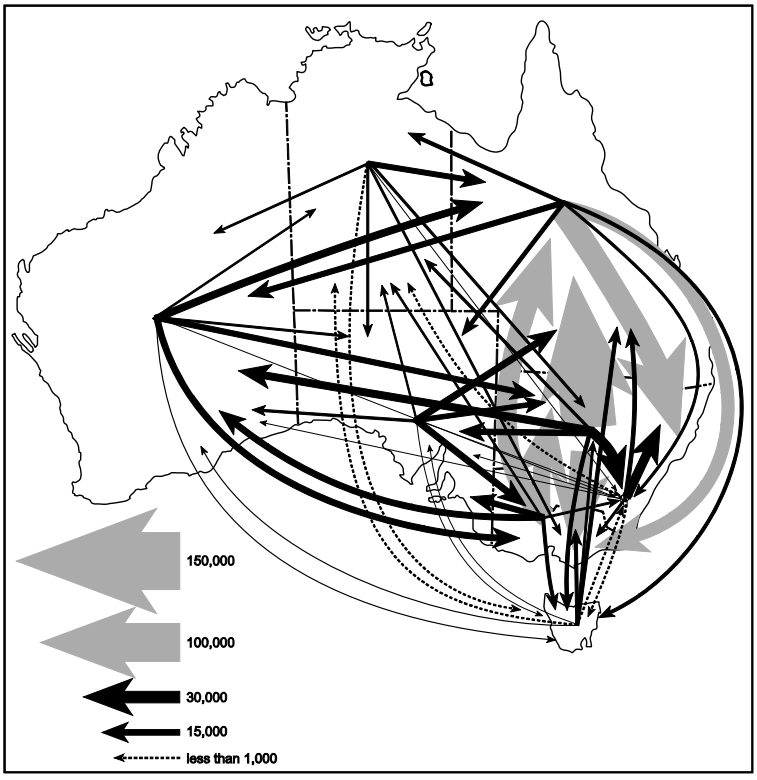


Figure 15: Australia: Internal Migration Between States, 2006-09
Source: ABS *Australian Demographic Statistics*, Catalogue No. 3101.0



Turning to international migration, one of the major features of postwar immigration not only to Australia but also North America and Europe was the increasing tendency with each census for a greater proportion of immigrant arrivals to settle in a few large 'gateway cities' (Price and Benton-Short, 2008). This pattern prevailed up to 2000 but Table 5 showed that in 2001-06 intercensal period the overseas population grew faster outside the major capital city statistical divisions than within it. This was the first time this occurred in the postwar period. Moreover, this decentralisation of migrant settlement has also been observed in the United States (Massey 2008), Canada (Carter *et al.*, 2008), Europe (Jentsch, 2007) and New Zealand (Spoonley and Bedford, 2008).

This represents a small, but perhaps significant, change and one that is a function of:

- The introduction of the State Specific and Regional Migration scheme which provides bonus points for settling outside of the main gateways.
- The DIAC scheme for encouraging refugee-humanitarian settlers to move initially to regional areas (Hugo and Vas Dev, 2010).
- A trend throughout OECD countries for migrants to settle outside major cities.
- Job shortages in regional Australia.

Table 9: Australia: Distribution of Overseas-Born Between Capital Cities and Rest of State, 2001 and 2006
Source: ABS Censuses

	2001		2006		Growth Rate
	Number	%	Number	%	2001-2006
Major Capital Cities	3,307,577	81.1	3,557,486	80.6	1.47
Rest of States	771,574	18.9	857,873	19.4	2.14
Total	4,079,151	100.0	4,415,359	100.0	1.60

Table 9 shows that as a result, although the overwhelming majority of overseas-born growth has occurred in the major cities in fact the growth rate has been faster outside the capitals.

SPATIAL DIFFERENCES IN THE IMPACT OF CLIMATE CHANGE IN AUSTRALIA

Environment has played a crucial part in shaping Australia's population distribution over the period of European settlement. Hence climate change which changes regional and local environments will have implications for future settlement patterns. Issues of rainfall are especially important from this perspective since availability of water is of significance in both urban and rural settlement. Writing a quarter of a century ago, Nix (1988, 72) pointed out the mismatch in Australia between water and population. Table 10 presents his data which showed that Far North Australia had 52 percent of annual mean surface run-off but only 2 percent of the national population while Southern Australia had only half of this proportion of

Table 10: The Mismatch Between Water and Population
Source: Nix, 1988, 72

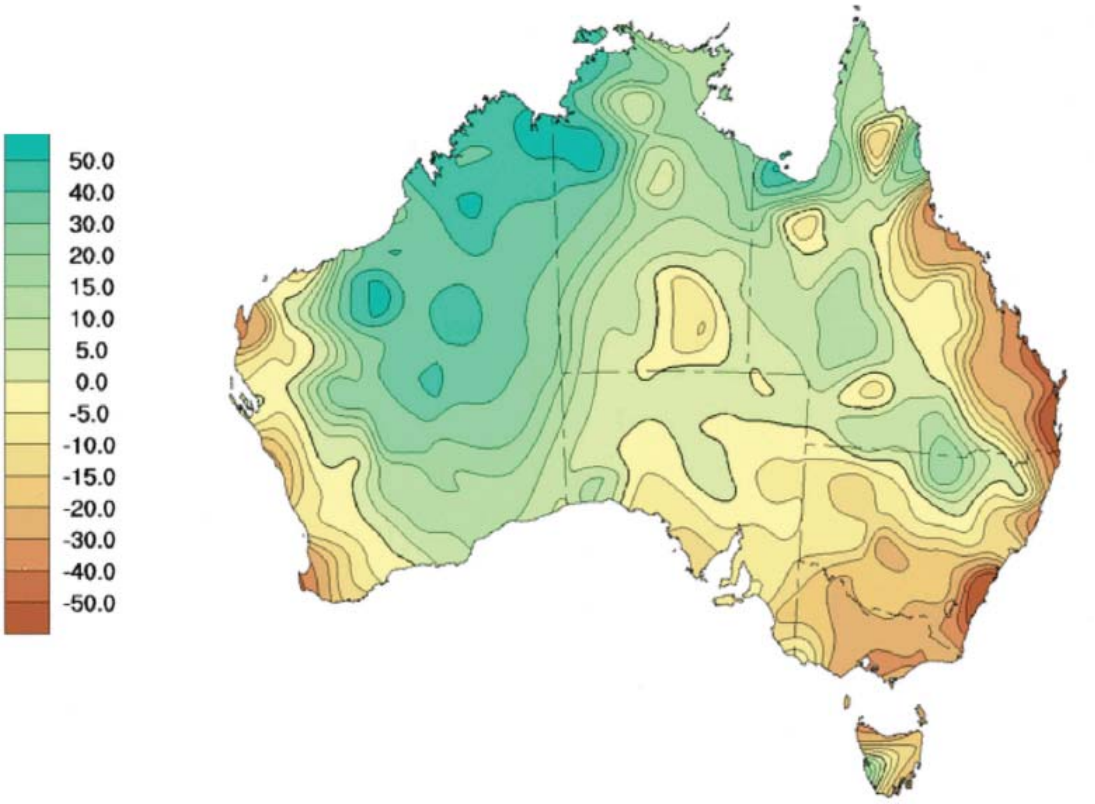
	Far North Australia (%)	Southern Australia (%)
Population	2	82
Potentially Arable Land	4	65
Annual Mean Surface Run-off	52	27

the run-off but 82 percent of the national population. Moreover, he pointed out that the water resources in the more closely settled parts of the country were already under pressure at that time (Pittock and Nix, 1986):

> 'By far the largest volumes of uncommitted water are in northern Australia and Western Tasmania. In the most heavily populated regions of south

western and south eastern Australia surface waters are committed to a high degree and the consequences of climate change are potentially most serious'.

Figure 16: Trend in Annual Total Rainfall, 1960-2009
Source: CSIRO and Bureau of Meteorology, 2010



One of the major effects of climate change is anticipated to be a change in the rainfall and run-off regimes. The recent 13 year drought in southeastern Australia demonstrated this and together with the continuing drought in southwestern Australia. In both cases these droughts have been seen as due in part to long-term rainfall declines associated with climate change (State of the Environment, 2011). Figure 16 presents the results of analysis by the CSIRO and the Bureau of Meteorology (2010) relating to trends in rainfall across the nation over the 1960-2009 period. There are clear long-term patterns of rainfall increase in northwestern Australia but significant decline in the closely settled southeastern part of the

nation. It is interesting to examine the numbers of people living in these two zones. Table 11 shows that the majority of Australians live in the area which is experiencing a long-term decline in rainfall. Moreover, the population is growing in this area while declining in the area experiencing an increase in rainfall.

Table 11: Australia: Population Growth in Long-Term Rainfall Trend Areas, 2001-06

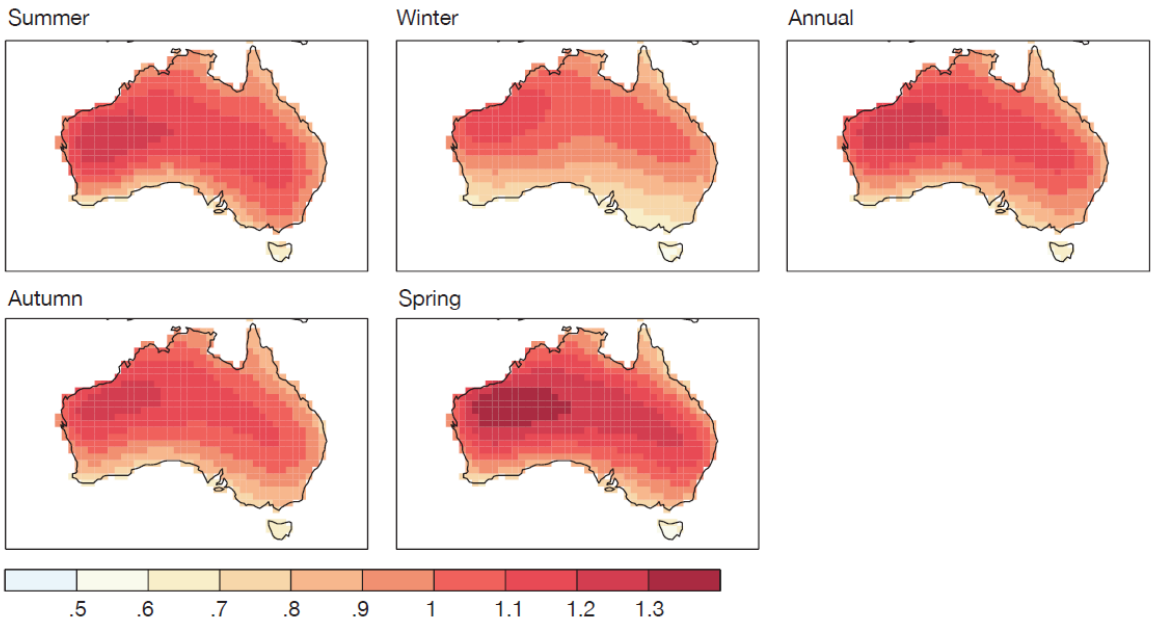
Longterm Rainfall Trend	2001	2006	Change 2001-2006	Change 2001-2006 (%)	Annual Growth Rate (%)
Increasing	655,803	586,318	69,485	-10.6	-2.12
Decreasing	18,314,011	19,225,221	911,210	5.0	1.00
No Data	2,531	2,270	-261	-10.3	-2.06

Notes:
Longterm rainfall trend regions sourced from CSIRO and Bureau of Meteorology (2010) and manually digitised into GIS
Population data based on ABS Census 2001 and 2006 CD centroid enumerated population counts
Annual growth rate has been calculated as five-year growth rate averaged over five years

What are the scenarios of future changes in rainfall? The CSIRO and Australian Bureau of Meteorology (2007) have produced a number of regional climate change projections. It is projected that by 2030 there will be an increase of around 1°C in average temperature – 0.7-0.9°C in coastal areas and 1-1.2°C inland. The projected spatial patterns of change are shown in Figure 17. There is little variation in the results over the full range of climate change scenarios in the 2030 projections. However, there is greater variation in the projections up to 2050 and 2070 which are depicted in Figure 18. The major regional variations are of less warming in the southern and northeast and more inland.

Figure 17: Best Estimate (50th) Percentile of the Change in Average Temperature (°C) Over Land by 2030 for A1B Emission Scenario for Summer, Autumn, Winter, Spring and Annual

Source: CSIRO and BOM, 2007, 54

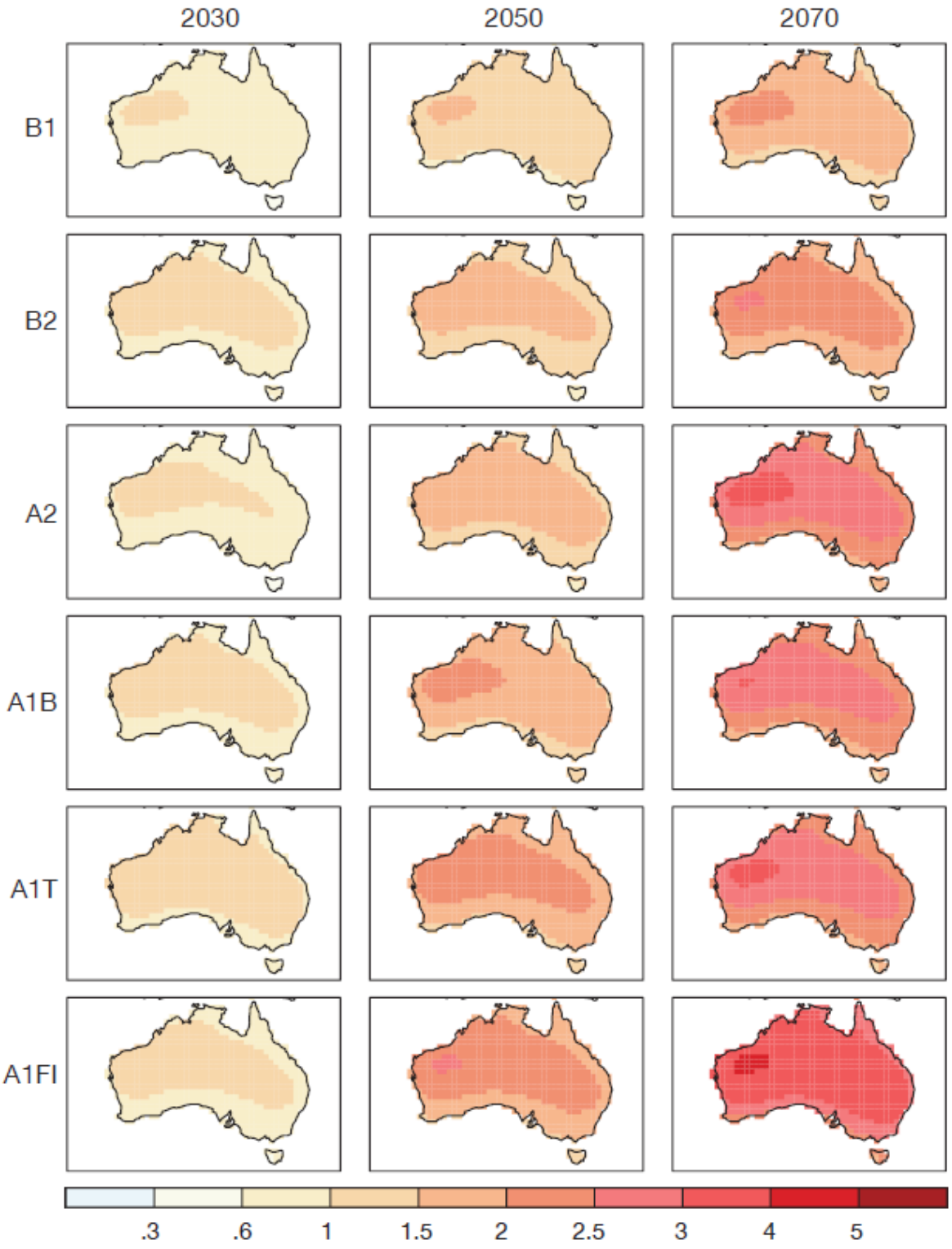


The CSIRO and BOM (2007, 59) point out that climate change models have caused spatial resolution (around 250 km between grid squares) and provide only an average over those grid squares so that within square heterogeneity is not captured. As they point out:

> 'These local details may be very important for understanding the impact of projected climate change on the natural and human environment.'

Application of fine resolution spatial downscaling techniques indicate that global warming is often greater than the average projections in high elevation areas and in coastal areas it tends to be lower. In association with the warming there is projected to be a significant increase in the number of extremely hot days and nights. The occurrence of an increase of extreme events in selected places in Australia is depicted in Table 12. There is also projected to be a reduction in frost frequency.

Figure 18: **Best Estimate (50th Percentiles) of Projected Change of Annual Mean Temperature (°C) for 2030 (left column), 2050 (middle) and 2070 (right)**
Source: CSIRO and BOM, 2007, 57



Results for all six emission scenarios are given, from top to bottom

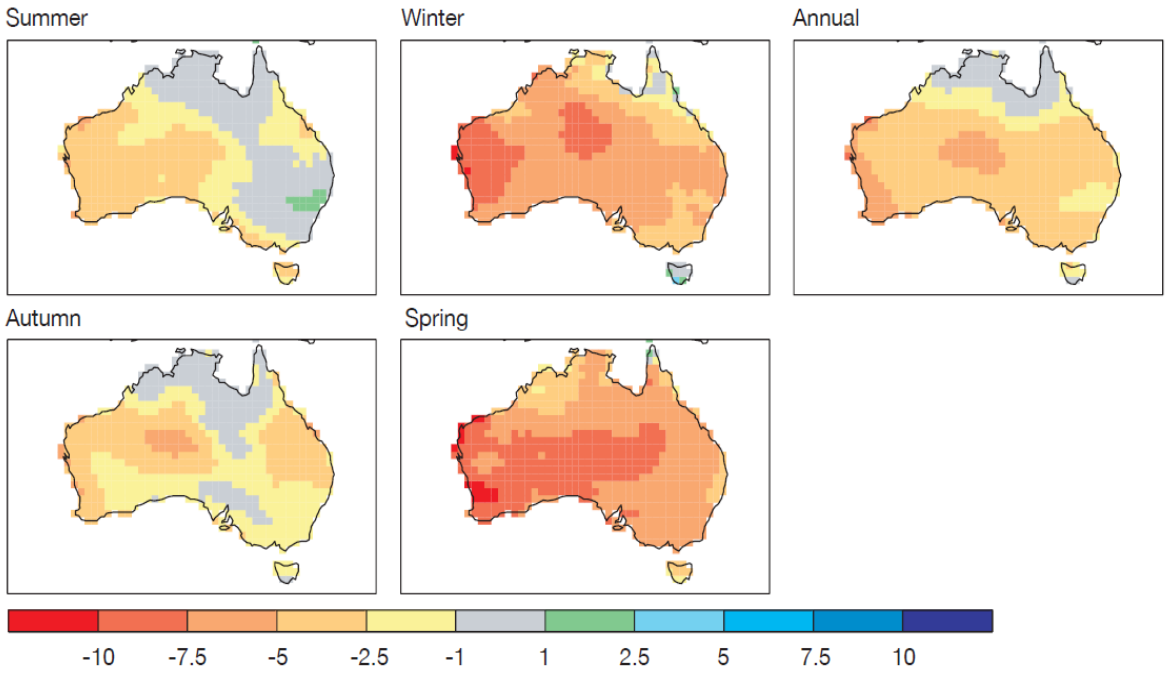
Table 12: Average Number of Days per Year Above 35°C at Selected Sites for the 'Current' Climate (Average for 1971-2000), and for 2030 and 2070
Source: CSIRO and BOM, 2007, 61

	Current	2030 A1B low	2030 A1B median	2030 A1B high	2070 B1 low	2070 B1 median	2070 B1 high	2070 A1F1 low	2070 A1F1 median	2070 A1F1 high
Adelaide	17	21	23	26	24	26	31	29	36	47
Alice Springs	90	102	109	118	112	122	138	132	155	182
Brisbane airport	1.0	1.5	2.0	2.5	2.1	3.0	4.6	4.0	7.6	20.6
Broome	54	71	86	107	89	119	173	147	220	281
Cairns	3.8	5	7	9	8	12	22	19	44	96
Canberra	5	7	8	10	8	10	14	12	18	26
Darwin	11	28	44	69	49	89	153	141	227	308
Dubbo	25	31	35	39	35	40	51	44	61	87
Hobart	1.4	1.6	1.7	1.8	1.7	1.8	2.0	2.0	2.4	3.4
Melbourne	9	11	12	13	12	14	17	15	20	26
Mildura	32	36	39	43	39	45	51	48	60	76
Perth airport	28	33	35	39	36	41	46	44	54	67
St George	47	56	63	72	64	74	91	80	103	135
Sydney	3.5	4.1	4.4	5.1	4.5	5.3	6.6	6	8	12
Wilcannia	63	71	77	82	79	85	96	92	106	129

Changes in rainfall are not associated with any increase in emissions but are a function of changing temperature patterns and changed wind directions associated with the temperature change. It is projected that by 2030 there will be little change in precipitation in the north and decreases of 2-5 percent elsewhere. The changes are depicted for annual rainfall and for the four seasons in Figure 19. The decreases are highest in winter and spring, especially in the southwest where they record 10 percent. In summer and autumn decreases are smaller and there are slight increases in the east. The CSIRO and BOM (2007, 68) report points out that there is a large range of precipitation changes between the different models.

Figure 19: Best Estimate (50th) Percentile of the Projected Change of Australian Precipitation by 2030 for Emissions Scenario A1B, as a Percentage of 1961-1990 Values for Summer, Autumn, Winter, Spring and Annual

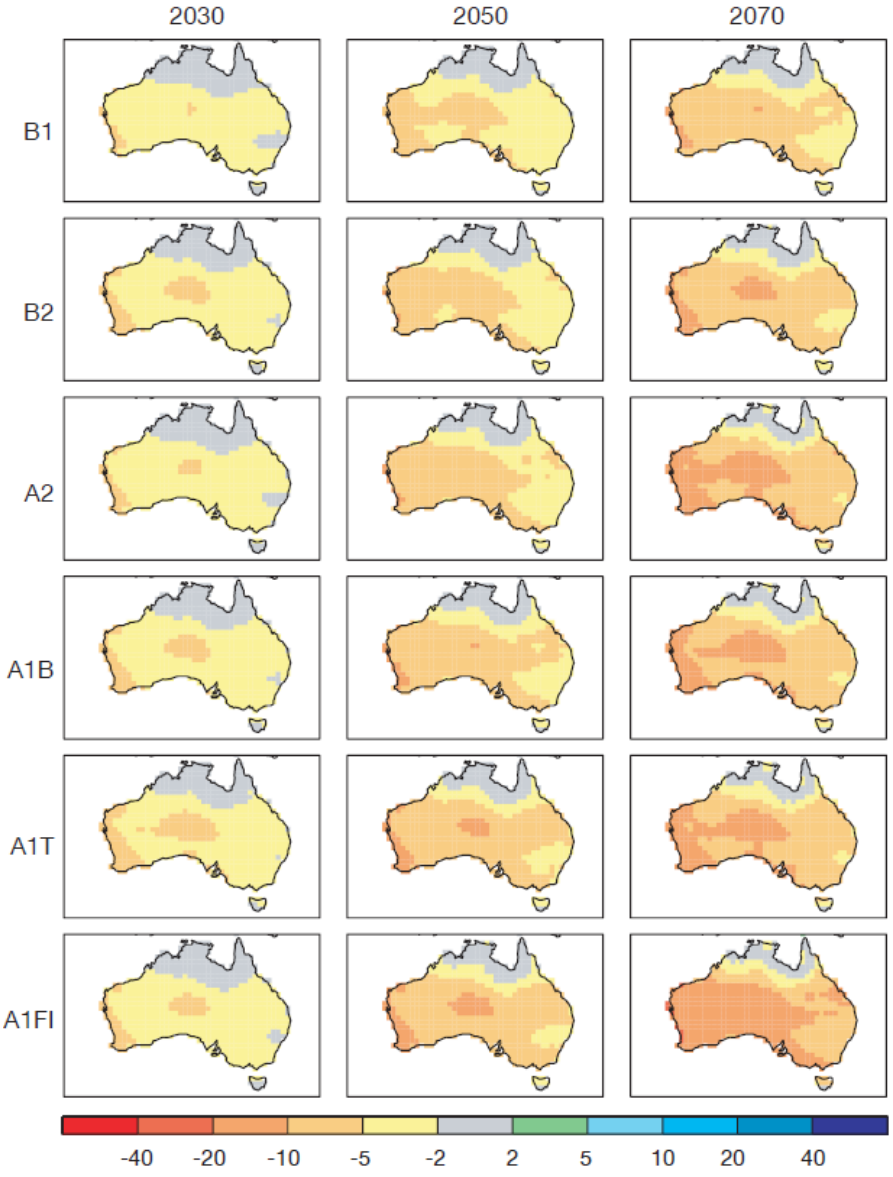
Source: CSIRO and BOM, 2007, 67



Later in the century the projected changes in precipitation are more sensitive to scenarios of emissions and hence there is less certainty in the projections. The best estimate scenarios are presented in Figure 20. Again the best estimates are of little increase in the north grading to decreases in southern areas ranging from 5 to 7.5 percent.

As is the case for temperature, statistical downscaling studies have shown that there could be significant local variation in rainfall change, especially in coastal and mountainous areas. Daily precipitation intensity will increase in the north and decrease in the south. The models show that droughts will increase in frequency over most of Australia but especially in the southwest. It is also shown that there is a substantial increase in fire-weather risk across most of Australia in southeastern Australia.

Figure 20: Best Estimate (50th Percentiles) of Percentage Change in Annual Precipitation, for 2030 (left column), 2050 (middle) and 2070 (right)
Source: CSIRO and BOM, 2007, 70



Results for all six SRES scenarios are given

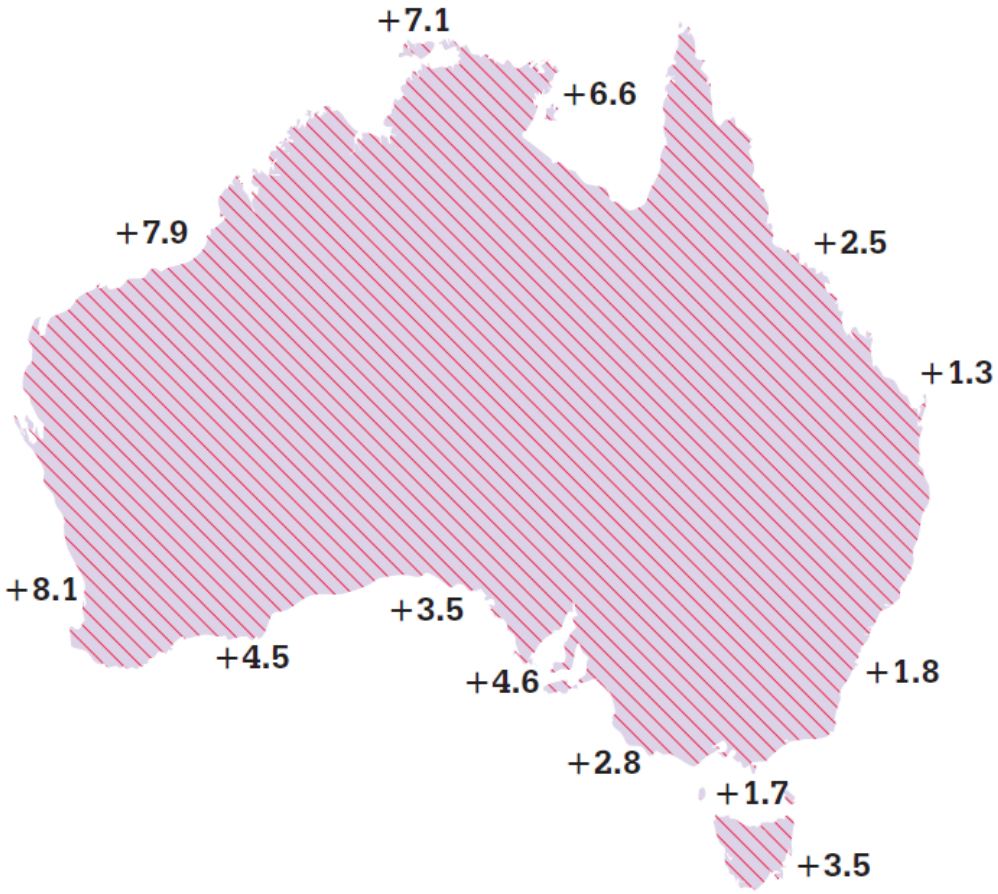
Turning to sea level rise, the CSIRO and BOM (2007, 92) point out that the IPCC project there to be an 18cm-59cm rise in sea level by 2100 with the east coast of Australia anticipated to record a greater rise than the global mean.[2] The impact of sea level rise,

[2] It should be noted that the IPCC put substantial qualifications on these numbers. For example, they do not include the full ice melt factors.

however, can be exacerbated by storm surges which enable inundation and damaging waves to penetrate further inland. The CSIRO and BOM (2007, 94) report studies of Victoria and Queensland coasts which demonstrate the potential of the impact of sea level rise and more intense weather systems. The study shows there is likely to be an increase in the proportion of tropical cyclones which are in the more intense categories but a possible decrease in the total number of cyclones.

On average, sea level rises have risen globally by 3.22mm/year since the early 1990s. However, Figure 21 shows that there are several places along the Australian coast where the increase in sea level has been even greater.

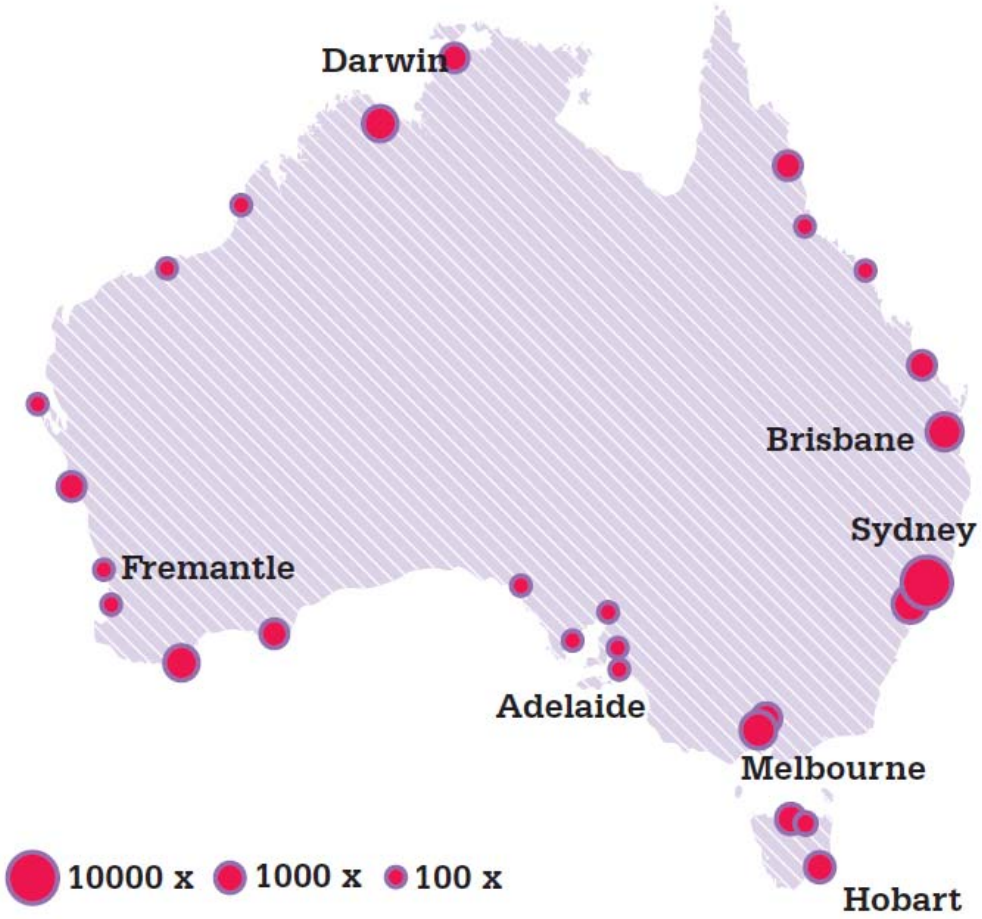
Figure 21: Local Sea Level Rise (mm/year) Around Australia from the Early 1990s to 2008
Source: Climate Commission, 2011, 12



The continuing increase in sea levels poses risk to assets such as housing, buildings, roads, enterprises, farmland etc. and this will be exacerbated by an increase in storm surge. Figure 22 shows that a rise of 50cm in sea level by later in the century would lead to increase in the frequency of high sea level events around coastal Australia, especially in the southeast and southwest.

Figure 22: Estimated Multiplying Factor for the Increase in the Frequency of Occurrence of High Sea Level Events Caused by a Sea Level Rise of 0.5 Metres

Source: Climate Commission, 2011, 27



Projection of future climate change is improving rapidly but the inherent uncertainty is exacerbated when it is spatially disaggregated. It is not yet possible to be precise in

anticipating climate change impacts at local and community levels but there are some clear generalisations that can be made:

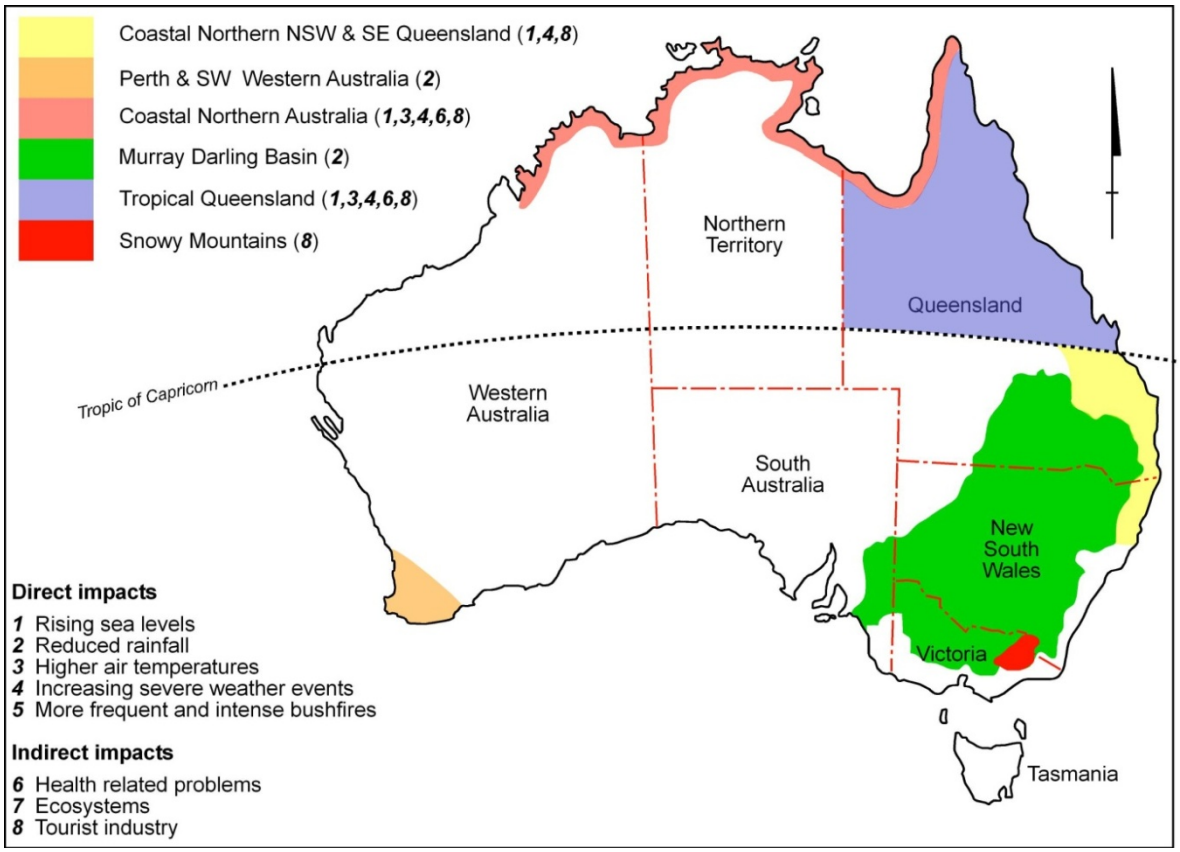
- Rainfall is likely to be reduced in the southern areas of Australia, especially in winter, and in southern and eastern areas in spring, brought about by the contraction in the rainfall belt toward higher latitudes. Most intense rainfall events in most areas will become more extreme and frequent although future changes in summer tropical rainfall in northern Australia remain uncertain (State of the Environment, 2011).
- Temperatures are increasing and the frequency of extremely hot days will increase, especially in inland Australia. There will be an increase in bushfire risk.
- There are likely to be an increase in sea levels and in storm surges.

The Climate Action Network (2006) has identified six major 'hot spots' of potential high impact of climate change in Australia which is shown in Figure 23. This classification focuses largely on non-metropolitan areas and hence misses some of the effects of climate change on large metropolitan centres which include:

- Potential inundation and storm surge impacts in coastal areas.
- Constraints on urban water supplies created by the reduced rainfall and run-off in the watersheds of large mainland metropolitan centres and in the Murray Darling basin which supplies a significant part of the water supply of Adelaide and Melbourne.
- The decreased run-off, especially in inland catchments will be exacerbated by increased evaporation due to higher temperatures. For example, for Sydney it is projected that there will be a 22 percent increase in pan evaporation in inland catchments and a 9 percent increase in coastal catchments by 2070 (Department of Climate Change and Energy Efficiency, 2011b, 1).
- There will be increased risk of extreme bushfires in the vicinity of several capitals. For Sydney, for example, fire seasons will start earlier and end later and the number

of extreme fire danger days will rise from 9 at present to 15 by 2020 (Department of Climate Change and Energy Efficiency, 2011a, 1).

Figure 23: Climate Change Impact Hot Spots
Source: Climate Action Network, 2006

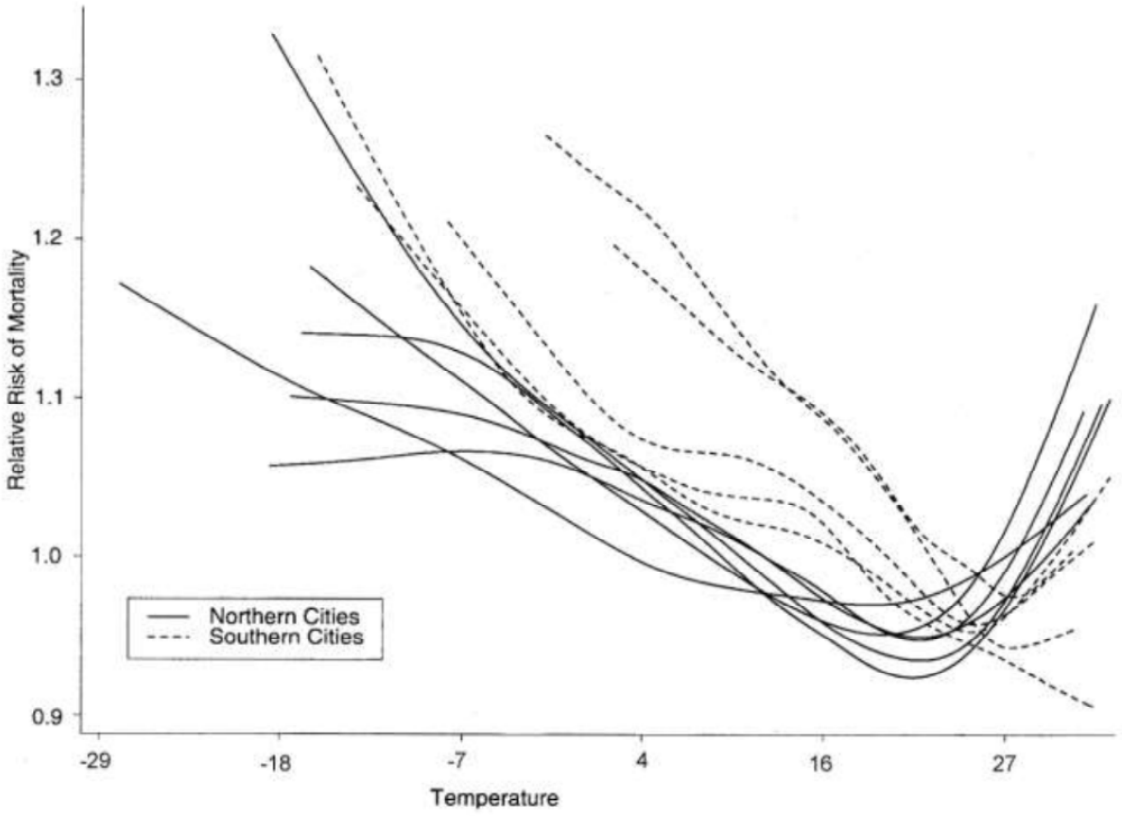


There are also a number of climate sensitive health outcomes which are especially important in large cities. For example, Gamble *et al.* (2008) have identified the following climate-sensitive health outcomes in the United States which are indicative of the likely health effects of climate change:

- Thermal extremes, heat waves. Figure 24 shows the relationship between temperature and mortality is non-linear or J shaped. Curriero *et al.* (2002) studied the relationship in 11 US cities and established a significant relationship. Moreover, this effect may

be exacerbated by air pollution. It is especially severe in its effects on the older population.

Figure 24: Temperature-Mortality Relative Risk Functions for 11 US Cities, 1973-94
Source: Curriero *et al.*, 2002



Northern cities: Boston, Massachusetts; Chicago, Illinois; New York, New York; Philadelphia, Pennsylvania; Baltimore, Maryland; and Washington, DC. Southern cities: Charlotte, North Carolina; Atlanta, Georgia,; Jacksonville, Florida; Tampa, Florida; and Miami, Florida. Relative risk is defined as the risk of an event such as mortality relative to exposure, such that the relative risk is a ratio of the probability of the event occurring in the exposed group versus the probability of occurrence in the control (non-exposed) group.

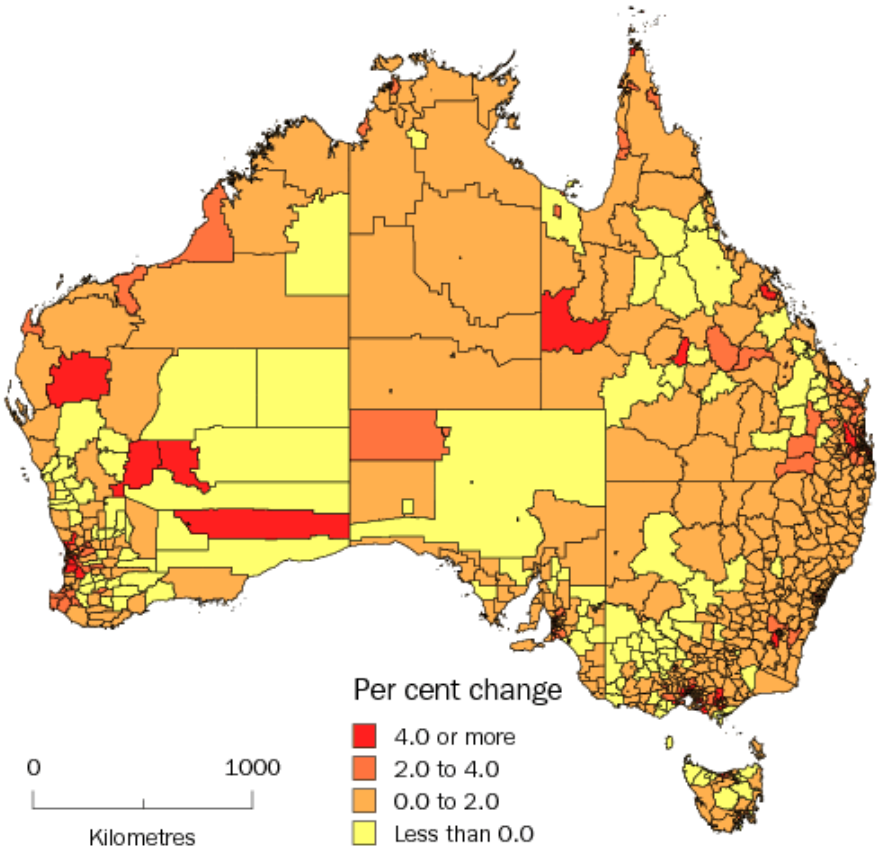
- Thermal extremes and cold waves which can be expected to increase with climate change have disproportionate effects on older and poor people in cities. In Sydney extreme heat days will increase from 3.5 per annum currently to 12 by 2070 (Department of Climate Change and Energy Efficiency, 2011a).

Despite its oversimplification, the classification in Figure 23 does provide some useful indications of the parts of Australia that will suffer the greatest degree of impact from climate change.

1. *Coastal Northern NSW and SE Queensland*

This region is one of the most rapidly growing regions of Australia as is evident in Figure 25. This region is identified to be effected by two major elements of climate change impact – increased sea levels and increased severe weather events. The rapid recent growth of population in this region has been associated with an increase in tourism and lifestyle related inmigration including some retirement migration. However, as Burnley and Murphy (2004) have demonstrated, much of the growth has been lifestyle led young family migration.

Figure 25: Australia: SLA Population Change, 2009-10
Source: ABS, 2011b



Nevertheless, the imminent retirement of baby boomers is likely to see a substantial influx of people in their 50s and 60s and of working age population to service them. This pattern of coastal areas of rapid population growth and inmigration being at substantial risk of significant impact of climate change is one which is replicated in many parts of the world (McGranahan *et al.*, 2007). Southeast Queensland is the most rapidly growing region of the country over the last few decades with the metropolitan peri-urban and coastal development associated with Brisbane-Gold Coast and Sunshine Coast complex.

It has been estimated that between 43,900 and 65,300 residential buildings with a current value of between 14 and 20 billion dollars are at risk in coastal NSW of inundation if sea levels were to rise by 1.1m. This would also put at risk up to 4,800 km of roads, 320 km of railways and up to 1,200 commercial buildings (DCCEE, 2011a, 1). In Queensland, there are similar patterns with between 48,300 and 67,700 residential buildings ($5.4-20 billion value), 4,700 km of roads and 570 km of railways at risk (DCCEE, 2011b, 1).

2. *Perth and Southwest Western Australia*

One of the most consistent findings in climate change modelling in Australia (CSIRO and BOM, 2009) is of a reduction in rainfall in the southwestern corner of the Australian continent. This has clear implications for the wheat-sheep as well as viticulture and other intensive agriculture in that region. In addition, Perth is currently Australia's most rapidly growing capital city but the reduction in rainfall anticipated in its hinterland has implications for the water supply of the capital.

It is estimated that there are 20,00-30,000 residential buildings along Western Australia's long coastline which are at risk of inundation if there was a sea level rise of 1.1 m. This also would affect 9,000 km of roads and 114 km of railway (DCCEE, 2011c, 1).

Rainfall has already fallen by around 15 percent in southwestern Western Australia since the 1970s. The annual average stream flow into Perth dams has fallen from 338 gigalitres over 1911-74 to 177 in 1975-2000 to 75 in 2000-10. Modelling suggests that there could be a 7 percent decrease in rainfall and a 14 percent decrease in run-off over the 2021-50 period and that the region could experience 80 percent more drought months by 2070 (DCCEE, 2011c, 1). Moreover, the number of days per year in Perth over 35°C will increase from 28 currently to 67 in 2070.

The impact of climate change on wheat growing could be considerable. The DCCEE (2011c, 2) argues:

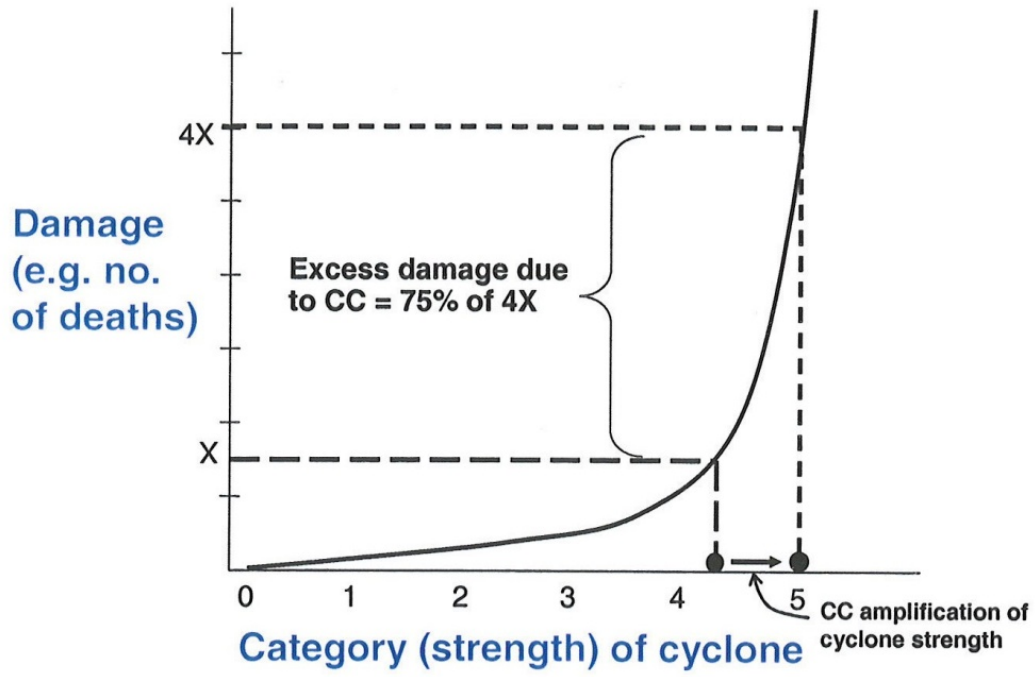
> 'Cropping may become non-viable at the dry margins with strong warming and significant reductions in rainfall. Some regional centres which depend on agriculture may be adversely affected. Projections indicate that wheat production in WA could decline by 8.9 per cent by 2030 and 13.4 per cent by 2050, with similar declines for sheep meat. More hot days and less rainfall could also affect livestock which are likely to be adversely affected by greater heat stress'.

3. *Coastal Northern Australia*

It is interesting that the north coast of the continent is designated a climate change hot spot. As was shown earlier, all of the climate change models suggest that this region is likely to experience little change in precipitation or even a small increase. This has led to some calls for encouraging population growth in the region based partly on transferring some primary industry into these areas. There is a long history of such calls, and mostly ill-fated attempts, to establish intensive agriculture in the north (Davidson, 1965). However, what is apparent from Figure 23 is that the region is vulnerable to a number of other negative climate

change impacts – rising sea levels, higher temperatures and increased severe weather events. These will clearly impinge upon the liveability of these areas as well as their potential to expand their primary production, especially food production. There are a number of implications of these changes for health (McMichael, 2006). There is a long history of debate in Australia about the potential for increased agricultural activity and settlement in the north (Griffith Taylor, 1958, Chapter XVIII). It is apparent, however, that the liveability of the region is likely to be reduced by increased incidence of extreme events and increased risk of disease. Extreme events such as cyclones, floods and wildfires are likely to increase with climate change and lead to greater loss of life. McMichael (2006) has shown that there is a disproportionate increase in loss of life and damage with an increase in severity of cyclones. Figure 26 shows the disproportionately great potential impact of climate change on deaths from cyclones due to increased severity of those events.

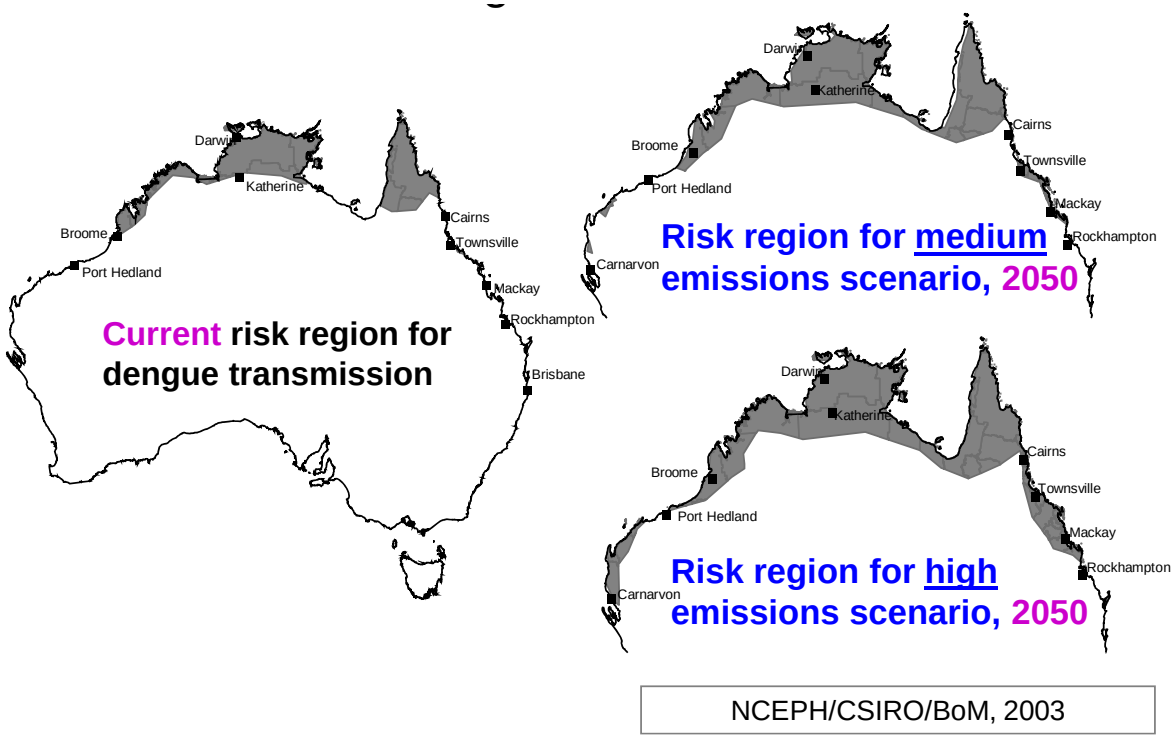
Figure 26: Apportioning Impact Between Natural and Climate Change Induced Cyclones
Source: McMichael, 2006



Among the indirect health impacts of climate change Gamble *et al.* (2008, 2-8) show that most vector, water or food borne diseases exhibit a distinct seasonal pattern so that *a priori* we can anticipate that a change in climate or weather will affect their distribution. They show that in the US, diseases such as rabies and cholera have become less widespread and typhoons, malaria, yellow fever and dengue fever have largely disappeared due to environmental modification and/or socioeconomic development. However, temperature modification is likely to see the distribution of vectors change with potential implications for disease. In Australia, warming associated with climate change will lead to the mosquito vector of dengue fever ranging over a wider area. Figure 27 shows the simulated patterns of expansion of dengue fever in Australia due to climate change. Newth and Gunasekara (2010) have demonstrated that projected regional warming and climate change analysis and health

Figure 27: Australia: Dengue Fever – Modelling of Receptive Geographic Region for *Ae. Aegyptii* Mosquito, Under Alternative Climate Change Scenarios for 2050

Source: McMichael, 2006



impact studies suggest that there will be a significant public health risk in the areas which mosquitoes are likely to spread to.

In the Northern Territory 260-370 residential buildings with a current volume of $100-$134 million are at risk of inundation with a sea level rise of 1.1 m (DCCEE, 2011d, 1). This will also threaten 2,045 km of roads and 32 km of railway. Darwin is especially vulnerable to riverine flooding and more intense cyclonic activity. In Darwin the number of days over 35°C will increase from 11 per year currently to 69 in 2030 and up to 308 in 2070 with major effects on liveability in the north (DCCEE, 2011d, 1).

In the north there is a strong likelihood of increased numbers and intensity of extreme events as a result of climate change. Hence as DCCEE (2011d, 2) point out:

> 'Projections indicate there may be an increase in the proportion of tropical cyclones in the more intense categories, with a decrease in the total number of cyclones. For example, the number of category 3 to 5 cyclones is projected to increase, and by 2030 there may be a 60 per cent increase in intensity of the most severe storms, and a 140 per cent increase by 2070'.

In addition, there may be a movement southward of tropical cyclones as sea surface temperatures increase (DCCEE, 2011b, 1).

4. *Murray-Darling Basin*

The release of the Murray-Darling Basin report in November 2011 has drawn attention to its significance to the national economy and the threats to the integrity of the system posed by excessive withdrawal of water from it for agriculture and urban uses (Murray-Darling Basin Authority, 2011). The thirteen year drought that broke in 2010 indicated the necessity to significantly reduce the withdrawal of water from the Murray-Darling if it was to survive as a healthy system. Projected climate change exacerbates this

situation. All of the models suggest that there is likely to be a reduction in rainfall in the watershed. Moreover, the reduction in run-off will be greater than the reduction in rainfall. This has important implications for irrigated agriculture along the system and for the cities who draw water from the system. One study by Cullen and Eckard (2011) has suggested that these changes may see a significant relocation in Australia's dairying industry over the next few decades. This would see the industry shift mainly to Tasmania as a result of declines in water availability in the mainland.

The Murray-Darling Basin shown in Figure 23 covers a substantial part of the Australian wheat-sheep belt as well as the large number of irrigated agriculture communities strung along the Murray-Darling and Murrumbidgee Rivers. Changes in rainfall and run-off have important implications for the future location of these primary industry activities. This needs close attention since the spatial patterning of this activity has been established for a long period. Climate change in this area will occur over several decades but if adaption to it is to avoid major disruptions it needs to be planned for now.

The decline in rainfall and run-off in the Murray-Darling Basin will have impacts on the water supply to major cities in the southeast of Australia. For example, it is anticipated that climate change could lead to a decline in annual rainfall in the Cotter and Gooyong catchments which provide water for Canberra and the ACT. The Department of Climate Change and Energy Efficiency (2011e, 1) points out:

> 'Annual rainfall could decline by up to 10 per cent by 2030 and 25 per cent by 2070, relative to 1990. Decreases in annual run-off are also projected in the ACT region of up to 20 per cent by 2030 and 50 per cent by 2070'.

In addition the increased temperatures could increase bushfire risk in the ACT.

Modelling by ABARE has estimated a significant decline in NSW agricultural production by 2030 and 2050 as a result of climate change in the rural areas of the state. Table 13 shows the anticipated decline if there is a significant climate change.

Table 13: New South Wales: Projected Decline in Primary Production Due to Climate Change, 2030-50
Source: Department of Climate Change and Energy Efficiency, 2011a, 2

	Approximate Decline in Production by 2030 (Percent)	Approximate Decline in Production by 2050 (Percent)
Wheat	8.4	11.6
Beef	0.7	3
Sheep meat	8.1	13.2
Dairy	5.5	11.3

5. *Tropical Queensland*

Tropical Queensland contains some of the fastest growing and most dynamic areas in the country. In coastal areas tourism, at least until recently, has been growing exponentially while mining activity has been growing apace. Yet Figure 23 shows that there are a number of significant impacts of climate change anticipated in the region. These include rising sea levels, increased temperatures, and increased incidence and severity of extreme weather events. As in the northern coastal region this has implications for the spread of diseases and could impact negatively on the tourist industry which is important in that region.

6. *Snowy Mountains*

One of the impacts of climate change is that the increase in temperature can be greater in mountain areas than at sea level (CSIRO and BOM, 2007). This will have the impact of reducing the amount of snow in Australia's alpine areas with consequences for the tourist

industry. It is projected that under an extreme emissions scenario with increased temperatures and decreased rainfall the length of the snow season in the Australian alps could decrease by 96 percent by 2050 with disastrous consequences for vulnerable alpine flora and fauna (Department of Climate Change and Energy Efficiency, 2011a).

The Garnaut Climate Change Review (2008) summarised the effects of climate change on states in the absence of any mitigation and these are summarised in Figure 28. It is clear from the Review that climate change will potentially have a major effect on primary industry activity in each state. For example, it is suggested that by mid century irrigated agriculture output in the Murray-Darling Basin could be reduced by half.

What are the characteristics of the populations living in these broadly defined hot spot areas? We'll now turn to looking briefly at some of the characteristics of these areas as reflected in 2006 population census data. Firstly we examine the issue of socioeconomic status. This is, of course, a major issue since there is a considerable literature which indicates that vulnerability and constraints to adaptation increase as the economic situation of individuals and communities declines. The analysis here is quite limited in that an average is taken across the entire hot spot area. In fact, within each area there is considerable variation. The measure used is the SEIFA (ABS, 2008c) Index derived from 2006 census data by the Australian Bureau of Statistics. The averaged measure was obtained as a mean from all Census Collection Districts included in each of the hot spot areas. It will be noted in Table 14 that only two of the hot spot areas have a SEIFA score average above that of the non-hot spot areas. These were Coastal NSW and SE Queensland and the very large Murray-Darling Basin. In most areas, however, there is below average socioeconomic status which must raise questions of the capacity of the communities in those areas to adapt to the impacts of climate change. It will especially be noted that there are low SEIFA scores in coastal Northern Australia and, to a lesser extent, the Snowy Mountains.

Figure 28: Impacts of Climate Change in Australia by 2100 Under the No-Mitigation Case

Source: Brook, 2012, 110

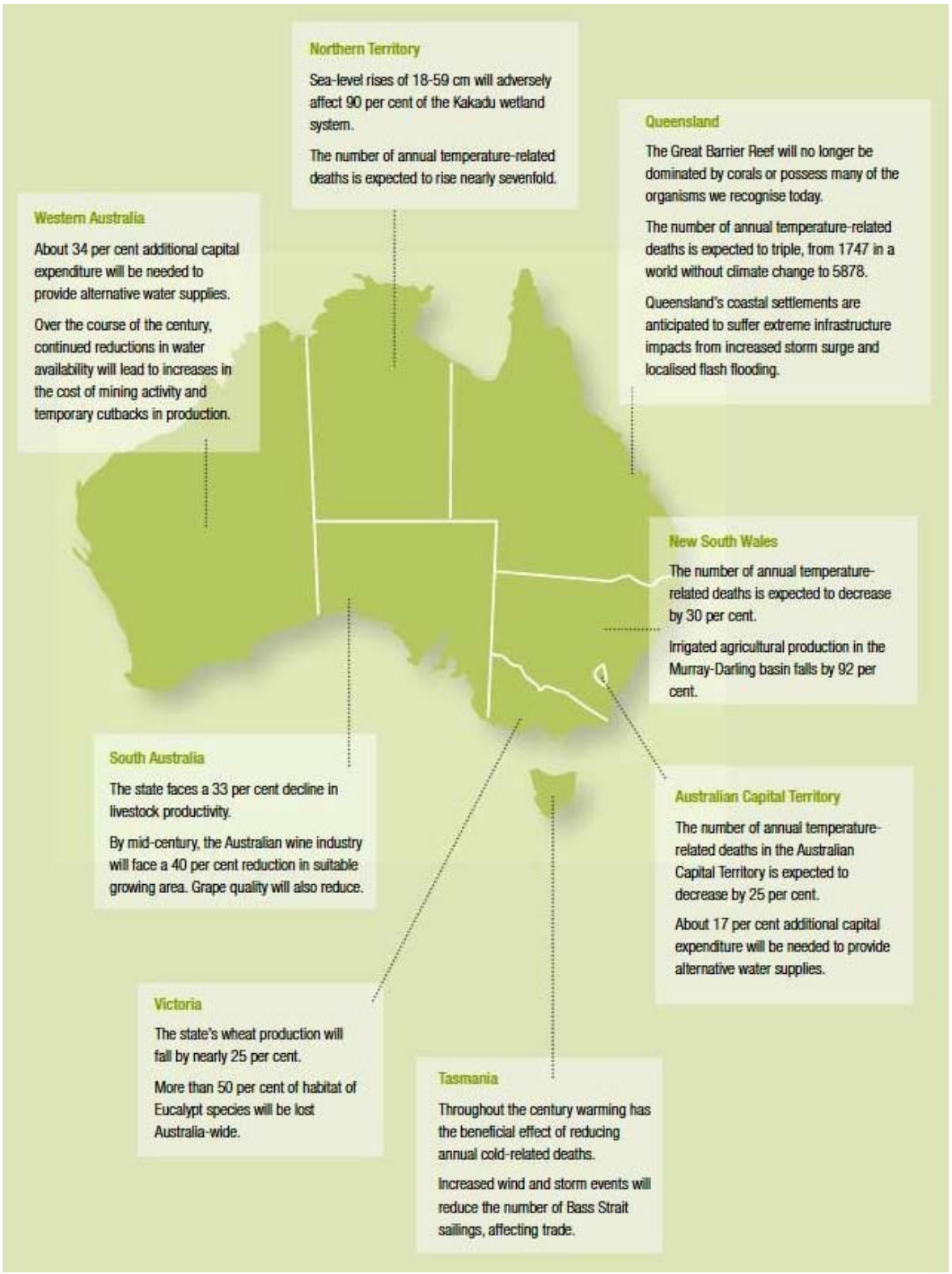


Table 14: Australia: Climate Change Hot Spot Areas by SEIFA Index, 2006
Source: ABS

Climate Change Areas	Mean SEIFA Score 2006
Non-HotSpot Areas	972.59
Coastal Northern Australia	690.81
Coastal Northern NSW & SE QLD	981.55
Murray Darling Basin	978.96
Perth & SW Western Australia	938.51
Snowy Mountains	795.72
Tropical Queensland	932.55

It is useful also to examine differences between hot spot areas in the proportion of households that have low incomes, defined as being below $650 per week. Table 15 shows that the lowest percentages were recorded in coastal northern Australia and the highest in the Murray Darling Basin. The income data are not as sensitive as SEIFA to identifying poverty because large numbers of elderly households may be 'income poor' but 'asset rich' so that the former doesn't fully accurately represent their economic situation.

Table 15: Australia: Climate Change Hot Spot Areas – Percentage of Households Earning Under $500 per Week and $650 per Week (Gross), 2006
Source: ABS 2006 Census and Climate Action Network 2006 (manually digitised for GIS analysis)

Climate Change Hot Spot Regions	Count-HH under 500pw	Count-HH under 650pw	Count-HH total income	% HH under $500pw	% HH under $650pw
Coastal Northern Australia	10,612	18,548	112,421	9.44	16.50
Coastal Northern NSW & SE Queensland	411,594	718,017	2,847,815	14.45	25.21
Murray Darling Basin	331,122	564,872	2,161,808	15.32	26.13
Perth & SW Western Australia	173,817	291,967	1,279,654	13.58	22.82
Snowy Mountains	1,214	1,999	7,890	15.39	25.34
Tropical Queensland	73,407	128,141	544,216	13.49	23.55
Non-Hotspot Areas	1,404,859	2,310,663	9,475,860	14.83	24.38
Total	**2,406,625**	**4,034,207**	**16,429,664**	**14.65**	**24.55**

In assessing the impacts of climate change the effects on agriculture are of particular significance as has been discussed earlier in this report. Accordingly, the numbers of workers in agriculture in each of the hot spot areas is of significance. Table 16 shows the proportions and numbers in each area employed in primary industry. The proportions are highest in Tropical Queensland and the Murray Darling Basin where the potential effects of climate change on agriculture are likely to be most severe.

Table 16: Australia: Climate Change Hot Spot Areas – Percentage Employed in Primary Industries, 2006
Source: ABS 2006 Census and Climate Action Network 2006 (manually digitised for GIS analysis)

Climate Change Hot Spot Regions	Sum-Employed in Primary Industries	Sum-Employed population	% Employed in Primary Industries
Coastal Northern Australia	2,230	33,943	6.57
Coastal Northern NSW & SE Queensland	46,155	813,270	5.68
Murray Darling Basin	107,142	618,897	17.31
Perth & SW Western Australia	34,721	421,599	8.24
Snowy Mountains	758	6,625	11.44
Tropical Queensland	35,822	168,711	21.23
Non-Hotspot Areas	160,881	2,846,258	5.65
Total	**387,709**	**4,909,303**	**7.90**

In addition to looking at the characteristics of the population in each of the hot spot areas it is relevant to consider households. The effects of climate change on families and households and the housing they occupy is of importance. Table 17 shows that average household sizes are bigger than those in non-hot spot areas in Coastal Northern Australia and Tropical Queensland. A distinctive feature of Australian households is the increasing proportion that are single person – accounting for about a quarter of all households. The hot spot areas except for Southwest Australia (which indicates Perth) tends to have slightly lower proportions in single person households as Table 18 shows. Finally, the tenure of housing is of significance. The hot spot areas contain some regions where a higher than average share

of the population own or are purchasing their own home (Murray Darling Basin and Perth-SW Australia) and others with below average levels (Coastal North Australia and Tropical Queensland). This is shown in Table 19.

Table 17: Australia: Climate Change Hot Spot Areas – Average Household Size, 2006

Source: ABS 2006 Census and Climate Action Network 2006 (manually digitised for GIS analysis)

Climate Change Hot Spot Regions	Sum-Persons in dwellings	Sum-Known occupied dwellings	Ave HH size
Coastal Northern Australia	117,577	41,760	2.82
Coastal Northern NSW & SE Queensland	3,119,471	1,219,296	2.56
Murray Darling Basin	2,426,957	939,238	2.58
Perth & SW Western Australia	1,456,934	581,772	2.50
Snowy Mountains	5,606	2,525	2.22
Tropical Queensland	602,067	231,568	2.60
Non-Hotspot Areas	10,645,657	4,127,222	2.58
Total	**18,374,269**	**7,143,381**	**2.57**

Table 18: Australia: Climate Change Hot Spot Areas – Percentage of Lone Person Households, 2006

Source: ABS 2006 Census and Climate Action Network 2006 (manually digitised for GIS analysis)

Climate Change Hot Spot Regions	Sum-Lone Person Households	Sum-Occupied Private Households	% Lone Person Households
Coastal Northern Australia	9,447	48,522	19.47
Coastal Northern NSW & SE Queensland	288,358	1,309,427	22.02
Murray Darling Basin	230,110	979,292	23.50
Perth & SW Western Australia	152,008	617,212	24.63
Snowy Mountains	863	3,716	23.22
Tropical Queensland	54,584	261,170	20.90
Non-Hotspot Areas	1,034,911	4,376,051	23.65
Total	**1,770,281**	**7,595,390**	**23.31**

Table 19: Australia: Climate Change Hot Spot Areas – Percentage of Population Who Own or Are Purchasing Their Home, 2006

Source: ABS 2006 Census and Climate Action Network 2006 (manually digitised for GIS analysis)

Climate Change Hot Spot Regions	Sum-Own or are purchasing their home	Sum-Total all tenure types	% Who own or are purchasing their home
Coastal Northern Australia	22,233	42,859	51.87
Coastal Northern NSW & SE Queensland	824,381	1,220,070	67.57
Murray Darling Basin	679,802	925,116	73.48
Perth & SW Western Australia	409,196	572,240	71.51
Snowy Mountains	1,935	2,979	64.95
Tropical Queensland	151,470	237,604	63.75
Non-Hotspot Areas	2,837,199	4,054,520	69.98
Total	**4,926,216**	**7,055,388**	**69.82**

Another dimension of population which is of relevance to vulnerability relates to ethnicity and birthplace. Cultural and language factors can be barriers to social inclusion and increase vulnerability to the risk of experiencing negative impacts from deterioration of the economic, social or environmental situation. Table 20 shows the proportion of the population in the hot spot areas who was born overseas at the 2006 census and some variation is evident. It will be noticed that the immigrant population is underrepresented in all but one of the hot spot areas. This is a function of the fact that the hot spot areas do not include several of the major metropolitan areas in Australia. A distinctive element of the distribution of the overseas-born in Australia, especially those from mainly non-English speaking (NES) areas, is their concentration in major metropolitan areas (Hugo, 2011). The one hot spot area with a high proportion of the population overseas-born is Perth and Southwestern Australia. This is because of the inclusion of Perth which has one of the largest representations of immigrant populations of any city (Hugo, 2011). It will be noted in Table 20, however, that the overrepresentation of overseas-born is concentrated among people born in mainly English speaking countries (MES) other than Australia. Perth has a particular concentration of

immigrants from the UK, Ireland, South Africa and New Zealand. Although the NES population is underrepresented in hot spot areas they can nevertheless be important in terms of being highly vulnerable to the effects of climate change. In this respect, recent patterns of settlement of refugee-humanitarian migrants in non-metropolitan areas in Australia is of considerable relevance. The recent displacement of Sudanese men living in a caravan by floods in Queensland points to the potential of being 'twice displaced' – displaced by war in their homeland and by the environment in their destination.

Table 20: Australia: Birthplace Composition of Hot Spot of Climate Change Impact, 2006
Source: ABS Census of Population and Housing

	% Australian Born	% Mainly English Speaking Countries	% Mainly Non-English Speaking Countries	% Not Stated
Non-Hotspot Areas	67.4	7.7	17.7	7.1
Coastal Northern Australia	77.1	5.6	8.4	8.7
Coastal Northern NSW & SE QLD	74.4	10.7	8.1	6.6
Murray Darling Basin	82.7	4.8	6.6	5.6
Perth & SW Western Australia	64.0	15.3	13.3	7.2
Snowy Mountains	77.1	5.6	4.7	12.3
Tropical Queensland	79.7	6.4	5.3	8.4
Total	70.9	8.4	13.7	6.9

Another very important dimension of ethnicity which needs to be considered is the representation of indigenous Australians in the hot spot areas. Table 21 shows that there is a striking pattern in evidence. In the Central Northern Australian hot spot area almost a quarter of the resident population are Aboriginal and Torres Strait Islanders. This clearly has significant implications for any adaptation strategies to be culturally sensitive. It is also noticeable that the Indigenous population is also overrepresented in the small population in the Snowy Mountains and in the Murray Darling Basin.

Table 21: Australia: Climate Change Hot Spot Areas – Percentage of Population Identifying as Aboriginal and/or Torres Strait Islander Decent, 2006
Source: ABS Census of Population and Housing

Climate Change Hot Spot Regions	Total Population	Aboriginal & Torres Strait Islander	% Aboriginal & Torres Strait Islander
Coastal Northern Australia	137,492	31,650	23.02
Coastal Northern NSW & SE Queensland	3,348,599	70,423	2.10
Murray Darling Basin	2,605,678	74,221	2.85
Perth & SW Western Australia	1,577,038	25,297	1.60
Snowy Mountains	7,137	36	0.50
Tropical Queensland	669,476	48,764	7.28
Non-Hotspot Areas	11,468,389	203,058	1.77
Total	**19,813,809**	**453,449**	**2.29**

The age structure of a population can have an impact on the capacity of communities to adjust to climate change. For example, older populations may experience the impacts of particular climate change more intensely than other groups. For example, it was established that the heat wave in Adelaide and Melbourne in 2010 resulted in amplified death rates among older residents. Table 22 shows that there is significant variation between the hot spot areas in the proportion of the resident population aged 65 years and over. It is evident that the representation of older population is quite low in Coastal Northern Australia. Elsewhere there is little variation in the proportion of the population in the older age groups. There is much greater variation at the local area level.

Table 22: Australia: Climate Change Hot Spot Areas, 2006 – Percentage of the Population Aged 65 Years and Over
Source: ABS Census of Population and Housing

Climate Change Hot Spot Regions	Total Population	Aged 65+	% Aged 65+
Coastal Northern Australia	147,692	7,103	4.81
Coastal Northern NSW & SE QLD	3,378,120	454,372	13.45
Murray Darling Basin	2,668,751	352,672	13.21
Perth & SW Western Australia	1,596,936	204,733	12.82
Snowy Mountains	10,251	1,645	16.05
Tropical Queensland	674,847	71,833	10.64
Non-Hotspot Areas	11,334,912	1,548,199	13.66
Total	**19,811,509**	**2,640,557**	**13.33**

POTENTIAL IMPACTS ON POPULATION DISTRIBUTION

The discussion in the previous section has shown that climate change impacts tend to be greater in some parts of Australia than others. This raises the question as to whether these impacts may lead to a change in the spatial distribution of population. One of the most controversial elements in the global discussion on the impacts of climate change has been the issue of population displacement and migration as a result of climate change. As the Fourth Assessment of the IPCC (2007) pointed out:

> 'Stresses such as increased drought, water shortages and riverine and coastal flooding will effect many local and regional populations. This will lead in many cases to relocation within and between countries, exacerbating conflicts and imposing migration pressures'.

However, the discourse on migration and climate change has been characterised by exaggeration and unsubstantiated claims of massive flows of so-called 'environmental refugees'. The relationship between climate change on the one hand and migration and population distribution on the other is in fact a complex one. As Perch Nielson, Battig and Imboden (2008) point out:

> 'The postulation that climate change will lead to mass migration has not been explicitly demonstrated but has been derived from "common sense". The connection between climate change and migration is much more complex and by no means deterministic'.

Nevertheless, it is important to note that environment does exert an important effect on population distribution. Indeed, the current configuration of the Australian population distribution is in part a function of environmental constraints (Griffith Taylor, 1922). Moreover, environmental change is a significant factor in migration although it rarely operates as a single cause and is usually interrelated with a number of social and economic

factors in impelling migration (Hugo, 1996). What are the climate changes which have been noted which may have an influence on future population distribution in Australia?

- In several capital cities there are increasing pressures on water supply exerted by a decline in rainfall in their catchment areas. Sea level rise and increased incidence of extremely hot days will also impinge upon liveability in cities.
- Reductions in rainfall and run-off will, in conjunction with increased temperatures, make sustained agricultural production more difficult in some areas.
- Coastal living will become more difficult in some areas because of rising sea levels, increased incidence of extreme weather events and spread of disease.

In considering this, cognisance must be taken of the time periods involved. The climate change models examined in the previous section relate to 2030 and 2070. Hence we are looking at change over a relatively long period. In this context it is useful to bear in mind the massive redistribution of population that Australia has experienced over the postwar period. Moreover Table 23 demonstrates the huge scale of urbanisation that has occurred over this period. It is not unthinkable then to achieve a significant shift in population distribution over a 30-40 year period. It can be achieved without massive relocations of the existing population. Even conservative population projections anticipate a significant growth of population over the period being considered in the climate change modelling. The most commonly accepted projection is the median ABS (2008a) figure of 34 million people in

Table 23: Australia: Growth of the Urban and Rural Population, 1947-2006
Source: Bowie, 1987; ABS 2006 Census

	Urban		Rural			Urban	Rural
Year	No	%	No	%	Year	Growth p.a.	
2006	17,480,986	88.0	2,374,301	12.0	1981-2006	1.36	0.50
1981	12,481,572	85.6	2,094,809	14.4	1947-1981	2.30	0.42
1947	5,764,728	76.1	1,814,630	23.9			

2050. Hence it is anticipated that there will be a net increase of 12 million in the population over the next four decades. Where this growth is located will have a substantial effect on overall population distribution.

Table 24: Views of Australian Government Regarding Spatial Distribution, 1976-2009
Source: United Nations, 2010

Year	View
1976	Major change desired
1986	Major change desired
1996	Minor change desired
2009	Minor change desired

It is also relevant to note that successive governments in Australia have had concerns about the nation's pattern of population distribution. The United Nations carries out a periodic review where it asks national governments about their population policies. Table 24 shows that since 1976 the Australian government has reported that it was not satisfied with the pattern of distribution and that it desired changes. It is interesting that in the 1976 and 1986 assessments taken at times when decentralisation was a major policy imperative in Australia, it was suggested that major changes were desirable. Subsequently, however, the government has opted for only minor changes being desired. Concerns about the distribution of the Australian population and the 'balance' between urban and rural areas goes back to the early years of Federation (Borrie, 1994, 203). In the two postwar periods these concerns lay behind the initiation of land settlement schemes and soldier settlement schemes (Rowland, 1973). However, as Day (1972, 1) pointed out:

> 'Since around the turn of the century decentralisation has been a commendable but unexciting part of the conventional wisdom. No one has ever been opposed to it. A great deal of lip service has been paid to it'.

The 1964 Premier's Conference set up a Commonwealth/State Officials' Committee on Decentralisation which submitted its final report to the Prime Minister in 1972. At this time the discussion on decentralisation gathered momentum due to rapid growth and emerging diseconomies in Australian cities and concerns about rural depopulation. However, for the first time the discussion about decentralisation began to focus on relocation of manufacturing and service activities into non-metropolitan areas rather than on extension and intensification of agriculture. State governments produced reports on decentralisation (e.g. Development Council of NSW, 1969; Victoria Decentralization Advisory Committee, 1967; South Australia Industries Development Committee, 1964) and there was active critiquing of such policies (Hefford, 1965; Simons and Lonergan, 1973; Daly, 1973). There was debate not only as to whether decentralisation was desirable or not but also as to whether decentralisation should be dispersed or selective and concentrated in particular areas.

By the early 1970s, the concentration of the Australian population in capital cities had reached unprecedented levels and was attracting increasing concern (Vipond, 1989, 66). Neutze (1965) analysed the increasing diseconomies apparent in Australia's growing cities, there was concern that large cities added to income inequalities (Stretton, 1970) and there was increasing pressure to develop a coherent national urban development strategy (Lloyd and Troy, 1981). With the development of the Cities Commission and the Department of Urban and Regional Development in 1972 the newly elected Labor Federal government saw Canberra become involved in settlement and population distribution for the first time in the postwar era (Logan *et al.*, 1975; Logan and Wilmoth, 1975). A National Growth Centre Policy was developed and investment in regional centres like Albury-Wodonga was initiated (Cities Commission, 1974). Moreover, there was the beginnings of a search for developing a comprehensive national settlement policy (Nielson, 1976). Such was the level of activity that in 1978 Pryor was able to compile an impressive list of State and Federal authorities and

specific policy measures related to decentralisation. However, as Whitelaw and Maher (1988, 133) subsequently pointed out:

> 'Attempts to create a national settlement strategy in the early 1970s lost momentum with a change in government'.

Since then from time to time interest in regional development has flared in the Federal arena such as in 2010 when two regional independent representatives held the balance of power in the House of Representatives. However, there has been no attempt to develop a comprehensive national settlement policy. The establishment of Regional Australia in 2010 as a separate Federal Government Department has signalled a strong contemporary interest in development of regional areas. Hence, federal policy favours development outside of the capitals. Nevertheless, most Australians remain and will remain living in the major cities.

There are, however, a number of reasons why the time seems opportune for us to examine the whole issue of whether or not the contemporary Australian settlement system is the most appropriate one to achieve national goals in the 21st century. The economic and environmental imperatives of the next four decades will present a very different set of challenges and opportunities to those which prevailed in the three decades following World War II when decentralisation and regional development policies were last seriously put forward in Australia. Is our settlement structure in part an artefact of earlier political economies and is optimal given climate change and likely changes in the economy? Certainly the Australian settlement system will remain dominated by a few large metropolitan centres but may it serve the nation better if a greater proportion of future growth is located in non-metropolitan Australia rather than added on to large metropolitan areas? These are questions which we don't, at present, have the empirical evidence to give definitive answers.

Where people live is important to their wellbeing. Under any realistic scenario of the next four decades most Australians will continue to live in major urban areas, especially the

capital cities. However, the question must be asked as to whether, in a climate change context, the current settlement system will deliver the most sustainable, efficient and liveable outcomes for Australians over the next two decades in the light of emerging environmental, economic and social trends. Two issues are of particular relevance:

- How can we reshape our large cities so that they are more liveable, equitable, efficient and environmentally sustainable and adapt to the realities of climate change?
- Can a shift in the regional balance of development between metropolitan and non-metropolitan Australia deliver more liveable, equitable, efficient and environmentally sustainable outcomes for Australians?

Retrofitting Australia's cities and changing the behaviour of the residents of those cities in the light of climate change to achieve more sustainable outcomes is clearly an important national priority as most of us will continue to live in large cities. However, we also need to ask whether some shift in the balance of population between different parts of Australia is desirable.

Why should we revisit the issue of regional development and decentralisation? Some would argue that policy initiatives for decentralisation in the 1950s and early 1970s were tried with limited, if any, success. There are at least five reasons why the issue needs to be revisited:

- Firstly, as has been demonstrated earlier in this paper, environment has been a major influence shaping Australia's settlement system since initial European settlement (Griffith Taylor, 1922). Moreover, climate change will add a new dimension to this with liveability and economic potential of some areas being considerably modified.
- Secondly, the 21st century economic context is totally different to that which prevailed a half century ago when manufacturing was the key driver of economic and employment growth in Australia.

- Thirdly, earlier initiatives often attempted to attract people 'artificially' to areas by creating job opportunities where there was not an existing economic potential (Daley and Lancy, 2011). Too much concentration in the past has been on 'artificially' trying to create employment opportunities where there is not the local economic base to make them sustainable. Such initiatives are doomed to failure.
- Fourthly, the dynamics of internal migration and international migrant settlement in Australia have changed significantly in the last decade and settlement outside of the capitals has become more significant. The retirement of baby boomers will exacerbate these trends.
- Fifthly, internationally in other OECD countries there are many examples where regions are more economically dynamic than major cities.

It is important to emphasise that climate change is unlikely to cause massive rapid dislocation of population and population redistribution. Nevertheless, as was indicated above, it does need to be considered in conjunction with a number of contemporary and impending social, economic and demographic trends which are likely to have an impact on population distribution. In addition, it is necessary to consider the impact of climate change not just in terms of displacement of existing population but where future population growth might be located. In this context it is important to recall the Australian population projections considered earlier in this paper. Under any realistic future scenario, Australia's population will continue to grow, at least for the next two decades. Hence a key issue shaping the distribution of the population is where future growth will be located. We are not just considering redistribution or migration of existing populations, economic activities and infrastructure but where growth in them will occur. Over a period of decades a significant shift can occur in the distribution of the population by this mechanism.

Climate change is likely to have an impact on where future growth will occur. Water is a key environmental issue which has an all important population dimension and the development of water and population policy needs to be an integrated process. Climate change will result in changes in the availability of water in different areas. Water must be an important (but not, only,) consideration in decision making about the location of future investments and while the mismatch between water and population in Australia does *not* call for a wholesale redistribution of population there are a number of important population dimensions as we face a drier future for southeastern and southwestern Australia: These include:

- Agriculture uses 50 percent of water in Australia (ABS, 2010), hence regional reduction in rainfall and run-off will have consequences for agriculture.
- The implications for agriculture need to be fully worked through. Do we need to consider some intensive agriculture being phased out in southeastern Australia and more developed in northern Australia and Tasmania where there is assured sustainable water supplies? If the science means such a redistribution is deemed necessary there are a number of population elements which need to be considered:
    - The agricultural workforce in Australia is the oldest of any sector (Barr, 2004). To what extent can intensive agriculturalists be brought out so they can retire with dignity into local communities and hence maintain local economies where they have established social networks? At the same time their water entitlements can be fed back into the system.
    - To what extent can the skills which have been built up in agriculture in areas like the Murray-Darling Basin be utilised to develop new specialised agriculture developments elsewhere in Australia? This was the way the agriculture frontier progressed in Australia in the 19th and 20th centuries by

new frontiers being settled by farmers with experience in earlier settled areas. How can this process be carried out in the 21st century to fully compensate those displaced, facilitate their migration and settlement elsewhere and encourage the growth of new agricultural industries in new parts of Australia? Simplistic suggestions of a massive relocation of Australian agriculture to well watered Northern Australia overlook the complexity which is involved in adapting Australian agriculture, horticulture, viticulture, dairying and other primary industry activity to the realities of climate change. However, there must be adaptation and to do this in an effective, equitable and efficient way it will need to be carefully planned. The considerable time period involved means that the change can be gradual but the sooner it begins the less painful and more effective the adaptation will be.

These processes will not be easy. They need to be given time and they must be based on not only the best science but the best social science as well and the rights and welfare of the Australians involved must be protected. The extended time period available makes it possible for these changes to be made over a generation rather than with uprooting suddenness. It means that the economic and social disruption caused can be minimised. However, if we are sure of these changes the process of change in settlement must begin sooner rather than later.

- The location of these areas where the agriculture currently being practised will no longer be viable due to climate change needs to be delineated with a great deal of care and sensitivity so that we are certain of the likely effects and so the transition to new more appropriate forms of land use can occur with the full consultation, involvement and compensation of the existing land holders. There are particular types of areas

where the impact of climate change will be to make the current patterns of agriculture unsustainable. These include:

- Some irrigated agriculture activities where river or groundwater sources will not be available to the same extent as they are currently (e.g. Murray-Darling Basin).
- Wheat growing areas which are currently marginal near the limits of the rainfall necessary for sustainable production (e.g. along Goyders Line in South Australia and parts of southwestern Western Australia). Shifts in the amount, seasonality and reliability of rainfall may make sustainable wheat growing no longer possible.
- There has been a discussion in the wine industry of the implications of climate change for the existing grape growing regions which indicates there may be a need for some relocation of the industry as well as a change in the types of grapes grown.

- Changing Australians' behaviour in the use of water, especially in cities, is clearly an area of enormous possibility. Response to recent water shortages in Australian cities has demonstrated conclusively that given appropriate information Australians can and will considerably modify their behaviour with respect to water consumption. Building on this experience to make better and less use of water is crucial. Indeed, this experience can be built upon to change other environmentally relevant behaviours as well. Again a combination of the best science and social science together with full engagement of the community will be necessary in this area.
- An additional part of a national strategy will also involve the traditional Australian response to expanding populations – seek other water sources (Troy, 2008). However, while in the past this has involved building new resources and pipelines,

there is a great deal of scope to develop new technologies of water storage (especially in aquifers), capturing run-off and water reuse.

Changing patterns of water availability are going to be one of the major elements influencing any change in population distribution. More than three decades ago the CSIRO (1973, 7-8) wrote:

> 'That Australia is a dry continent as an intrinsic part of our national ethos, and the present distribution of population is in a large measure related to the supply of water and the disposal of effluents.
>
> … The availability of water constitutes one of the major factors in determining the size and distribution of Australia's population'.

Water availability is a crucial determinant of agricultural and pastoral activity and is crucial to all urban settlements. The fact is that at the time the CSIRO was writing, it pointed out that most of the available water in southeastern Australia was committed. Since then consumption has soared and we are now faced with a reduction in the quantum available. Holmes (1973) produced a map of Australian water potential which is reproduced as Figure 29. This shows the number of people that could be supported if there were no other limiting factors other than water. Of course, there are many other limiting factors – soil fertility, rainfall variability, climatic factors etc. Nevertheless, the figure does indicate where water is most abundant. It is interesting that the greatest densities of population that could be supported when water is the only limiting factor are in Tasmania. The southeast and northeast coasts are also capable of supporting large populations. It does also show, however, that South Australia and Western Australia have very low capacity. The Holmes calculations are presented in Table 25.

Figure 29: Densities of Maximum Permissible Population and Drainage Divisions of Australia

Source: Holmes, 1973

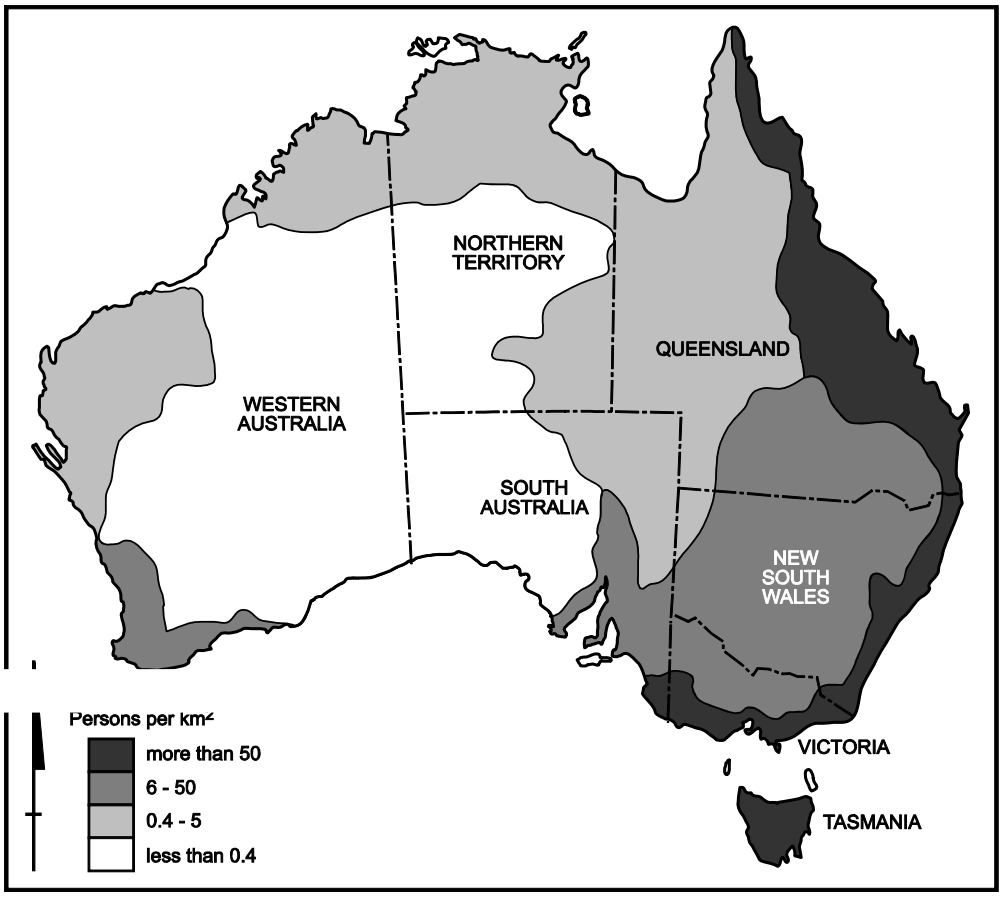


Table 25: The Maximum Permissible Population of Australia, Limited by Water Potentially Available

Source: Holmes, 1973

Drainage Division		Fraction of Water That Could be Utilized	Maximum Permissible Population (millions)
(a)	Tasmania	0.5	90
(b)	North-East Coast	0.2	70
(c)	South-East Coast	0.4	60
(d)	Murray-Darling	0.1 to 0.5 of -1 14Ml yr	23
(e)	Timor Sea	0.075	23
(f)	Carpentaria	.05	13
(g)	South-West Coast	0.3 of 3.6 -1 Ml yr	4.5
(h)	South Australian Gulf	0.4	0.8
(i)	Indian Ocean	0.03 of 4.9 -1 Ml yr	0.6
(j)	Lake Eyre	0.02	0.4
(k)	Bulloo-Bancannia	0.02	0.04
(l)	Western Plateau	Water can be imported as, for example, by the Kalgoorlie pipeline	
	Total Population		About 280

Note: It is to be emphasized that the figures in this table refer to water used in rural and urban areas for domestic and industrial use, but exclude irrigation.

What these data show is that much of the available water which is not currently being accessed is in Tasmania and the north of Australia, especially the northeast. But it does need to be stressed that while water is abundant in the northeast and northwest other factors such as rainfall variability, soil fertility, occurrence of extreme events and other climatic factors render any simple attempts to relocate Australian agriculture problematical. There is a need for careful modelling to identify those existing areas where a changed water regime due to climate change will not allow continuation of existing patterns of use. Equally we need to identify the potential for food production in the well watered areas of the north as part of food security initiatives. It is not, however, simply a matter of transplanting existing farm operations to new locations. Moreover, it involves people whose dignity and rights must be fully respected. The fact that the adaptations will occur over several decades provides the basis for developing an adaptation process which is not only based on the most robust empirical evidence but also can proceed over sufficient time to minimise the disruption caused.

Turning to coastal areas the most significant impacts are likely to be associated with rising sea levels and inundation associated with this and storm surges. This issue is of particular relevance in major coastal capital cities where significant areas are at risk of inundation and property loss and damage if there is a significant rise in sea level. Figure 30, for example, indicates the areas of the Adelaide metropolitan area which would be inundated under a medium sea level rise scenario of 0.8 metres by 2100. The impacts may diverge from those shown because the modelling does not take into account the effects of sea walls, storm surges, erosion or the northeast of the city. Moreover, the current 30 Year Plan for Adelaide (Government of South Australia, 2010) envisages further urban developments to the northwest in the area known as Buckland Park which also is very low lying. Each of the capitals faces similar problems.

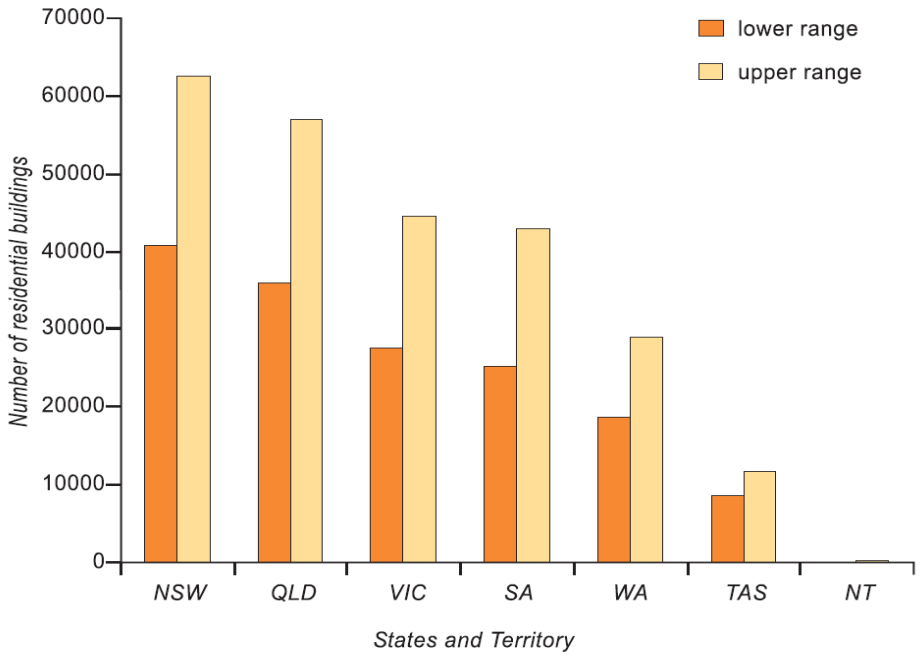
Figure 30: Areas of the Adelaide Metropolitan Area Which Would be Inundated Under a Medium Level Rise Scenario of 0.8 Metres by 2100
Source: Australian Online Coastal Information, http://www.ozcoasts.gov.au/climate/sd_visual.jsp

However, it is not just in the capital cities that rising sea levels present a problem. As a report on *Climate Change Risks to Australia's Coasts* (Department of Climate Change, 2009, 6) points out, 'Australia has become a coastal society'. With around 85 percent of Australians living in the coastal zone, more than one in four of these live outside of the capitals. Moreover, as was shown earlier, the non-metropolitan coastal zone contains some of the fastest growing communities in Australia. Figure 31 shows the extent of the number of existing residential buildings that would be at risk of inundation in each state if there were a

sea level rise of 1.1 metres. This indicates that the potential scale of the impact of sea level rise on coastal communities is considerable in all of the states.

Figure 31: Estimated number of Existing Residential Buildings at Risk of Inundation from a 1.1 Metre Sea Level Rise (including 1-in-100 Storm Tide for NSW, Victoria and Tasmania and high tide event for others)

Source: DCC, 2009, 7



An issue of considerable concern here is one that is important in considerations of the impact of climate change on population distribution and migration worldwide – *the fact is that many of the hot spots of greatest climate change impact are in fact areas which are currently magnets of rapid population growth which are experiencing substantial net inmigration*. This, for example, is the case with Asia's Megacities, most of which are located in coastal areas and are at substantial risk of inundation. In coastal Australia there has been rapid population growth over the last couple of decades. Table 26 shows patterns of population growth in coastal and non-coastal statistical divisions (SDs) over the 2001-09 period. It shows that in recent years population growth in coastal areas has not only been

greater than in inland SDs but also faster than in capital city SDs. Moreover, it is important to note that migration has been an important part of the growth of these areas. Table 27 shows the components of the 2001-06 intercensal population growth in non-metropolitan coastal SDs in eastern, southeastern and southwestern Australia. This indicates that net internal migration is overwhelmingly the main factor of growth. International migration is

Table 26: Australia: Coastal, Non-Coastal and Capital City Statistical Divisions, Average Annual Growth Rates and Percent of National Population, 2001, 2006 and 2010

Source: ABS, 2011b

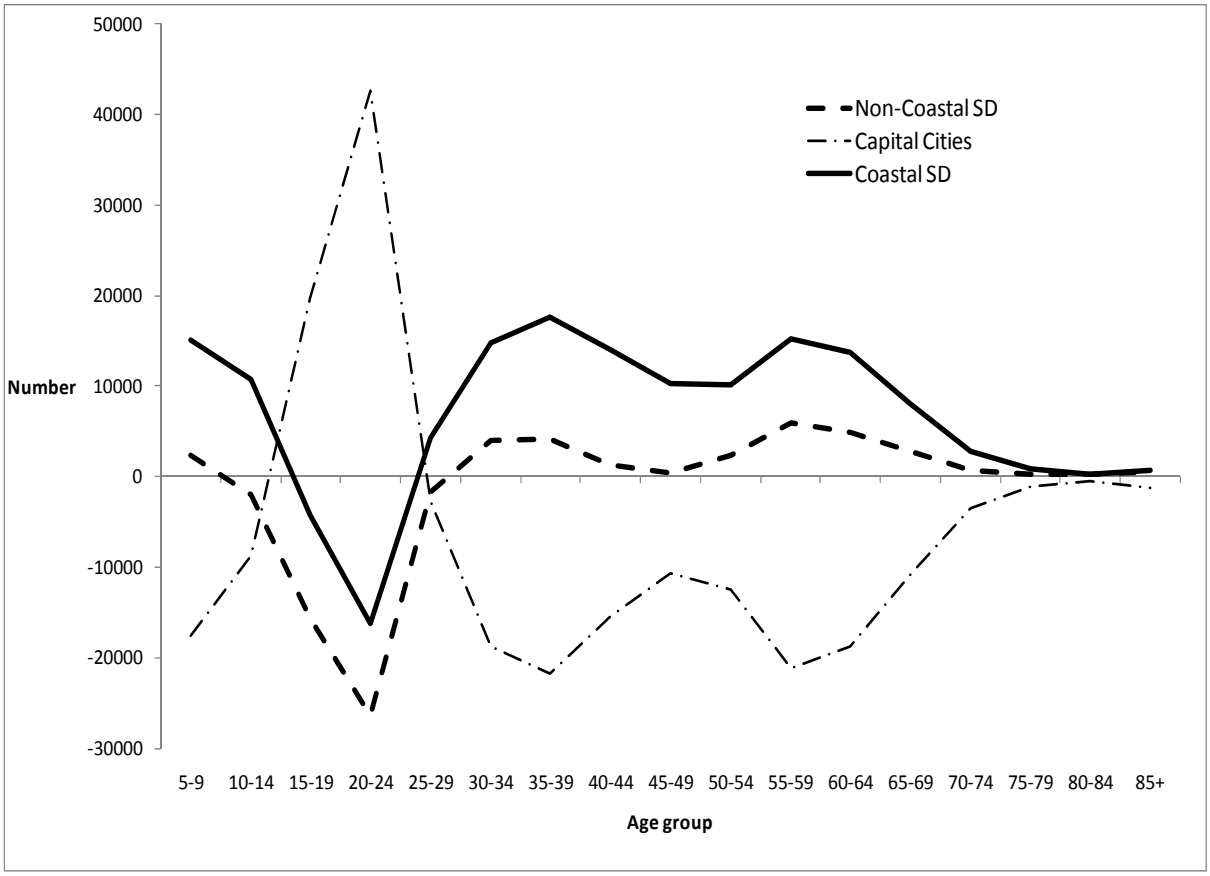
	Average Annual Growth Rate		Percent of National Population		
	2001-06	2006-10	2001	2006	2010
Coastal	1.77	2.02	20.6	21.0	21.1
Non-Coastal	0.68	1.35	15.6	15.2	14.8
Capital City	1.28	2.01	63.8	63.8	64.0
Total	1.29	1.91	100.0	100.0	100.0

Table 27: Dynamics of Population Change in East, Southeast and Southwest Non-Metropolitan Coastal SDs, 2001-06

Net Internal Migration	134,563
Natural Increase	123,823
Overseas-Born Resident in Australia <5 Years	35,049

quite small. The latter contrasts with the capital cities where international migration is the main engine of population growth. It is noticeable too that natural increase (births minus deaths) is also important in coastal population growth. This is a function of the fact that the coastal non-metropolitan population growth involves young families. Figure 32 shows the age distribution of the net internal migration recorded by coastal SDs between 2001 and 2006

Figure 32: Australia: Coastal, Non-Coastal and Capital Cities Age-Specific Net Migration, 2001-06
Source: ABS 2006 Census, Table Builder



and compares them with those for inland non-metropolitan SDs and capital city SDs. A striking pattern is in evidence. Coastal SDs have net gains in all ages except the young adult ages. There is in fact a 'twin peaks' pattern of net migration in coastal areas involving substantial gain of young families (young adults and dependent children) and people in the pre- and early post-retirement years.

The fact that non-metropolitan coastal areas are the main areas to experience net internal migration gains is confirmed in Table 28 shows the SDs which are experiencing the largest net gains of internal migrants in Australia. This indicates that all but Brisbane among the SDs with the largest net gains are non-metropolitan coastal areas. On the other hand the major SDs with net losses of internal migrants are metropolitan SDs. This points to a little

known fact in Australian demography – there is an overall net internal migration loss in Australia's main capital cities. Some key features of the significant 'sea change' net migration flow to coastal Australia are included in Box 1. The key point is that one of the areas most vulnerable to climate change impacts – coastal Australia – is currently an area of inmigration. The extent to which this rapid growth is making the coastal areas even more vulnerable to environmental degradation is not well understood.

Table 28: Australia Statistical Divisions: Major Sinks and Sources of Net Internal Migration, 2001-06

Source:

Sinks		Sources	
Statistical Division	Net Migration	Statistical Division	Net Migration
Brisbane (Q)	42,750	Sydney (NSW)	121,012
Gold Coast (Q)	29,312*	Melbourne (V)	18,709
Sunshine Coast (Q)	20,561*	Adelaide (SA)	9,611
Wide Bay-Burnett (Q)	15,798*	Northwestern (Qld)	6,506
Southwest (WA)	10,805*	Balance (NT)	4,443
Mid North Coast (NSW)	10,254*	Southeastern (WA)	3,725
Hunter (NSW)	9,656*	Northwest (NSW)	3,439
Outer Adelaide (SA)	7,454*	Northern (SA)	3,089
Southeastern (NSW)	6,501*	Northern (NSW)	3,033
Richmond Tweed (NSW)	6,143*	Murrumbidgee (NSW)	2,849

* Coastal non-metropolitan SD

Box 1: Key Findings on Internal Migration to Non-Metropolitan Coastal Areas

- Concentration of net migration gain in two groups – pre- and early retirees and young families.
- Continued outflow of young adults and adolescents from regional areas to capitals, even from coasts.
- Jobs are a necessary but not sufficient condition for relocation to regional areas.
- Services and infrastructure are crucial. Withdrawal of services from regional areas by state governments is a major brake on regional development.
- The inmigration to regional areas is strongly spatially concentrated along coastal areas.
- Return migration is an important element in migration to regional areas.
- Significant coastal inmigration is from inland non-metropolitan areas.

In considering population in non-metropolitan coastal Australia and the potential impacts of climate change, two additional issues need to be mentioned:

- The census data on population do not capture the large temporary populations who are in coastal areas on weekends and holidays.
- There are some indications that we may be on the verge of a significant rapid growth of non-metropolitan coastal populations.

Both of these issues have important implications for the impact of climate change in coastal Australia.

The first issue relates to the fact that the population data presented so far is derived from the Australian census of population and housing. The census is conducted on a *de jure* basis which assigns people to their usual place of residence. Moreover, the census is conducted mid week and mid winter so it does not capture most of the people who are temporary users of coastal resort communities. Census data, therefore, underestimates the numbers of people to be impacted by climate change in these areas.

The second issue relates to the issue of potential impending rapid growth in many non-metropolitan coastal communities. The impending retirement of Australian baby boomers who make up 27 percent of the national population raises a number of issues. The Department of Treasury's Intergenerational Reports (e.g. Swan, 2010) have indicated several of the challenges this will present for the national economy. One issue which has been given little consideration, however, is where will baby boomers live during their retirement? Historically, older Australians have been the least mobile group in the population with *ageing in place* being dominant as most older people remain in the family home after their retirement. There are some indications, however, that baby boomers will move house more than earlier generations in the pre-retirement and early post-retirement stages of the life cycle.

Moreover, there are some indications that many of these movers will move to a seaside non-metropolitan location.

One of the factors which is pointing to a substantial move of baby boomers to non-metropolitan coastal communities upon retirement is the second home phenomenon. A key feature of most coastal communities is the fact that a significant proportion of their housing stock is made up of holiday homes that are occupied only on weekends or holidays and are owned by absentee rate payers. There is no data collected in the Census of Population and Housing on second homes *per se* but the census does show the numbers of houses unoccupied on the night of the census. Figure 33, for example, shows the percentage of houses unoccupied on census night 2006 in non-metropolitan South Australia. Coastal areas have high proportions of dwellings unoccupied on census night reflecting significant numbers of holiday homes. These are shown in Table 29 together with data supplied by local governments on the proportion of rate notices that were sent to people living outside the LGA. Second homes are an important phenomenon in non-metropolitan coastal Australia. It is also important to note that baby boomers are dominant among holiday home owners in Australia. Figure 34, for example, shows the age distribution of absentee owners in Yankalilla, South Australia, and the dominance of baby boomers is evident. The key issue, therefore, becomes the extent to which baby boomers intend to move their permanent residence to their holiday homes when they retire. This process has the potential to increase the populations of some coastal communities very quickly. Even if they only significantly increase the number of days each year they spend in their holiday homes rather than definitively move there it will have significant effects on the populations of coastal areas.

Figure 33: South Australia: Percent Unoccupied Private Dwellings, 2006
Source: ABS 2006 Census

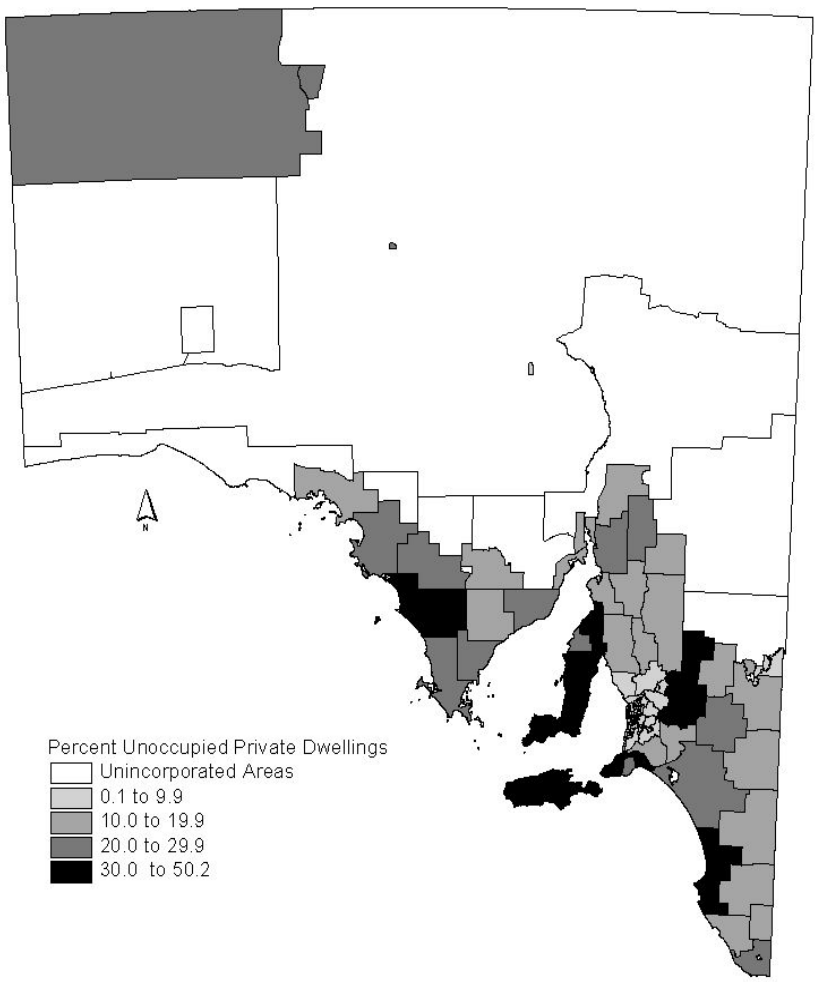
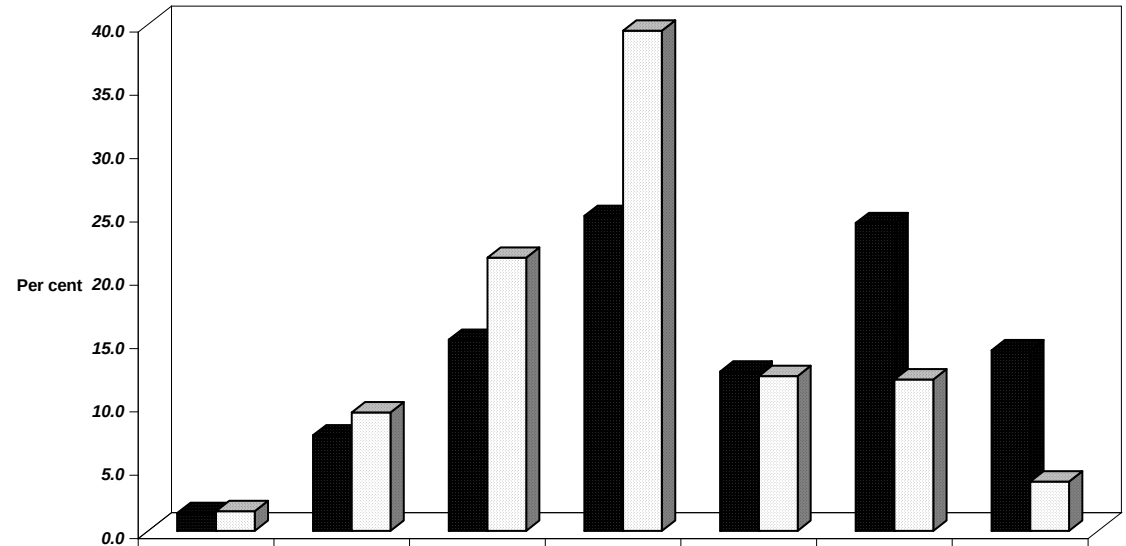


Table 29: Spencer Gulf LGAs, 2006: Percentage of Dwellings Unoccupied, 2006
Source: ABS 2006 Census

Local Government Area	Private Dwellings		Percent Unoccupied	Percent of Assessment Notices Sent Outside LGA
	Occupied	Unoccupied		
Barunga West	1 077	674	38.5	
Copper Coast	4 837	1 979	29.0	35.7
Cleve	853	153	15.2	
Franklin Harbour	571	198	25.7	26.5
Lower Eyre Peninsula	1 651	493	23.0	
Mount Remarkable	1 195	313	20.8	25.5
Port Augusta	5 431	785	12.6	
Port Lincoln	5 454	690	11.2	
Port Pirie City and Districts	7 020	697	9.0	8.0
Tumby Bay	1 098	387	26.1	32.9
Whyalla	9 010	1 086	10.8	11.9
Yorke Peninsula	4 866	3 966	44.9	48.1
Total	43 063	11 421	21.0	

Figure 34: Yankalilla: Age Structure of Resident and Non-Resident Respondents
Source: Yankalilla Permanent Resident Survey and Property Owner Survey



	<30	30-39	40-49	50-59	60-64	65-74	75+
Residents	1.4	7.5	15.1	24.9	12.6	24.3	14.2
Non-residents	1.6	9.4	21.6	39.5	12.2	11.9	3.9

Hence the populations which will be affected by climate change in coastal areas of Australia are likely to be substantially larger than those indicated in contemporary census data.

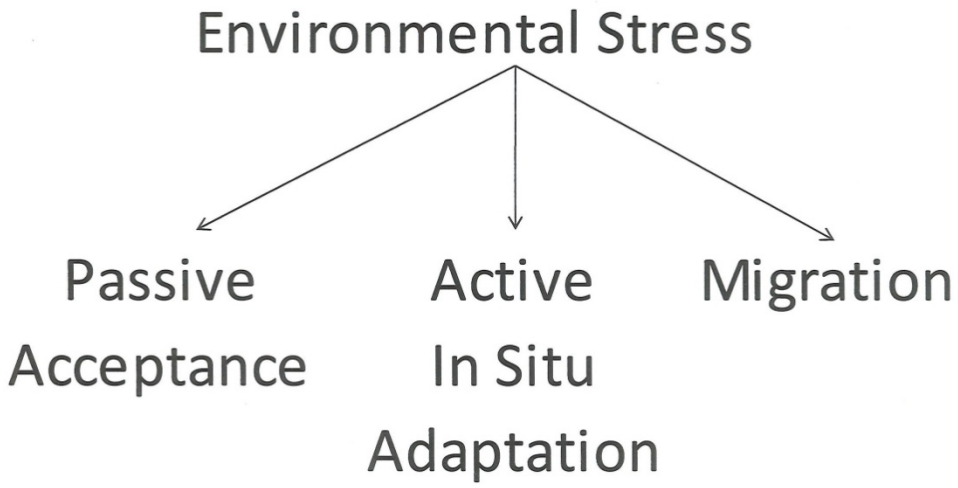
CONCLUSION

Although our knowledge of climate change at the national level in Australia is robust and convincing, information on the nature and severity of impacts at regional and community levels is less complete. Nevertheless, this paper has been able to show that there are significant spatial variations in the anticipated effects of climate change. Many of the 'hot spots' expected to experience the most intensive effects from climate change have substantial populations, and in many cases, are currently experiencing rapid population growth. Climate change will affect the economic base of many of these communities, especially in areas reliant upon agriculture, and on the liveability of those communities.

In the international discourse on the effects of climate change there has been a preoccupation with population displacement, forced migration and 'climate change refugees'.

The reality, however, is that migration is only one of the potential responses to climate change as is depicted in Figure 35. In fact, for many, probably most, in the affected areas the response will *not* involve migration – the response will be *in situ* adaptation. In some cases it will mean passive acceptance of its effects through people putting up with a decline in their ability to earn a livelihood and/or declines in the liveability of their area. This is especially the case for the most vulnerable people in the community who have little or no margin to invest in some form of *in situ* adaptation or in migration. The poor, the disabled, the powerless, the elderly, some ethnic groups, single-parent families, the homeless and other disempowered and excluded groups are especially vulnerable to these effects. There are real chances that climate change may exacerbate existing inequalities which exist within and between communities and this must be an area of major policy concern.

Figure 35: Responses to Impacts of Climate Change at the Community Level



For a large group, too, there will be *in situ* adaptations to the effects of climate change. The construction of seawalls to prevent inundation or other engineering solutions are one such form of *in situ* adaptation. Modifying house design to cope with increased

incidence and severity of extreme climatic events is another. Developing better and more sustainable use of existing water resources in both urban and rural areas is also an important part of the adaptation process. In some rural areas it will be necessary to modify existing ways in which people earn a livelihood. Perhaps growing different crops or using different agricultural methods are possibilities while development of new types of economic activity may also occur.

Migration responses will generally be taken up by a minority and it is unrealistic to see climate change leading to massive, large scale relocations of the existing population. Nevertheless, there are a range of migration responses. For some, temporary migration will provide an option. One example of this is the northern Eyre Peninsula of South Australia where in the 1990s and 2010s on the margins of the area suitable for wheat cultivation several continuous years of drought were experienced which meant that wheat farmers were unable to make a livelihood. Many moved on a 'drive-in-drive-out' basis to the rapidly developing mining community of Roxby Downs to the north east (408 km). The workers left their families behind in northern Eyre Peninsula and the movement reached such proportions that Roxby Downs was referred to as 'Kimba North'.[3]

The other mobility option is of course relocation. There may be a case for some primary industry activities to be relocated as a result of climate change as the CSIRO has demonstrated with respect to dairying. However, such shifts will occur over an extended period. The literature on environment and migration has demonstrated that environment change usually operates as a contributory or proximate cause of migration and is rarely the only or main factor in migration. Hence the effects of climate change on the ability to earn a livelihood in an area or upon livelihood in that area may contribute to people's migration decisions. It is difficult to see that climate change in Australia will cause a massive

[3] Kimba is a northern Eyre Peninsula town.

relocation of people. Its effects are more likely to be through directing new investment and growth into areas not negatively influenced as much by climate change rather than shifting existing population or activity.

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