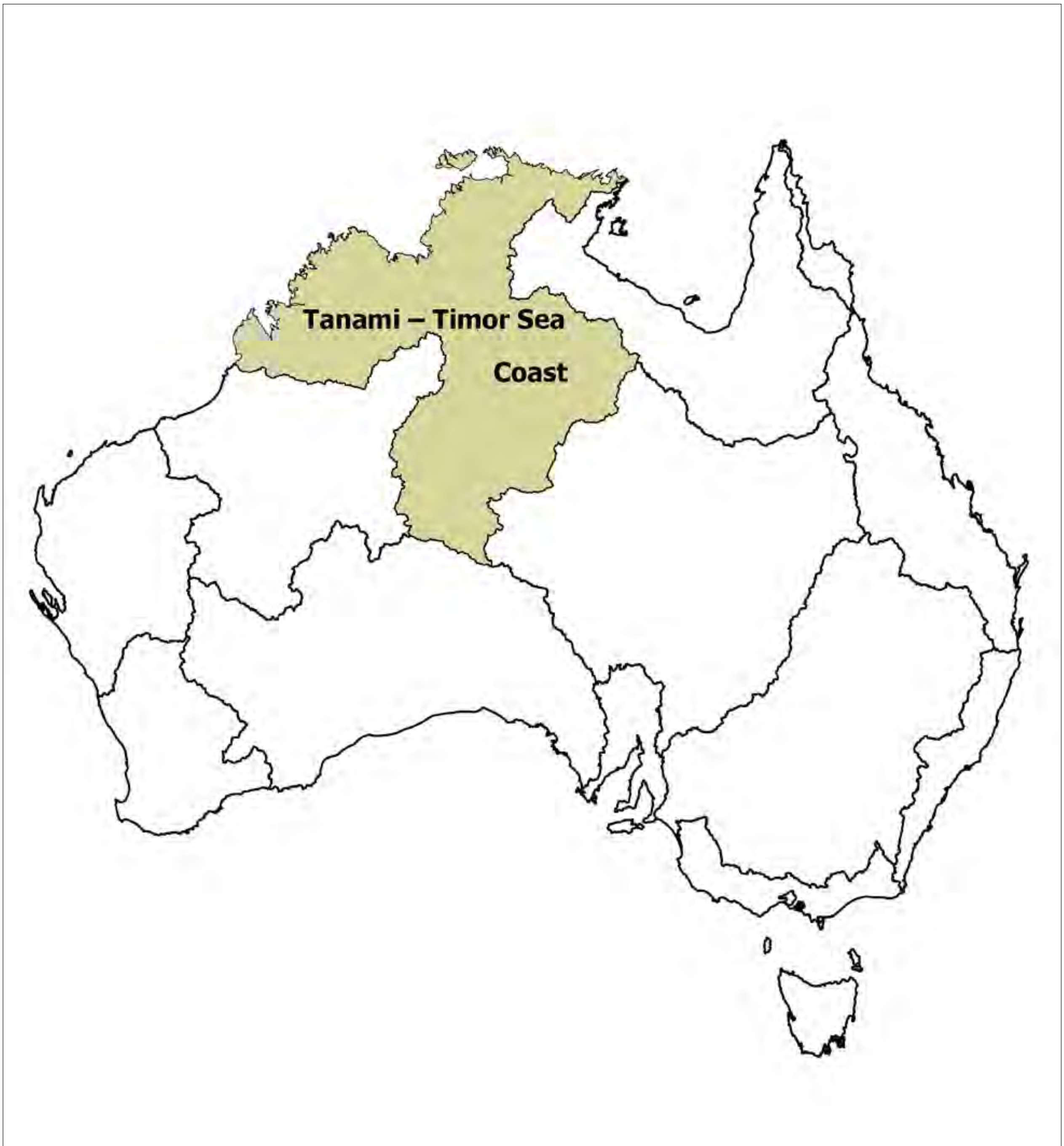
Tanami – Timor Sea Coast

13 Tanami – Timor Sea Coast

13.1 Introduction

This chapter examines water resources in the Tanami – Timor Sea Coast region in 2011–12 and over recent decades. It starts with summary information on the status of water flows, stores and use. This is followed by descriptive information for the region including the physiographic characteristics, soil types, population, land use and climate.

Spatial and temporal patterns in landscape water flows are presented as well as an examination of the surface and groundwater resources. The chapter concludes with a review of the water situation for urban centres and irrigation areas. The data sources and methods used in developing the diagrams and maps are listed in the Technical Supplement.



13.2 Key information

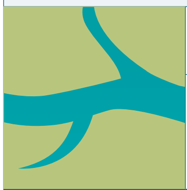
Table 13.1 gives an overview of the key components of the data and information in this chapter.

Table 13.1 Key information on water flows, stores and use in the Tanami – Timor Sea Coast region

Landscape water flows

	Region average	Difference from 1911–2012 long-term annual mean	Decile ranking with respect to the 1911–2012 record
Rainfall	754 mm	+35%	9th—above average
Evapo-transpiration	646 mm	+40%	10th—very much above average
Landscape water yield	142 mm	+53%	9th—above average

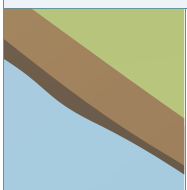
Streamflow (at selected gauges)

	Annual total flow:	Predominantly average to above average flow in river basins in the central north
	Flooding:	Localised minor to moderate flooding in the northern half of the region

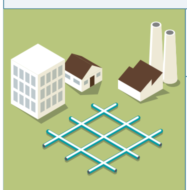
Surface water storage (comprising about 96% of the region's total capacity of all major storages)

	Total accessible capacity	30 June 2012		30 June 2011		Change	
		accessible volume	% of total capacity	accessible volume	% of total capacity	accessible volume	% of total capacity
	10,733 GL	10,549 GL	98%	10,710 GL	100%	-161 GL	-2%

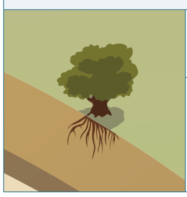
Groundwater (in selected aquifers)

	Salinity:	Non-saline groundwater (<3000 mg/L) throughout the region

Urban water use (Darwin)

	Total sourced in 2011–12	Total sourced in 2010–11	Change	Restrictions
	35.5 GL	32.3 GL	+3.2 GL (+10%)	No restrictions

Annual mean soil moisture (model estimates)

	Spatial patterns:	Predominantly above average to very much above average annual mean soil moisture
	Temporal patterns in regional average:	Very much above average soil moisture throughout most of the year, above average in the wet season

13.3 Description of the region

The Tanami – Timor Sea Coast region extends over a large area of northern Australia covering much of the Northern Territory and the north of Western Australia. The region is approximately 1,162,000 km² and includes the Ord, Darwin, Daly, Victoria and Fitzroy river basins (Figure 13.1).

The region is dominated by two major drainage systems with a dense network of northern rivers that drain to the Timor Sea, and drier rivers generally draining south to inland ephemeral lake systems. Subsections 13.3.1–13.3.4 provide more information on the topography and soil types.

With a population of 201,500 the region is home to 0.9% of the nation's total population (Australian Bureau of Statistics [ABS] 2011b).

Major population centres in the region are shown in Figure 13.1 and include Darwin, Palmerston, Broome, Katherine and Kununurra. Further discussion of the region's population distribution and urban centres can be found in subsection 13.3.6 and section 13.6 respectively.

Land use in the region mainly consists of pasture and nature conservation reserves (see subsection 13.3.5). Some of the most well-known natural landscape features and conservation reserves in Australia are located in this region, including the Kimberley, Kakadu National Park and Uluru–Kata Tjuta National Park.

The Ord Irrigation Scheme, located in the Ord River catchment in the far northeastern part of Western Australia, is the largest area of irrigated agriculture in the region. Subsection 13.3.5 provides more information on the region's agricultural activities.

The region extends across distinct climatic zones and is characterised by a humid tropical climate to the north and a very dry arid climate to the south. Subsections 13.3.7 and 13.3.8 provide more information on the rainfall patterns and deficits across the region.

River flows in the tropical northern climate zone experience distinct seasonal patterns, with approximately 90% of the average annual flow occurring in the wet season from November–April.

The hydrogeology of the region is dominated by the Kimberley hard rock plateau and Canning basin sedimentary rocks. In the hard rock plateau, groundwater occurs in low but valuable quantities in fractured rocks and surficial river alluvium. Substantial quantities of confined and unconfined groundwater of varying quality occur in the sedimentary basins. The extensive groundwater resources associated with the widespread fractured and cavernous limestone of the Daly basin are important for the region. Shallow groundwater is often of good, low salinity quality, reflecting the annual fill-and-spill cycle, and can provide good supplies of potable water. A more detailed description of the rivers and groundwater status in the region is given in section 13.5.

Kata Tjuta (the Olgas) | stefaniaandreetto (iStockphoto)

Figure 13.1 Major rivers and urban centres in the Tanami – Timor Sea Coast region

13.3.1 Physiographic characteristics

The physiographic map in Figure 13.2 shows areas with similar landform evolutionary histories (Pain et al. 2011). These can be related back to similar geology and climatic impacts which define the extent of erosion processes. The areas have distinct physical characteristics that influence hydrological processes. The Tanami – Timor Sea Coast region has four such dominant physiographic provinces, namely:

- Barkly–Tanami Plains (38%): black clay, sand and limestone plains and sandstone rises and plateaus, some with ferruginous mantles and occasional granitic and sedimentary hills;
- North Australian Plateaus (23%): dissected basaltic, quartzite and sandstone plateaus (some with laterite-capping), rounded ridges of folded metamorphic rocks, lowlands of limestone and weak sedimentary rocks including alluvial plains;
- Kimberley (21%): granitic, volcanic and sedimentary ranges, plateaus and hills with some partially laterised tableland and undulating plains; and
- Central Australian Ranges (13%): ranges and hills of igneous rock, sandstone and quartzite amongst sand, stone and hardpan plains with some dune fields and salt lakes.

The remaining two provinces occupy only 5% of the region. These are:

- Sandland (4.7%): east-west longitudinal dunes and minor salt lakes with some narrow sandstone ranges; and
- Carpentaria Fall (0.3%): dissected coastal fall, tabular ridges giving way seawards to sloping plains and low hills.

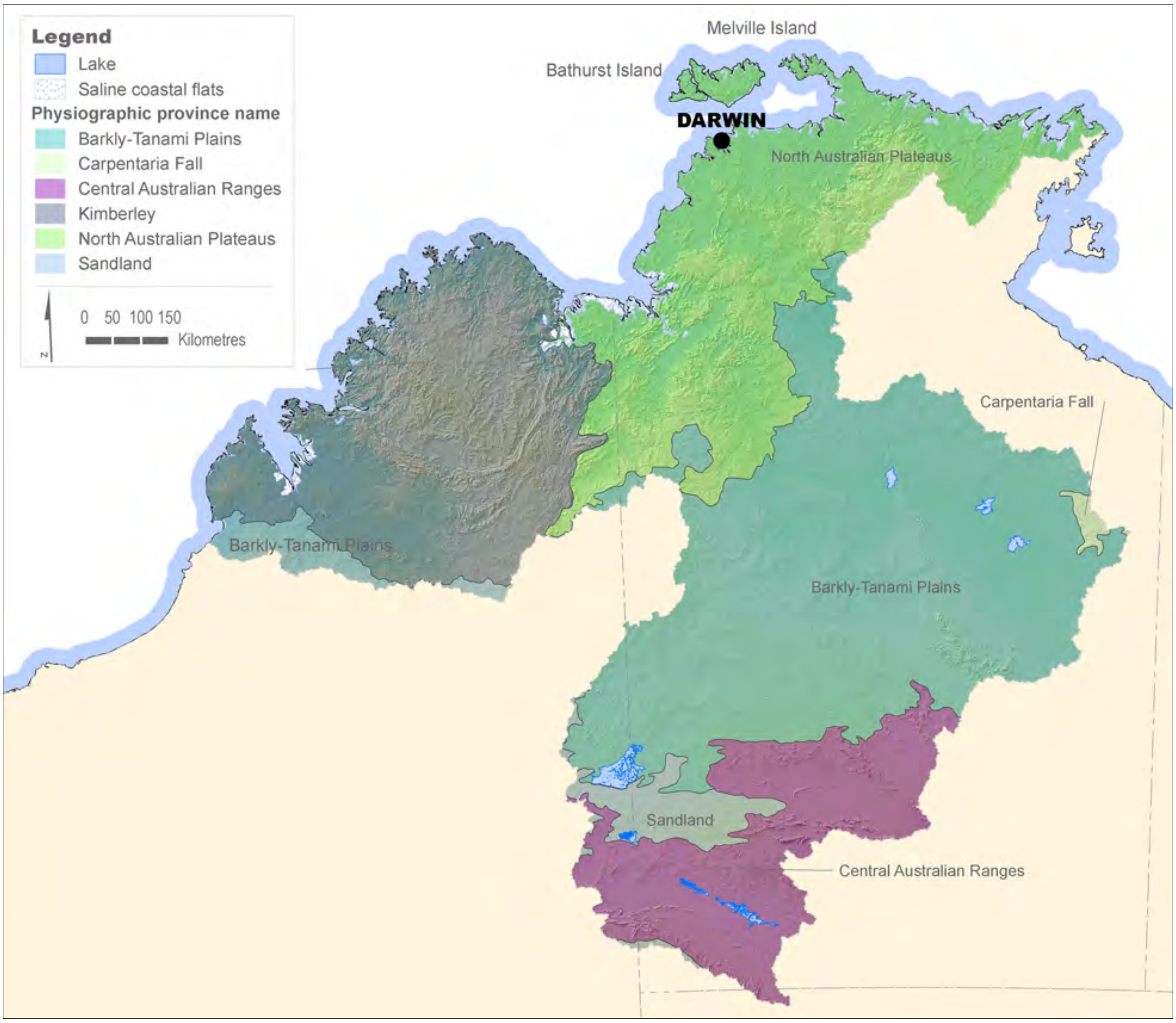


Figure 13.2 Physiographic provinces of the Tanami – Timor Sea Coast region

13.3.2 Elevation

Figure 13.3 presents ground surface elevations in the Tanami – Timor region. Information was obtained from the Geoscience Australia website (www.ga.gov.au/topographic-mapping/digital-elevation-data.html). The topography of the region has generated two major drainage systems with the floodplains of northern rivers draining to the Timor Sea and the arid zone rivers of the Tanami Desert draining south, terminating in ephemeral lakes (Figure 13.3).

In the west of the region most rivers originate from the Kimberley Plateau, which has peaks exceeding 600 m above sea level. The rivers to the west and east of the plateau pass through extensive floodplains, draining to the sea.

The rivers in the northeast of the region have their headwaters in the many mountain ranges and plateaus of this area, including the Arnhem Land escarpment. Peaks in these mountainous areas occasionally reach 300 m above sea level.

More mountainous ranges are present in the Tanami Desert and the far south of the region including the MacDonnell Ranges just west of Alice Springs. Some peaks in the area exceed 1,000 m above sea level.

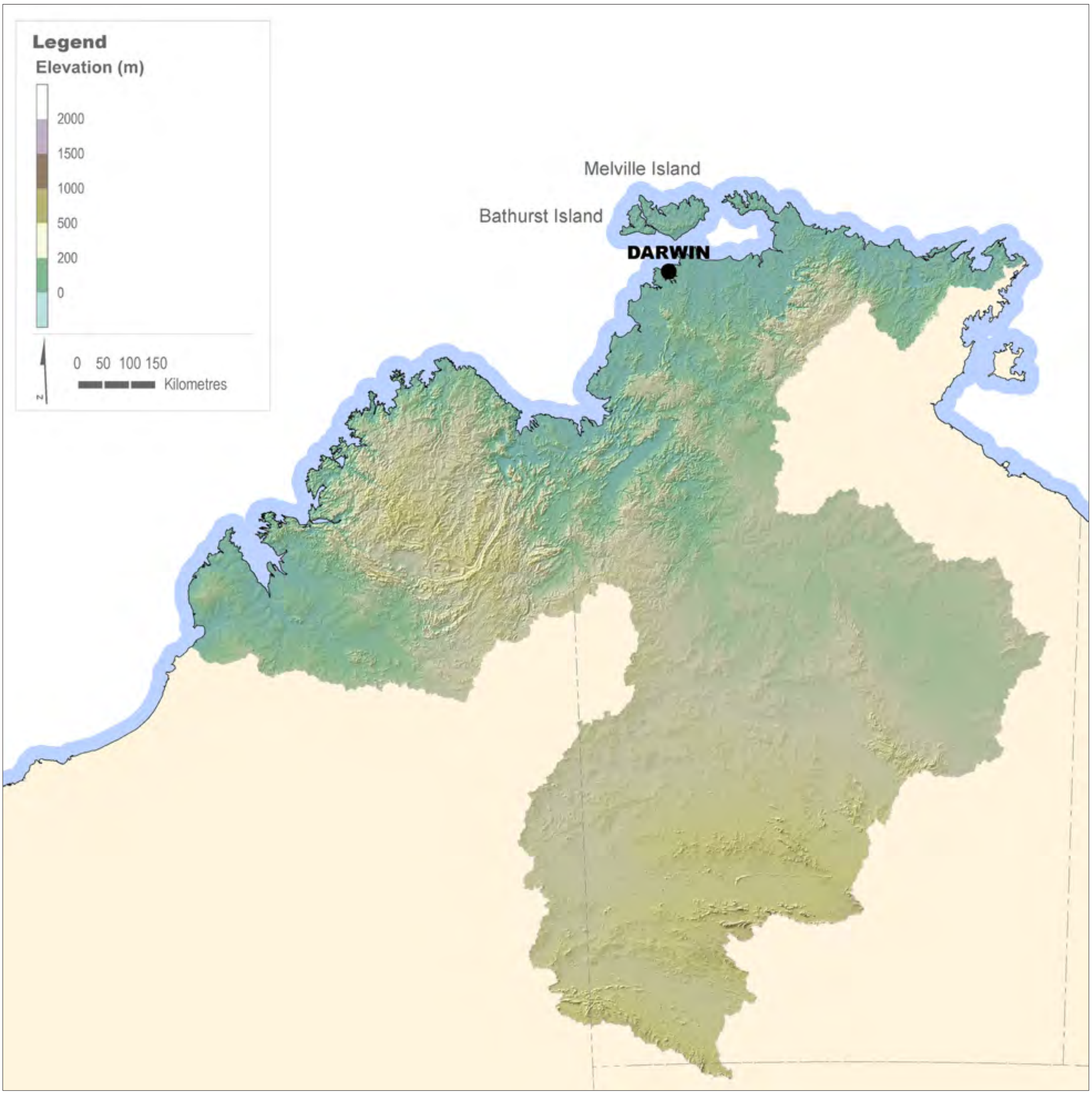


Figure 13.3 Ground surface elevations in the Tanami – Timor Sea Coast region

13.3.3 Slopes

Areas with steep slopes provide higher run-off generating potential than flat areas. The Tanami – Timor Sea Coast region has very few areas with steep slopes (see Table 13.2) and the inland area is particularly flat (Figure 13 4). The slopes were derived from the elevation information used in the previous section.

Table 13 2. Proportions of slope classes for the region

Slope class (%)	0–0.5	0.5–1	1–5	> 5
Proportion of region (%)	48.1	18.4	26.1	7.4

The ranges surrounding the Kimberley Plateau in the northwest have the steepest slopes in this part of the region. Some quite steep slopes can also be found on the escarpment of the Arnhem Land Plateau.

Due to the low topography of the arid inland parts of the region, rivers need to receive large quantities of water before starting to flow. When the arid zone rivers do flow in large volumes, they terminate in and occasionally fill the ephemeral lakes in the area.

The Fitzroy River crosses the plains to the southwest of the Kimberley Plateau. In this part of the region the Fitzroy River has a complex arid floodplain system of meandering flow paths with an average width of around 10 km.

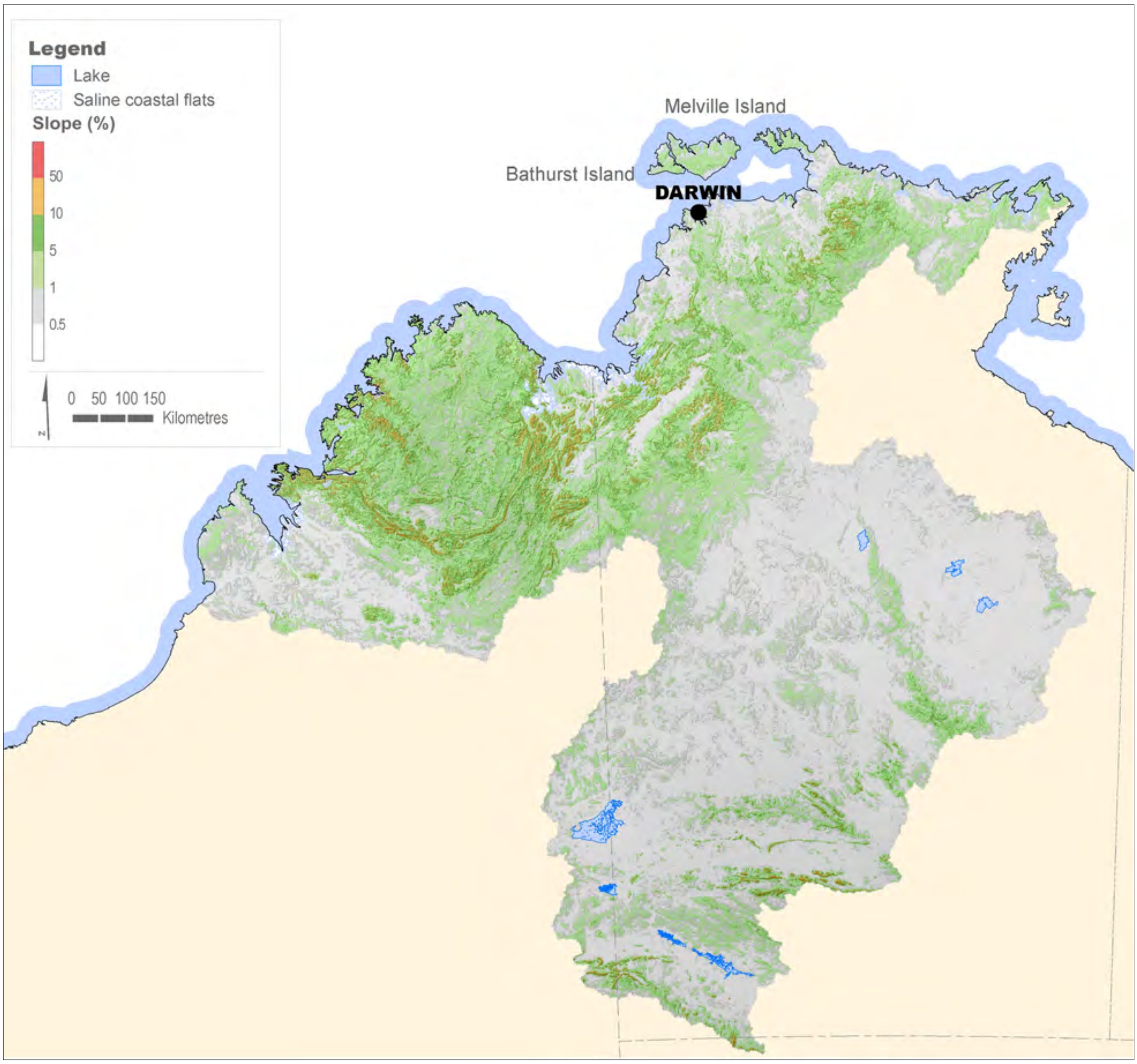


Figure 13.4 Surface slopes in the Tanami – Timor Sea Coast region

13.3.4 Soil types

Soils play an important role in the hydrological cycle by distributing water that reaches the ground. Water can be transported to rivers and lakes via the soil surface as run-off or enter the soil and provide water for plant growth as well as contributing to groundwater recharge.

The nature of these hydrological pathways and the suitability of the soils for agricultural purposes are influenced by soil types and their characteristics. Soil type information was obtained from the Australian Soil Resource Information System website (www.asris.csiro.au).

About 90% of the total Tanami – Timor Sea Coast region consists of four soil types, namely tenosols, rudosols, kandosols and vertosols (Figure 13.5 and Figure 13.6). These soils are usually widely distributed across the region and are mostly used for grazing and nature conservation.

Tenosols and rudosols are characterised by having a weak and minimal development. They show no or little change in texture and colour and are often shallow in depth. They also have low chemical fertility and have a low water-holding capacity, thus their agricultural potential is low. Both soil types are mostly present in areas used for nature conservation rather than for agriculture.

Kandosols are structureless soils which are often very deep, that is, up to 3 m or more. They do not have a strongly contrasting texture and they do not contain carbonate throughout their profile. They are low in chemical fertility and are well-drained with only moderate water holding capacity compared with other soil types; thus they only have low to moderate agricultural potential

Vertosols are mostly distributed between the northwest and northeast of the Tanami – Timor Sea Coast region. Vertosols are clay-rich soils which tend to crack when dry and swell during wetting. They are highly fertile and have a large water-holding capacity; however they must hold a significant amount of water before it becomes available to plants. In this region they are mostly used for grazing.

The other soil types that have minimal representation in the Tanami – Timor Sea Coast region are hydrosols, ferrosols, sodosols, chromosols, calcarosols and dermosols (0.8–3% of the total area).

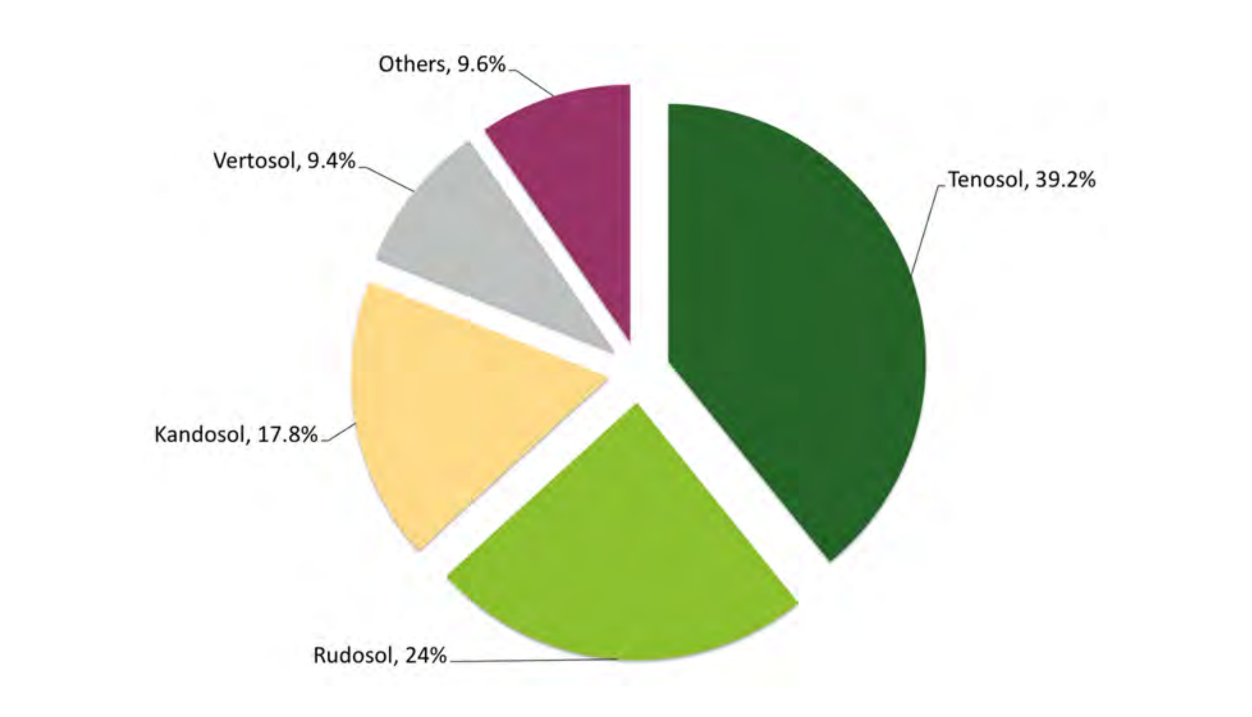


Figure 13.5 Soil types in the Tanami – Timor Sea Coast region

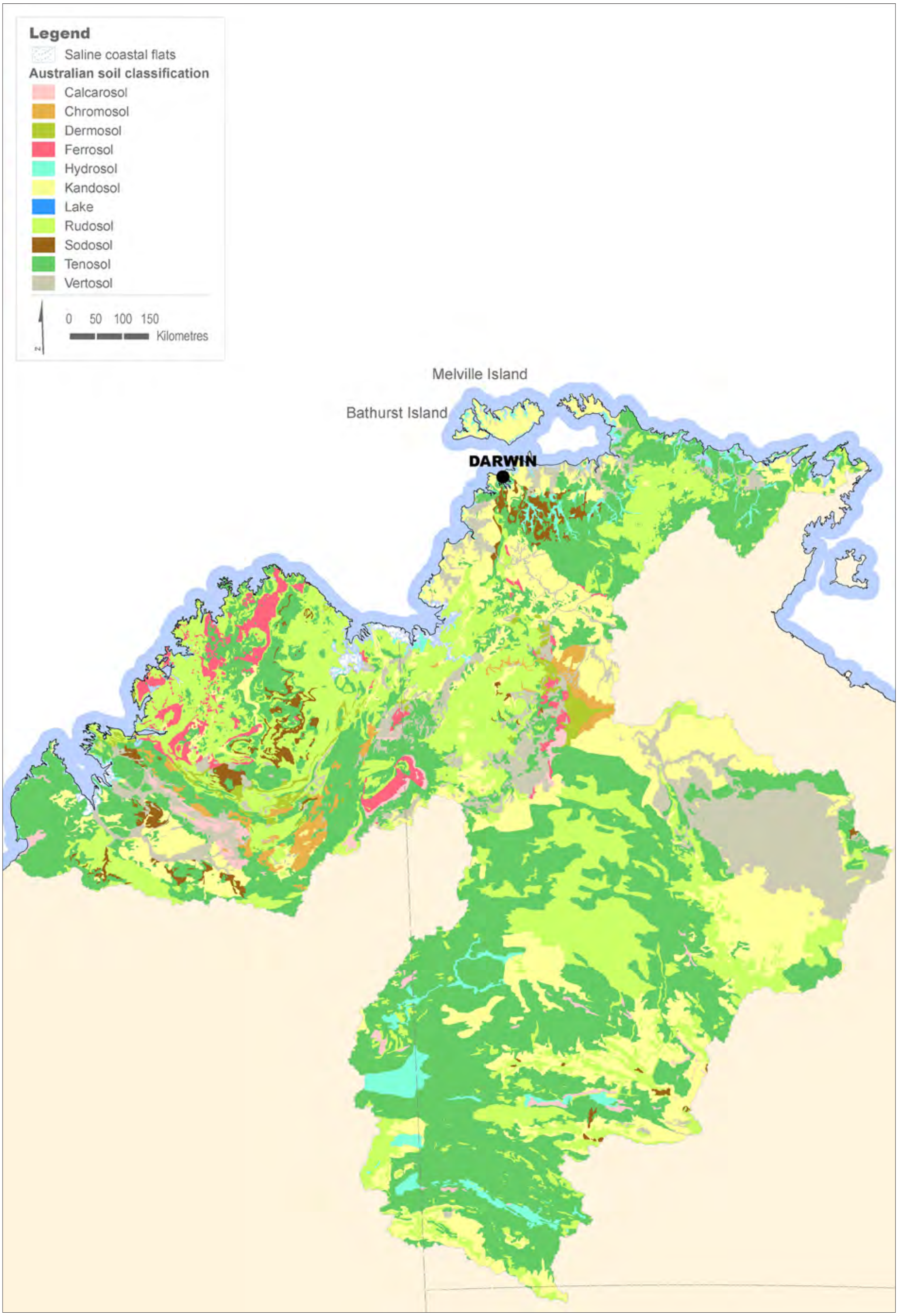


Figure 13.6 Soil type distribution in the Tanami – Timor Sea Coast region

13.3.5 Land use

Land use in the region consists mainly (more than 95%) of pasture and natural conservation (data from data.daff.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml). Some of the most famous natural attractions in Australia are located in this region including the Kimberley and Kakadu National Park. Irrigated agriculture makes up less than 1% of the land use in the region, much of which is concentrated in the Ord River basin (Figure 13.7 and Figure 13.8). The main industries within the Ord River basin are agriculture, horticulture, tourism and mining.

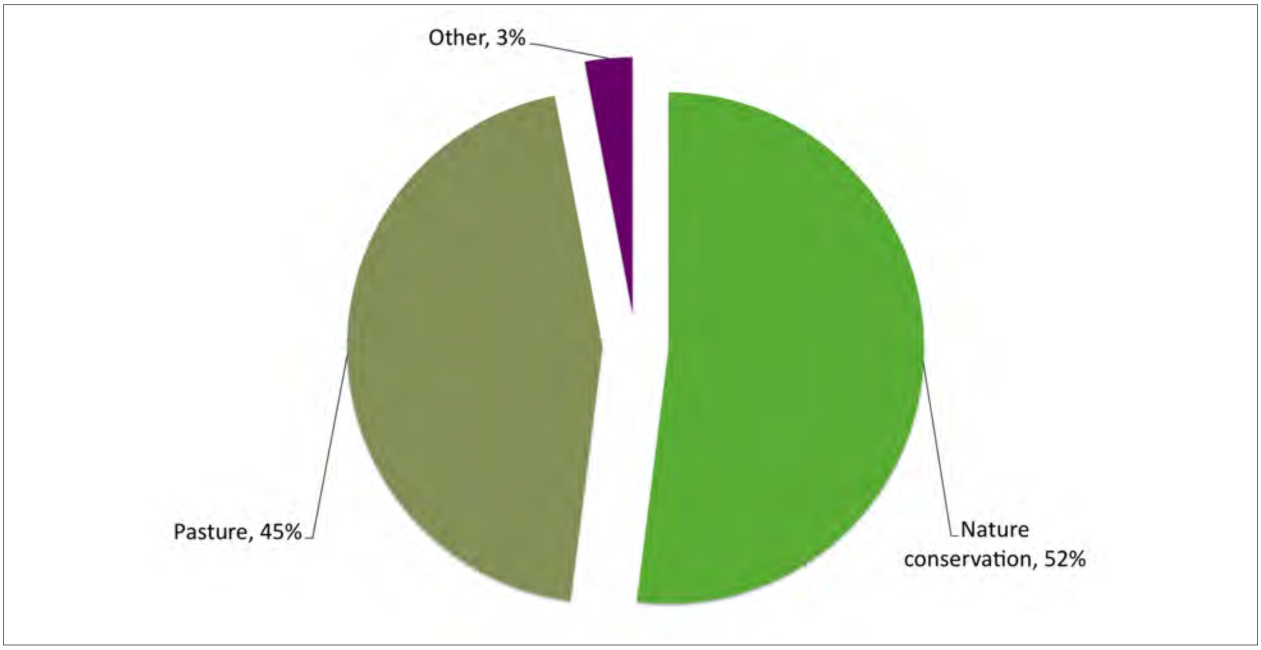


Figure 13.7 Land use in the Tanami – Timor Sea Coast region

Ord River valley | Simon Krzic (Dreamstime)

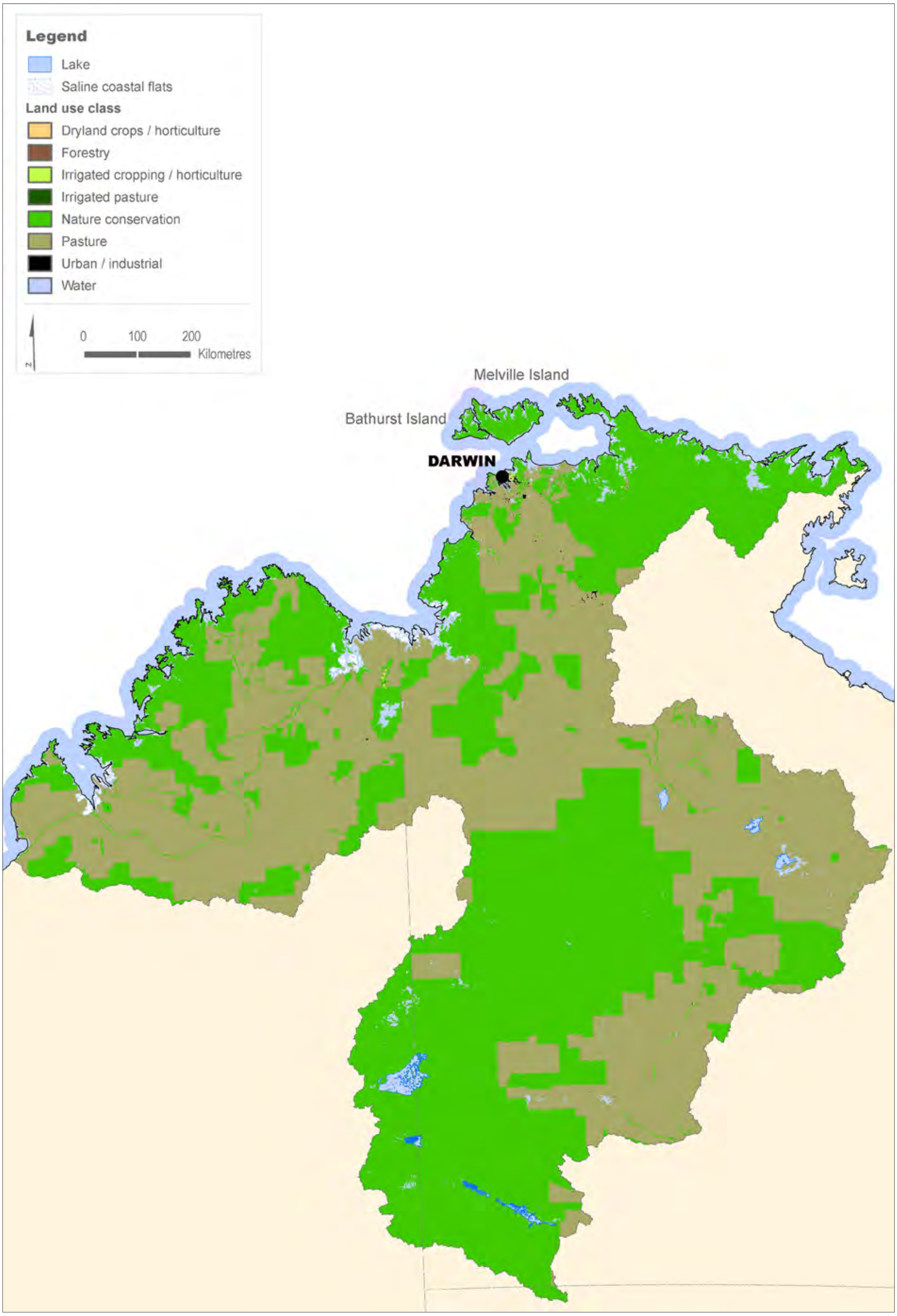


Figure 13.8 Land use distribution in the Tanami – Timor Sea Coast region

13.3.6 Population distribution

The Tanami – Timor Sea Coast region is one of the most sparsely populated in Australia. This is despite some populated centres on its coastline (Figure 13.9), and a number of smaller irrigation and mining centres (ABS 2011b).

Darwin, located in the far north, is the largest city in the region, followed by Broome, which is situated on its coastal western tip.

Outside of the major regional urban centres, mining leases, Indigenous communities and a number of small towns and settlements located adjacent to major roads in the region (including the Stuart, Kakadu and Arnhem highways) account for much of the remaining population.

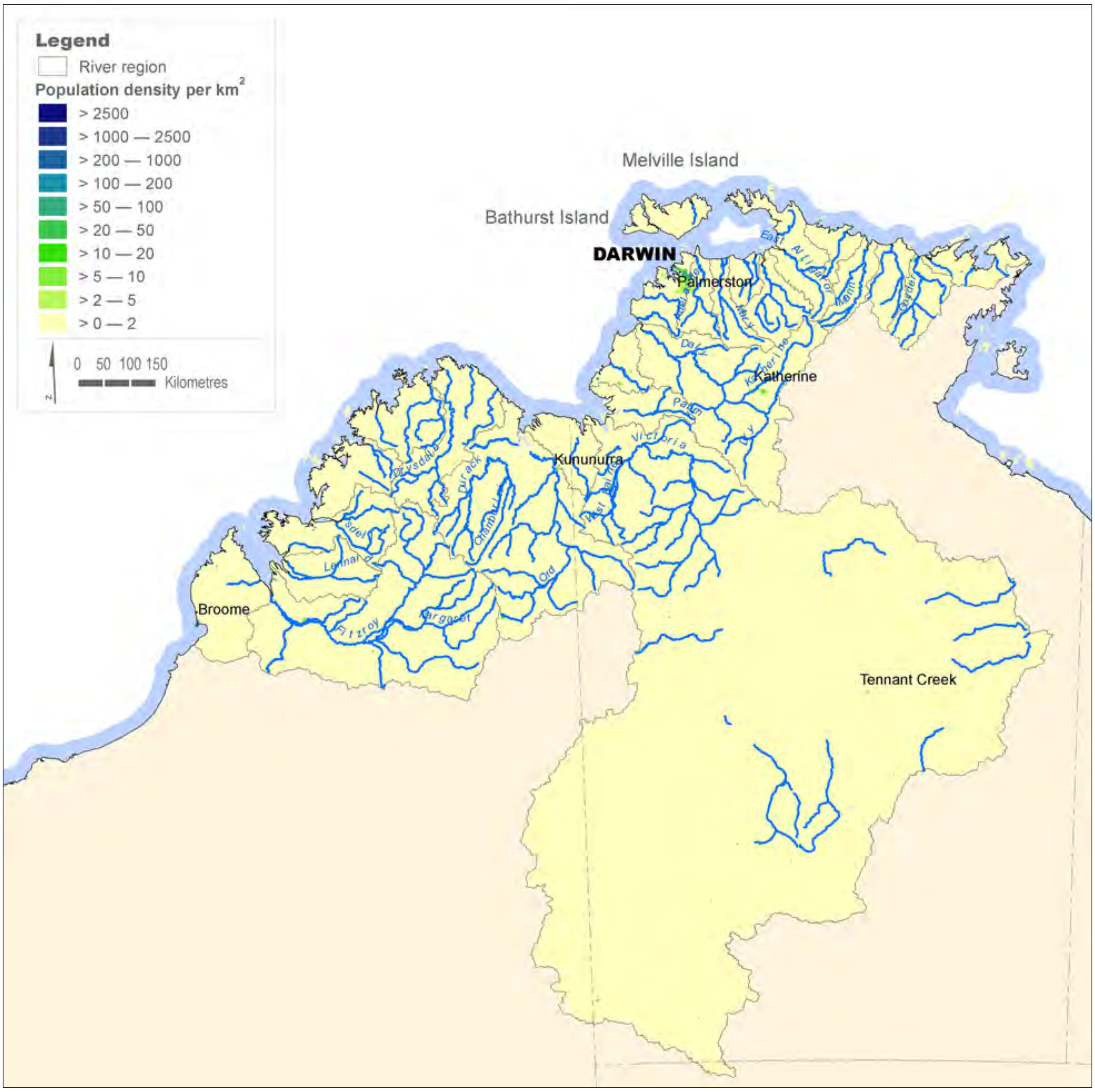


Figure 13.9 Population density and distribution in the Tanami – Timor Sea Coast region

13.3.7 Rainfall zone

The region extends across distinct climatic zones and is dominated by a humid tropical climate to the north and a very dry arid climate to the south. Median rainfall is variable throughout the region (Figure 13.10).

Rainfall in the north of the region is summer dominant. Monsoonal rain and tropical cyclones and depressions contribute to average annual rainfall totals exceeding 1,500 mm in the far north of the region. Moving inland from the coast, average annual rainfall totals gradually reduce.

In the south, the region includes a large component of the Australian dry inland area where average annual rainfall does not exceed 400 mm.

For more information on this and other climate classifications, visit the Bureau of Meteorology's (the Bureau's) climate website: www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp

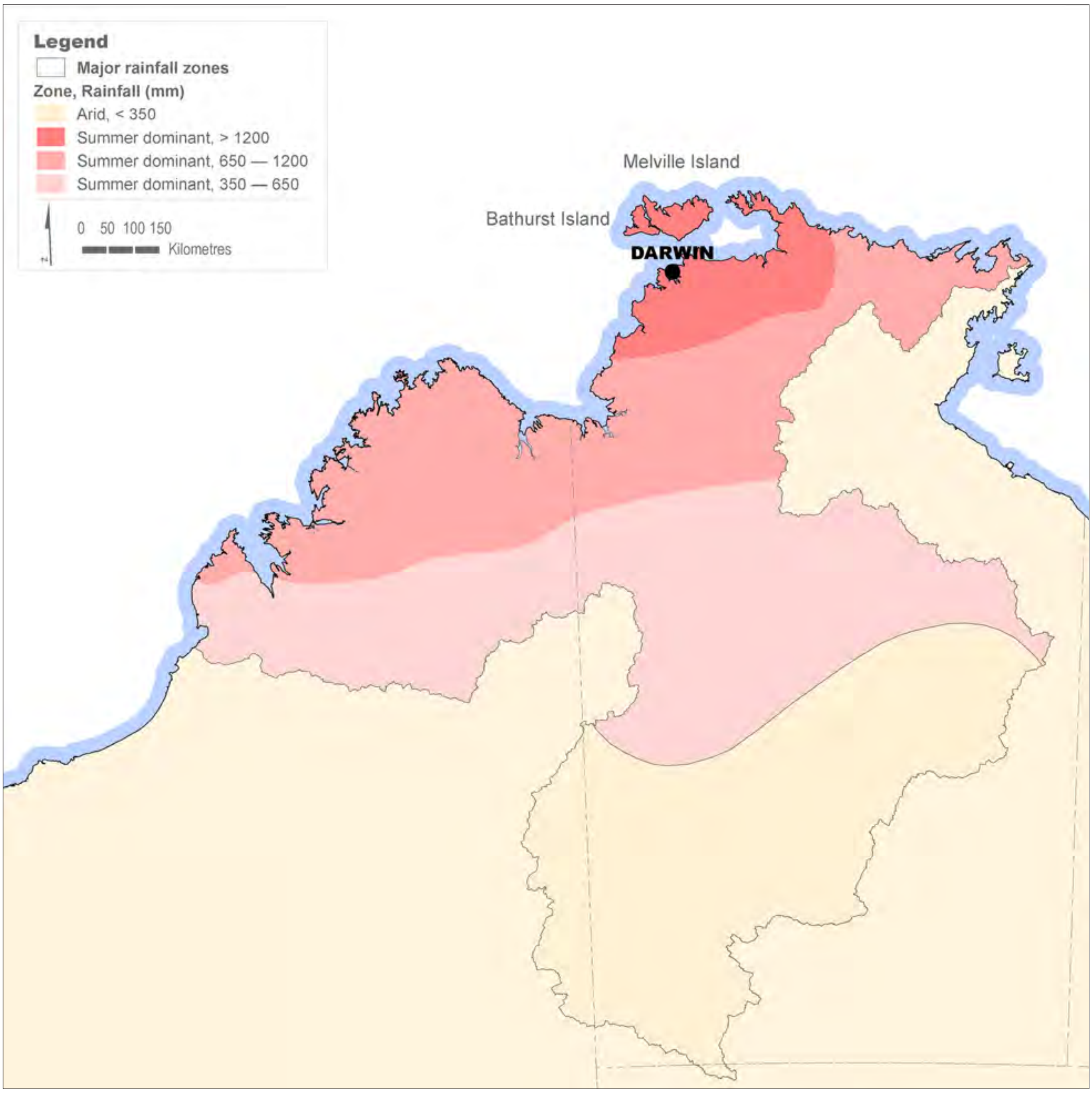


Figure 13.10 Rainfall zones in the Tanami – Timor Sea Coast region

13.3.8 Rainfall deficit

The rainfall deficit indicator, that is, rainfall minus potential evapotranspiration, gives a general impression about which parts of the region are likely to experience moisture deficits over the period of a year. The Tanami – Timor Sea Coast region has a rather uniform pattern of high potential deficits over the whole region (Figure 13.11).

Due to the seasonality of rainfall in the north, with humid wet summers and dry, warm winters, there is a clear pattern of moisture deficits in the dry winter season and moisture recharge in the wet summer season; however, on an annual average basis, the potential evapotranspiration exceeds rainfall.

In the southern arid part of the region, rainfall deficits are high and, as a consequence, vegetation density is low. Most of the southern part of the region is covered by pasture, sparsely used for stock farming and nature conservation.

For more information on the rainfall and evapotranspiration data, see the Bureau's maps of average conditions: www.bom.gov.au/climate/averages/maps.shtml

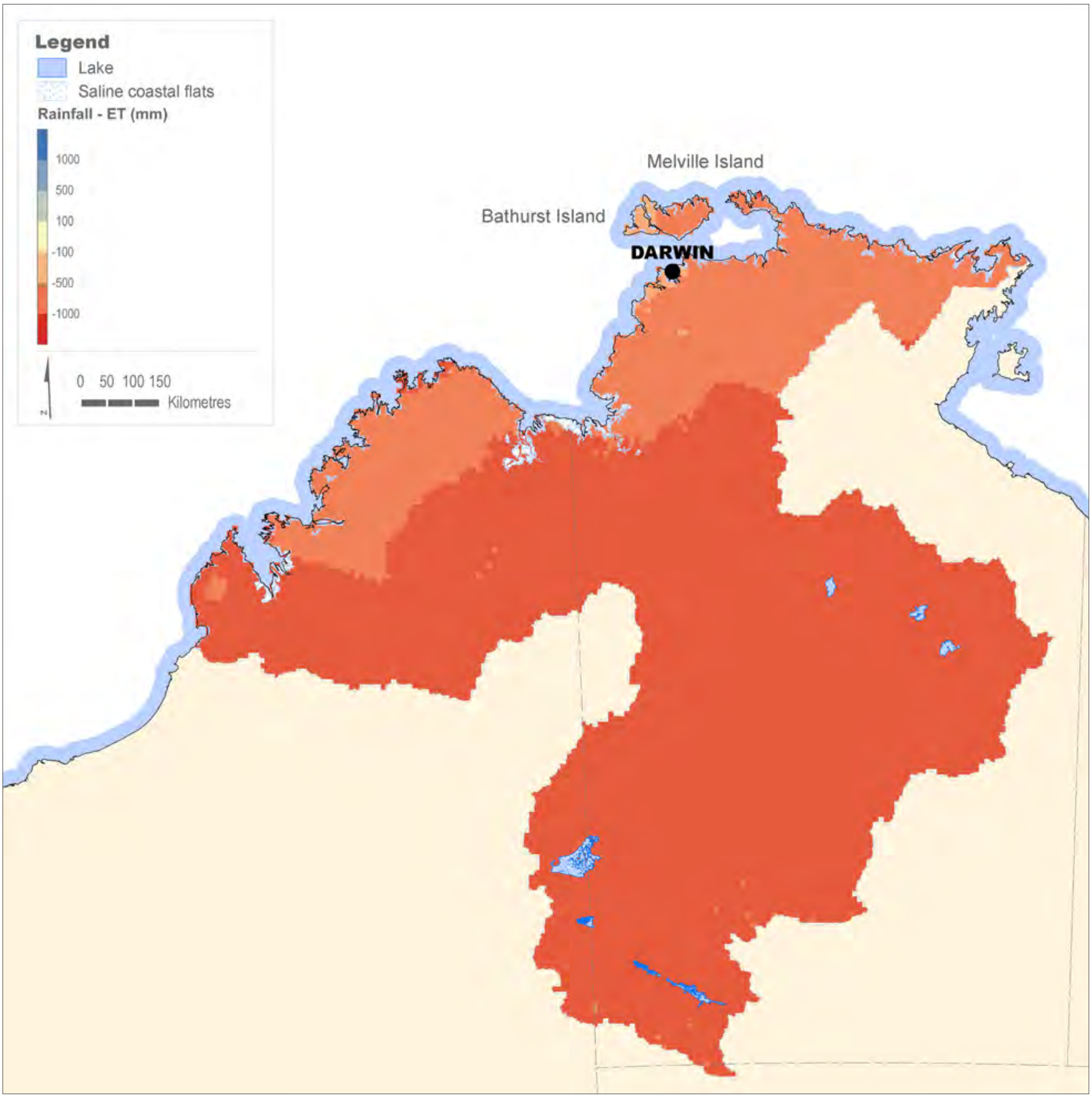


Figure 13.11 Rainfall deficit distribution for the Tanami – Timor Sea Coast region

13.4 Landscape water flows

This section presents analyses of the spatial and temporal variation of landscape water flows (rainfall, evapotranspiration and landscape water yield) across the Tanami – Timor Sea Coast region in 2011–12. National rainfall grids were generated using data from a network of persistent, high-quality rainfall stations managed by the Bureau. Evapotranspiration and landscape water yields were derived using the landscape water balance component of the Australian Water Resources Assessment System (Van Dijk 2010). These methods and associated output uncertainties are discussed in the Introduction and addressed in more detail in the Technical Supplement.

Figure 13.12 shows that the region has a highly seasonal rainfall pattern with a wet summer period (November–April) and a dry winter period (May–October). Evapotranspiration in the dry season generally exceeds rainfall. After the wet season the soils normally contain a lot of moisture that is available for evapotranspiration.

The monthly landscape water yield history for the region shows a stable pattern of very low yield in the dry season. It gradually increases during December through to February and subsides in March and April.

The 2011–12 year was a relatively wet year, with the wet season starting particularly early. An active monsoon in the region's north contributed to particularly high rainfall totals for the month of March.

With wet soil conditions present in July 2011 and above average rain in October and November, evapotranspiration was above average for the first six months of 2011–12. After the March rainfall, evapotranspiration again remained above the 75th percentile until June 2012.

The landscape water yield for 2011–12 closely followed the monthly rainfall pattern. Landscape water yield in March was the fourth highest on record (1911–2012), following the seventh highest, as a consequence of the seventh highest rainfall on record for that month.

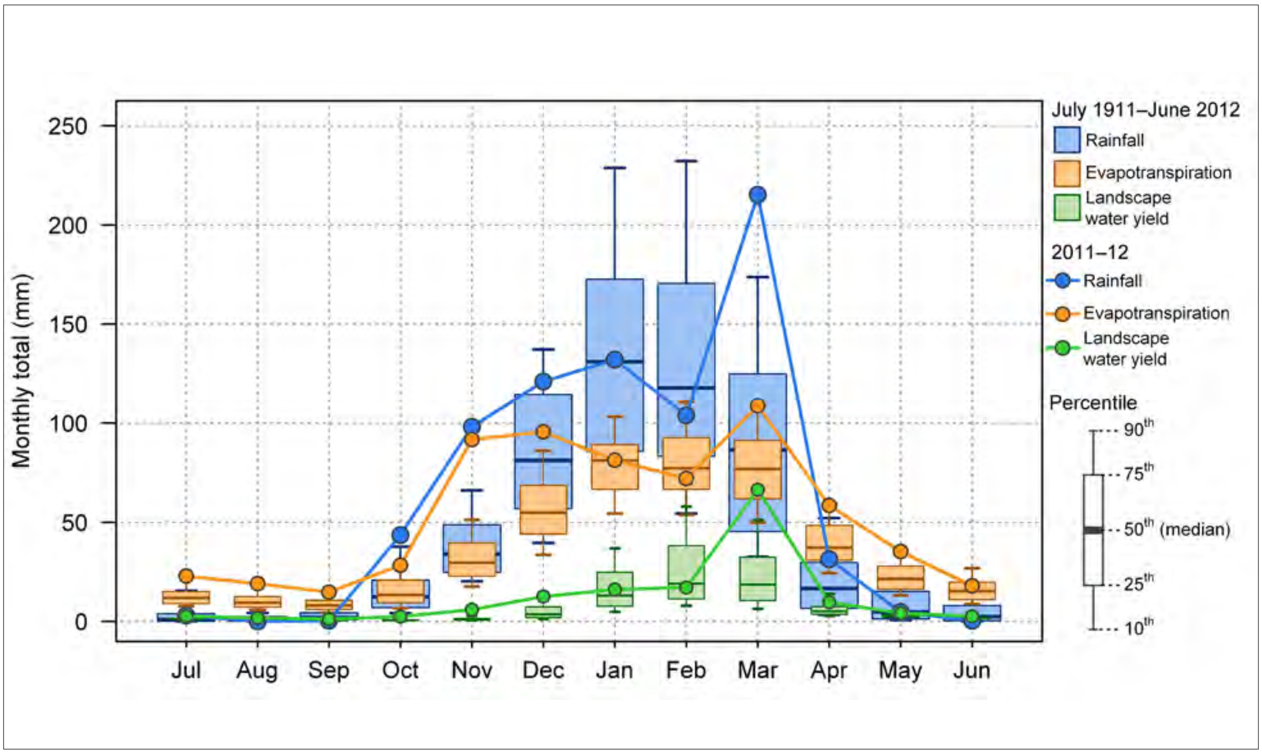


Figure 13.12 Landscape water flows in 2011–12 compared with the long-term record (July 1911–June 2012) for the Tanami – Timor Sea Coast region

13.4.1 Rainfall

Rainfall for the Tanami – Timor Sea Coast region for 2011–12 is estimated to be 754 mm. This is 35% above the region's long-term average (July 1911–June 2012) of 559 mm. Figure 13.13a shows that the highest rainfall occurred in the tropical north with annual totals exceeding 1,200 mm in many areas for 2011–12. The Tanami district in the south had rainfall not exceeding 600 mm.

The high data uncertainty areas in the map indicate those areas where rain gauge density is too low to accurately capture localised rainfall, often in the form of localised thunderstorms.

Rainfall deciles for 2011–12 indicate average to above average rainfall for the entire region over the course of the year (Figure 13.13b). Scattered throughout the region are areas with very much above average rainfall.

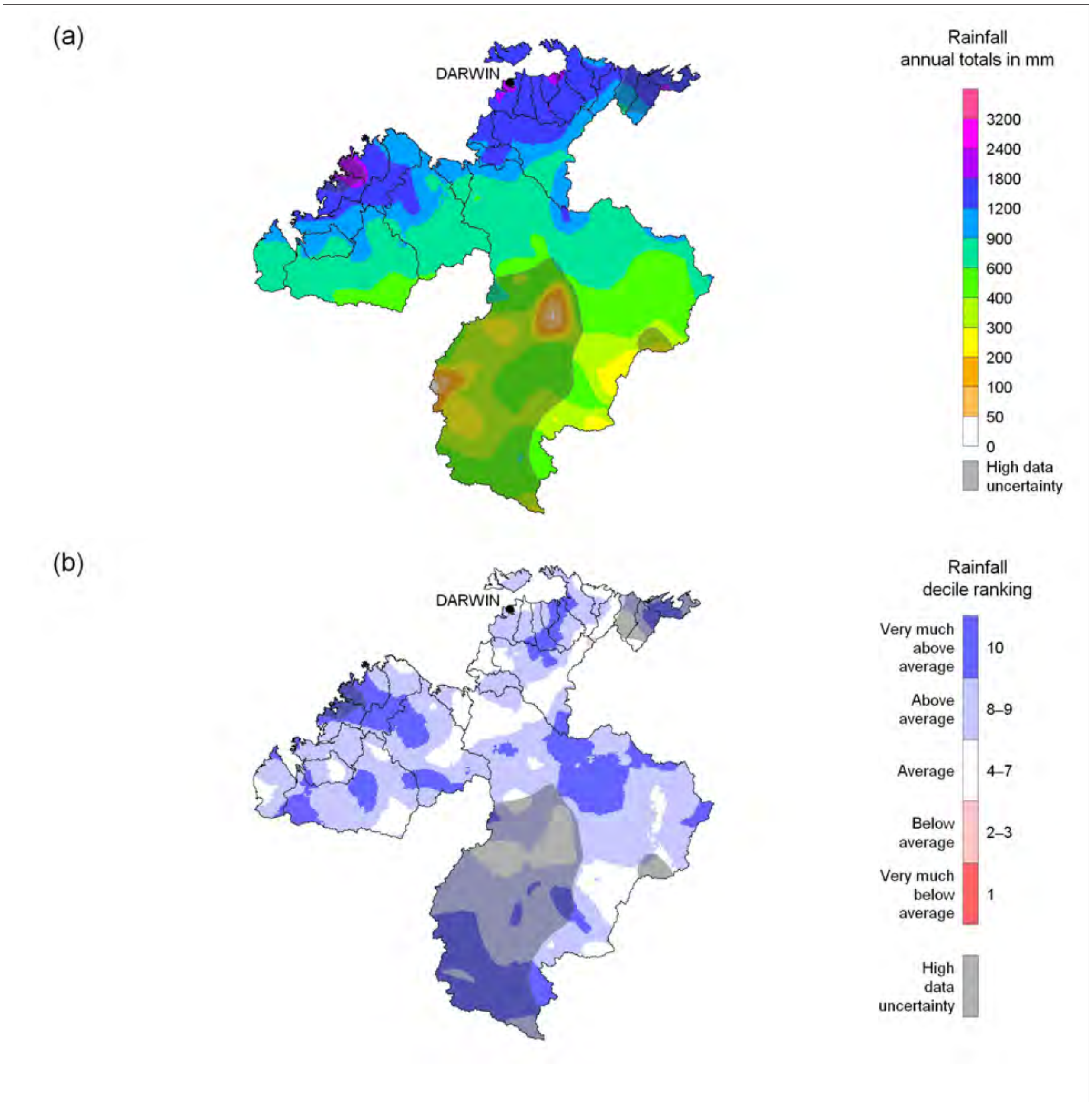


Figure 13.13 Spatial distribution of (a) annual rainfall in 2011–12, and (b) their decile rankings over the 1911–2012 period for the Tanami – Timor Sea Coast region

Rainfall variability in the recent past

Figure 13.14a shows annual rainfall for the region from July 1980 onwards. Over this 32-year period the annual average was 679 mm, varying from 362 mm (1991–92) to 1,236 mm (2010–11). Temporal variability and seasonal patterns since 1980 are presented in Figure 13.14b.

The graphs indicate the presence of a rising trend in average rainfall over the region from 1990 onwards; however, the last six years had close to average rainfall in the region with only 2010–11 having exceptionally high rainfall.

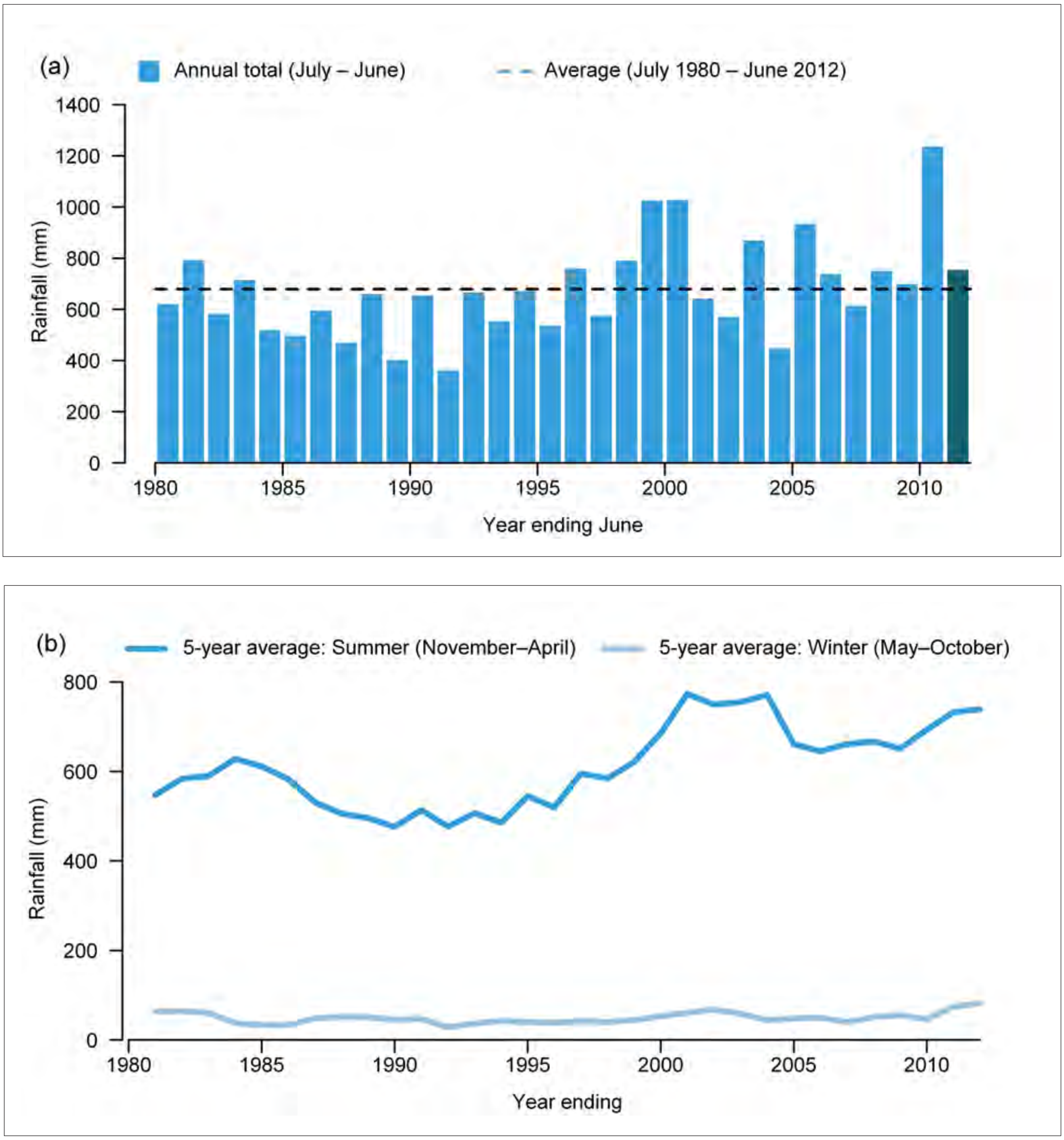


Figure 13.14 Time-series of (a) annual rainfall, and (b) five-year retrospective moving averages for the wet summer (November–April) and dry winter (May–October) periods for the Tanami – Timor Sea Coast region

Recent trends in rainfall

Figure 13.15a presents the spatial distribution of the trends in annual rainfall for July 1980–June 2012. These are derived from linear regression analyses on the time-series of each model grid cell.

The statistical significance of the trends is provided in Figure 13.15b.

Figure 13.15a shows that since 1980 a strong increase in rainfall has occurred in large parts of the region, particularly towards the north. Some areas reached trends of up to 20 mm/year. The trends are strongly significant in most of these areas (Figure 13.15b).

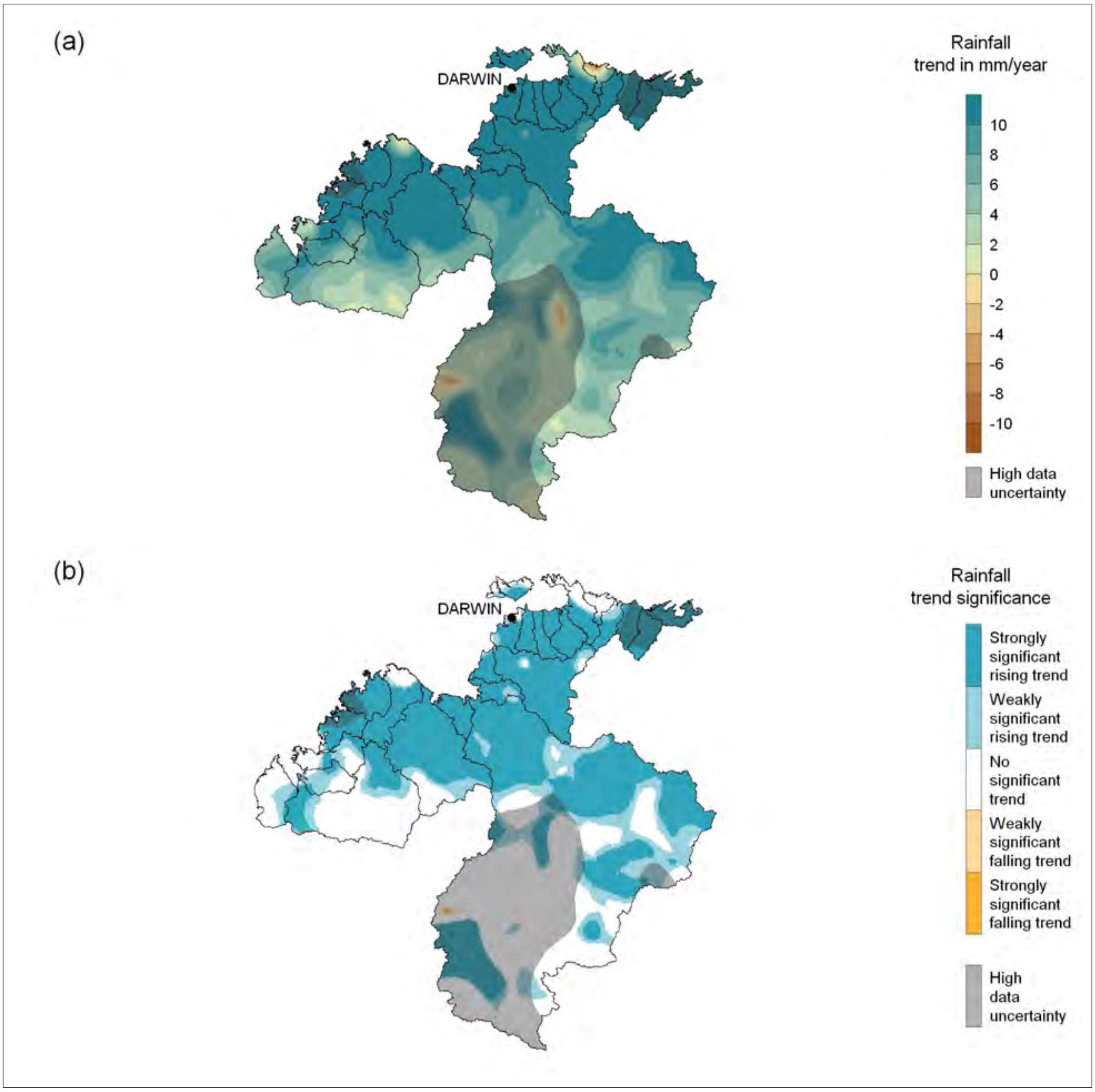


Figure 13.15 Spatial distribution of (a) trends in annual rainfall from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the Tanami – Timor Sea Coast region

13.4.2 Evapotranspiration

Modelled annual evapotranspiration for the Tanami – Timor Sea Coast region for 2011–12 is estimated to be 646 mm. This is 40% above the region's long-term (July 1911–June 2012) average of 461 mm. The spatial distribution of annual evapotranspiration in 2011–12 (Figure 13.16a) is similar to that of rainfall (Figure 13.14a), but with lower annual totals in the north of the region.

Evapotranspiration deciles for 2011–12 indicate above average or very much above average totals across most of the region (Figure 13.16b). The larger areas of very much above average evapotranspiration in comparison to rainfall was made possible by the high soil moisture levels at the start of the year, due to record high rainfall the previous year, which allowed evapotranspiration to be higher than average in the dry months of July– September 2011 (see Figure 13.12).

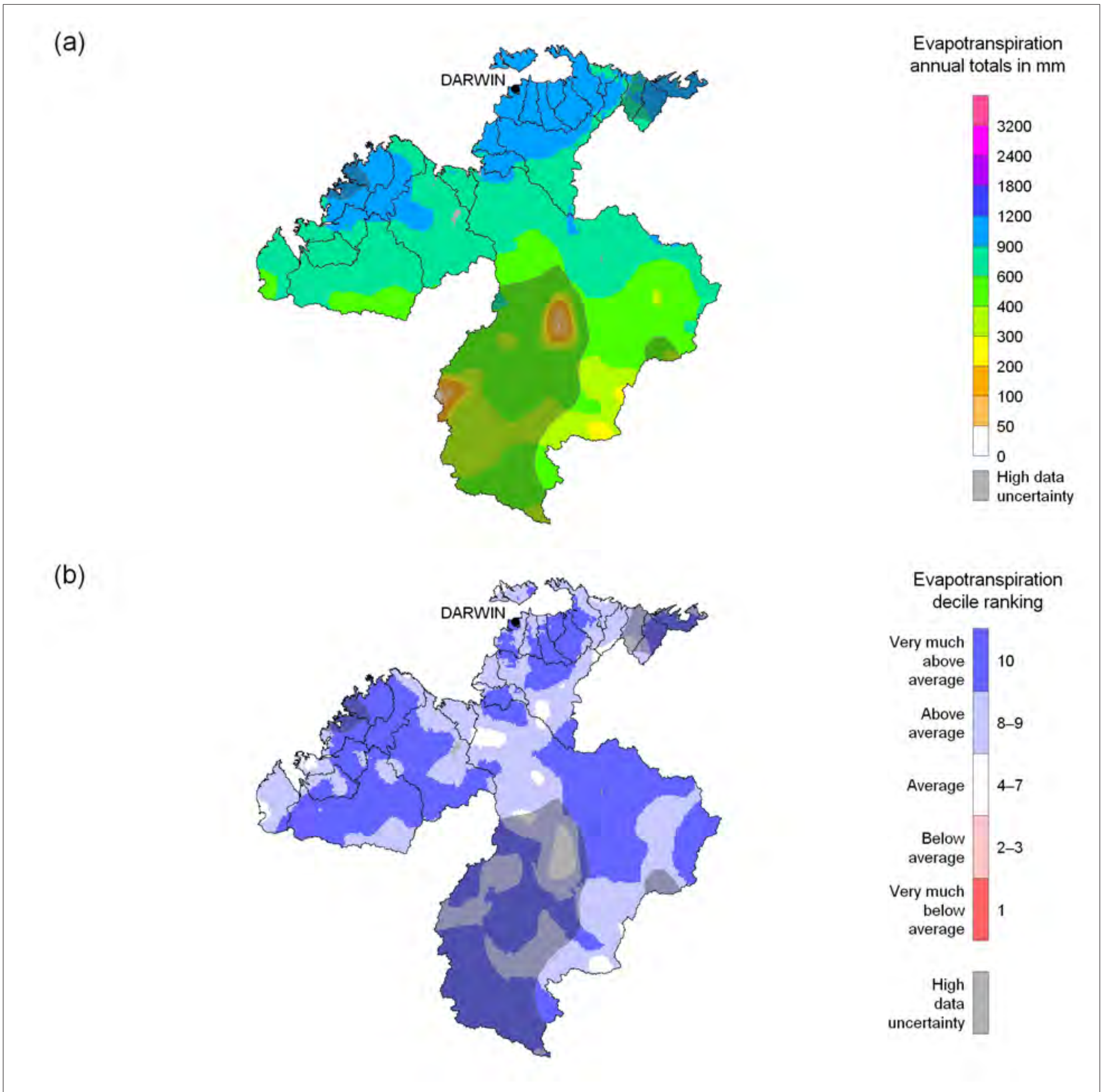


Figure 13.16 Spatial distribution of (a) modelled annual evapotranspiration in 2011–12, and (b) their decile rankings over the 1911–2012 period for the Tanami – Timor Sea Coast region

Evapotranspiration variability in the recent past

Figure 13.17a shows annual evapotranspiration for the region from July 1980 onwards. Over this 32-year period the annual evapotranspiration average was 541 mm, varying from 379 mm (1991–92) to 807 mm (2010–11). Temporal variability and seasonal patterns since 1980 are presented in Figure 13.17b.

The wet period (November–April) shows consistently higher evapotranspiration than the dry period. Evapotranspiration in the dry period is substantially higher than rainfall in this period (Figure 13.14b), whereas evapotranspiration in the wet period is substantially lower than rainfall in this period.

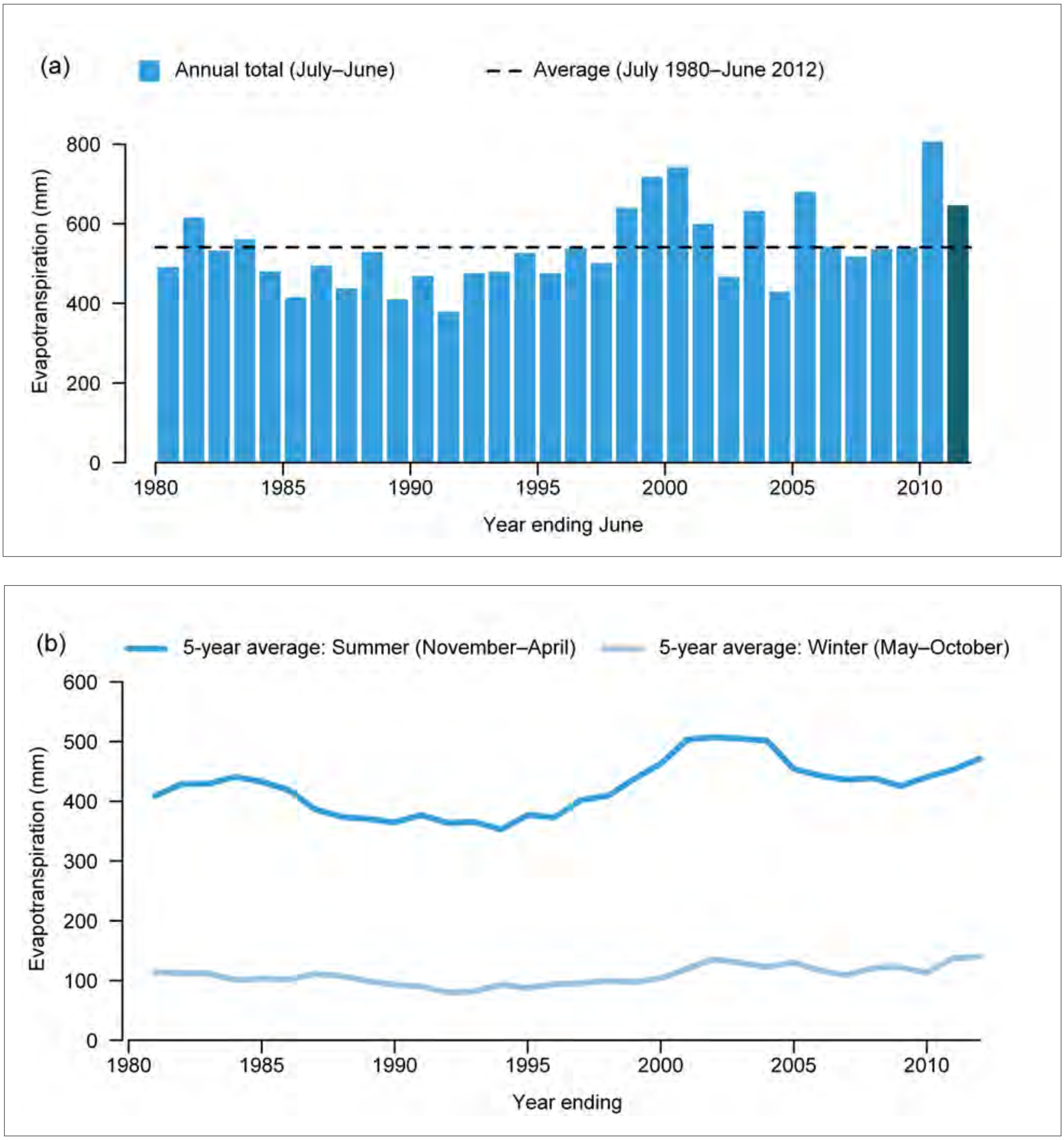


Figure 13.17 Time-series of (a) annual evapotranspiration, and (b) five-year retrospective moving averages for the wet summer (November–April) and dry winter (May–October) periods for the Tanami –Timor Sea Coast region

Recent trends in evapotranspiration

Figure 13.18a presents the spatial distribution of the trends in modelled annual evapotranspiration for 1980–2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 13.18b.

The trends in evapotranspiration are rising throughout the region with some local exceptions along the northern coastline. As shown in Figure 13.18b, the trends are statistically significant in most parts of the region, particularly in those areas where the rising trends are high.

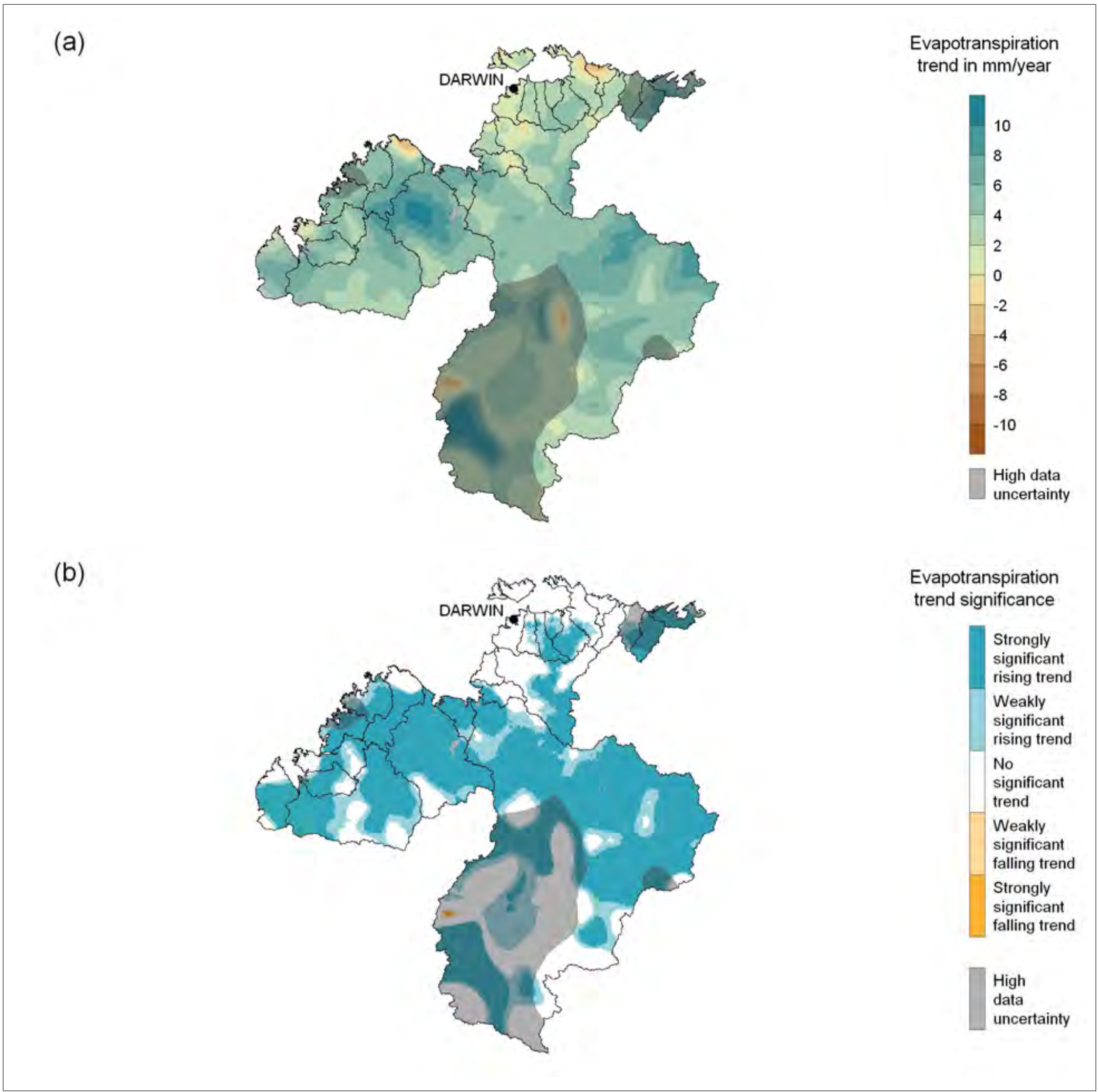


Figure 13.18 Spatial distribution of (a) trends in annual evapotranspiration from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the Tanami – Timor Sea Coast region

13.4.3 Landscape water yield

Modelled landscape water yield for the Tanami – Timor Sea Coast region for 2011–12 is estimated to be 142 mm. This is 53% above the region's long-term (July 1911– June 2012) average of 93 mm. Figure 13.19a shows the spatial distribution of landscape water yield for 2011–12, which is similar to the annual rainfall distribution (Figure 13.13a).

The highest landscape water yields in 2011–12 are observed in some areas along the coast, locally exceeding 600 mm. In the southern Tanami district landscape water yield did not exceed 50 mm.

The decile-ranking map for 2011–12 (Figure 13.19b) shows average to above average landscape water yields, which again shows high similarity with the rainfall decile map of Figure 13.13b.

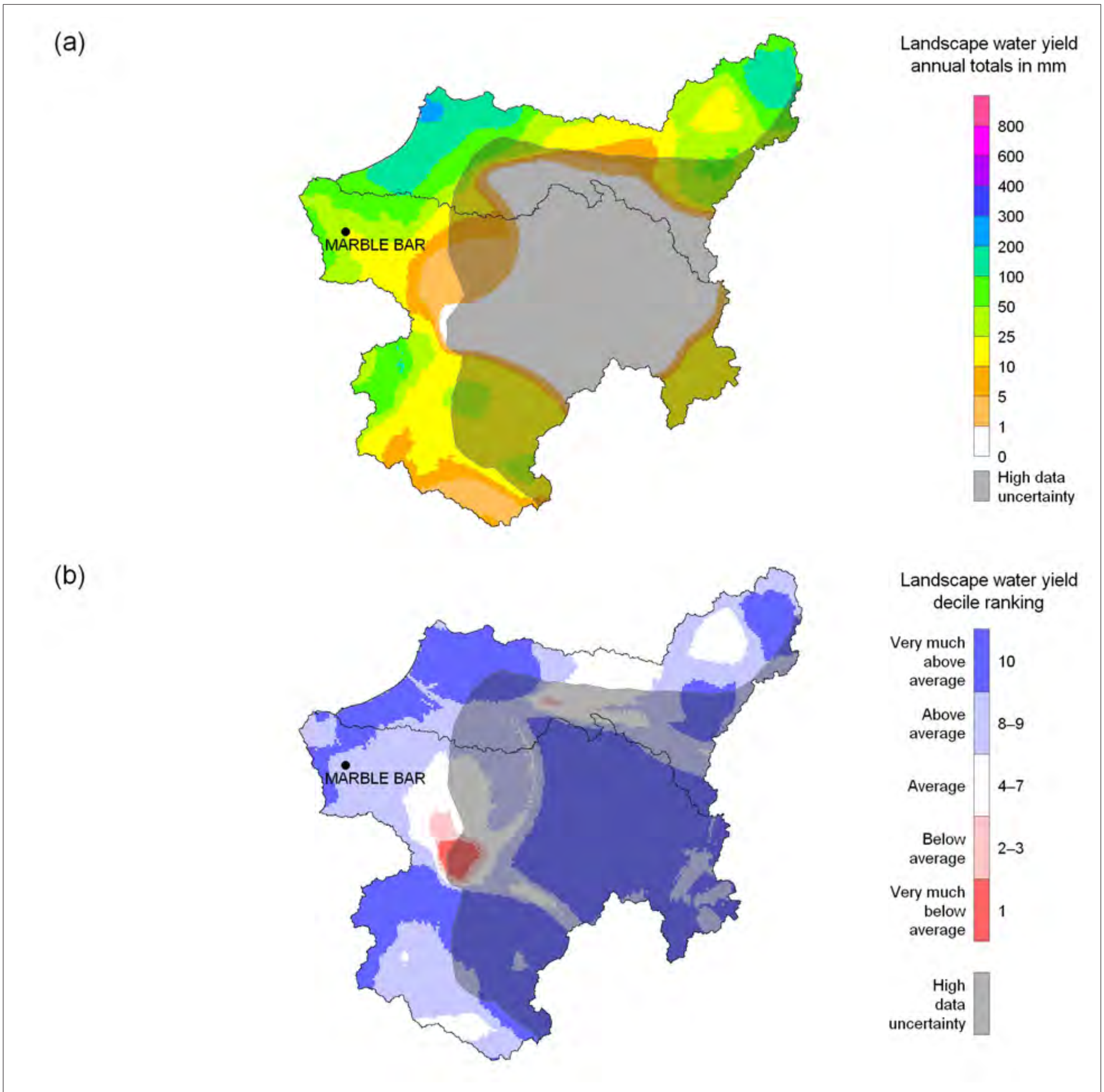


Figure 13.19 Spatial distribution of (a) modelled annual landscape water yield in 2011–12, and (b) their decile rankings over the 1911–2012 period for the Tanami – Timor Sea Coast region

Landscape water yield variability in the recent past

Figure 13.20a shows annual landscape water yield for the Tanami – Timor Sea Coast region from July 1980 onwards. Over this 32-year period, annual landscape water yield was 132 mm, varying from 30 mm (1989–90) to 377 mm (2010–11). Temporal variability and seasonal patterns since 1980 are presented in Figure 13.20b.

Landscape water yield in 2010–11 was very much above average, but even without this exceptional year the general trend in regional average annual landscape water yield shows a rising trend since 1990. This can be totally allocated to increased rainfall in the wet period. In the first half of the reference period, only three years reached total annual landscape water yields that were above the periods average, albeit only marginally.

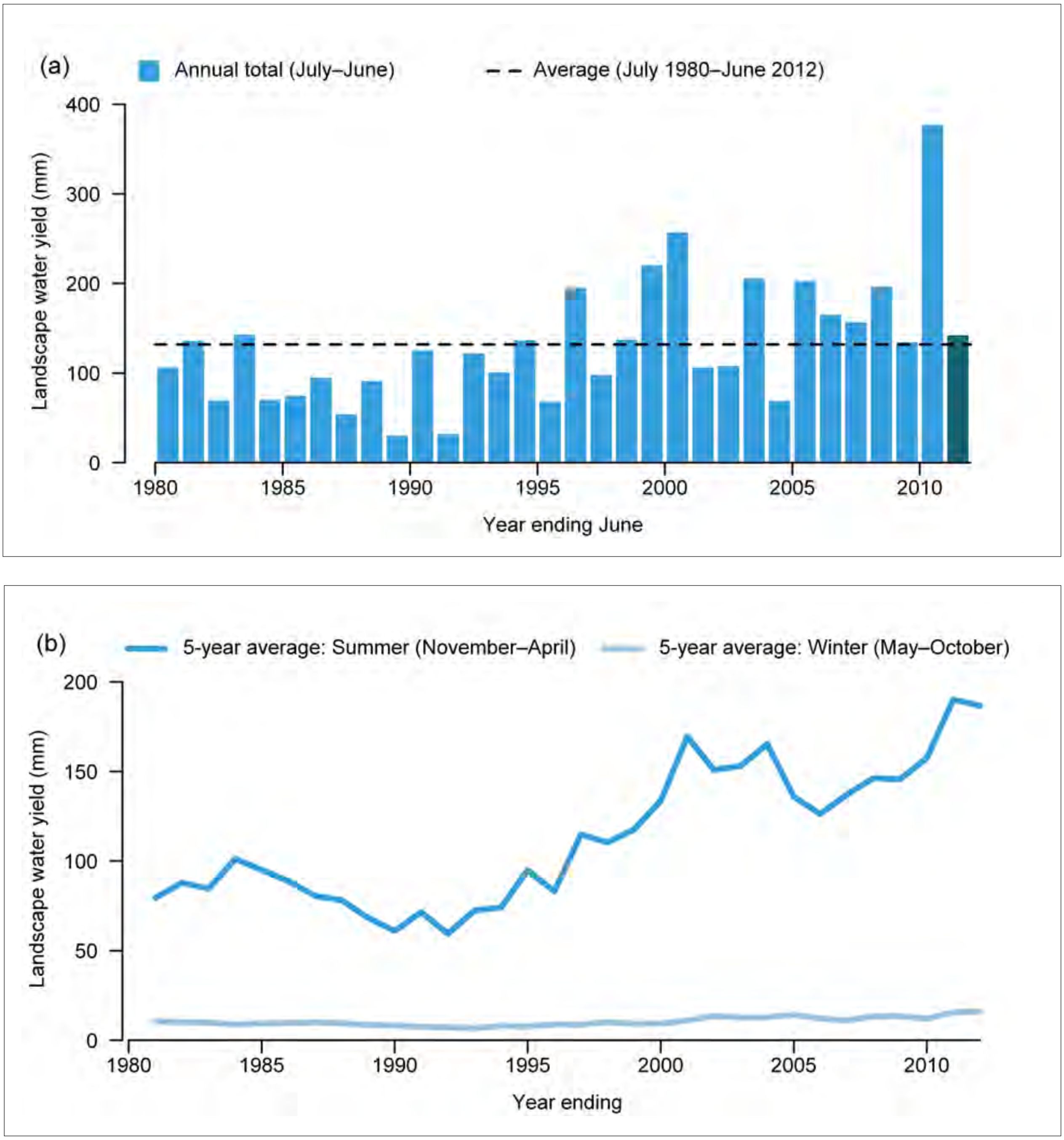


Figure 13.20 Time-series of (a) annual landscape water yield, and (b) five-year retrospective moving averages for the wet summer (November–April) and dry winter (May–October) periods for the Tanami – Timor Sea Coast region

Recent trends in landscape water yield

Figure 13.21a shows the spatial distribution of the trends in modelled annual landscape water yield for 1980–2012. These are derived from linear regression analyses on the time-series of each model grid cell. The statistical significance of the trends is provided in Figure 13.21b. Figure 13.21a shows strong rising trends occur in the north of the region. In some areas these trends exceed 16 mm/year.

As well as the trends being statistically significant in the north, a large area of strongly significant rising trends is also present in the central east of the region. With much lower landscape water yield in this part of the region, the small rise in annual totals is still statistically significant.

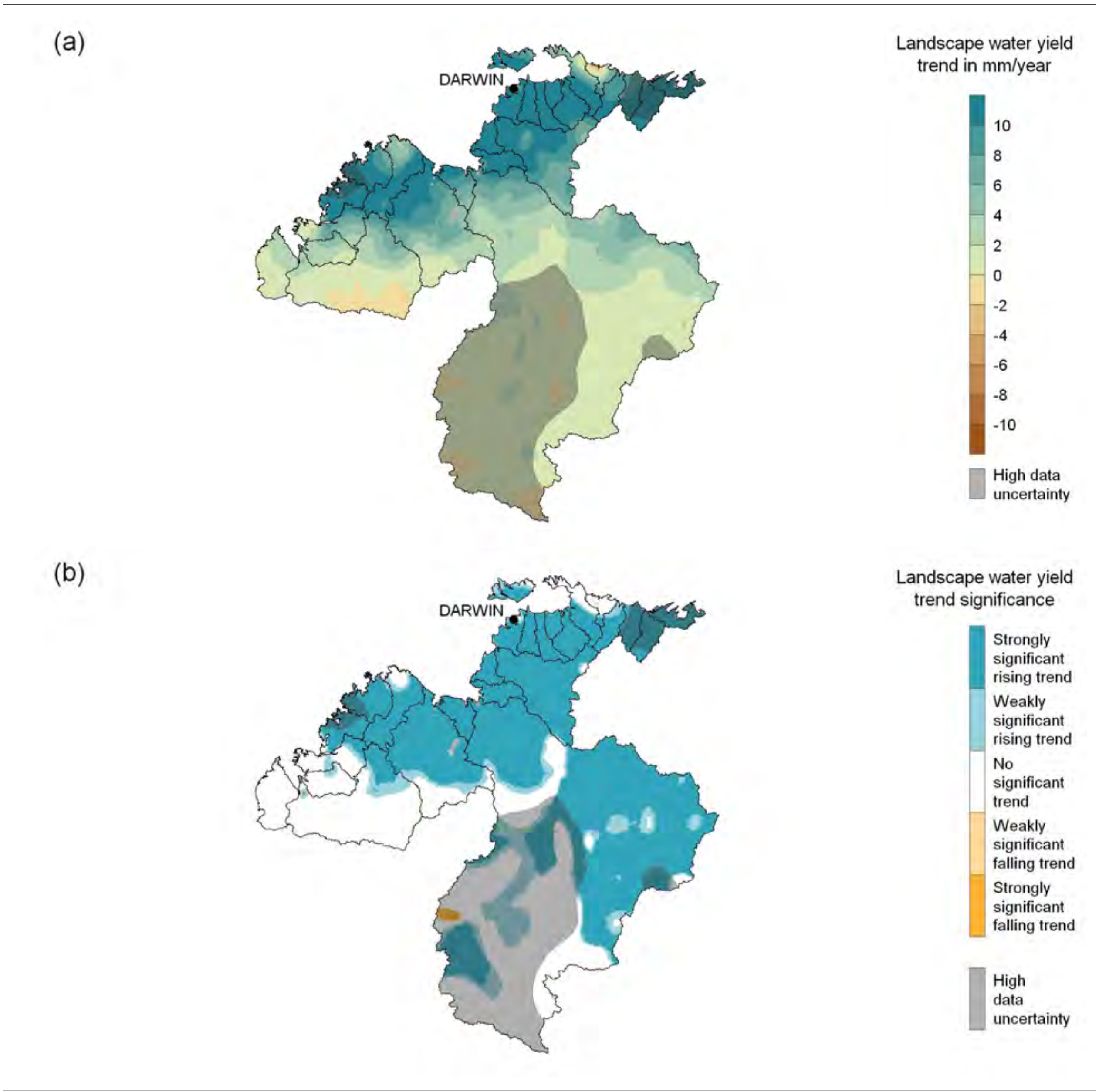


Figure 13.21 Spatial distribution of (a) trends in annual landscape water yield from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the Tanami – Timor Sea Coast region

13.5 Surface water and groundwater

This section examines surface water and groundwater resources in the Tanami – Timor Sea Coast region in 2011–12. Rivers, wetlands and storages are discussed to illustrate the state of the region's surface water resources. The region's watertable aquifers and salinity are described. No data was available at the Bureau in a suitable format for a detailed analysis on individual aquifers.

13.5.1 Rivers

There are 25 river basins in the Tanami – Timor Sea Coast region, varying in size from 4,800 to 670,000 km^2 (Figure 13.22).

Major river basins of the region are the Ord, Daly, Fitzroy, Victoria and Finniss. The topography of the region generates two dominant drainage patterns.

There is a complex network of floodplain rivers that flow north to the Timor Sea. The inland Victoria River–Wiso catchment, however, covers the Tanami Desert, with several ephemeral rivers draining southwards to temporarily fill inland ephemeral lakes, depending on the scale and intensity of rainfall and run-off.

River flows in the tropical northern parts of the region experience distinct seasonal patterns with approximately 90% of the average annual discharge occurring in the four-month wet season from December–March. One of the largest rivers, the Ord River with an approximate length of 650 km, has its headwaters in the Dixon Range near Hill's Creek. The flow at the headwaters is seasonal, but has become perennial below Lake Argyle. This is due to agricultural developments in this area and flow modifications for irrigation supply.The lower section of the Ord River is a large tidal estuary.

Katherine Gorge | photosbyash (iStockphoto)

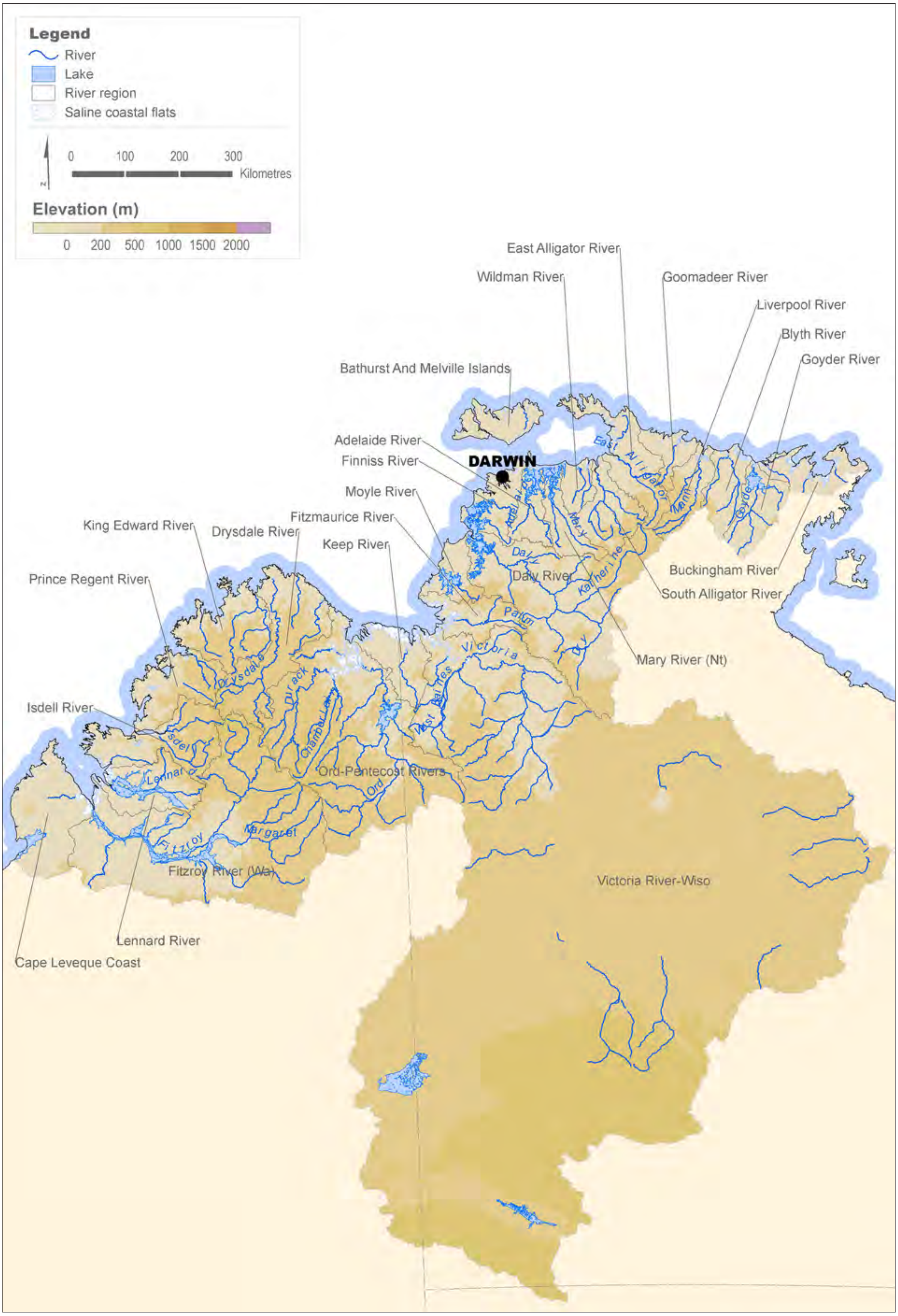


Figure 13.22 Rivers and catchments in the Tanami – Timor Sea Coast region

13.5.2 Streamflow volumes

River monitoring gauges are relatively sparsely distributed in the Tanami – Timor Sea Coast region due to the low population. Figure 13.23 presents an analysis of flows at 13 monitoring sites during 2011–12 relative to annual flows for the period from July 1980–July 2012. Monitoring gauges with relatively long records across five geographically representative rivers were selected (see Technical Supplement for details). The annual flows for 2011–12 are colour-coded according to the decile rank at each site over the 1980–2012 period.

The flows generally reflect the mostly average to above average modelled landscape water yield results shown in Figure 13.19b.

Very much above average flows were observed at one monitoring site located on the Douglas River in the central north of the Tanami – Timor Sea Coast region. Above average total flows were recorded at three monitoring sites. These were mainly located on the rivers in the north of the region.

Average flows occurred at eight sites in the region which were located on the rivers in the region's central north. Of the 13 monitoring sites, there was only one below average flow recorded across the region in 2011–12. This one monitoring site was on Rapid Creek, a flash flood system in the far north.

Flow deciles in the wet season (November 2011–April 2012) were similar to total annual flows for 2011–12 as shown in Figure 13.23. Wet season high river levels are the typical pattern for flows in this part of Australia, especially in the region's north. There were a few monitoring sites that did not show this general pattern of high wet season flows. Lower flows during this period were recorded for the Katherine and the Douglas rivers in the central north of the region.

Suitable salinity data were not available during this period. Therefore, streamflow salinity analysis is not included in the chapter.

13.5.3 Flooding

Figure 13.24 shows that some moderate flooding occurred at the monitored river gauge sites, associated with heavy rainfalls in January and March. The most significant flood occurred in the Daly River south of Darwin.

Other rivers had a minor flood level measured during 2011–12, but most rivers remained below flood levels.

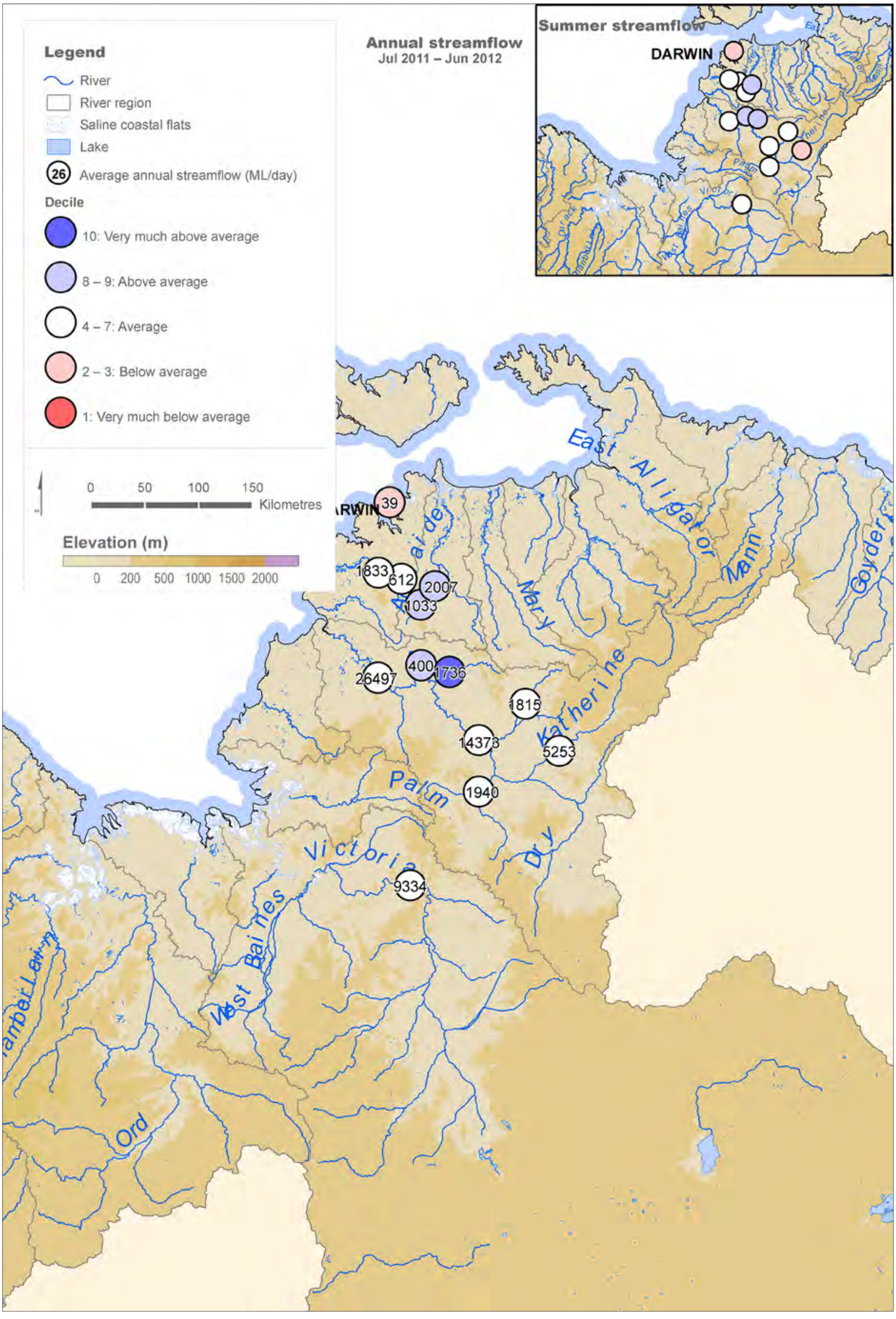


Figure 13.23 Average annual and wet season (November 2011–April 2012) flow volumes at monitoring sites for 2011–12 and their decile rankings over the 1980–2012 period in the Tanami – Timor Sea Coast region

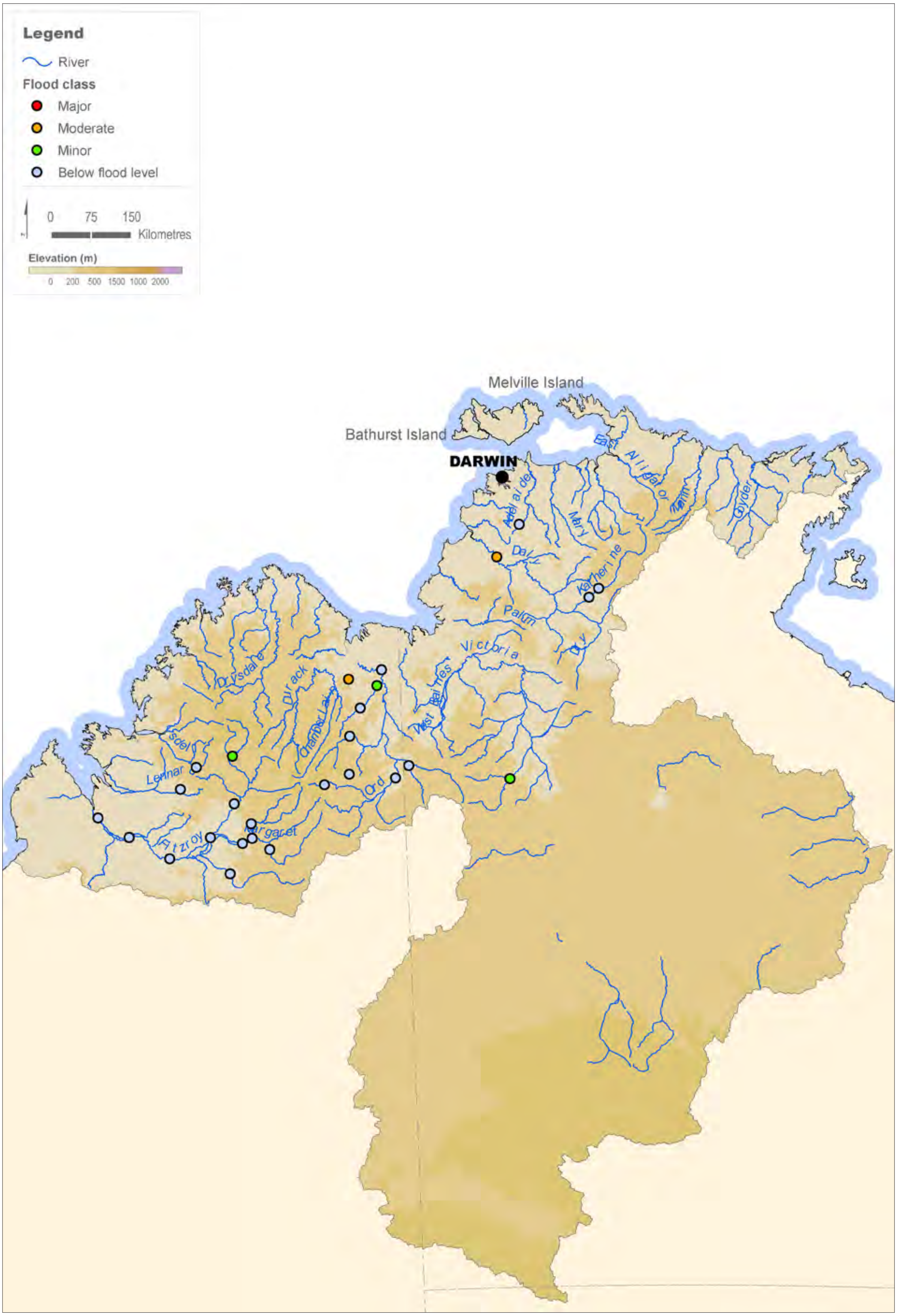


Figure 13.24 Flood occurrence in 2011–12 for the Tanami – Timor Sea Coast region

13.5.4 Storage systems

There are ten major, publicly owned, storages in the Tanami – Timor Sea Coast region with a total storage capacity in excess of 11,200 GL. The Bureau's water storage website includes information on approximately 96% of the region's publicly owned storages (as at August 2012).

The major storages in the region supply the Ord irrigation scheme and the city of Darwin. Table 13.3 gives a summary of the region's major storage systems together with an overview of the storage levels at the end of 2010–11 and 2011–12. Storage volumes reflect the situation in the middle of the dry season. The location of all the systems and associated storages are shown in Figure 13.25.

Lake Argyle, the major storage in the Ord irrigation scheme with an accessible capacity of 10,400 GL, is the second largest storage of Australia, after Lake Gordon in Tasmania, and is the result of a major plan to increase the generally abundant water resources in the north of the country. During 2011–12, the storage volumes were much above full supply level and spilling, with the exception of February 2012 and the end of June 2012.

The Darwin River storage also has no water shortage and hence the city of Darwin has no water conservation rules in place. The storage was filled up to full supply level during the wet season.

Further information on the past and present volumes of the storage systems and the individual storages can be found on the Bureau's water storage website (http://water.bom.gov.au/waterstorage/awris/).

13.5.5 Wetlands

There are five Ramsar-listed, internationally important wetlands in the Tanami – Timor Sea Coast region as well as a number of wetlands of national importance mentioned in the *Australian Directory of Important Wetlands* (www.environment.gov.au/water/topics/wetlands/database/diwa.html).

The wetlands mainly consist of river floodplains and estuaries as well as inland ephemeral lakes (Figure 13.26). The artificial lakes Argyle and Kununurra are listed under the Ramsar convention.

No detailed assessment on the inflows of selected wetlands has been performed for this region.

Table 13.3 Storage systems in the region as identified in the Bureau's water storage information (August 2012), with 'non-allocated' accounting for the storages not allocated to a particular system

System name	System type	System capacity	Accessible volume at 30 June 2011	Accessible volume at 30 June 2012
Ord	rural	10,446 GL	10,440 GL—100%	10,286 GL—98%
Darwin	urban	285 GL	268 GL—94%	262 GL—92%
Non-allocated	—	1.8 GL	1.7 GL—94%	1.7 GL—94%
Total		10,733 GL	10,710 GL—100%	10,549 GL—98%

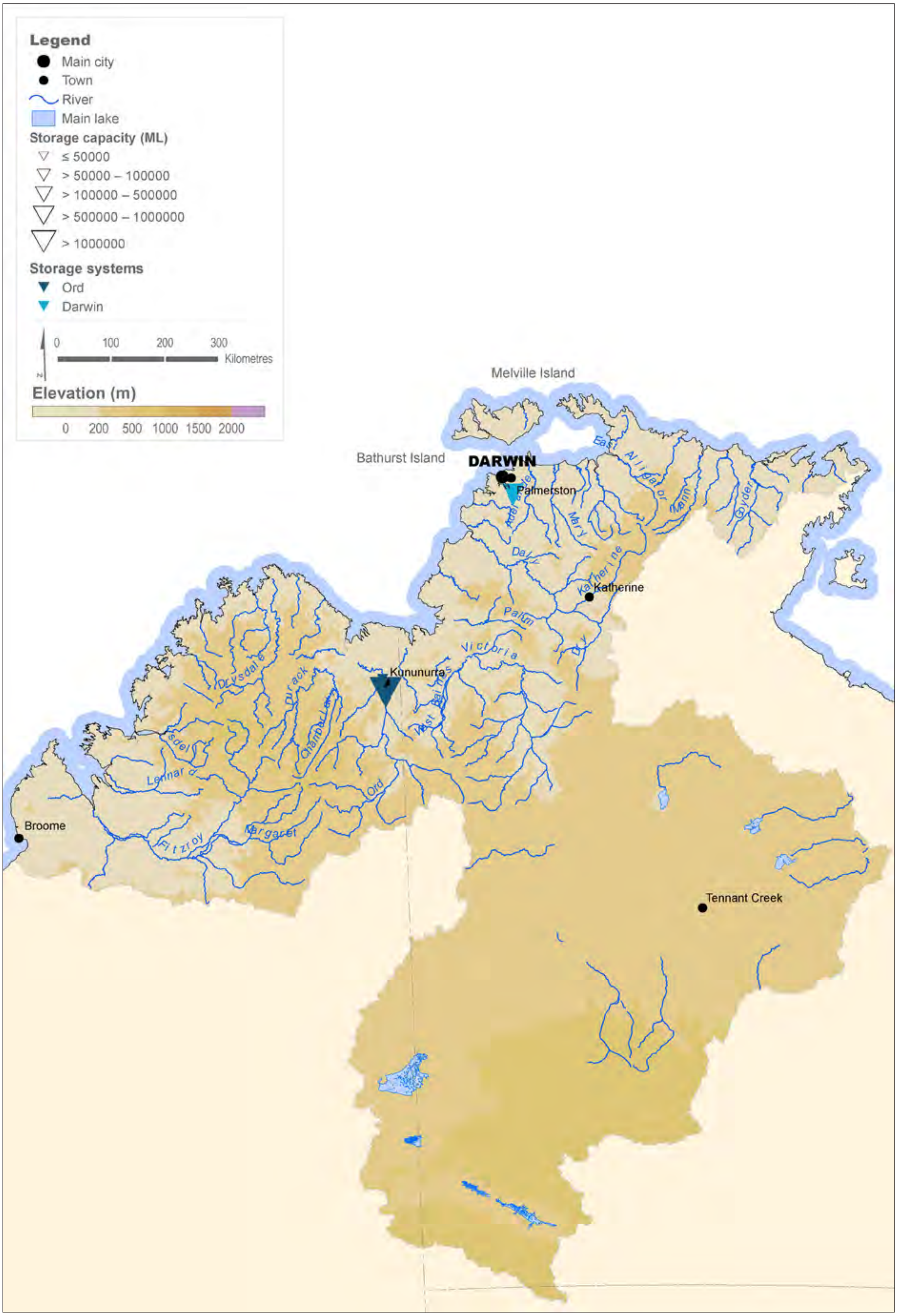


Figure 13.25 Storage systems in the Tanami – Timor Sea Coast region (information extracted from the Bureau of Meteorology's water storage website in August 2012)

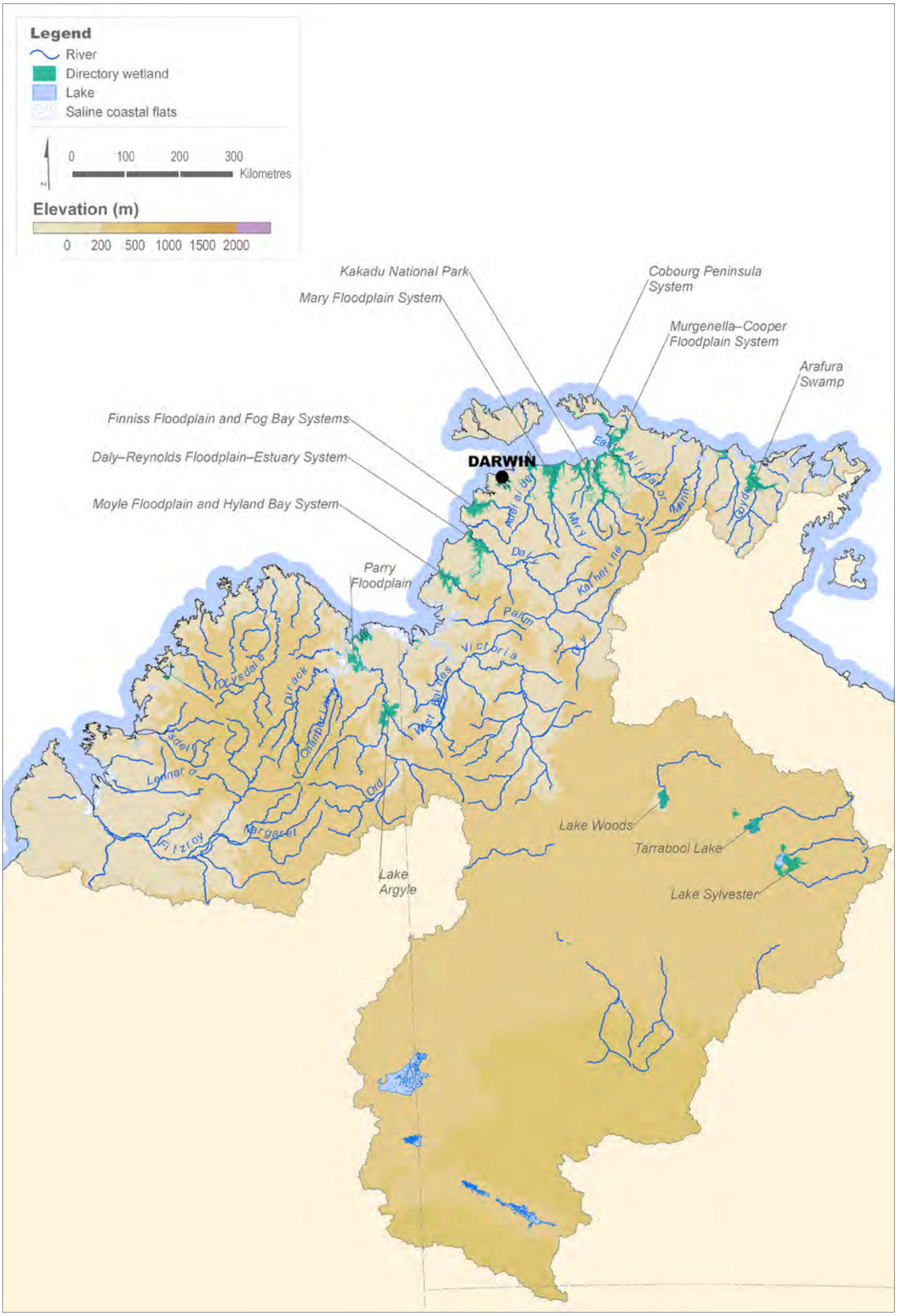


Figure 13.26 Location of important wetlands in the Tanami – Timor Sea Coast region

13.5.6 Hydrogeology

The watertable aquifers present in the region are given in Figure 13.27 below. The hydrogeology of the region is dominated by the Kimberley hard rock plateau and Canning basin sedimentary rocks and by the extensive regional karstic system in the central-east part of the region. In the hard rock plateau, groundwater occurs in lesser but valuable quantities in fractured rocks and surficial river alluvium.

Substantial quantities of confined and unconfined groundwater of varying quality occur in the sedimentary basins. The extensive groundwater resources associated with the widespread fractured and cavernous limestone of the Daly basin are very important for the region.

Groundwater systems that provide great potential for extraction are labelled as:

- Fractured and Karstic rocks, regional scale and local scale aquifers; and
- Mesozoic sediment aquifer (porous media — consolidated).

13.5.7 Watertable salinity

Figure 13.28 shows the classification of watertable aquifers as fresh (total dissolved solids [TDS] < 3,000 mg/L) or saline (TDS ≥ 3,000 mg/L) water according to watertable salinity. Shallow groundwater generally has good quality throughout the region, reflecting the annual fill-and-spill cycle, and can be a good source of local supply of potable water.

In the northern part of the region, watertables in shallow aquifers respond dramatically to the seasonal rains, often rising and falling several metres each year. Many shallow aquifers fill to capacity and drain slowly to the rivers and the coast during the dry season.

The extensive regional aquifers of the Tindall limestone and Oolloo dolostone (in the Daly River basin) are often the primary sources of water that keep local streams flowing year-round (CSIRO 2009).

The areas with high salinity values are relatively small.

13.5.8 Groundwater management units

The groundwater management units within the region are key features that control the extraction of groundwater through planning mechanisms. Figure 13.29 shows that most of the major groundwater management units within the Northern Territory are located within the fractured and karstic rocks aquifers. In Western Australia the major groundwater management unit is the Canning–Kimberley.

Most of the population in the region is concentrated in Darwin, Broome, Katherine and Kununurra. Increasingly surface water, a major source of water for Darwin and Katherine, is supplemented by groundwater while smaller communities usually rely mostly on groundwater. In rural areas, domestic production bores are the main sources of water. The pastoral industry across the region also uses groundwater. Irrigated agriculture occurs predominantly along the Ord River and, at a smaller scale, near Darwin and Katherine.

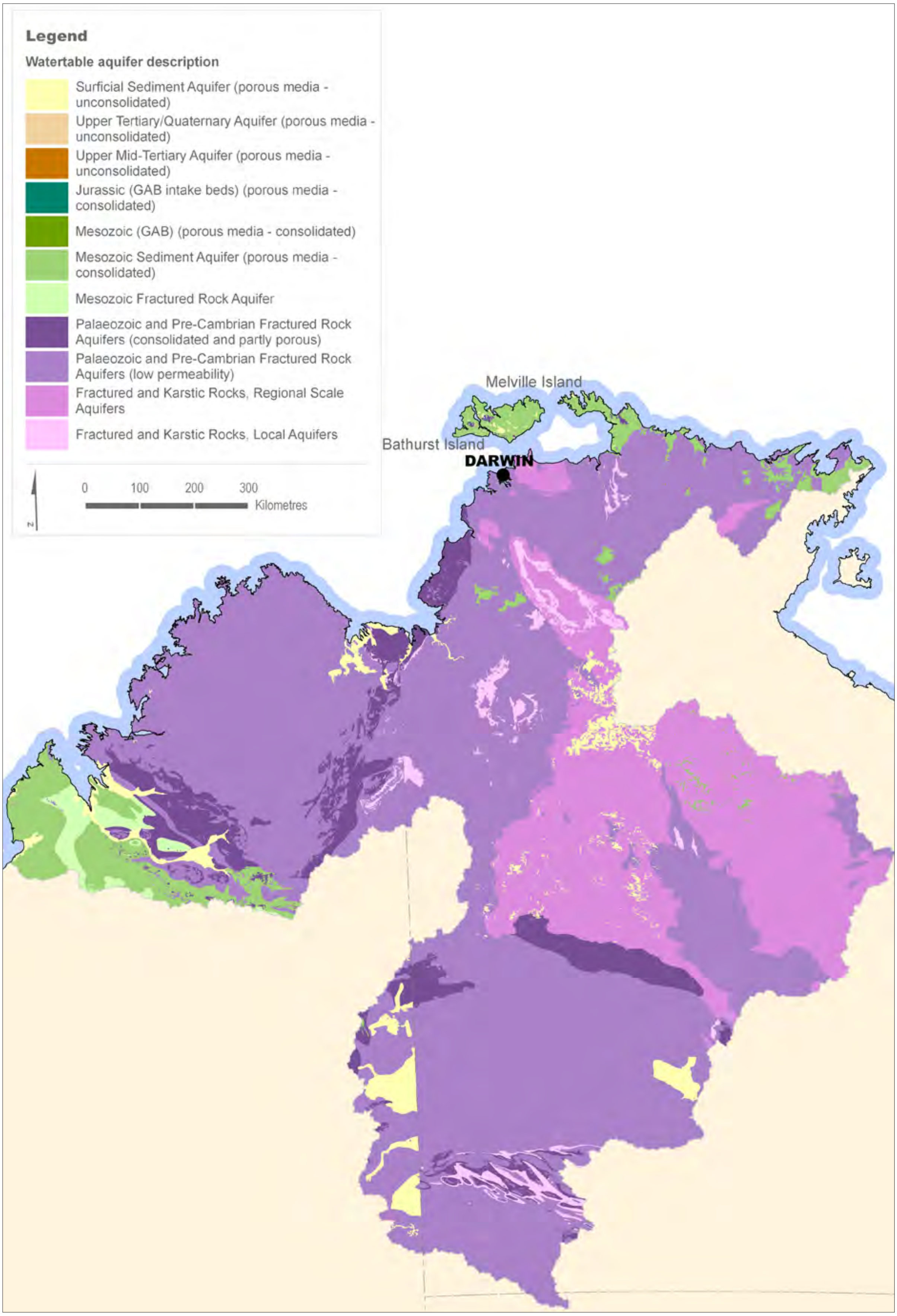


Figure 13.27 Watertable aquifers of the Tanami – Timor Sea Coast region, data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

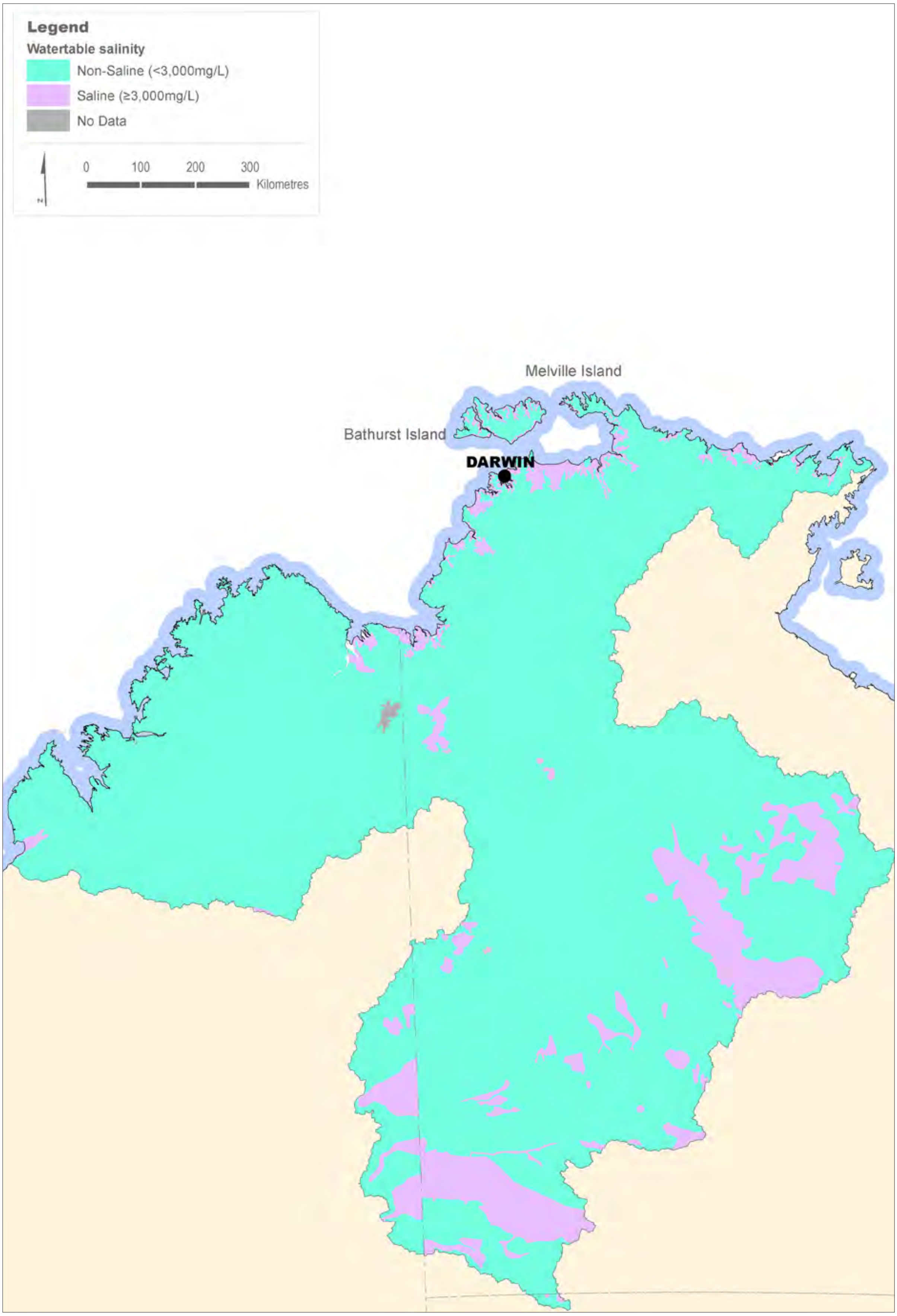


Figure 13.28 Watertable salinity classes in the Tanami – Timor Sea Coast region, data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

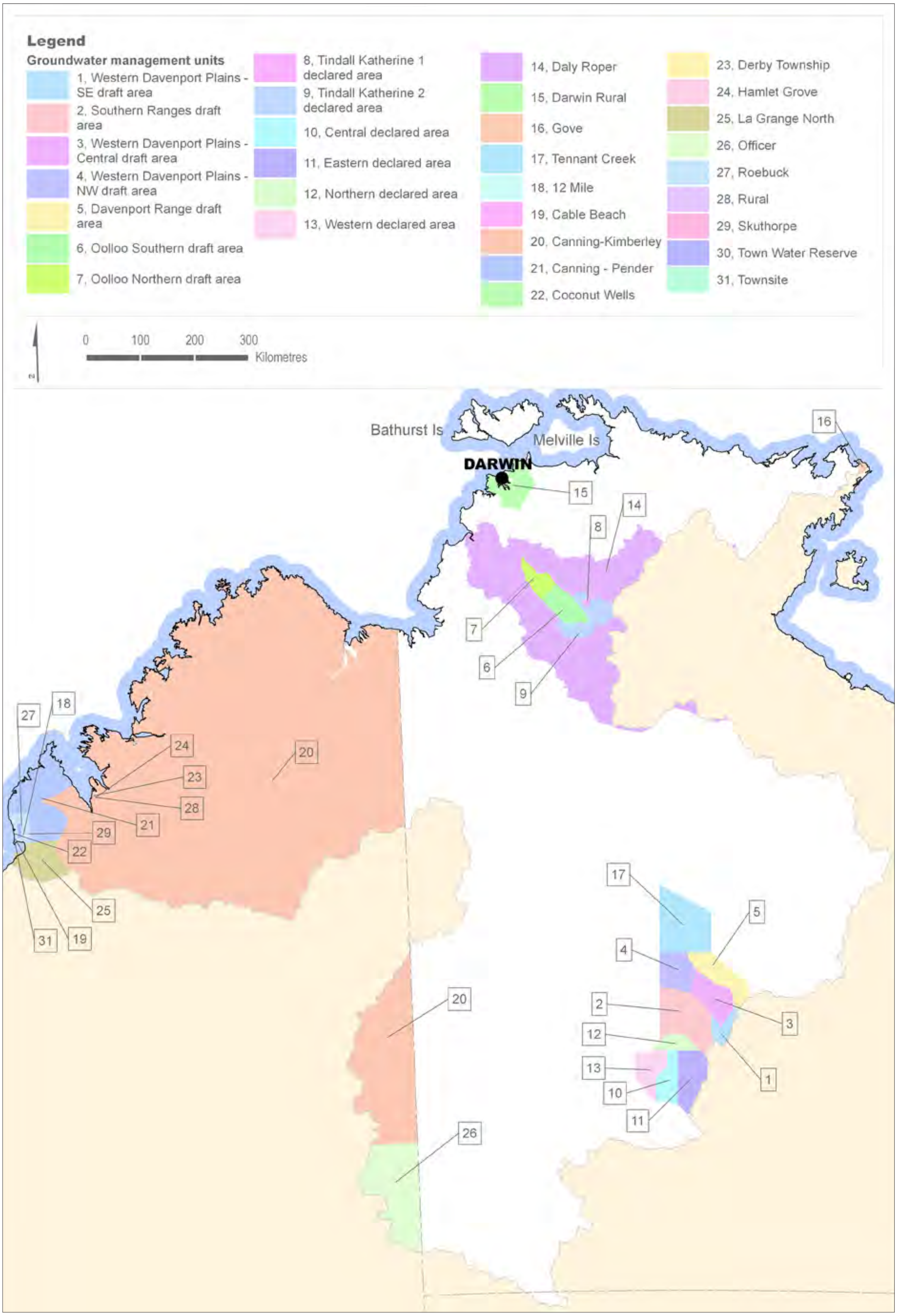


Figure 13.29 Groundwater management units in the Tanami – Timor Sea Coast region; data extracted from the National Groundwater Information System (Bureau of Meteorology 2013)

13.6 Water for cities and towns

This section examines the urban water situation in the Tanami – Timor Sea Coast region in 2011–12. The large urban centres in the region, their water supply systems and storage situations are briefly described. The main urbanised area, Darwin, is addressed in more detail and a breakdown is provided for water obtained for and delivered to this city.

13.6.1 Urban centres

Darwin, Palmerston, Broome, Katherine and Kununurra are the major urban centres in the Tanami – Timor Sea Coast region and are shown in Figure 13.30 in conjunction with their population ranges.

Darwin is the capital city of the Northern Territory and has a population of 103,000 people, making it by far the largest and most populated city in the sparsely populated region. It is the smallest of the Australian capital cities.

The second largest town in the region is Palmerston, a planned satellite city close to Darwin. Palmerston is situated near Darwin Harbour and has a population of 27,700 people. Palmerston briefly held in the past the title of the fastest growing city in Australia.

The third largest town in the region is Broome with a population of 12,800 people. It was built on an industry of pearl harvesting, but nowadays residents are supported by a large tourism industry.

Katherine and Kununurra both have populations below 7,000 and have much less relative growth than Darwin and Palmerston.

13.6.2 Sources of water supply

Surface and groundwater are both significant sources of urban water supplied in the region. Many of the region's small, and in some cases isolated communities rely predominantly on groundwater supplies.

The region's only major surface water storage, the Darwin River storage, is shown in Figure 13.31. It supplies surface water to the residents of Darwin and Palmerston.

Groundwater is used throughout the region and in addition to augmenting the supply of the Darwin and Palmerston areas it is the major source for water supplied to the population centres of Broome, Katherine and Kununurra.

Management of groundwater and surface water resources is the responsibility of the Northern Territory's Department of Land Resource Management.

Recycled water plays a minor role in the region and is used to meet the irrigation needs of a number of sporting facilities and playing fields across Darwin.

13.6.3 Darwin–Palmerston

The Power and Water Corporation is owned by the Northern Territory Government and supplies water, sewerage and power services in the Northern Territory, including the Darwin and Palmerston areas. With respect to water supply it operates as both a bulk water supplier and retail utility.

Darwin has a tropical climate with distinct wet and dry seasons which impacts greatly on the availability of surface water in the storages and recharge to the groundwater. Most of the annual rainfall is experienced from December–April. The timing of the onset of regular evening storms, together with the presence or absence of dry season rainfall, significantly influences water consumption.

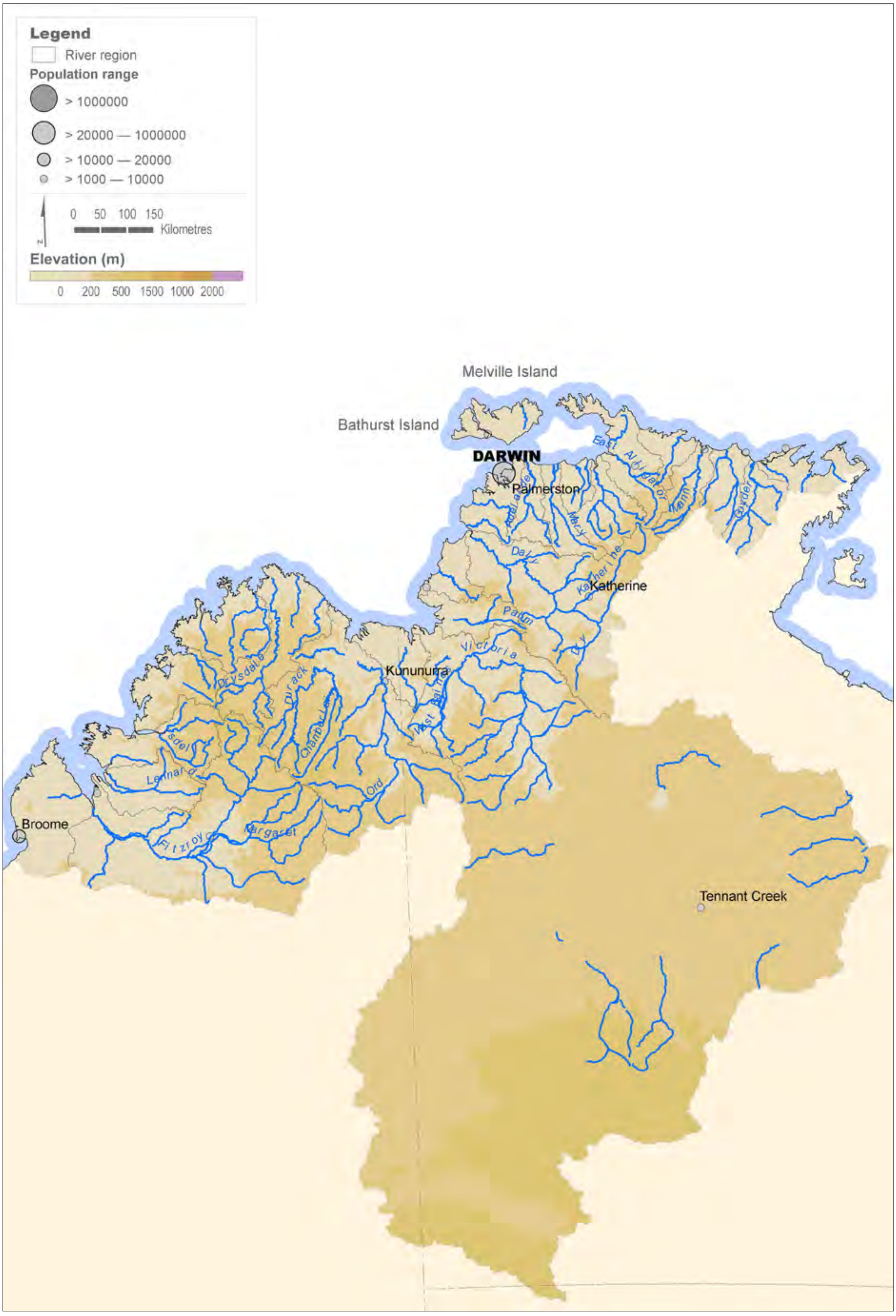


Figure 13.30 Urban population range in the Tanami – Timor Sea Coast region

Figure 13.31 Urban supply storages in the Tanami – Timor Sea Coast region

Supply system

Water is supplied from a combination of surface water and groundwater sources. Most of this water is sourced from the Darwin River storage and is supplemented from the Howard East and McMinns bore fields.

In 1972, the Darwin River Dam was built to address growing water needs arising from the increasing population in the supply area. With the raising of the dam spillway height in January 2011 by 1.3 m, the total accessible storage capacity of the Darwin River storage is now 259 GL.

Sources of water obtained

Figure 13.32 presents the volumes and sources of water sourced to meet Darwin–Palmerston's urban demand (National Water Commission 2013). The data clearly illustrates the region's reliance on surface water, which typically comprises over 80% of the total supply source.

Groundwater as a secondary source has exhibited some growth over this period; however, its extraction is correlated with the available surface water volume and hence is relied upon more significantly in dry years. Recycled water has grown in the recent years, up by almost 25%; however, this growth has been from a very low base, and on a volumetric basis remains less than 1% of the total water sourced to supply the region.

A series of wetter years, including Australia's wettest two-year period on record (2010–2011), saw an improvement in surface water storage levels and a commensurate rise not only in the volume sourced from surface water but also in the total volume extracted for urban use.

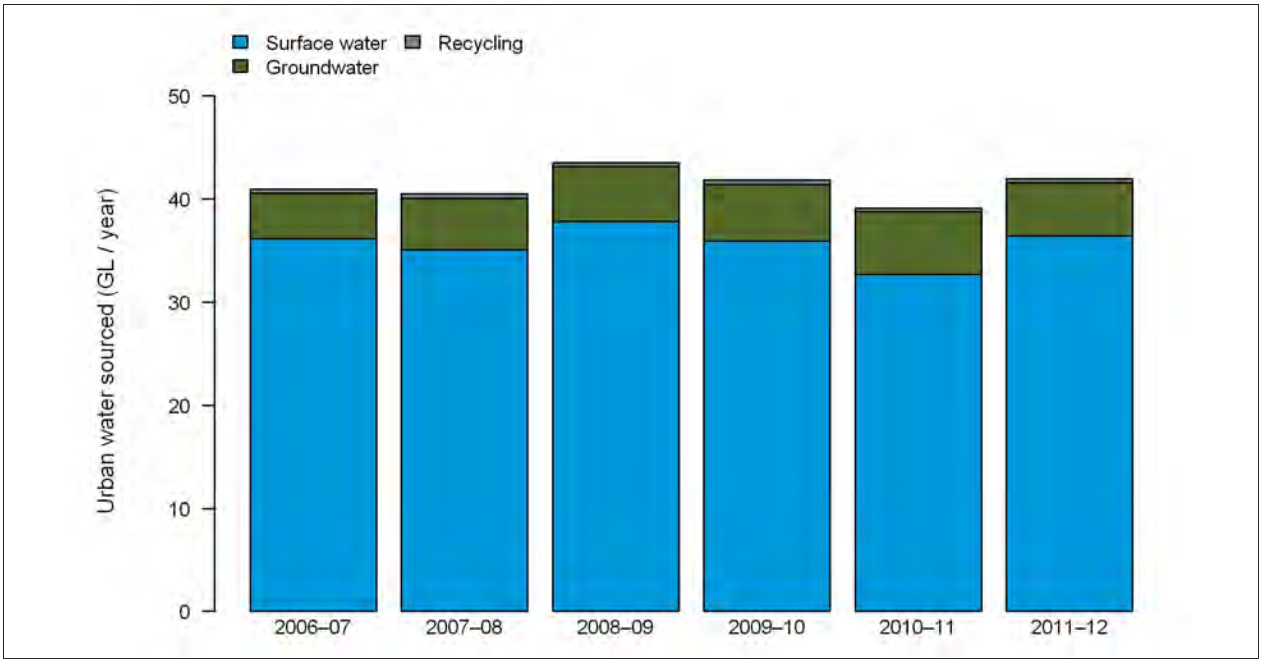


Figure 13.32 Total urban water sourced for Darwin from 2006–07 to 2011–12

Categories of water delivered

Figure 13.33 shows the total volume of water delivered to residential, commercial, municipal and industrial consumers by the Power and Water Corporation (National Water Commission 2013).

After an across-the-board reduction in water consumption levels during 2010–11, above average rainfall and improving storage levels saw residential consumption return to the previous highs. Based on data obtained from the National Performance Reports (National Water Commission 2013), the average water supplied by the Power and Water Corporation for residential use over the analysis period was 507 kL per property per year, making Darwin residents some of the highest residential water users in the country.

After exhibiting a downward trend between 2008–09 and 2010–11, water use was up in 2011–12 along with water supplied to users classified as 'other'. This trend is again, in part, explained by the improving water resources outlook resulting from above average rainfalls in 2010 and 2011 and improving water storage levels in the Darwin River storage.

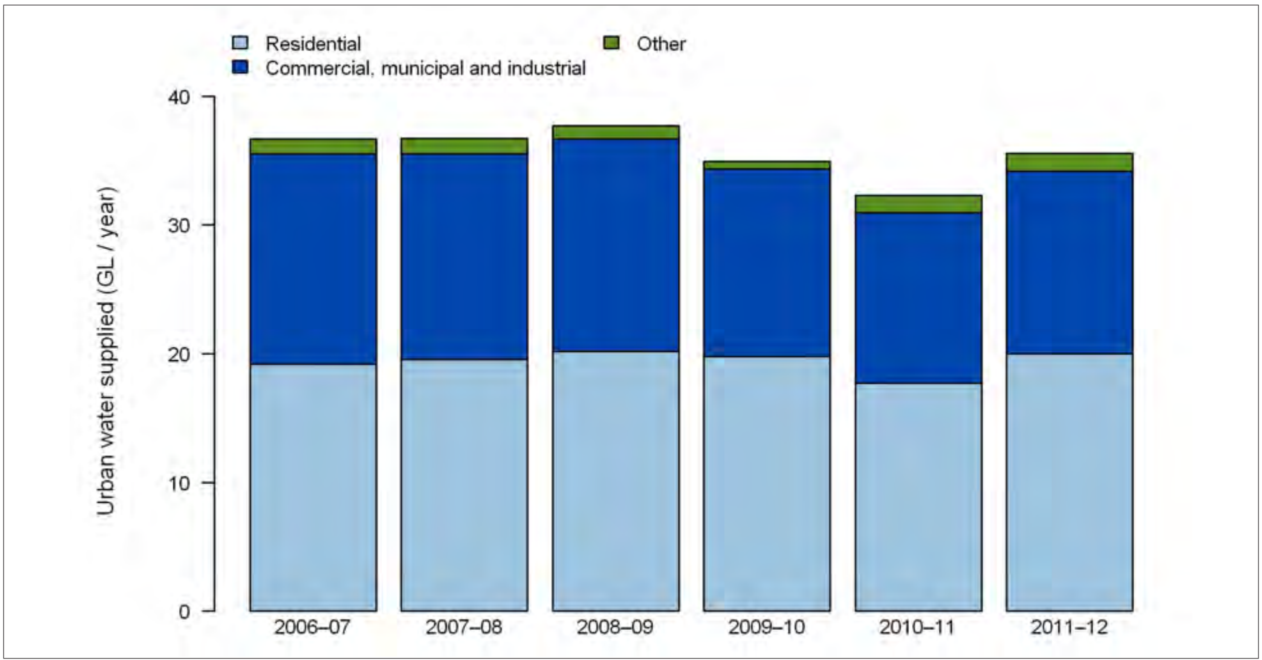


Figure 13.33 Total urban water supplied to Darwin from 2006–07 to 2011–12

13.7 Water for agriculture

This section describes the water situation for agriculture in the Tanami – Timor Sea Coast region in 2011–12. Soil moisture conditions are presented and important irrigation areas are identified. The Ord River irrigation area is described in more detail and information is provided regarding surface storage and groundwater.

13.7.1 Soil moisture

Since model estimates of soil moisture storage volumes are based on a simple conceptual representation of soil water storage and transfer processes averaged over a 5 km x 5 km grid cell, they are not suitable for comparison with locally measured soil moisture volumes. This analysis therefore presents a relative comparison only, identifying how modelled soil moisture volumes of 2011–12 relate to modelled soil moisture volumes of the 1911–2012 period, expressed in decile rankings.

Soil moisture conditions during the 2011–12 year were above average in many parts of the landscape (Figure 13.34) due to above average rainfall from October through to December 2011.

Only in the mid to late summer months did the soil moisture in the region drop to average and below average, but returned to above average conditions as a result of very high rainfalls in March 2012 in the region (Figure 13.35).

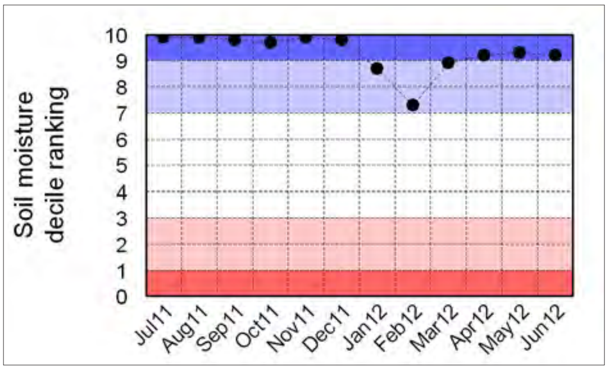


Figure 13.35 Decile ranking of the monthly soil moisture conditions during the 2011–12 period in the Tanami – Timor Sea Coast region

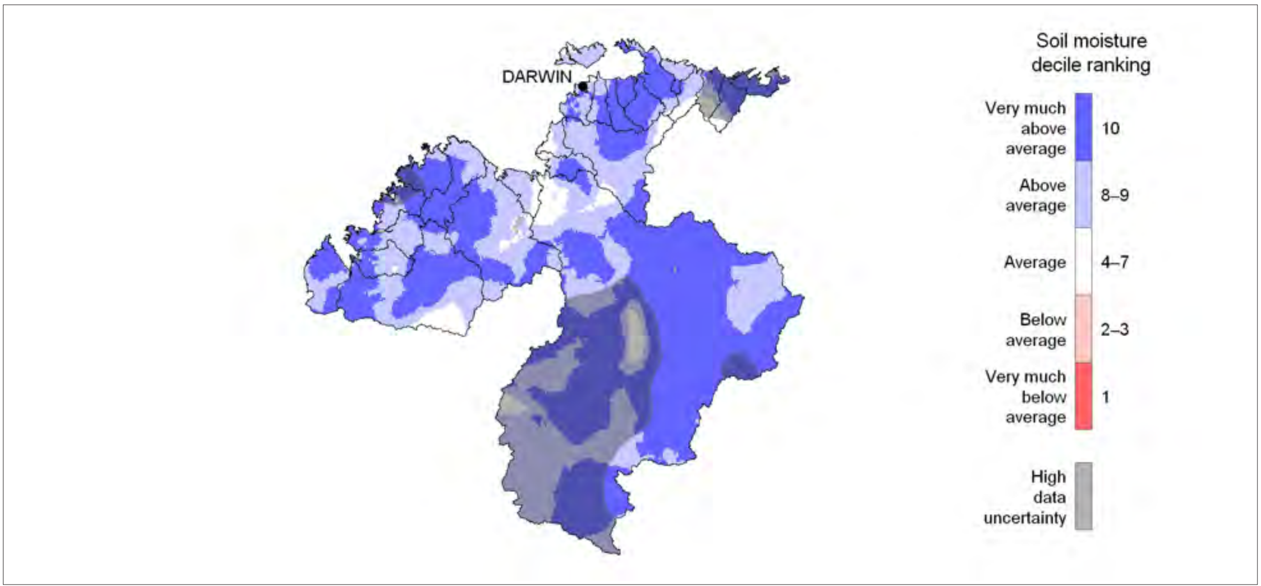


Figure 13.34 Deciles rankings of average soil moisture over 2011–12 with respect to the 1911–2012 period in the Tanami – Timor Sea Coast region

13.7.1 Irrigation areas

The Tanami – Timor Sea Coast region extends across a range of climatic zones including a humid tropical climate to the north and arid conditions across the southern inland areas. In addition to nature conservation, much of the region is pastoral lands. Irrigated agriculture is concentrated in the Ord River basin (Figure 13.37).

13.7.2 Ord River Irrigation Area

The Ord River basin is located in the east of northern Western Australia. The Ord River, 650 km long, is one of the major rivers of the State (Figure 13.38). The main tributaries of the Ord River include the Negri, Wilson and Bow rivers (upstream of Lake Argyle), and the Dunham River, which joins the Ord River downstream of the Kununurra Diversion Dam.

The Ord River irrigation area was developed in 1962 with the construction of the Kununurra Diversion Dam which led to the formation of Lake Kununurra. It comprises approximately 13,000 ha of irrigable soils. In 1973 the Ord Dam was built that created Lake Argyle. This supplied water for an irrigation project of more than 50,000 ha. In 1996, the spillway wall was raised by 6 m, which doubled the dam's capacity.

The main industries within the Ord River basin are agriculture, horticulture, tourism and mining. Mean annual rainfall in the Ord River basin ranges from 780 mm in the north to 450 mm in the south.

Lake Argyle, the storage behind the Ord River Dam with an accessible capacity of 10,700 GL, is the largest irrigation storage in Australia. The Kununurra Diversion Dam, downstream of Lake Argyle, diverts water to irrigation areas near Kununurra (Government of Western Australia Department of Water 2010a).

Water is released from Lake Argyle through hydro-power outlets and a series of controlled release valves at the base of the dam. Additional flow is released through a spillway plug. These combined releases provide inflow into Lake Kununurra from where it is diverted to the Ivanhoe Plains systems and the Packsaddle pumping stations (Ord Irrigation 2011).The Ord Irrigation Cooperative provides water and drainage services to the farms within the Ord River Irrigation Area.

Prolonged dry periods could have a major impact on water supply reliability of Lake Argyle (Government of Western Australia Department of Water 2010b); however, the large storage capacity of Lake Argyle buffers the system against isolated drier years. Evaporation from the surface accounts for a large component of loss from the lake.

Surface water storage volumes

Despite the large storage capacity of Lake Argyle, prolonged dry periods have a major impact on water supply reliability (Government of Western Australia Department of Water 2010b). Open water evaporation also accounts for a large component of loss from the lake.

The historic data (Figure 13.36) shows that the volume of water in the lake regularly exceeded its total storage capacity. This was also the case in 2011–12, where the water level in the storage for two consecutive years was at or above its capacity for the most part of the year.

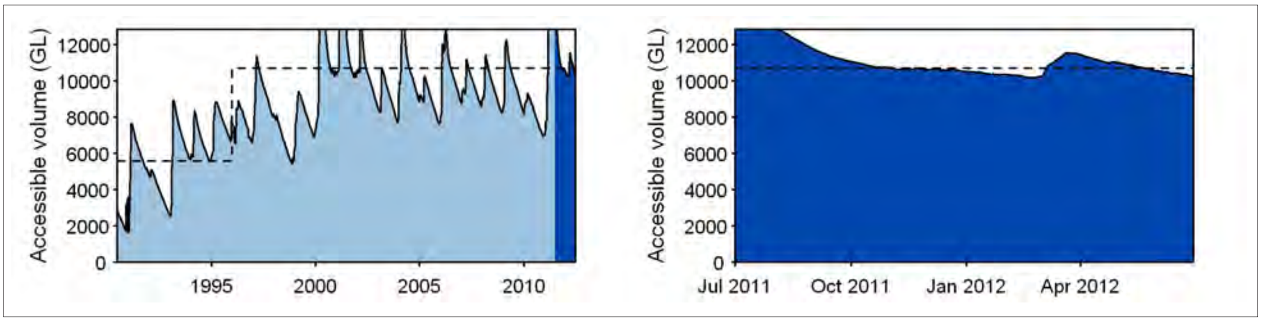


Figure 13.36 Variation in the amount of water held in storage over recent years (light blue) and over 2011–12 (dark blue) for the Lake Argyle storage, as well as total accessible storage capacity (dashed line)

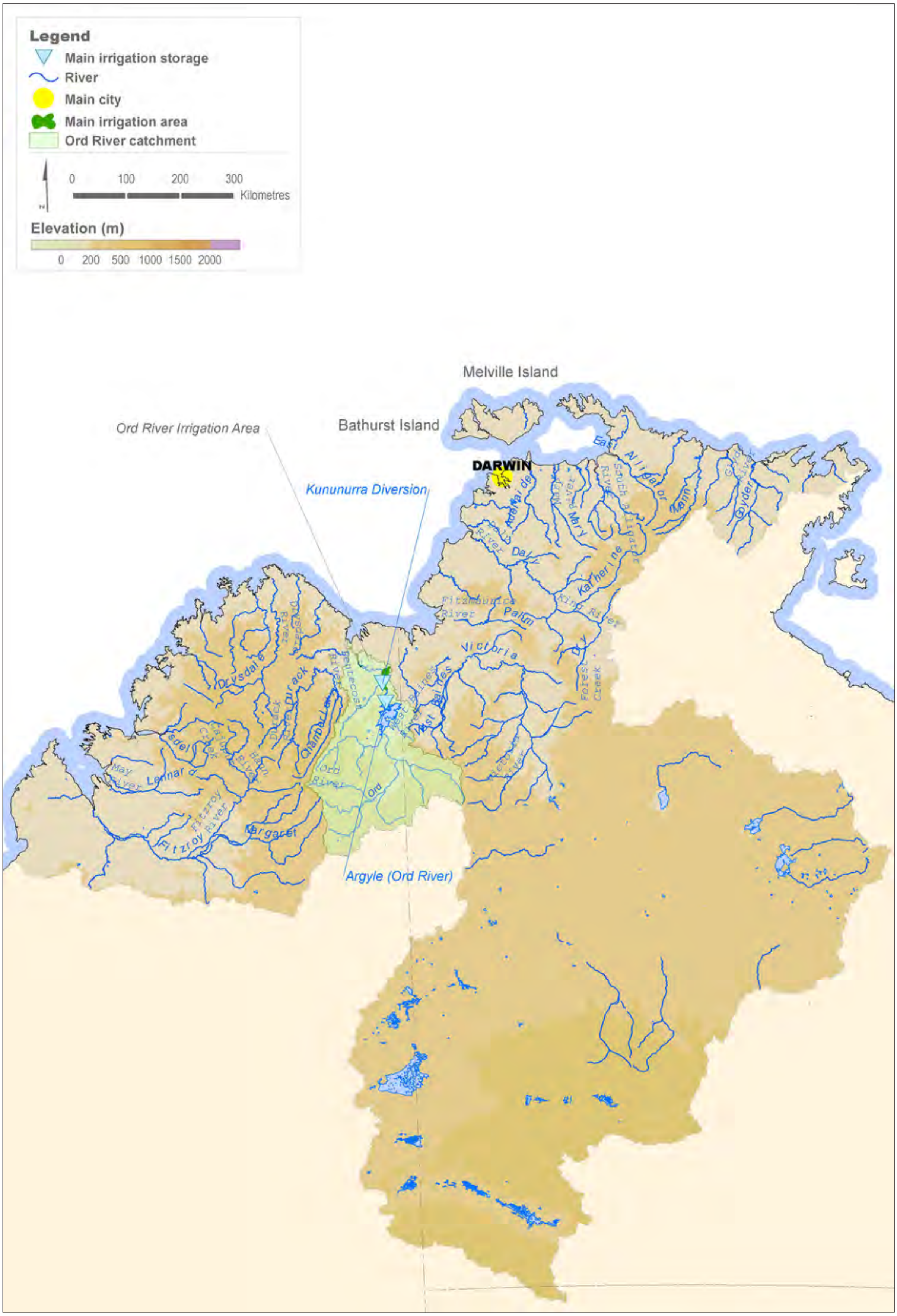


Figure 13.37 Irrigation areas in the Tanami – Timor Sea Coast region

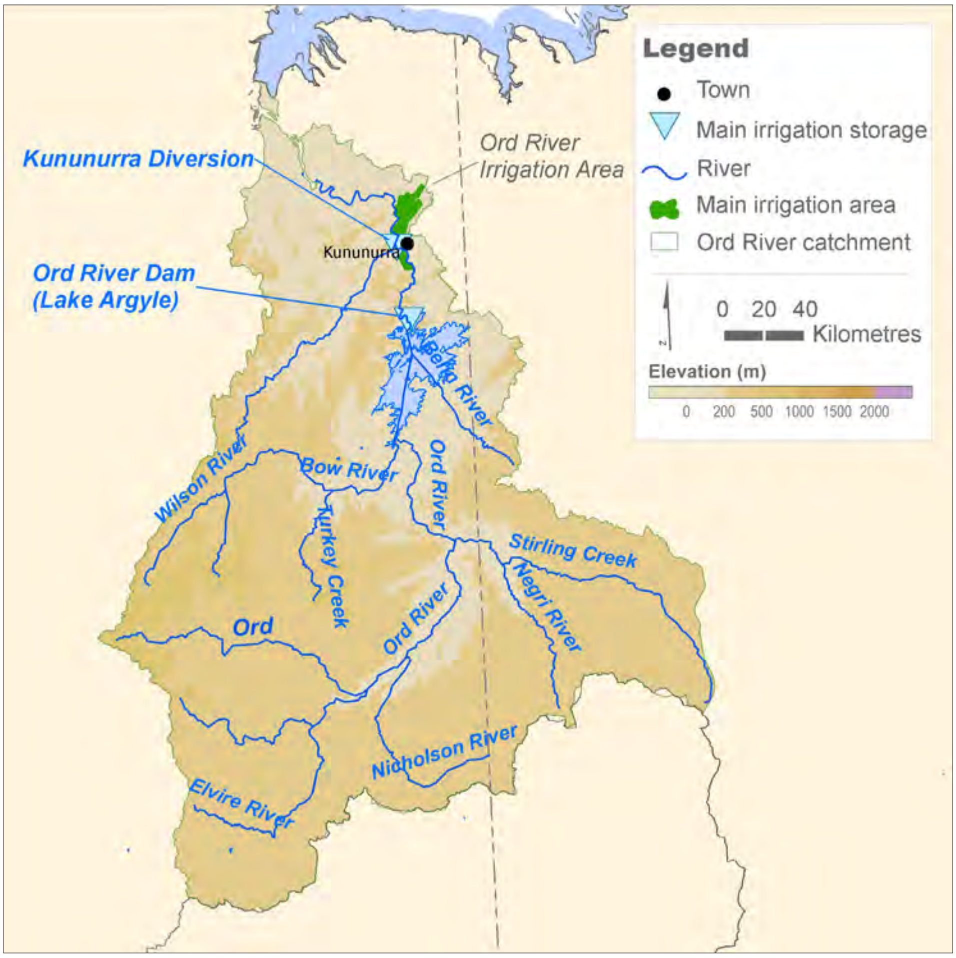


Figure 13.38 The Ord River irrigation area