Pilbara–Gascoyne

11 Pilbara–Gascoyne

11.1 Introduction

This chapter examines water resources in the Pilbara–Gascoyne 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. The data sources and methods used in developing the diagrams and maps are listed in the Technical Supplement.

11.2 Key information

Table 11.1 gives an overview of the key components of the data and information in this chapter.

Table 11.1 Key information on water flows, stores and use in the Pilbara–Gascoyne region

Landscape water flows

	Region average	Difference from 1911–2012 long-term annual mean	Decile ranking with respect to the 1911–2012 record
Rainfall	338 mm	+29%	9th—above average
Evapo-transpiration	341 mm	+36%	9th—above average
Landscape water yield	19 mm	+73%	10th—very much above average

Streamflow (at selected gauges)

Flooding:	Minor flooding limited to two gauges in the far northern rivers in single gauges in the midstream part of the Gascoyne and Ashburton rivers

Surface water storage (comprising all of the region's major surface water 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
63 GL	36 GL	57%	62 GL	98%	-26 GL	-41%

Groundwater (in selected aquifers)

Salinity:	Large areas of saline groundwater (≥3000 mg/L) along the coast and in alluvial aquifers surrounding major river beds

Urban water use (Geraldton)

Total sourced in 2011–12	Total sourced in 2010–11	Change	Restrictions
7.8 GL	8.1 GL	–0.3 GL (-4%)	Permanent Water Conservation Measures

11.3 Description of the region

The Pilbara–Gascoyne region is the central western corner of Western Australia. It covers a long coastal section and a dry inland section bordered by the North Western Plateau and South Western Plateau regions in the east, and the South West Coast region in the south. The region covers about 478,000 km² of land area. River basin areas vary in size from 18,000 km² to 91,000 km².

The area encompasses two major plateaus: the Pilbara plateau in the north and the Gascoyne plateau in the southeast. The western part of the region includes coastal and inland dunes and alluvial floodplains, with some low hills in the southwest. Seasonal or persistent aridity has resulted in low vegetation cover and intermittent river systems. Subsections 11.3.1–11.3.4 give more detail on the physical characteristics of the region.

The Pilbara–Gascoyne region has a population of approximately 117,000 people, which is 0.5% of the nation's total population (Australian Bureau of Statistics [ABS] 2011b).

Major population centres are shown in Figure 11.1 and include the city of Geraldton as well as the regional centres of Karratha, Port Hedland (including South Hedland) and Carnarvon. Further discussion of the region's population distribution and regional urban centres can be found in subsection 11.3.6 and section 11.6 respectively.

Most of the region is in a relatively natural state, much of which is used for grazing (See Figure 11.1).

Dryland agriculture accounts for approximately 3% of the land use in the region. Irrigation is limited and intensive land uses such as urban areas account for 0.03%. Section 11.7 has more information on agricultural activities in the region.

The region has an arid subtropical climate, with a temperate Mediterranean climate predominantly occurring in the south. Rainfall is generally low and variable. Irregular monsoonal rain occurs in the north. Subsections 11.3.7 and 11.3.8 provide more information on the rainfall patterns and deficits across the region.

The generally flat landscapes ensure high rainfall infiltration rates. Rivers are sparse and drain internally or towards the Indian Ocean. The major rivers only generate substantial amounts of flow during and after high rainfall periods.

The hydrogeology of the region is dominated by the large area of outcropping Palaeozoic fractured basement rock of low permeability. The groundwater systems in this rock typically offer restricted low volume groundwater resources. A more detailed description of the rivers and groundwater status in the region is given in section 11.5.

Python Pool, Millstream–Chichester National Park, Western Australia | Tourism Australia

Figure 11.1 Major rivers and urban centers in the Pilbara–Gascoyne region

11.3.1 Physiographic characteristics

The physiographic map in Figure 11.2 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 can influence hydrological processes. The Pilbara–Gascoyne region has three physiographic provinces, namely the Pilbara, Western Coastlands and the Yilgarn Plateau.

The Pilbara province occupies 50% of the region. In the north along the coast are flood and deltaic plains with tidal flats and some metamorphic, volcanic and granitic hills. Inland from this are dissected flat-topped hills of igneous and metamorphic rocks interspersed by stony plains on granite. Further south are dissected plateaus and ranges of sandstone, quartzite and volcanic rocks. There are also some alluvial lowlands with sand, stony and hardpan plains.

The Western Coastlands province occupies 29% of the region and comprises mainly plains of sand, stone and calcrete with dunes, some low ridges, plateaus and hills of sandstone and shale.

The Yilgarn Plateau province occupies 21% of the region and comprises sand and hardpan plains with outgoing drainage and salt lakes, broken by ridges of metamorphic rocks and granite.

Figure 11.2 Physiographic provinces of the Pilbara–Gascoyne region

11.3.2 Elevation

Figure 11.3 presents ground surface elevations in the Pilbara–Gascoyne region. Information was obtained from the Geoscience Australia website (www.ga.gov.au/topographic-mapping/digital-elevation-data.html).The region encompasses two major plateaus: the Pilbara plateau in the north and the Gascoyne plateau in the southeast. The western part of the region includes coastal and inland dunes and alluvial floodplains, with some low hills in the southwest.

In the north of the region, the Hamersley Range form a dominant landscape feature. Peaks exceed 1,200 m above sea level, the highest in Western Australia.

The low-lying coastal zone covers a large part of the region and is only intercepted by the Cape Range. It contains limestone plateaus exceeding 300 m in altitude.

The eastern border of the region is not an obvious water divide in a topographical sense. Many smaller and larger internally draining basins exist on both sides of the border.

Figure 11.3 Ground surface elevations in the Pilbara–Gascoyne region

11.3.3 Slopes

Areas with steep slopes provide higher run-off generating potential than flat areas. The Pilbara–Gascoyne region has few areas with steep slopes. Most of the area is rather flat (Table 11.2). The slopes were derived from the elevation information used in the previous section.

Table 11 2. Proportions of slope classes for the region

Slope class (%)	0–0.5	0.5–1	1–5	> 5
Proportion of region (%)	44.0	21.6	28.3	6.1

Steep slopes are particularly concentrated in the Hamersley Range in the north (Figure 11.4).

The flat stretch to the north of the ranges is the Fortescue River and includes the Fortescue Marsh wetland.

The Gascoyne plateau is located in the centre of the region. Most of it is drained by the Gascoyne River. Slopes have a minor impact on flooding in this region. It was the rainfall intensity and duration only that created a major flood in December 2010.

The coastal plains are flat and contain many lakes that are separated from the sea by dunes. The most dominant lake is Lake MacLeod. The extent of Lake MacLeod varies over time depending on the occasional inflows. It is identified as an important wetland, but is also a salt-harvesting site.

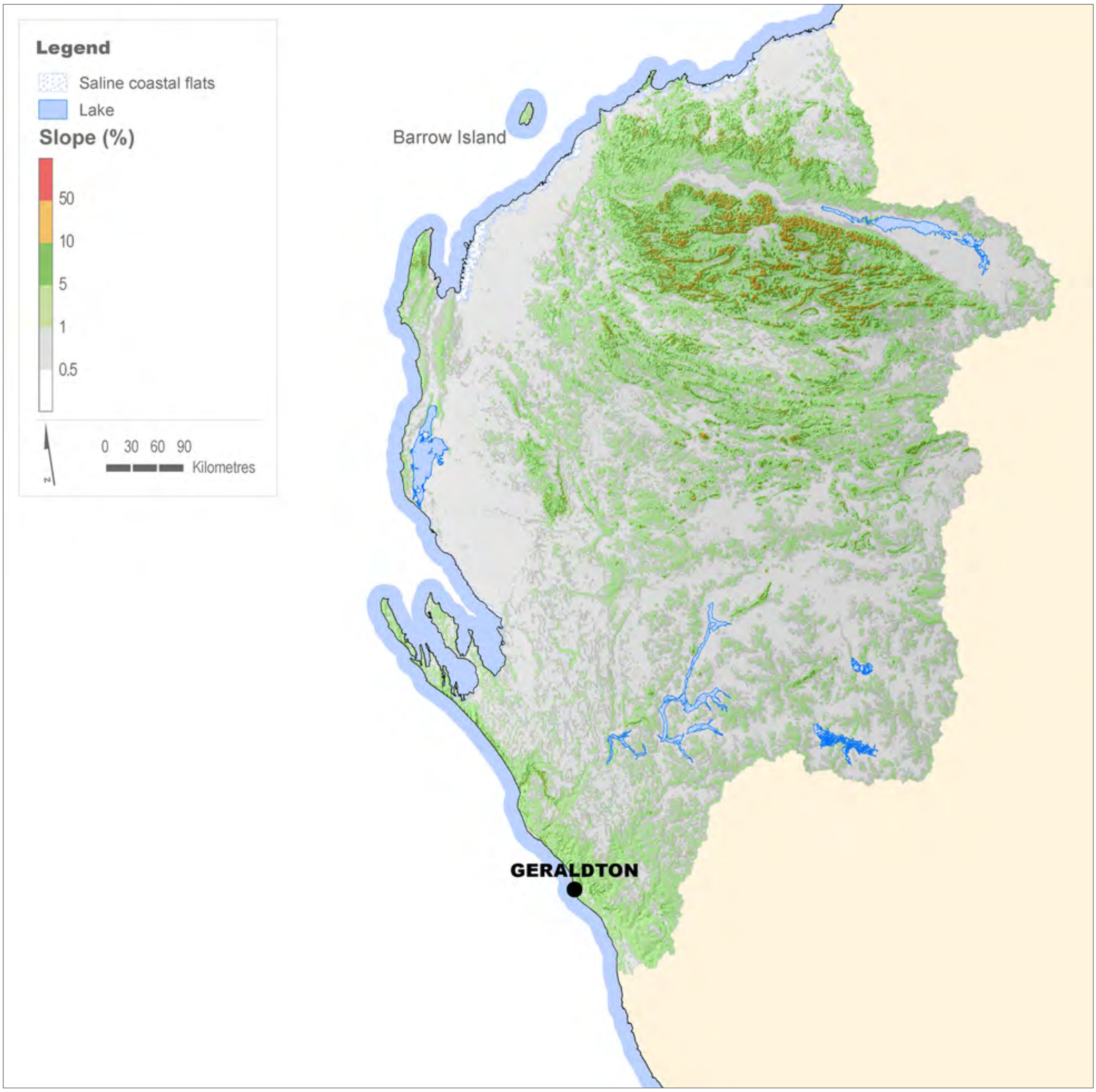

Figure 11.4 Surface slopes in the Pilbara–Gascoyne region

11.3.4 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 almost 90% of the Pilbara–Gascoyne region is covered by three soil types, namely tenosols, sodosols and kandosols (see Figure 11.5 and Figure 11.6). Among those more than 40% of the area is covered by tenosols. They are scattered throughout the entire region and are mixed with mostly sodosols in the north and with kandosols in the south of the region. These soils are mostly used for pastoral agriculture and to some extent for nature conservation in the region.

Tenosols are typically sandy and are often shallow in depth. These soils have low fertility and water-holding capacity and thus are of low agricultural potential. Sodosols have clear textural contrast, with impermeable, sodic subsoils arising from elevated sodium concentrations and clay.

They are susceptible to dryland salinity as well as erosion if vegetation is removed. Sodosols are usually low in nutrient status.

Kandosols are structureless soils which are often very deep (up to 3 m or more), but 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, they only have low to moderate agricultural potential.

The other soil types that have minimal representation in the Pilbara–Gascoyne region are calcarosols, rudosols, vertosols, chromosols and hydrosols (1–4%).

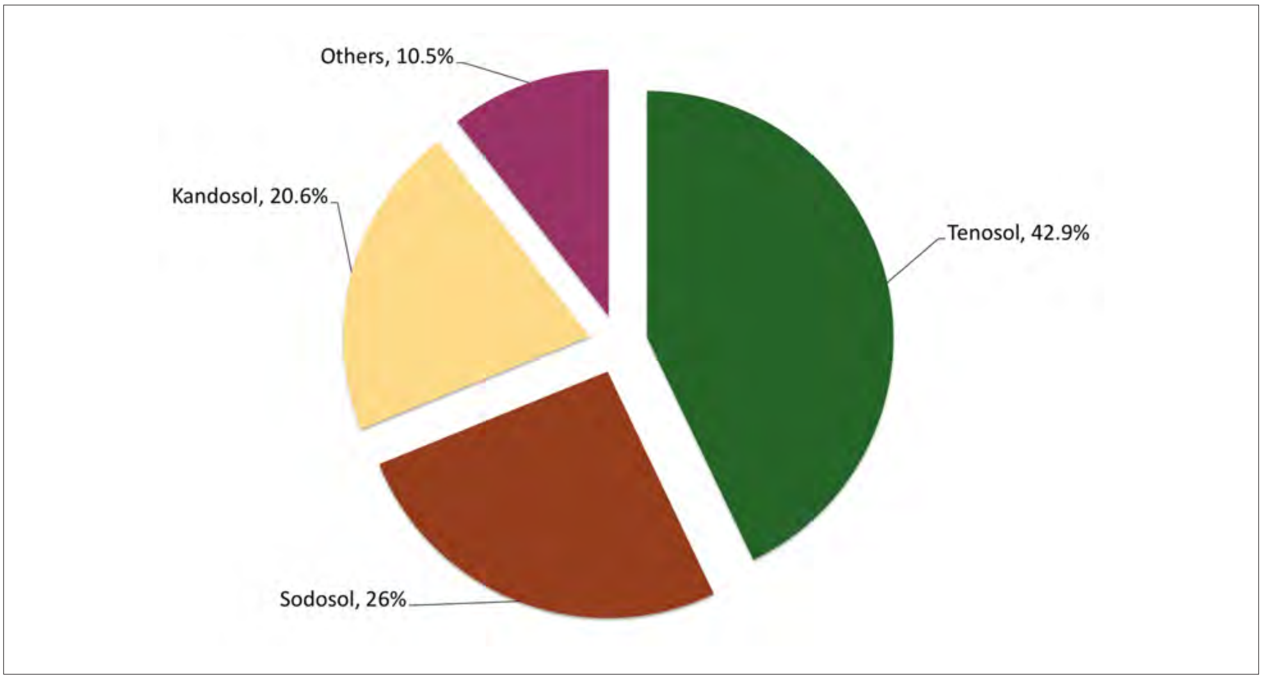

Figure 11.5 Soil types in the Pilbara–Gascoyne region

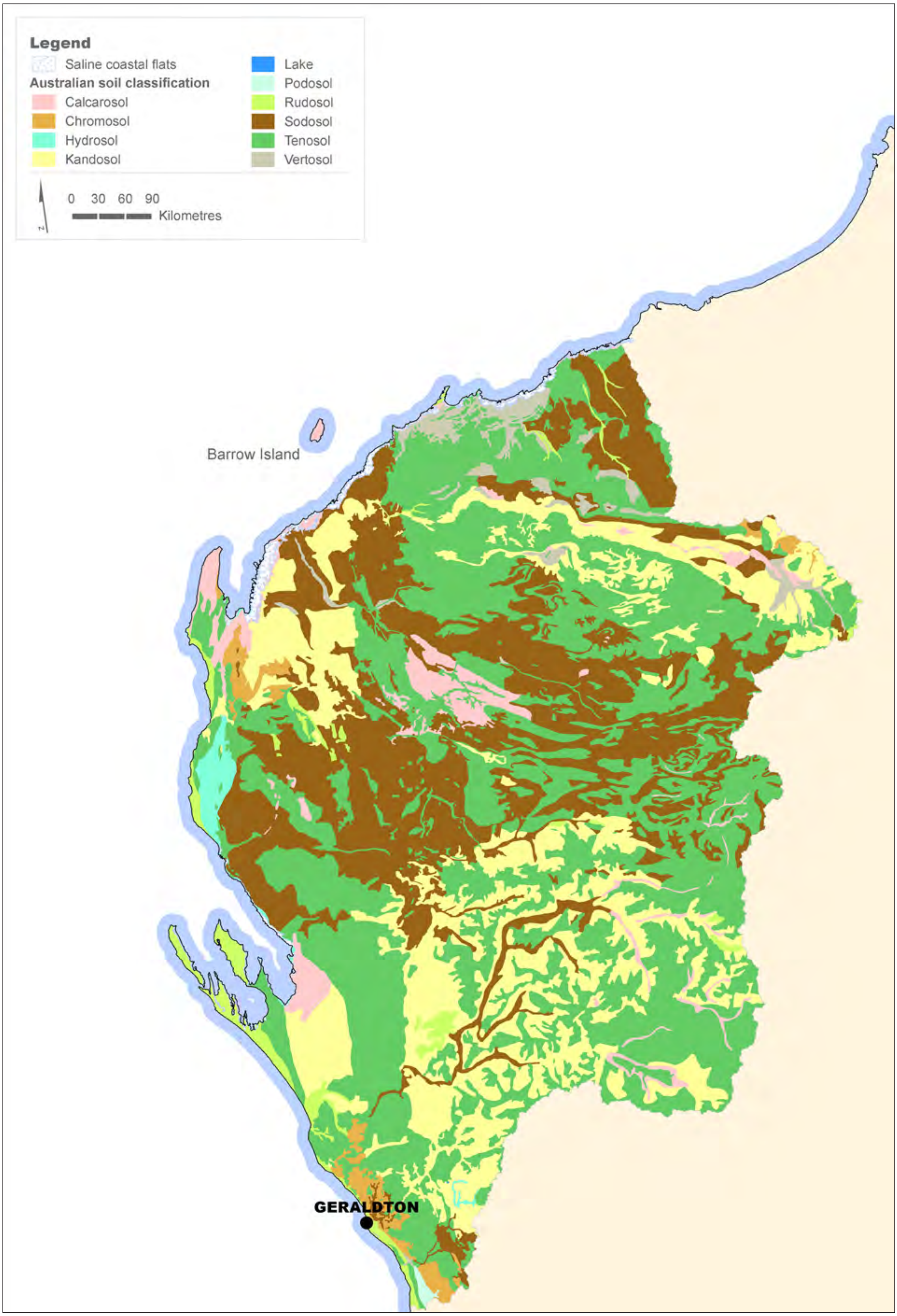

Figure 11.6 Soil type distribution in the Pilbara–Gascoyne region

11.3.5 Land use

Most of the Pilbara–Gascoyne region is in a relatively natural state, much of which is used for grazing (data from data.daff.gov.au/anrdl/metadata_files/pa_luav4g9abl07811a00.xml). Aridity has resulted in low vegetation cover in the inland section. Dryland agriculture accounts for approximately 3% of the region's land use.

Irrigation is limited to the southern coastal part of the region. The Carnarvon horticultural district close to the Gascoyne River is one of the most productive areas in Western Australia for horticulture, producing a wide variety of fruit and vegetable crops, particularly over the winter months. Although the Gascoyne River is mostly dry, underground aquifers provide irrigation water to the crops.

Intensive land uses such as urban areas account for 0.03% of the region (Figure 11.7 and Figure 11.8).

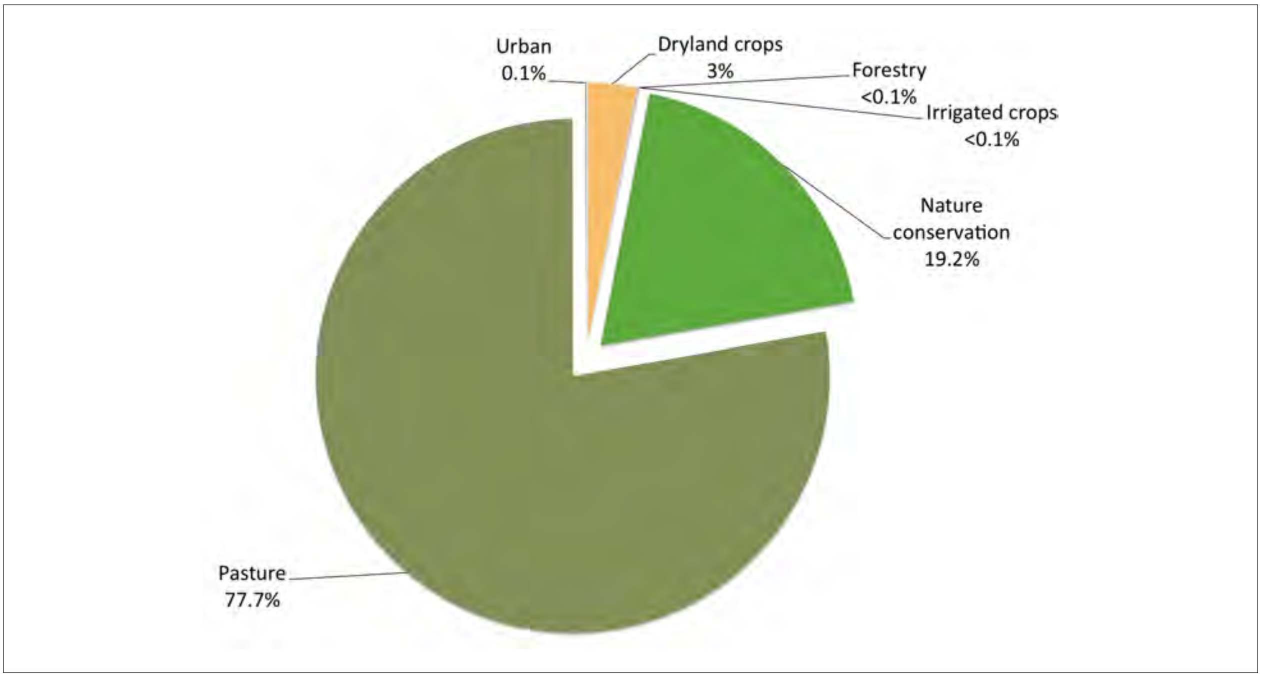

Figure 11.7 Land use in the Pilbara–Gascoyne region

Basil growing at one of the many plantations near Carnarvon, Western Australia | Gascoyne Development Commission

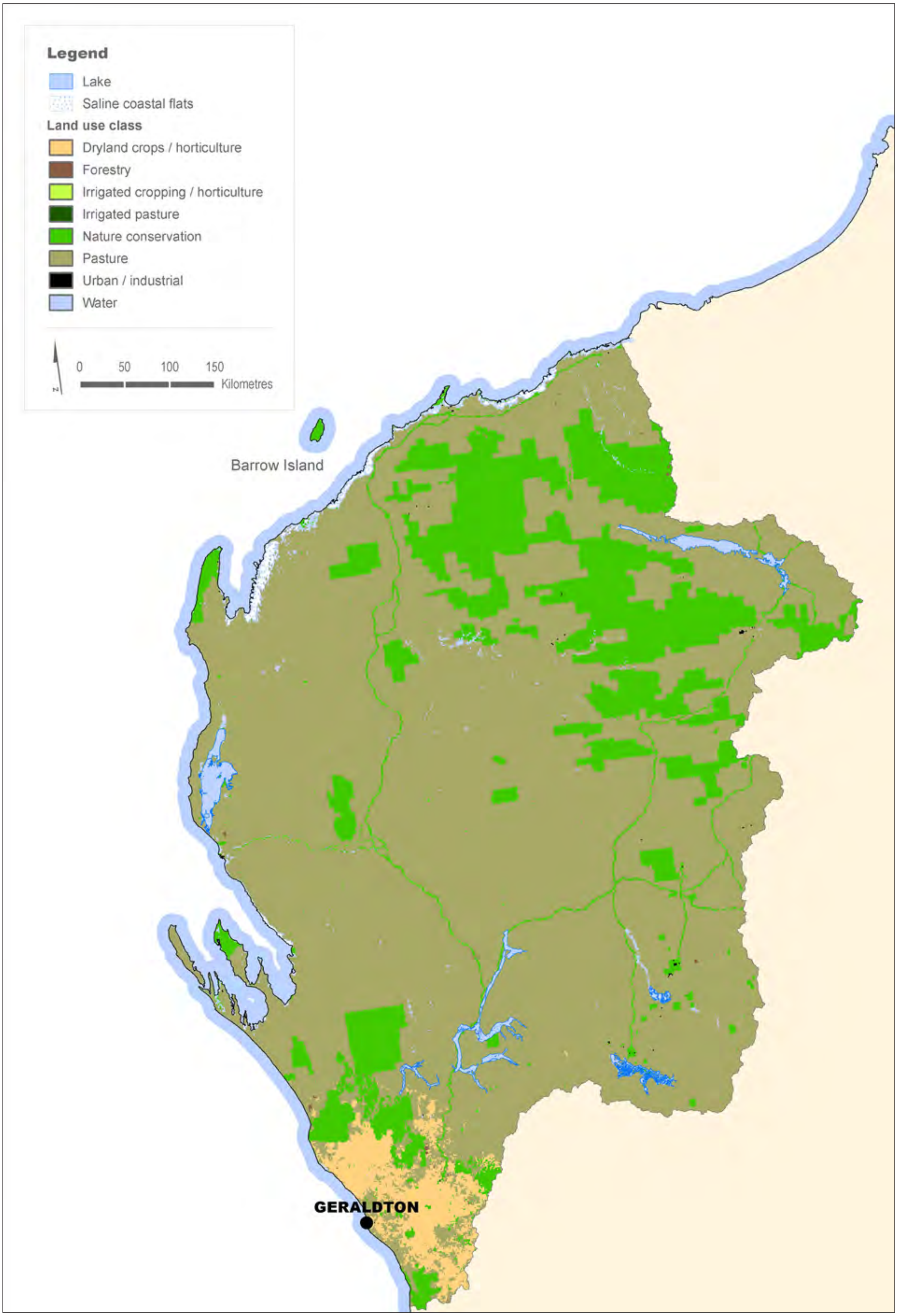

Figure 11.8 Land use distribution in the Pilbara–Gascoyne region

11.3.6 Population distribution

With a population representing just over 0.5% of the nation's total and a land area of 478,000 km² (Figure 11.9), Pilbara–Gascoyne is one of the most sparsely populated regions (ABS 2011b).

The region is home to a number of remote Indigenous communities, and mining is the most significant driver for the region's population distribution. Permanent settlements have developed around the many mining leases across the region; however, the coastal port cities and towns provide the focal point for the population. The city of Geraldton, in the southwest, is the largest population centre in the region. The northern coastal centres of Karratha, Dampier and Port Hedland (including South Hedland) are centres with growing mining activities.

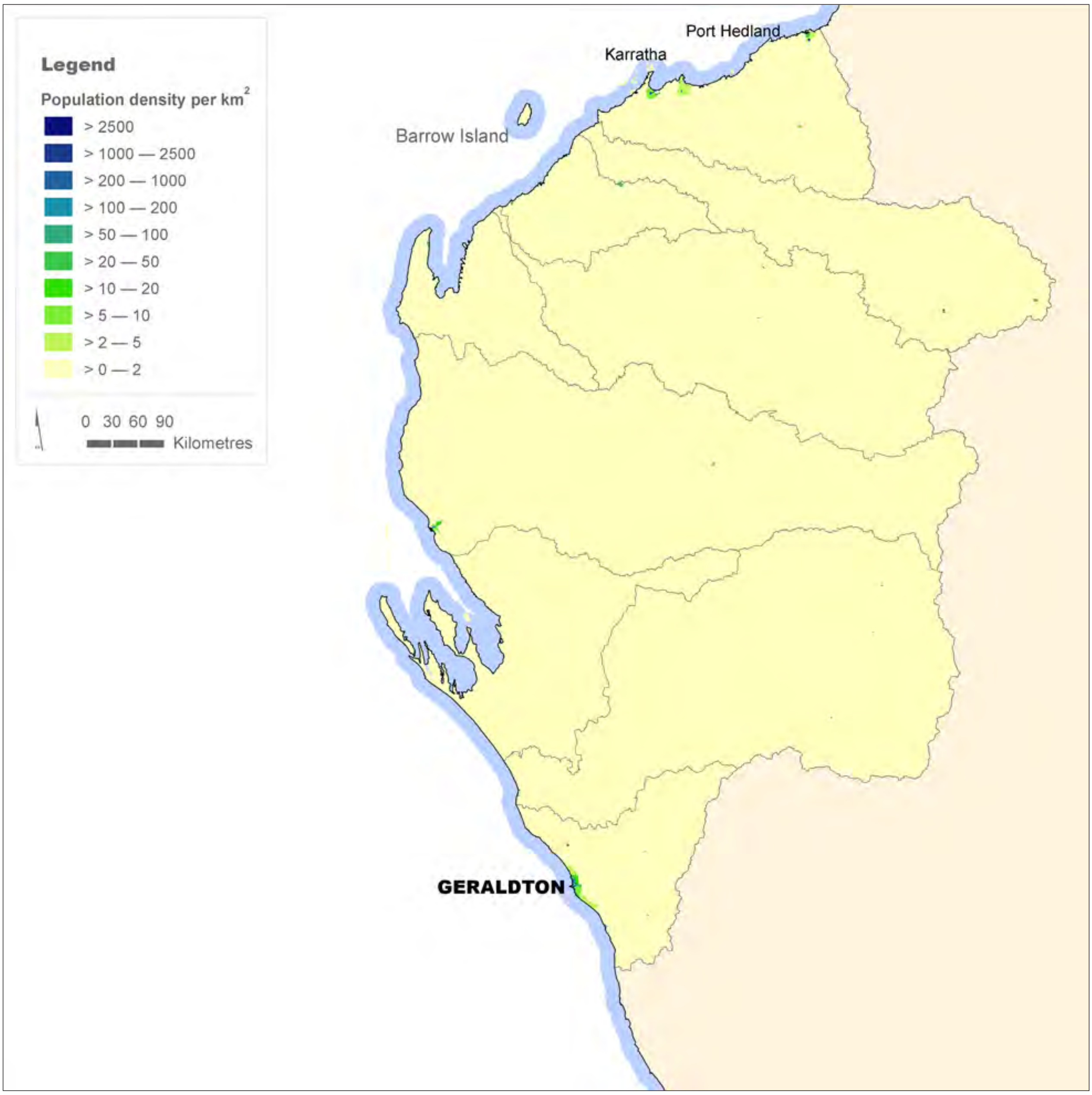

Figure 11.9 Population density and distribution in the Pilbara–Gascoyne region

11.3.7 Rainfall zones

The region has an arid subtropical climate, with a temperate Mediterranean climate predominantly occurring in the south. Rainfall in the north is highly variable and dependent on the passage of tropical cyclones and monsoon activity. Elsewhere, rainfall is typically low.

Median rainfall does not exceed 500 mm and is generally highly variable (Figure 11.10).

Most of the region is classified as arid but, especially in the north, monsoons supply enough rain to cause average annual rainfall totals in some of these areas to exceed 400 mm.

Together with the Nullarbor coast, the Pilbara coast experiences the lowest average annual rainfall totals for coastal areas in Australia. Even along the Gascoyne coast the winter dominant rainfall does not exceed average annual totals of 500 mm.

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

Figure 11.10 Rainfall zones in the Pilbara–Gascoyne region

11.3.8 Rainfall deficit

The rainfall deficit indicator, that is, rainfall minus potential evapotranspiration indicator gives a general impression about which part of the region moisture deficits are likely to occur over the period of a year. The Pilbara–Gascoyne region has a rather uniform pattern of serious potential deficits over the whole region (Figure 11.11).

Due to the seasonality of the rainfall along the south coast, this area is still well-suited for dryland agriculture, which occurs at an extensive scale.

The rest of the region is covered by either pasture, sparsely in use for stock farming. The north is covered by many national park and conservation lands. A fair amount of mining occurs in the region. The rainfall deficits form serious challenges to supply the mine workers with fresh drinking water from natural resources.

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

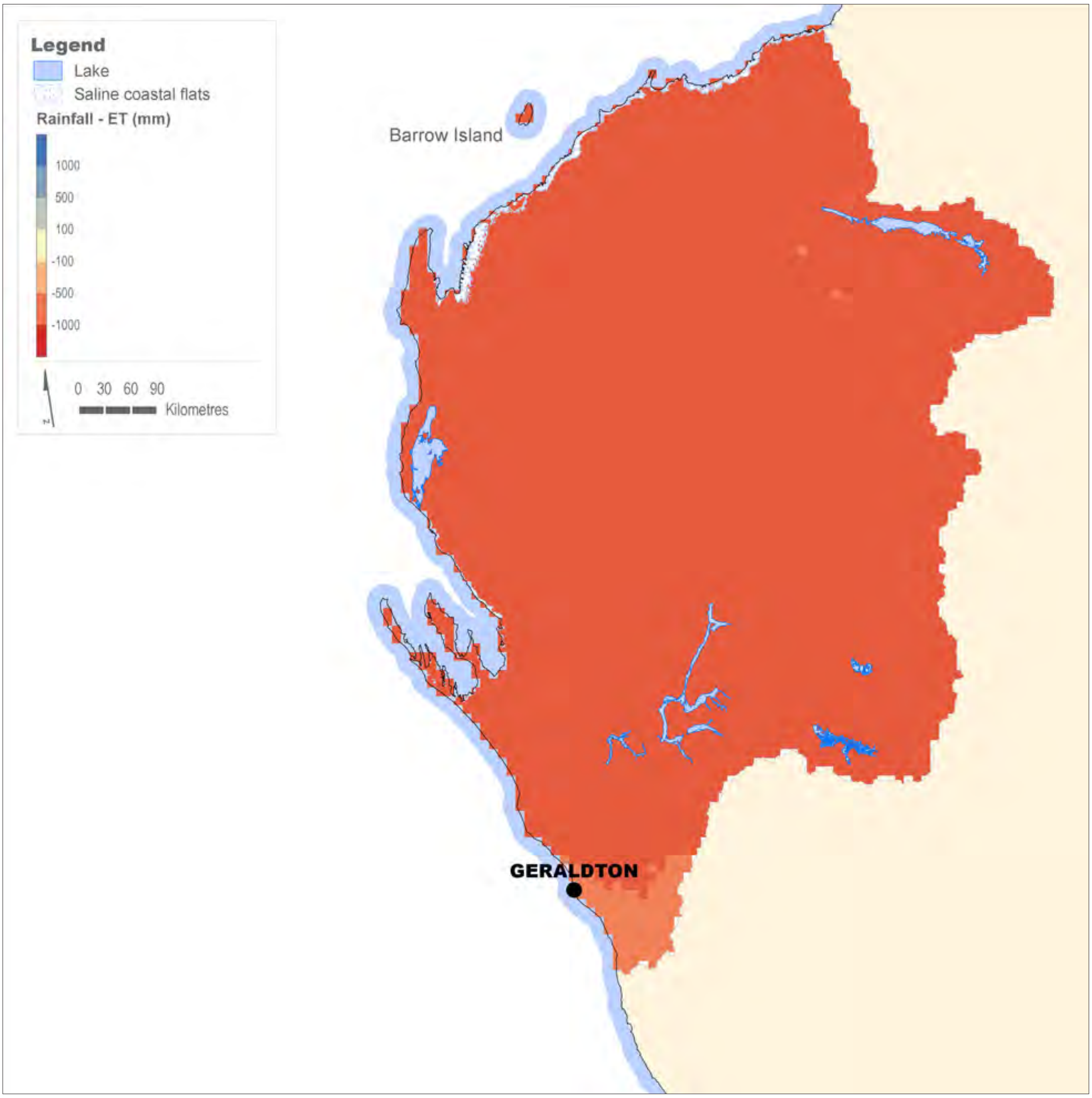

Figure 11.11 Rainfall deficit distribution for the Pilbara–Gascoyne region

11.4 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 Pilbara–Gascoyne 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 11.12 shows that the region has a seasonal rainfall pattern of a predominantly wet January–July period and a dry August–December period. Evapotranspiration in the dry period generally exceeds rainfall. After the wet period the soils normally contain plenty of moisture that is available for evapotranspiration.

The monthly landscape water yield history for the region shows a stable pattern of very low yield throughout the year.

The 2011–12 year was a relatively wet year. The month of January recorded the second highest regional rainfall total over the 1911–2012 period. Two tropical cyclones hit the region in this month. The first (*Heidi*) made landfall in the north of the region. The second (*Iggy*) also affected the region in the north.

With wet soil conditions present at the start of the year, evapotranspiration rates were higher than rainfall for the first six months of 2011–12. With the exception of January, March and June 2012, evapotranspiration rates remained above rainfall for the rest of the year as a result of high water availability after the January rainfall.

Following the high January rainfall, landscape water yield was highest on record for this month. The other months also saw some high landscape water yields, but these were not really significant in absolute terms.

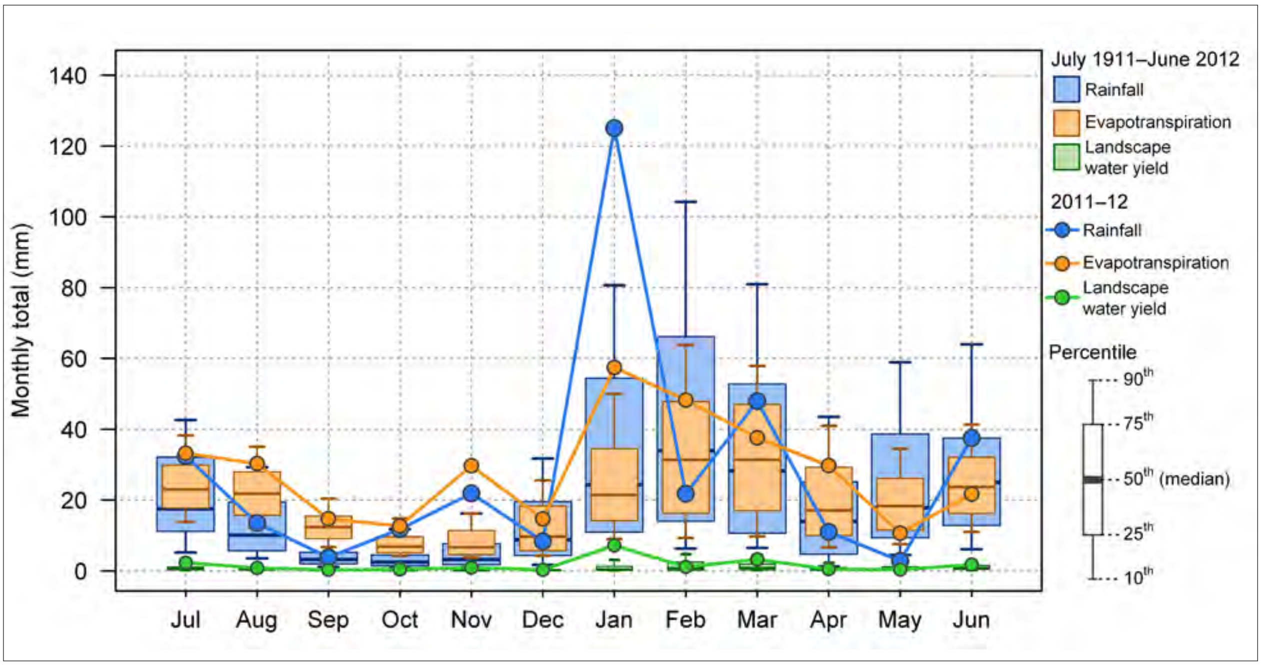

Figure 11.12 Landscape water flows in 2011–12 compared with the long-term record (July 1911– June 2012) for the Pilbara–Gascoyne region

11.4.1 Rainfall

Rainfall for the Pilbara–Gascoyne region for 2011–12 is estimated to be 338 mm. This is 29% above the region's long-term average (July 1911–June 2012) of 263 mm. Figure 11.13a shows that the highest rainfall for 2011–12 occurred in the Pilbara district along the northeast and in the far south around Geraldton. Most of the coastal zone had rainfall not exceeding 300 mm, whereas in the northeast rainfall exceeded 400 mm throughout.

Rainfall deciles for 2011–12 indicate a gradient of below average rainfall in the northwest, increasing to very much above average in the central east of the region (Figure 11.13b). Most of the inland parts of the region received above average rainfall and along the coast average rainfall generally occurred. The very much above average rainfall in the central west was caused almost entirely by tropical cyclone *Heidi*.

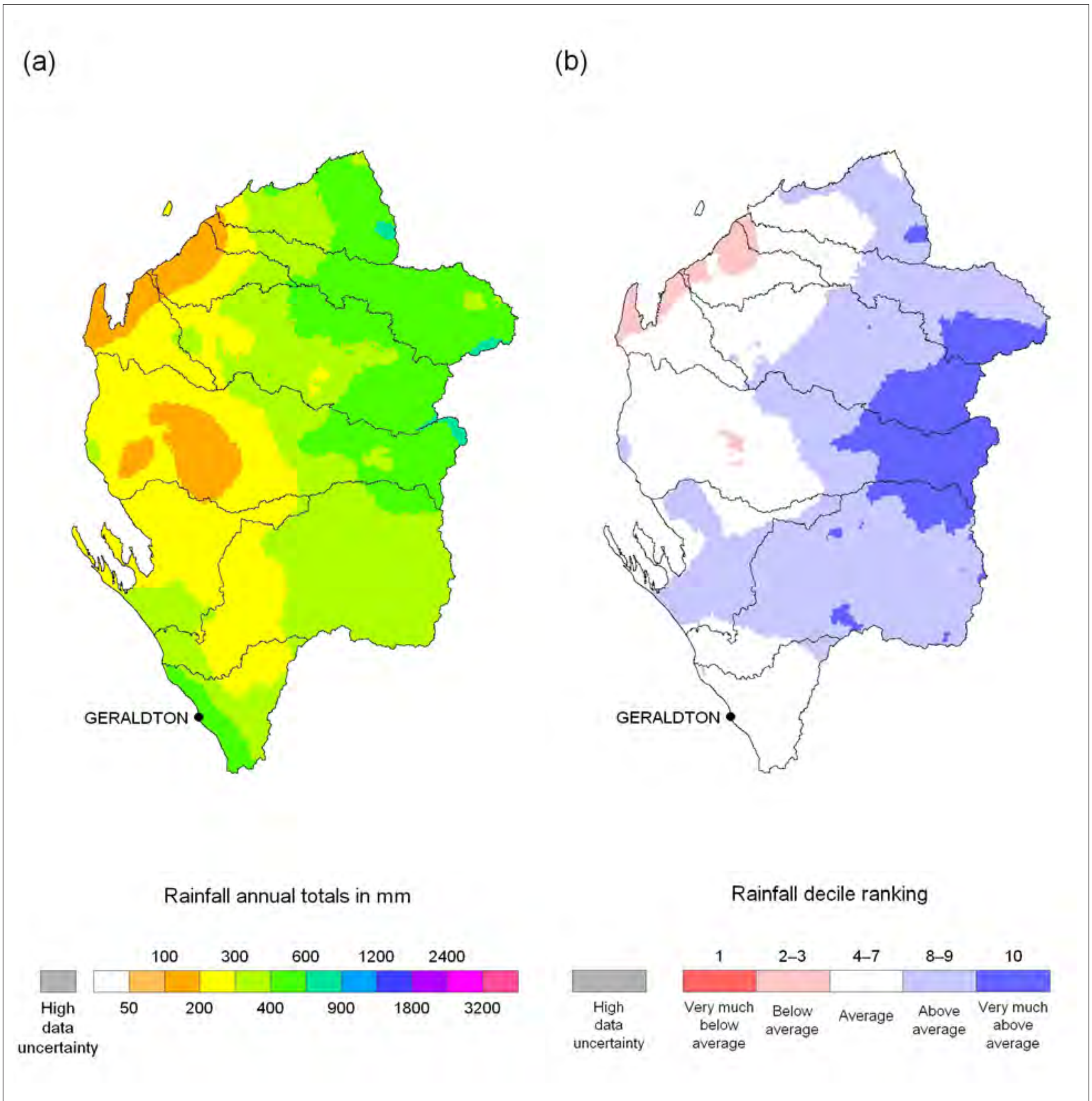

Figure 11.13 Spatial distribution of (a) annual rainfall in 2011–12, and (b) their decile rankings over the 1911–2012 period for the Pilbara–Gascoyne region

Rainfall variability in the recent past

Figure 11.14a shows annual rainfall for the region from July 1980 onwards. Over this 32-year period the annual average was 295 mm, varying from 131 mm (2009–10) to 601 mm (1998–99). Temporal variability and seasonal patterns since 1980 are presented in Figure 11.14b.

The graphs indicate a highly variable pattern of annual rainfall totals over the last 32 years. In fact, the Pilbara–Gascoyne region has the highest coefficient of variation (standard deviation divided by the mean) in annual rainfall of all regions. This means that rainfall is highly unpredictable. It normally depends on the occurrence of large monsoonal or tropical storms.

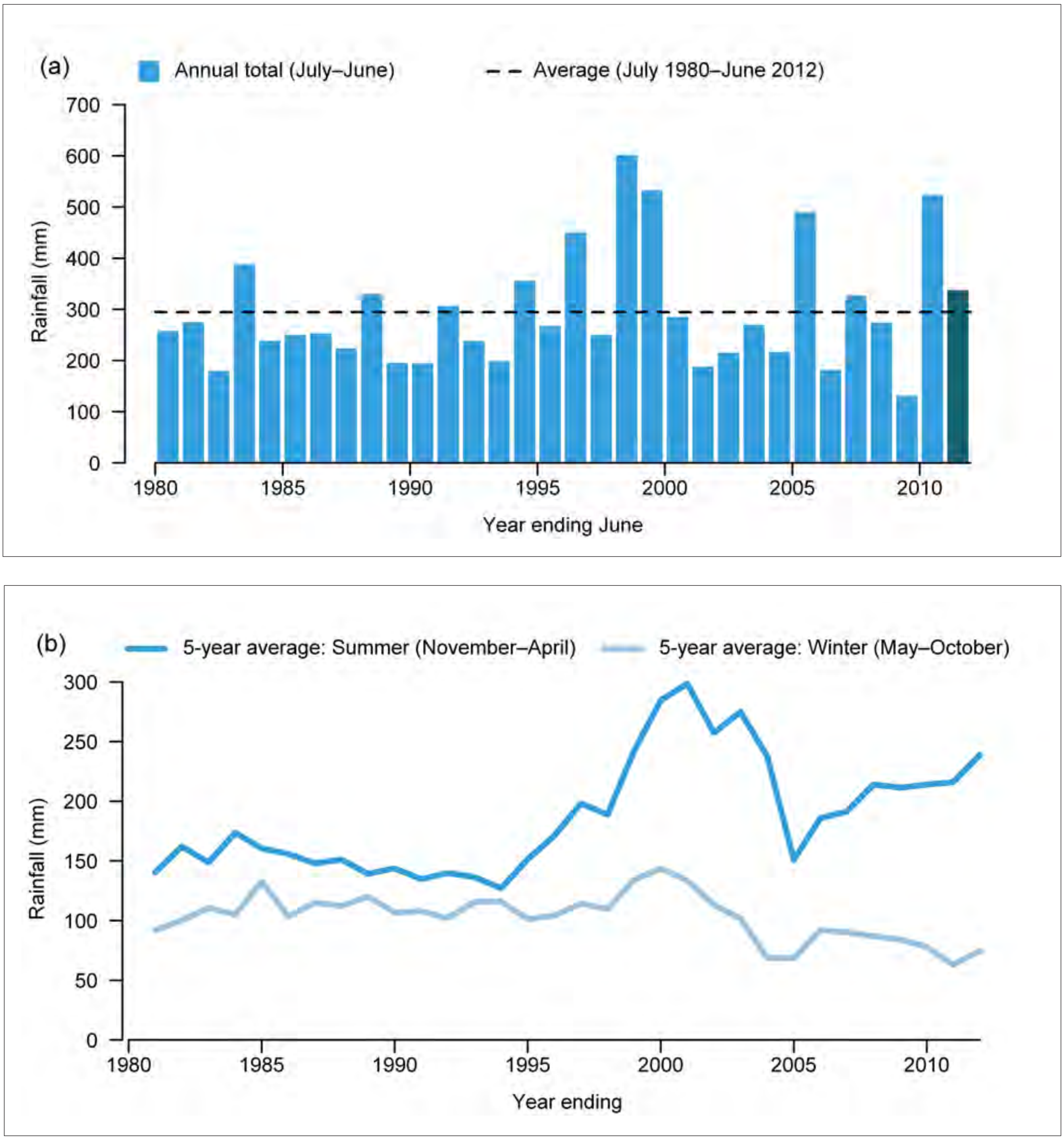

Figure 11.14 Time-series of (a) annual rainfall, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the Pilbara–Gascoyne region

Recent trends in rainfall

Figure 11.15a 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 11.15b. This analysis indicates that the region experienced a general increase in rainfall since 1980, with the exception of the far south coast where the trend is falling.

However, the rising trends are strongly significant in 4% of the region only (Figure 11.15b). In the south, only some small areas recorded a significant falling trend in rainfall since 1980.

Because of the high variability in rainfall, these trends are highly dependent on the reference period chosen. Since most of the high rainfall years happened in the second half of the reference period (see Figure 11.14), a rising trend is to be expected; however, the driest year occurred in 2009–10 which shows that the trend analysis is not very relevant in the context of highly variable time-series.

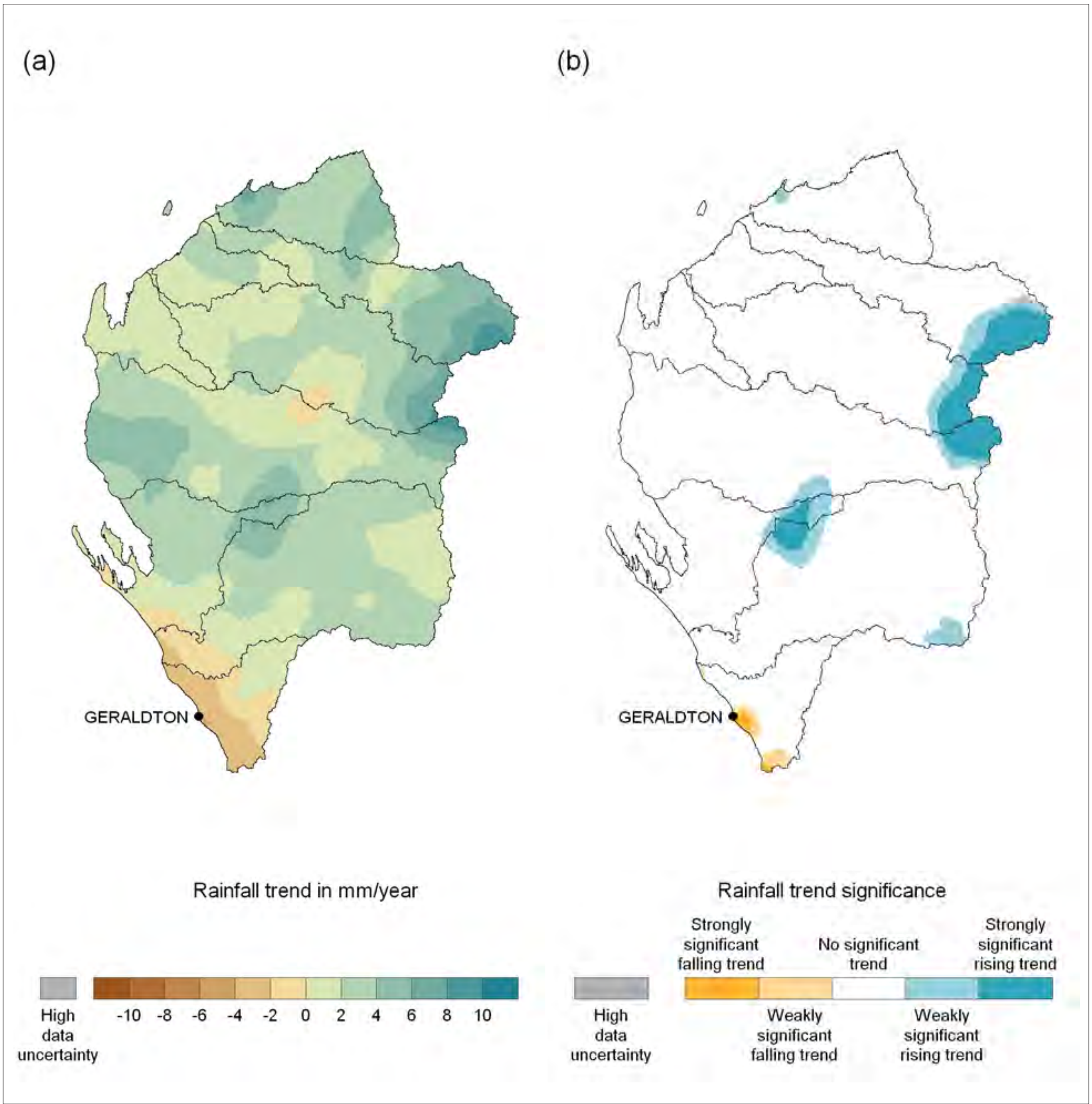

Figure 11.15 Spatial distribution of (a) trends in annual rainfall from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the Pilbara–Gascoyne region

11.4.2 Evapotranspiration

Modelled annual evapotranspiration for the Pilbara–Gascoyne region for 2011–12 is estimated to be 341 mm. This is 36% above the region's long-term (July 1911–June 2012) average of 251 mm. The spatial distribution of annual evapotranspiration in 2011–12 (Figure 11.16a) was similar to that of rainfall (Figure 11.13a).

Relatively high soil moisture volumes at the start of the year allowed the annual total evapotranspiration to exceed annual total rainfall in large areas along the northwest coast.

Evapotranspiration deciles for 2011–12 indicate above average or very much above average totals across most of the region (Figure 11.16b). The decile levels of total annual evapotranspiration throughout the region are a little higher than rainfall (Figure 11.13b), again caused by the relatively high soil moisture availability at the start of the year. Most coastal areas are estimated to have average evapotranspiration, with some areas having above average annual evapotranspiration.

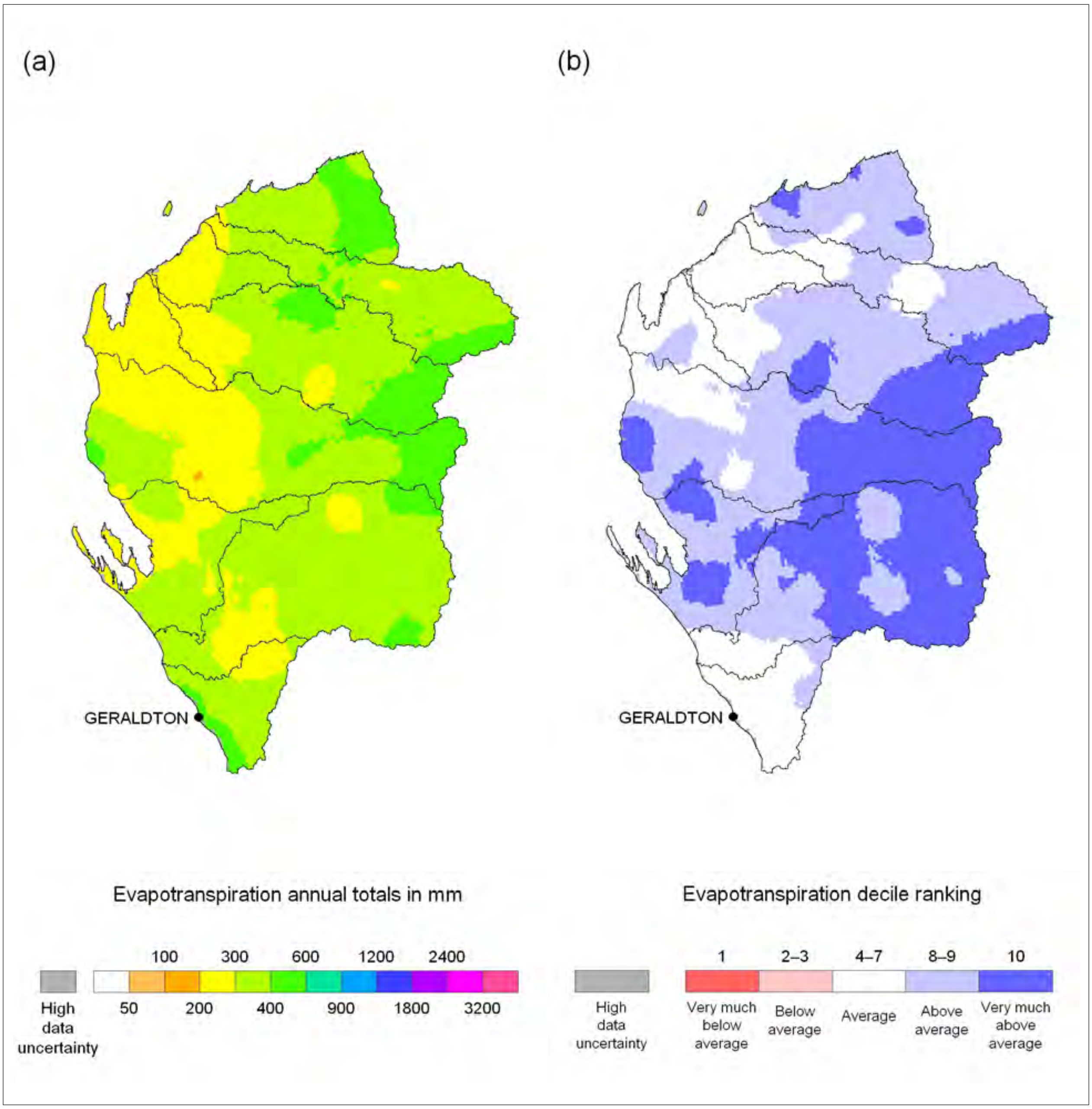

Figure 11.16 Spatial distribution of (a) modelled annual evapotranspiration in 2011–12, and (b) their decile rankings over the 1911–2012 period for the Pilbara–Gascoyne region

Evapotranspiration variability in the recent past

Figure 11.17a shows annual evapotranspiration for the region from July 1980 onwards. Over this 32-year period the annual evapotranspiration average was 279 mm, varying from 172 mm (2009–10) to 489 mm (1998–99). Temporal variability and seasonal patterns (over the summer and winter periods) since 1980 are presented in Figure 11.17b.

The summer period showed a sudden increase in evapotranspiration since 1996, following a similar trend in rainfall (Figure 11.14b). Due to the higher water availability in the summer period, evapotranspiration was higher than the winter period evapotranspiration on a five-year average basis.

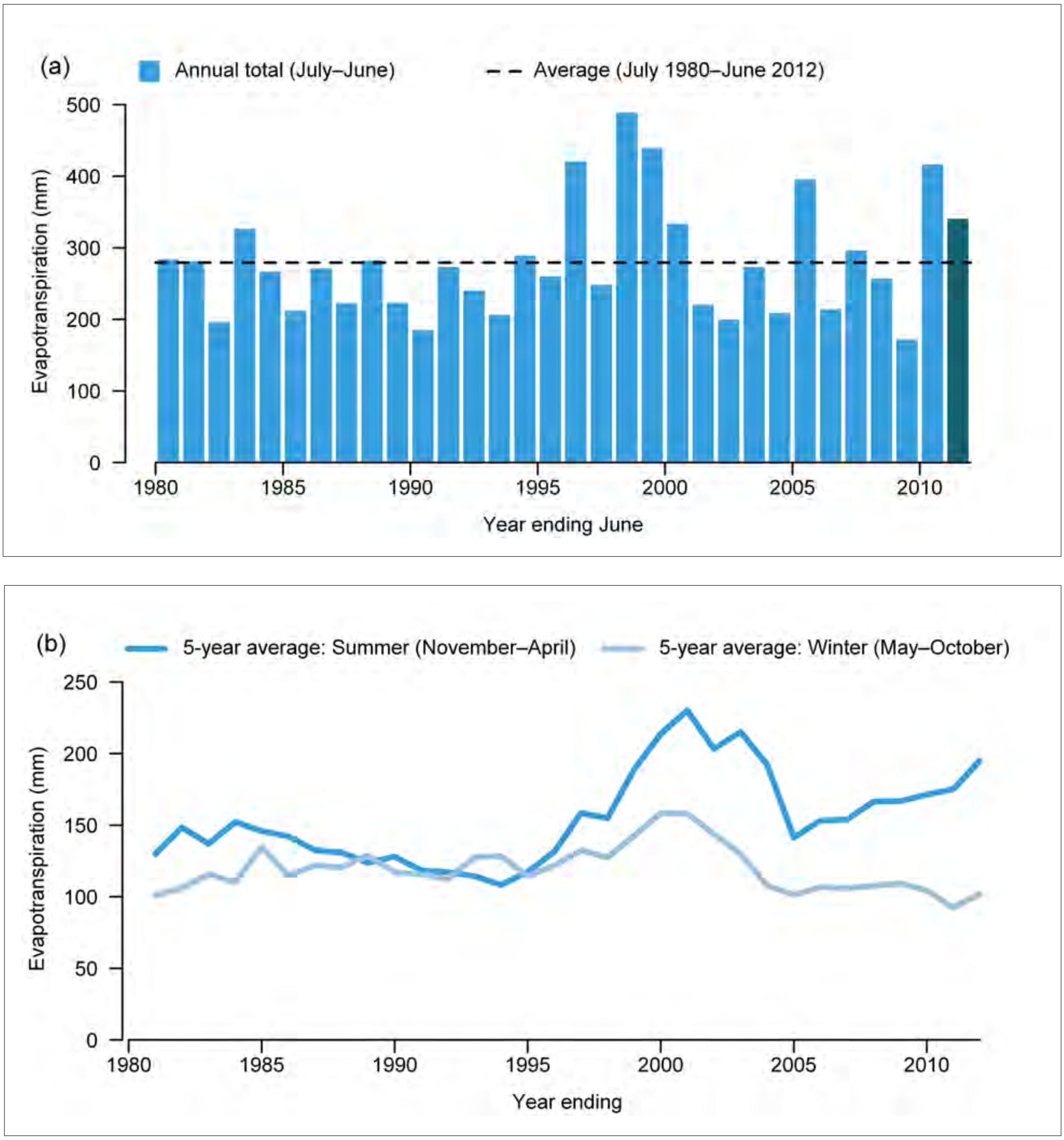

Figure 11.17 Time-series of (a) annual evapotranspiration, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the Pilbara–Gascoyne region

Recent trends in evapotranspiration

Figure 11.18a 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 11.18b.

Figure 11.18a shows that trends in evapotranspiration are almost identical to those of rainfall (Figure 11.15a).

As shown in Figure 11.18b, the trends are generally only statistically significant in some inland parts of the region as well as around Karratha and Dampier on the north coast; however, the total area indicated as having a strongly significant trend of rising evapotranspiration covers only 6% of the region.

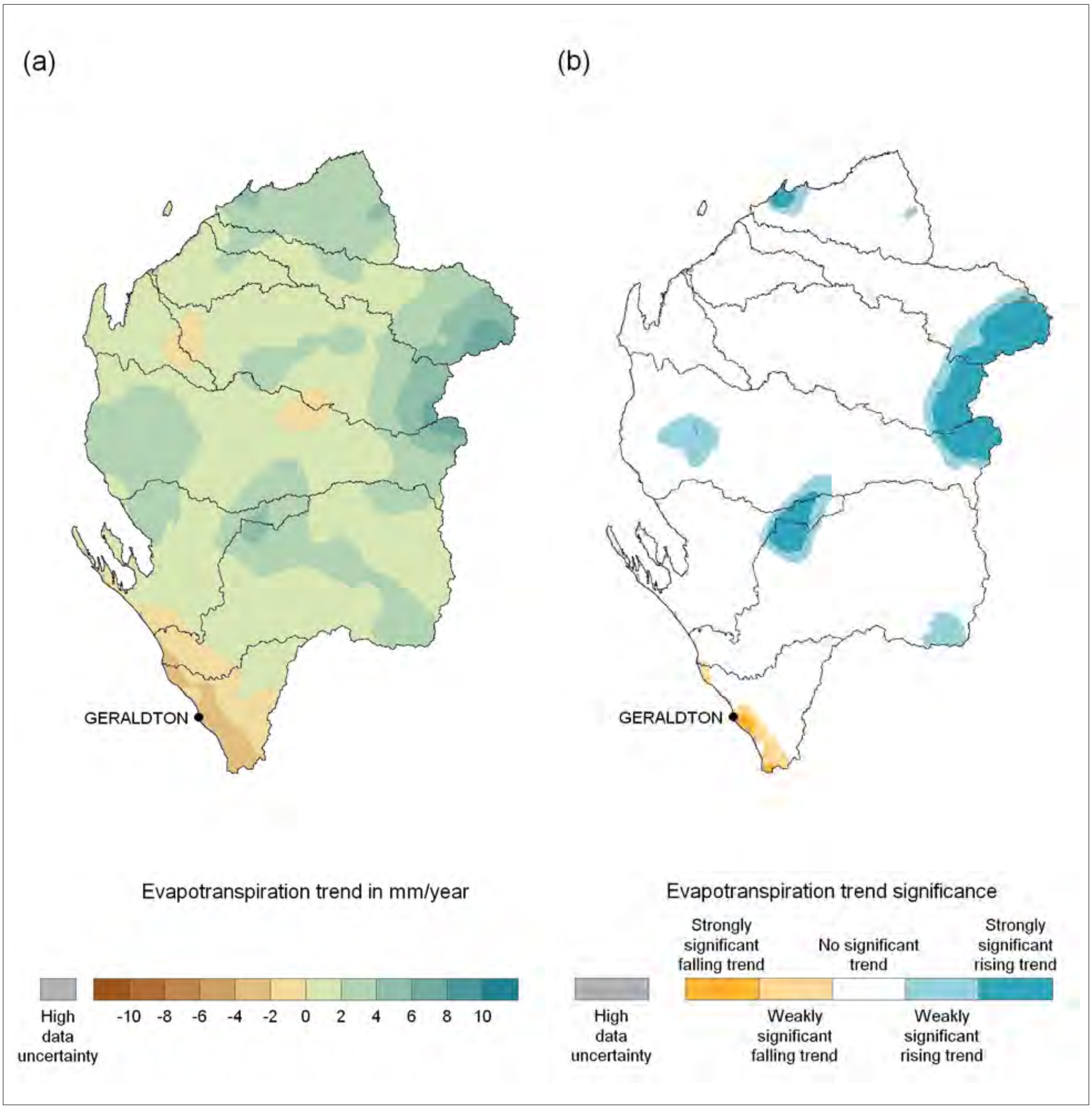

Figure 11.18 Spatial distribution of (a) trends in annual evapotranspiration from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the Pilbara–Gascoyne region

11.4.3 Landscape water yield

Modelled landscape water yield for the Pilbara–Gascoyne region for 2011–12 is estimated to be 19 mm. This is 73% above the region's long-term (July 1911–June 2012) average of 11 mm. Figure 11.19a shows the spatial distribution of landscape water yield for 2011–12, which is similar to the annual rainfall distribution (Figure 11.13a, note the difference in the scale of the two figures).

The highest landscape water yields in 2011–12 are observed in the northeast of the region where tropical cyclone *Heidi* made landfall in January 2012.

The decile-ranking map for 2011–12 (Figure 11.19b) shows average to above average landscape water yields. Very much above average water yields are found across much of the Gascoyne area. Below average landscape water yields are found only in some areas around Exmouth in the northwest and Geraldton in the south.

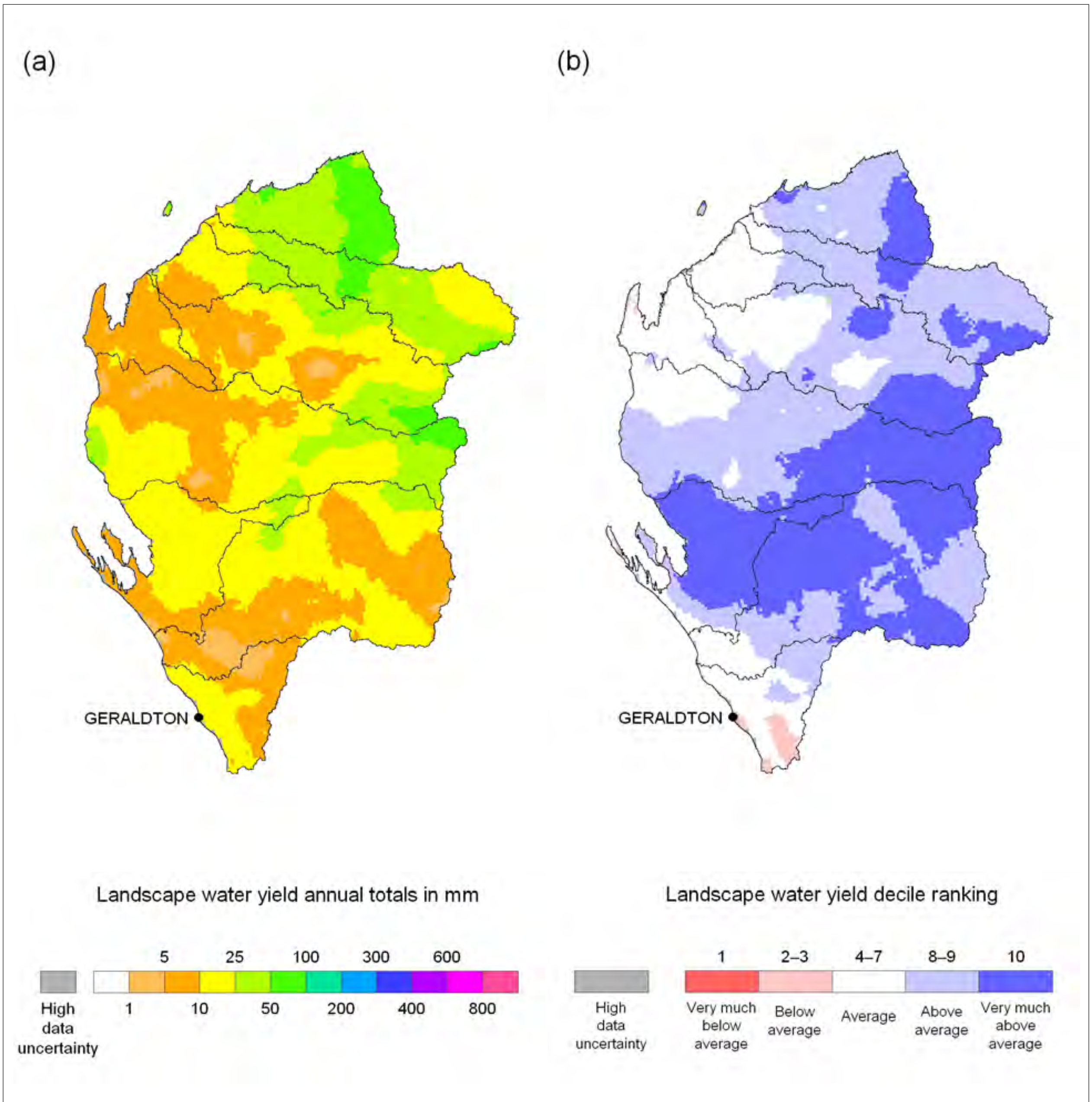

Figure 11.19 Spatial distribution of (a) modelled annual landscape water yield in 2011–12, and (b) their decile rankings over the 1911–2012 period for the Pilbara–Gascoyne region

Landscape water yield variability in the recent past

Figure 11.20a shows annual landscape water yield for the Pilbara–Gascoyne region from July 1980 onwards. Over this 32-year period, annual landscape water yield was 16 mm, varying from 4 mm (1982–83) to 67 mm (1999–2000). Temporal variability and seasonal patterns (over the summer and winter periods) since 1980 are presented in Figure 11.20b.

The sudden increase in rainfall in the summer period since 1997 has had a major impact on landscape water yield for the region. Landscape water yield increased fivefold for the five-year retrospective moving average for the years 2000–2004 , and remained significantly higher for the rest of the period.

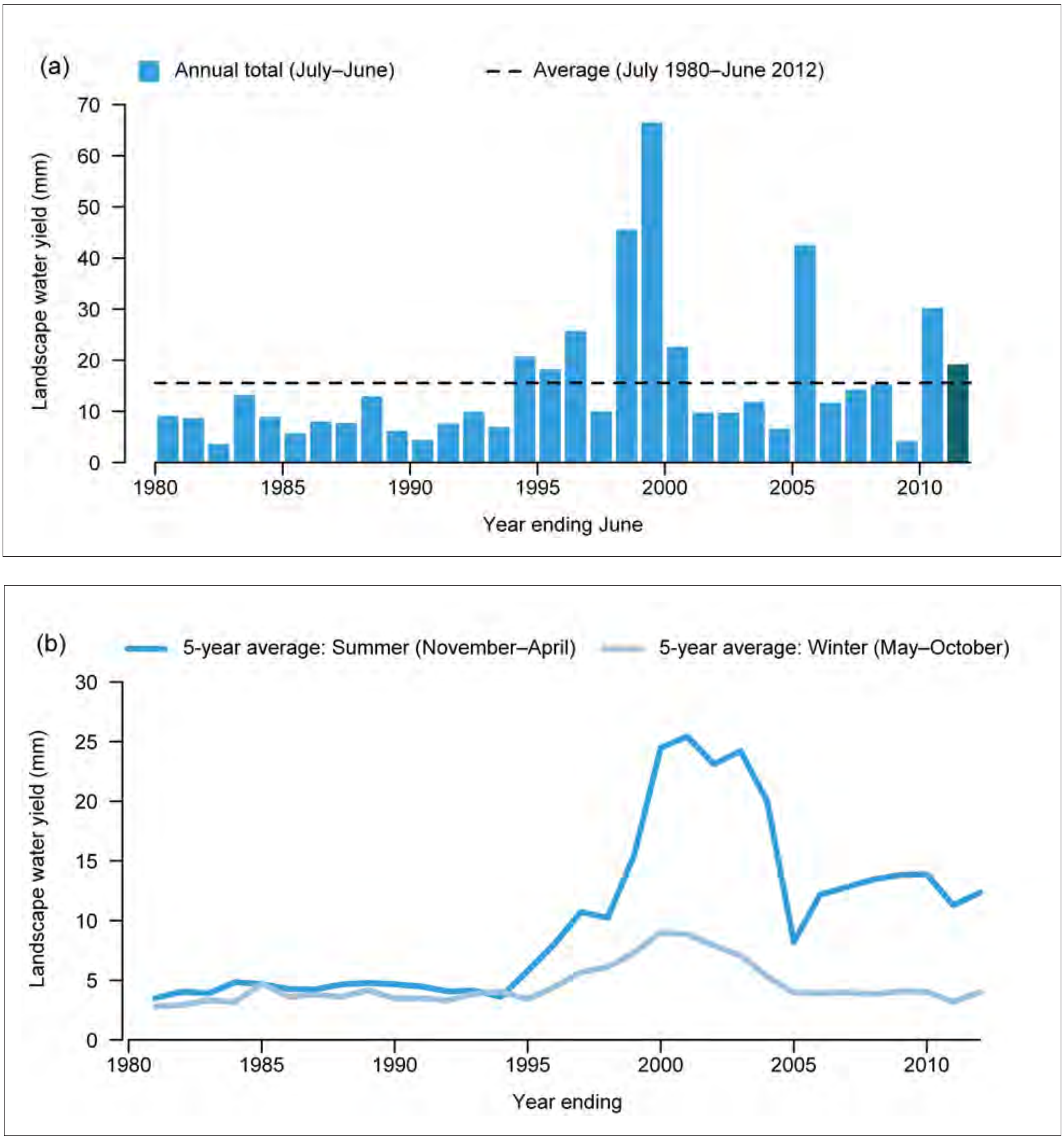

Figure 11.20 Time-series of (a) annual landscape water yield, and (b) five-year retrospective moving averages for the summer (November–April) and winter (May–October) periods for the Pilbara–Gascoyne region

Recent trends in landscape water yield

Figure 11.21a 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 11.21b.

Figure 11.21a shows that since 1980 trends are marginal in comparison to the rainfall trends. This can be expected when applying linear regression to time-series of particularly low annual totals.

However, Figure 11.21b shows strongly significant trends occur over a large area in the centre of the region. The magnitudes of the trends associated with this area are mostly limited to 0.5 mm/year in the east and 1 mm/year in the west. The area with a strongly significant rising trend in the north has a trend of 2 mm/year. The area with a falling trend in the south does not appear to have any statistical significance.

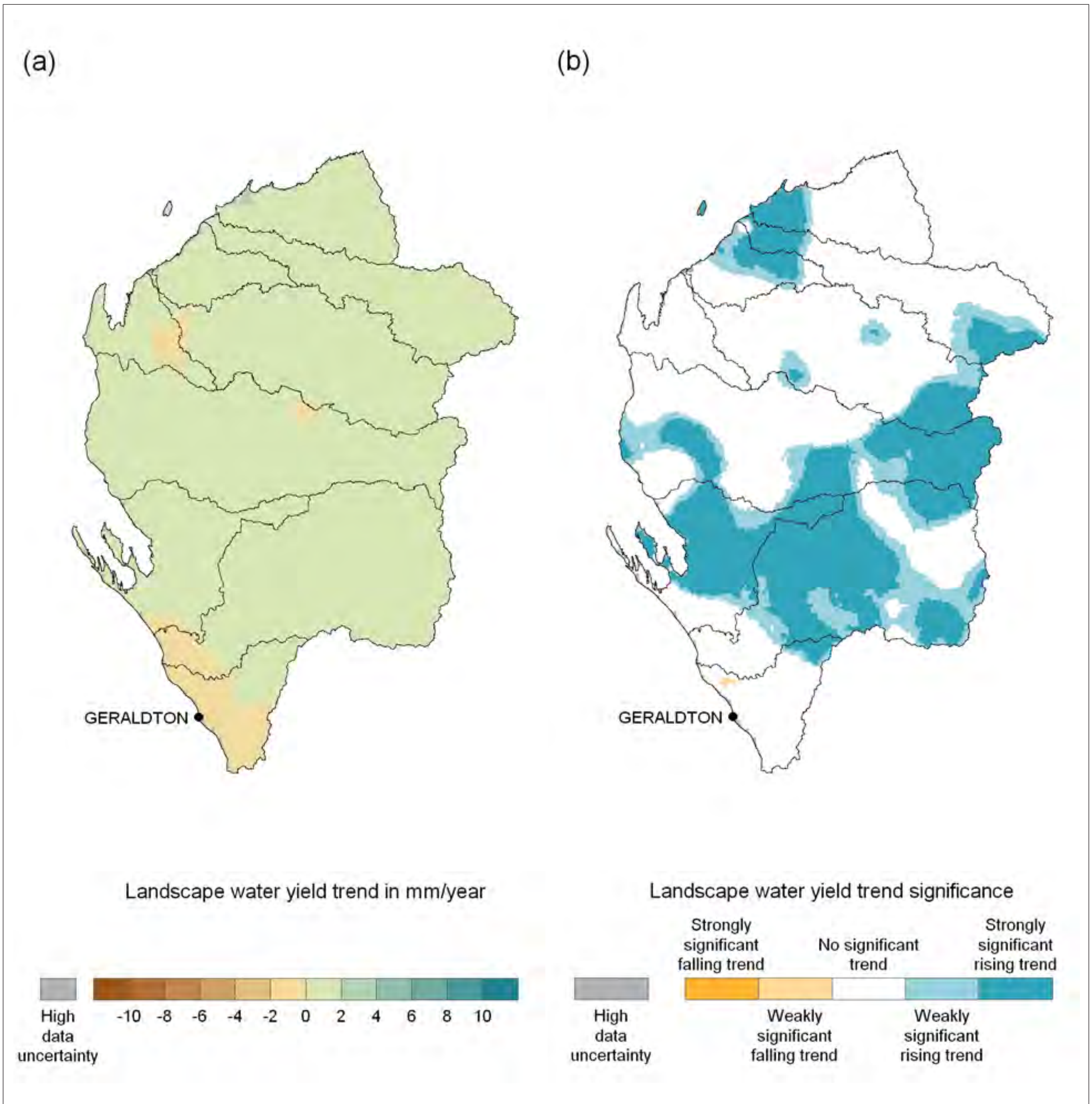

Figure 11.21 Spatial distribution of (a) trends in annual landscape water yield from 1980–2012, and (b) their statistical significance at 90% (weak) and 95% (strong) confidence levels for the Pilbara–Gascoyne region

11.5 Surface water and groundwater

This section examines surface water and groundwater resources in the Pilbara–Gascoyne 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.

11.5.1 Rivers

There are nine river basins in the Pilbara–Gascoyne region, varying in size from 18,400 to 108,000 km^2. The major basins are the Gascoyne, Murchison and Ashburton river basins (Figure 11.22). The watersheds are a maze of mountains covering almost the entire region from which the rivers flow in all directions.

Rivers are sparse, large, and drain internally or towards the Indian Ocean. They are relatively flat and streamflows tend to quickly recharge alluvial aquifers through the riverbeds. Rivers are all seasonal, flowing only during and after heavy rains. The major rivers generate substantial amounts of flow at high rainfall periods. The Murchison River is about 700 km long, originating in the Robinson Range 450 km from the coast. It merges with the Hope, Roderick and Sandford rivers, which are all seasonal like the Murchison, and flows across the coastal lowlands into the Murchison Gorge.

Analysis of streamflow volumes and salinity was not possible for this region due to unavailability of data.

11.5.2 Flooding

There were no major floods on the gauged rivers in the Pilbara–Gascoyne region during 2011–12 (Figure 11.23). Rainfall was mainly above average in the inland parts of the region due to tropical cyclone *Heidi*, where it did cause some minor flooding.

11.5.3 Storage systems

There is only one major storage located in the Pilbara–Gascoyne region, being Harding. This storage provides industrial and domestic water to the towns of Dampier, Karratha, Wickham, Roebourne, Point Samson and Cape Lambert. The location of this storage is 20 km south of Roebourne on the Harding River. The storage has an accessible capacity of 63 GL.

At the beginning of 2011–12 Harding's storage volume was just short of 100% at 62 GL, but over the year this volume dropped, reaching 36 GL by the end of June 2012. The absence of a large inflow event, as had happened previous years, and the continued use of the water in combination with the normally high evaporation levels, caused this 41% decrease in storage volume.

11.5.4 Wetlands

There are no Ramsar-listed, internationally important wetlands in the Pilbara–Gascoyne region; however, there are 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 vary from coastal floodplains, lakes and tidal flats to inland ephemeral lakes and river floodplain systems (Figure 11.24).

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

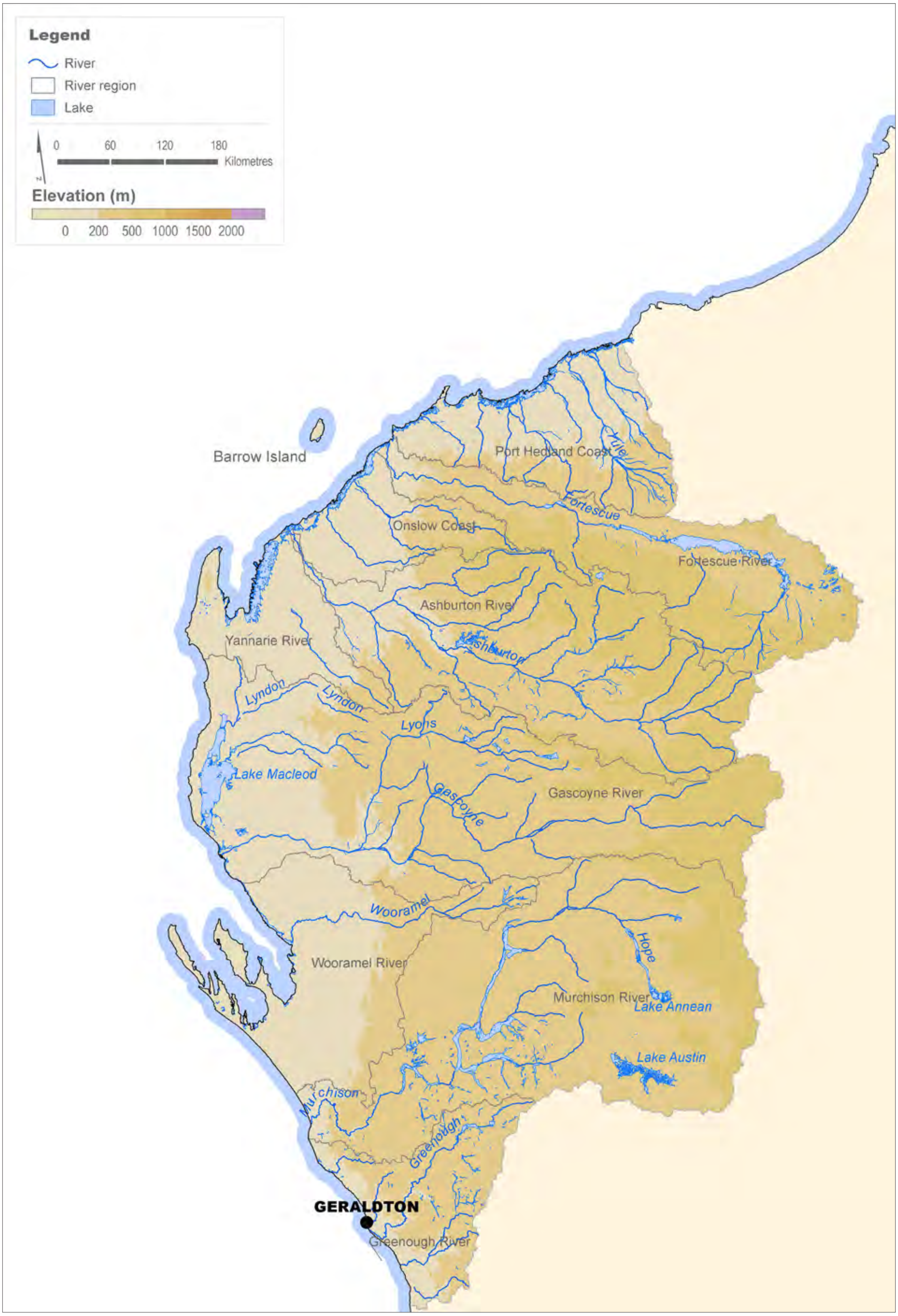

Figure 11.22 Rivers and catchments in the Pilbara–Gascoyne region

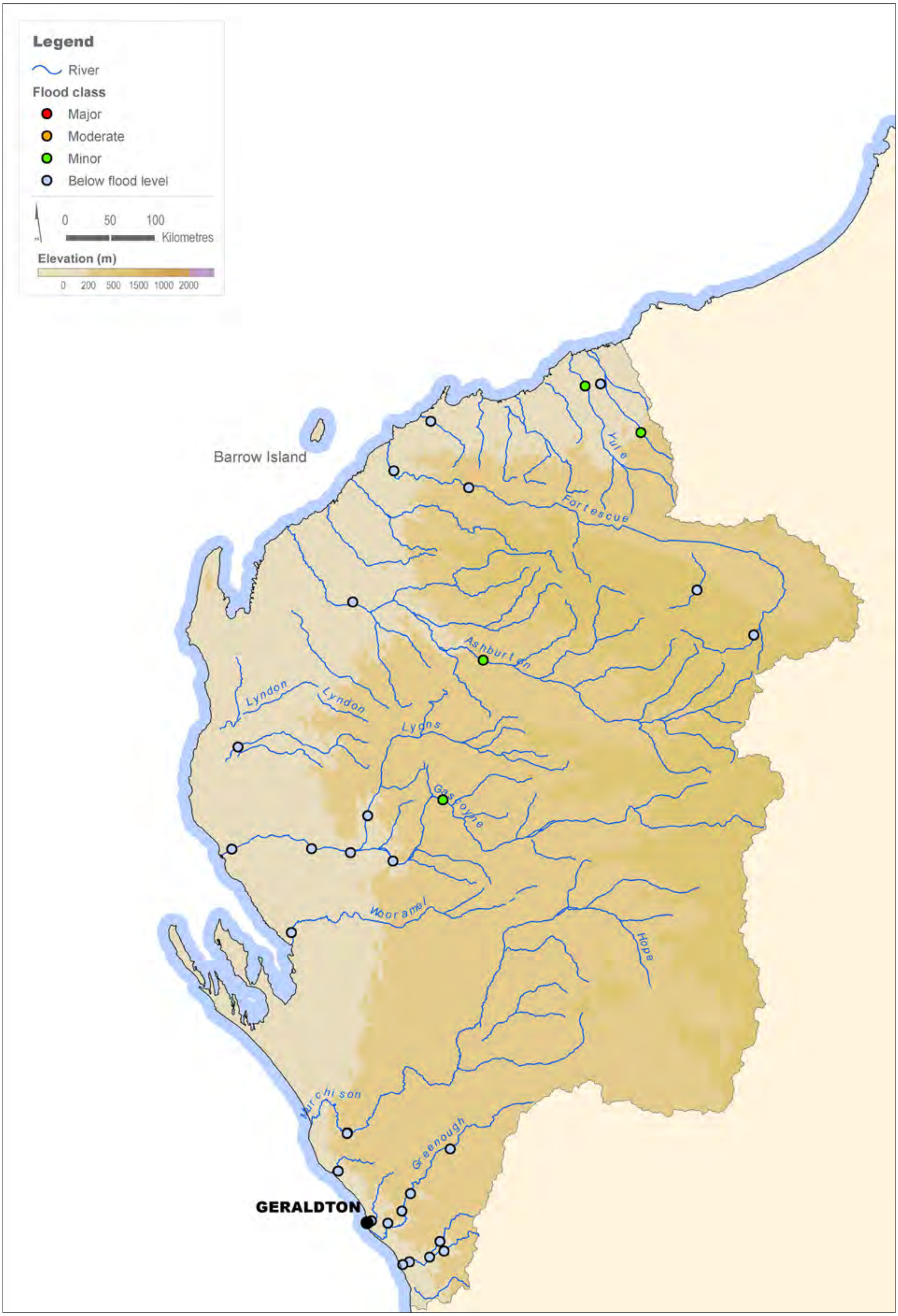

Figure 11.23 Flood occurrence in 2011–12 for the Pilbara–Gascoyne region

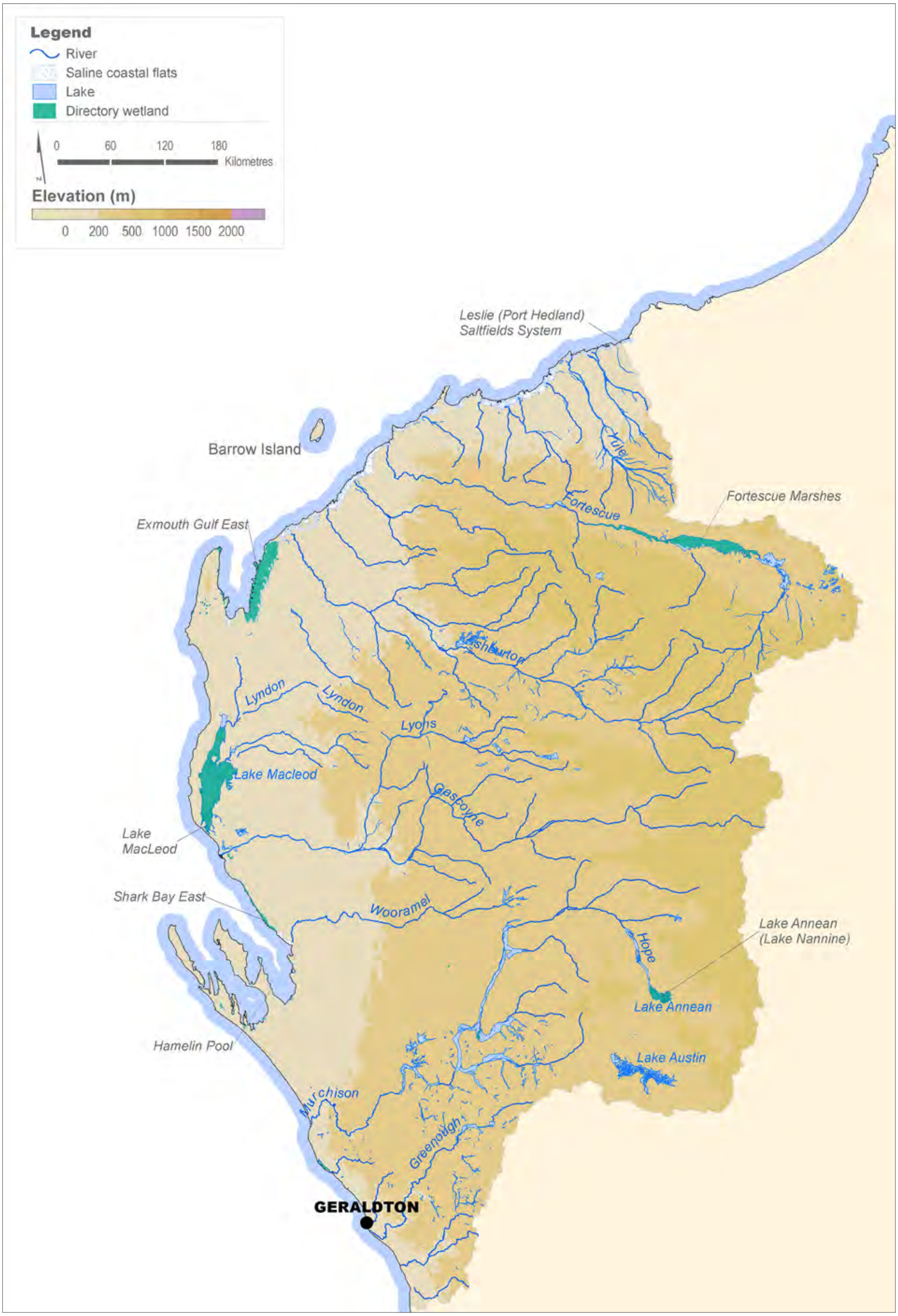

Figure 11.24 Location of important wetlands in the Pilbara–Gascoyne region

11.5.5 Hydrogeology

The watertable aquifers present in the region are given in Figure 11.25. The hydrogeology of the region is dominated by the large area of outcropping Palaeozoic fractured basement rock of low permeability. The main groundwater resources in the region are contained in the Mesozoic fractured rock aquifer which corresponds to the Carnarvon artesian basin and a small part of the Leederville and Yarragadee aquifers beneath the Swan Coastal Plain.

The Carnarvon artesian basin contains the Birdrong sandstone aquifer, Western Australia's most geographically extensive artesian aquifer. Artesian groundwater from the Birdrong has historically been used by the pastoral industry but is under increasing demand from new development proposals. While the resources of the Birdrong aquifer are significant, recharge is limited.

11.5.6 Water table salinity

Figure 11.26 shows the classification of the groundwater in the watertable aquifer as fresh (total dissolved solids (TDS) < 3,000 mg/L) or saline (TDS ≥ 3,000 mg/L). As shown in the figure, the Palaeozoic fractured basement is shown to have fresh water, while the Mesozoic fractured rock aquifer which corresponds to the Carnarvon artesian basin along the coastal region is identified as having mainly saline groundwater water.

However, the Carnarvon artesian basin contains six overlapping main hydrogeological formations with the principal aquifer being the Birdrong, a portion of which contains significant fresh groundwater resources.

11.5.7 Groundwater management units

The groundwater management units within the region are key features that control the extraction of groundwater through planning mechanisms. Figure 11.27 shows that major groundwater management units within the region include Gascoyne, East Murchison and Pilbara. Of these only Gascoyne and Carnarvon are proclaimed.

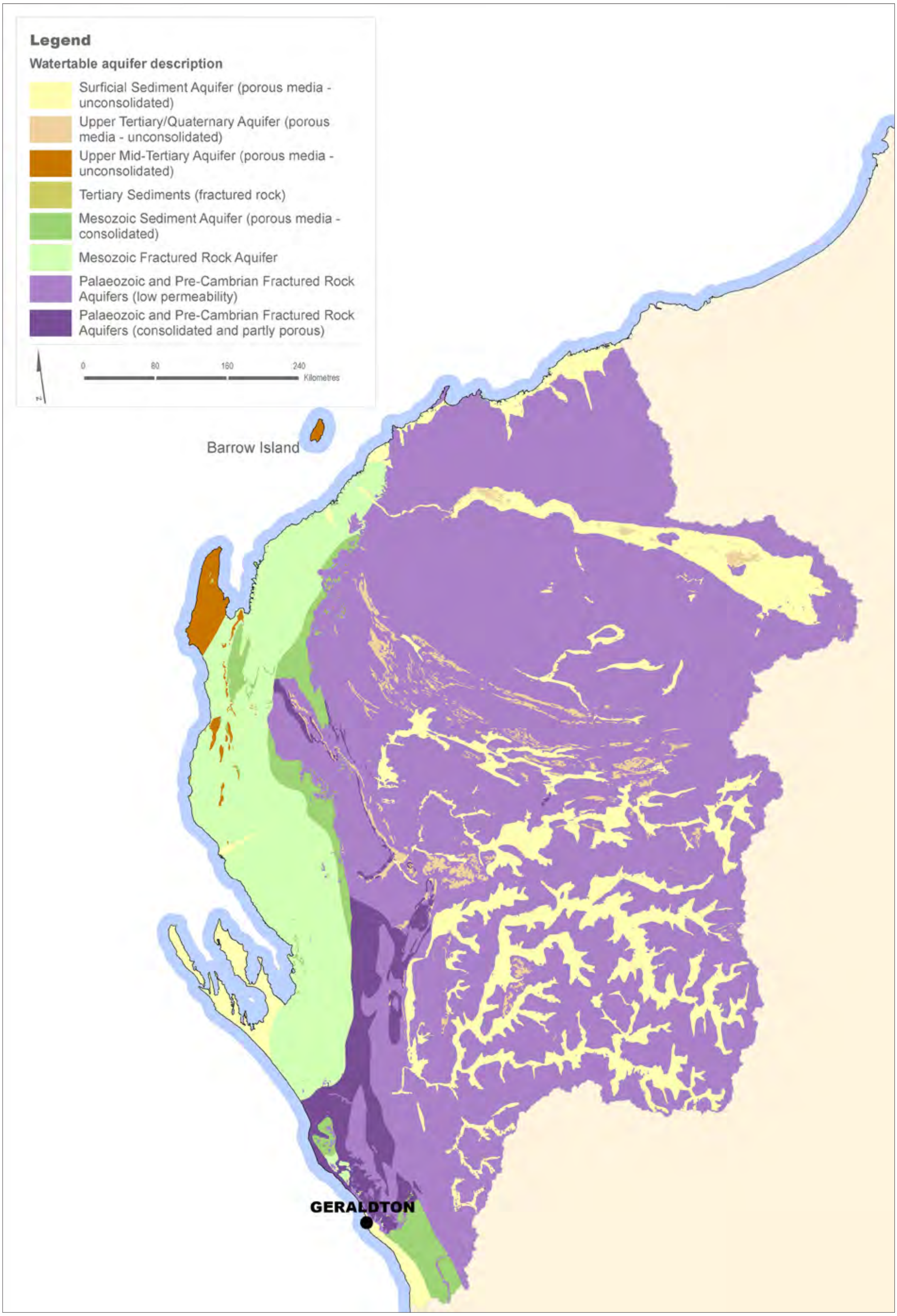

Figure 11.25 Watertable aquifers of the Pilbara–Gascoyne region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

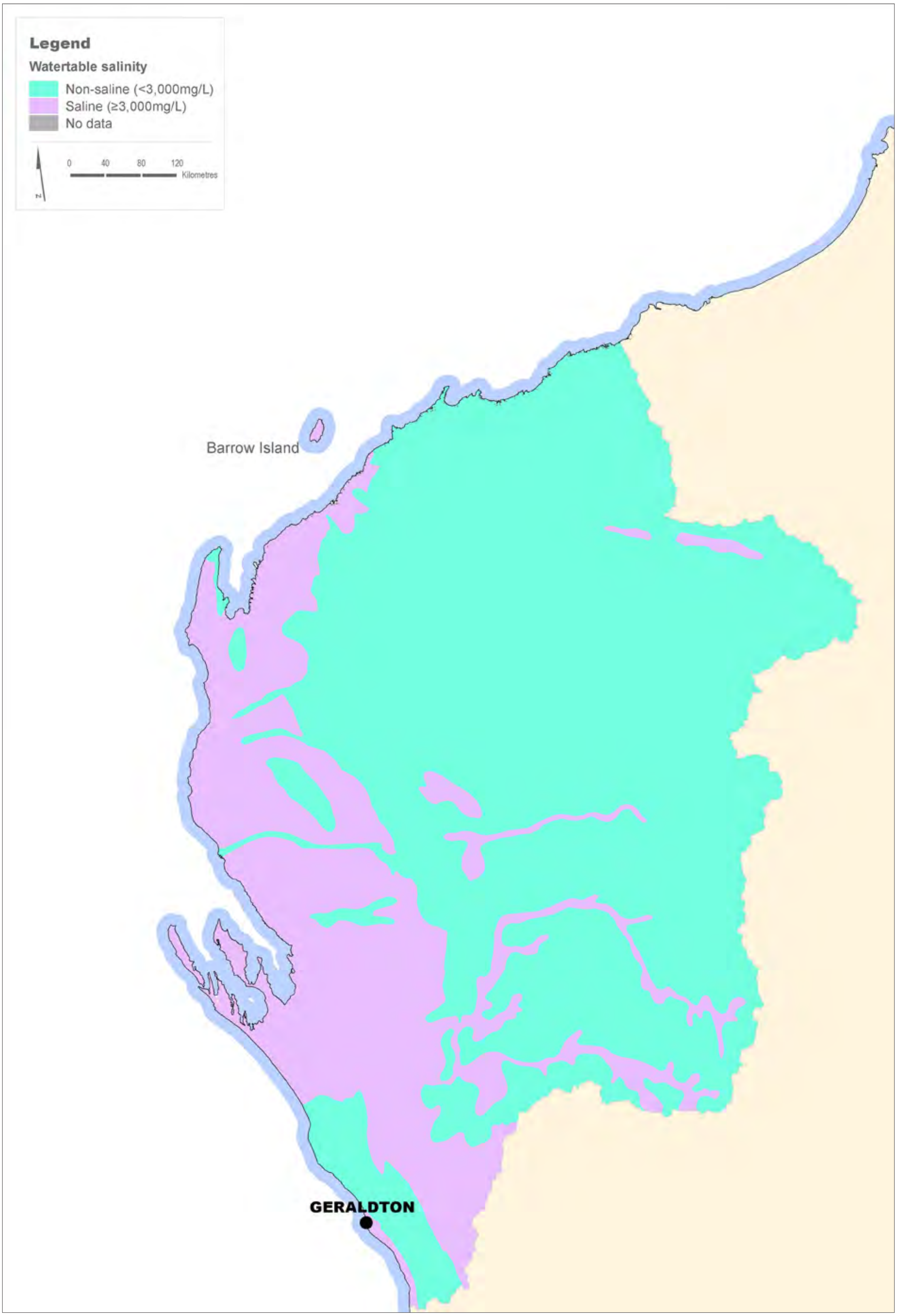

Figure 11.26 Water table salinity classes of the Pilbara–Gascoyne region; data extracted from the Groundwater Cartography of the Australian Hydrological Geospatial Fabric (Bureau of Meteorology 2012)

Figure 11.27 Groundwater management units in the Pilbara–Gascoyne region; data extracted from the National Groundwater Information System (Bureau of Meteorology 2013)

11.6 Water for cities and towns

This section examines the urban water situation in the Pilbara–Gascoyne region in 2011–12. The large urban centres in the region, their water supply systems and storage situations are briefly described. The main townships, Geraldton, Karratha and Port Hedland, are addressed in brief. A breakdown is provided for water obtained for and delivered to Geraldton, which is the largest town in the region.

11.6.1 Urban centres

Geraldton, Karratha and Port Hedland are the three major urban centres in the Pilbara–Gascoyne region with a combined population of more than 60,000 people. Figure 11.28 shows the population range for the region.

Geraldton is the largest centre with a population of about 31,500 people. Geraldton is a port in the mid-west area of Western Australia, located about 425 km north of Perth. The town is an important service centre for regional mining, fishing, wheat, sheep and tourism industries.

Karratha is the second largest urban centre in the region with a population of just under 16,500 people and adjoins the port of Dampier. It was developed in the late 1960s to accommodate the processing and exportation workload of the Hamersley Iron mining company. Further development of the town occurred in the 1980s to support the petroleum and liquefied natural gas operations of the North West Shelf Venture.

Port Hedland is the third major town, with a population of just under 14,000, including the satellite town of South Hedland. Port Hedland is a natural deep anchorage port which, as well as being the main fuel and container receival point for the region, serves for shipment of the iron ore being mined in the ranges located inland from the town. Other major resource activities supported include the offshore natural gas fields, salt, manganese, and livestock.

11.6.2 Sources of water supply

The Water Corporation of Western Australia manages the urban water supply in the Pilbara–Gascoyne region for all the major urban centres.

Domestic water supplied to Geraldton is sourced from groundwater. The aquifer that supplies Geraldton forms part of the Yarragadee formation, a vast store of groundwater that stretches from Allanooka, just south of Geraldton in the north, to Augusta in the south. Since 1967, Geraldton has been supplied from the Allanooka and Mt Hill borefields situated 55 km southeast of Geraldton. There are 19 production bores of various capacities supplying Geraldton, 13 of these being in the Allanooka borefield with the remainder at Mt Hill. The bores are between 50 and 150 metres deep. Mt Hill bores are only used to help meet summer peak demand.

The major source of water for Karratha is groundwater from the Millstream wellfield, located approximately 100 km south of Karratha. This wellfield is a reliable source of water, augmented by storage water from Harding. These two sources of water are used by the Water Corporation to supply water to the West Pilbara water supply scheme. This scheme supplies water to Karratha, Dampier, Roebourne, Wickham, Point Samson, Cape Lambert and the Burrup Peninsula.

Port Hedland and South Hedland are supplied with drinking water via the East Pilbara Water Supply Scheme. The system has two independent groundwater sources, the Yule River and the De Grey River borefields. The licensed allocation from the sources is 13.5 GL per year. While the current demand on the scheme is less than the licensed allocation, commitments to industry and domestic growth will fully utilise the capacity of the scheme when they are taken up.

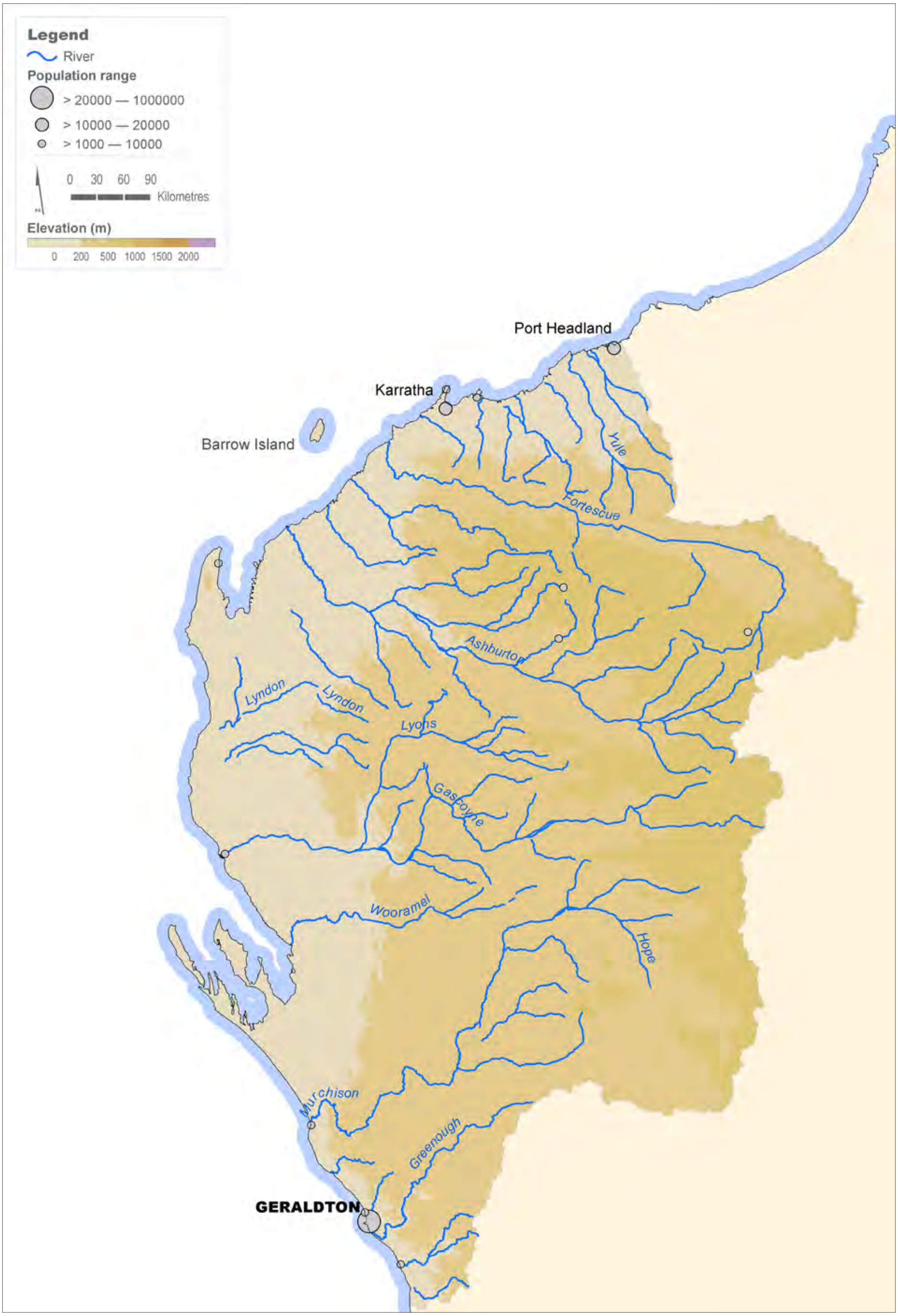

Figure 11.28 Population range of major urban centres in the Pilbara–Gascoyne

11.6.3 Geraldton

Sources of water obtained

Figure 11.29 illustrates the different sources of water for Geraldton from 2006–07 to 2011–12. Data were obtained from the National Performance Report for 2011–12 (National Water Commission 2013). On average about 97% of water is sourced from groundwater. The use of recycled water is limited to less than 3%.

The use of groundwater ranged from about 9.4–7.8 GL between 2006–07 and 2011–12. Due to water restrictions being in place, there was less water used in 2011–12 compared to 2006–07 which may be due to increased community awareness of the need to conserve water.

Recycled water use ranged between 290 and 220 ML in 2006–07 to 2011–12. Figure 11.29 reveals a decreasing trend of water use.

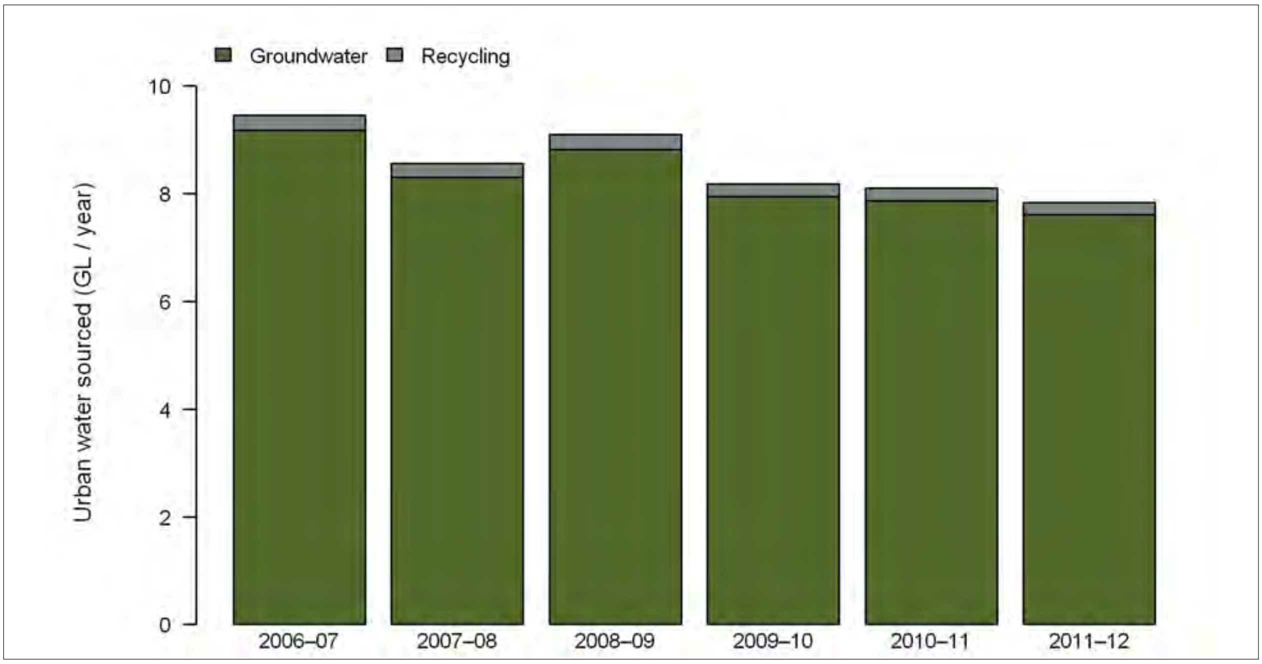

Figure 11.29 Total urban water sourced for Geraldton from 2006–07 to 2011–12

Categories of water delivered

Figure 11.30 shows the total volume of water delivered to residential, commercial, municipal and industrial consumers in Geraldton (National Water Commission 2013) from 2006–07 to 2011–12. Between 62% and 72% of the water was supplied for residential use and between 23% and 30% was for commercial, municipal and industrial use. The total water use decreased slowly from 8.2 GL to 7.8 GL between 2006–07 and 2011–12 largely as a result of water restrictions. The water used for other purposes also decreased from 1.25 GL to 0.8 GL from 2009–10 to 2011–12.

Based on the data from the National Performance Reports (National Water Commission 2013), the average residential water supplied to each property was estimated to be 387 kL from 2006–07 to 2011–12. The maximum residential water use per property was 457 kL in 2006–07 and the minimum was 343 kL in 2011–12.

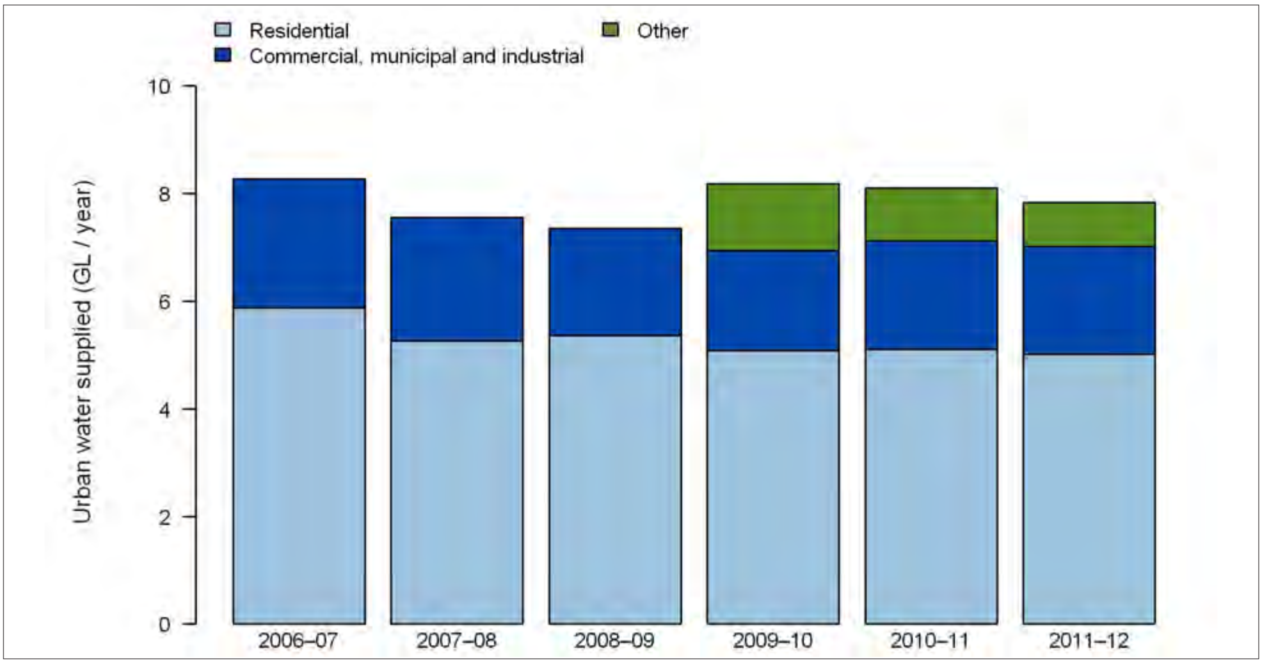

Figure 11.30 Total urban water supplied to Geraldton from 2006–07 to 2011–12