

Mathematics Level 7

Chapter 1 — Biomes and food security

This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

Attribution: Classbasics Pty Ltd, vwx.au

Curriculum codes refer to the *Victorian Curriculum F–10 Version 2.0*, published by the Victorian Curriculum and Assessment Authority (VCAA). Classbasics is not affiliated with the VCAA; the VCAA does not endorse this resource and makes no warranties regarding it.

Distribution note: this document may be distributed, and whole pages may be removed from it, provided only WHOLE pages are removed (never part of a page). This allows teachers to remove tests, exams and subtopics they do not want to issue.

Aboriginal and Torres Strait Islander content has been excluded as accuracy cannot be guaranteed, and it is better to be respectful than cover the entire curriculum inaccurately.

Significant effort has been made to ensure this content is legal. Please send any areas of concern to admin@vwx.au with appropriate document/legal references so errors can be verified and changes be made.

Contents

Section	Page
Biomes: what they are, where they are, and how they feed the world	2
Why crops grow where they do	16
Can Australian farming keep going? Soils, incomes and communities	29
Feeding a growing world: limits, climate change and food security	39

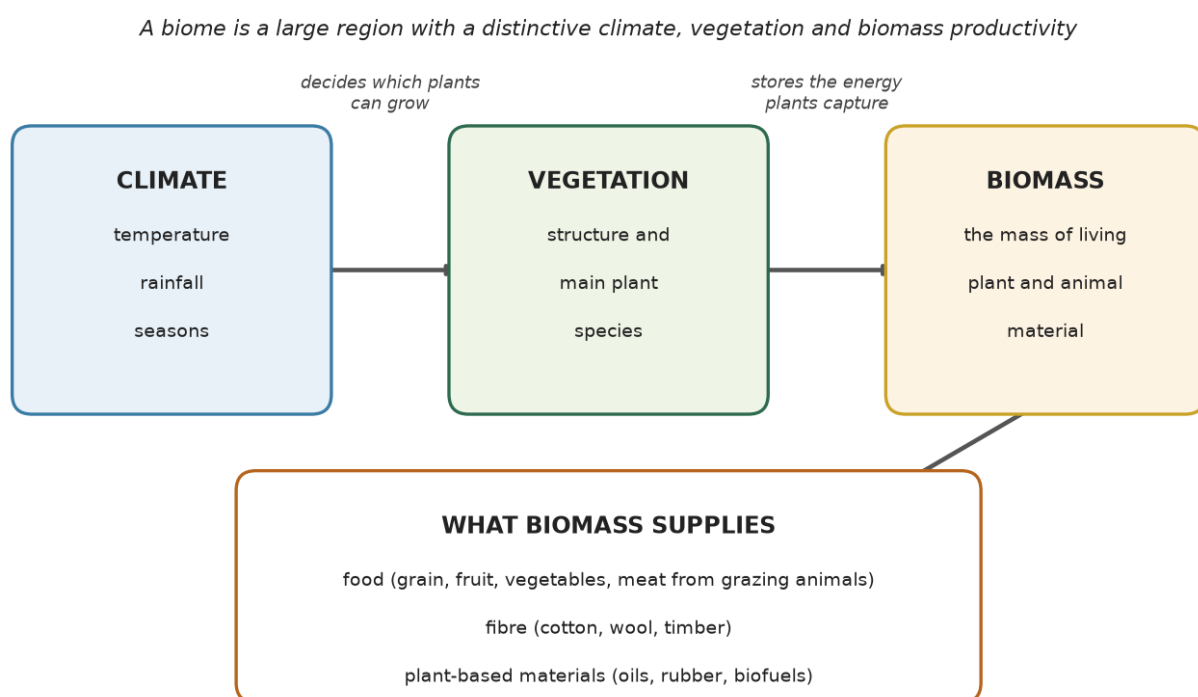
Biomes: what they are, where they are, and how they feed the world

Curriculum: VC2HG10K01. The elaborations are tagged at the end of each part as VC2HG10K01.E01–E04.

Theory

What is a biome? A **biome** is a large region of the Earth with its own **climate** (the long-run pattern of temperature, rainfall and seasons), its own **vegetation** (the structure and main kinds of plants), and its own **biomass productivity** — the rate at which new plant and animal material is made. Figure 1 shows the three parts as a linked system: climate decides which plants can grow, the vegetation stores **biomass** (the mass of living plant and animal material), and that biomass is the raw material of most of what people eat, wear and build with — food (grain, fruit, vegetables, meat from grazing animals), fibre (cotton, wool, timber) and plant-based industrial materials (oils, rubber, biofuels — fuels made from plants).

A biome as a linked system: climate, vegetation and biomass



Original diagram for this section (model, not to scale).

A biome as a linked system: climate shapes vegetation, vegetation stores biomass, and biomass supplies food, fibre and plant-based materials

Figure 1 — A biome as a linked system. Climate, vegetation and biomass pull in one direction: change the climate and the biome changes.

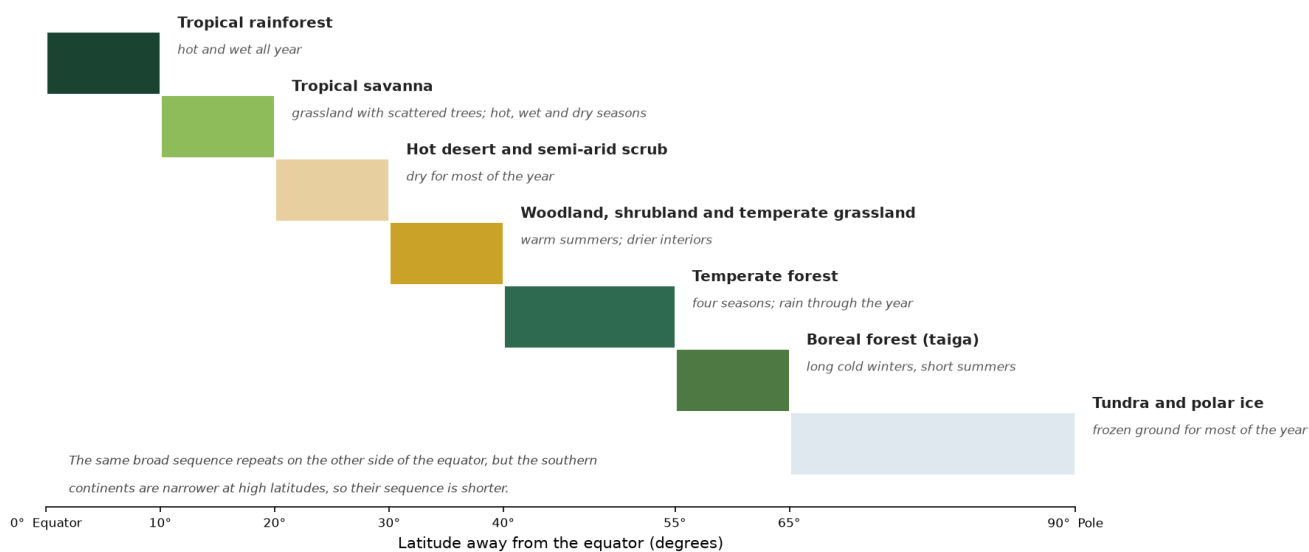
The rate at which a biome makes new plant material is called its **net primary productivity (NPP)**: the mass of new plant growth left over each year after the plants have used some of the captured energy to keep themselves alive. NPP is the ceiling on how much food, fibre and plant material a biome can supply, so it is the key measure of a biome's **potential to produce food**. It is measured either as a rate per unit area — grams of dry plant matter per square metre per year ($\text{g}/\text{m}^2/\text{yr}$) — or as a yearly total for the whole biome.

(VC2HG10K01.E01)

Where are the world's biomes? Climate changes in broad bands away from the equator — hot and wet near it, dry around $20\text{--}30^\circ$ of latitude, cooler towards the poles — so the world's land biomes sit in broad bands too (Figure 2).

The same sequence repeats in the southern hemisphere, but the southern continents narrow towards the pole, so the cool end of the sequence is mostly missing outside Tasmania and New Zealand. Biomes also include **aquatic biomes** — the open ocean, coastal waters and estuaries, and lakes and rivers — which cover about seven-tenths of the planet.

An idealised model of land biomes from the equator to the pole



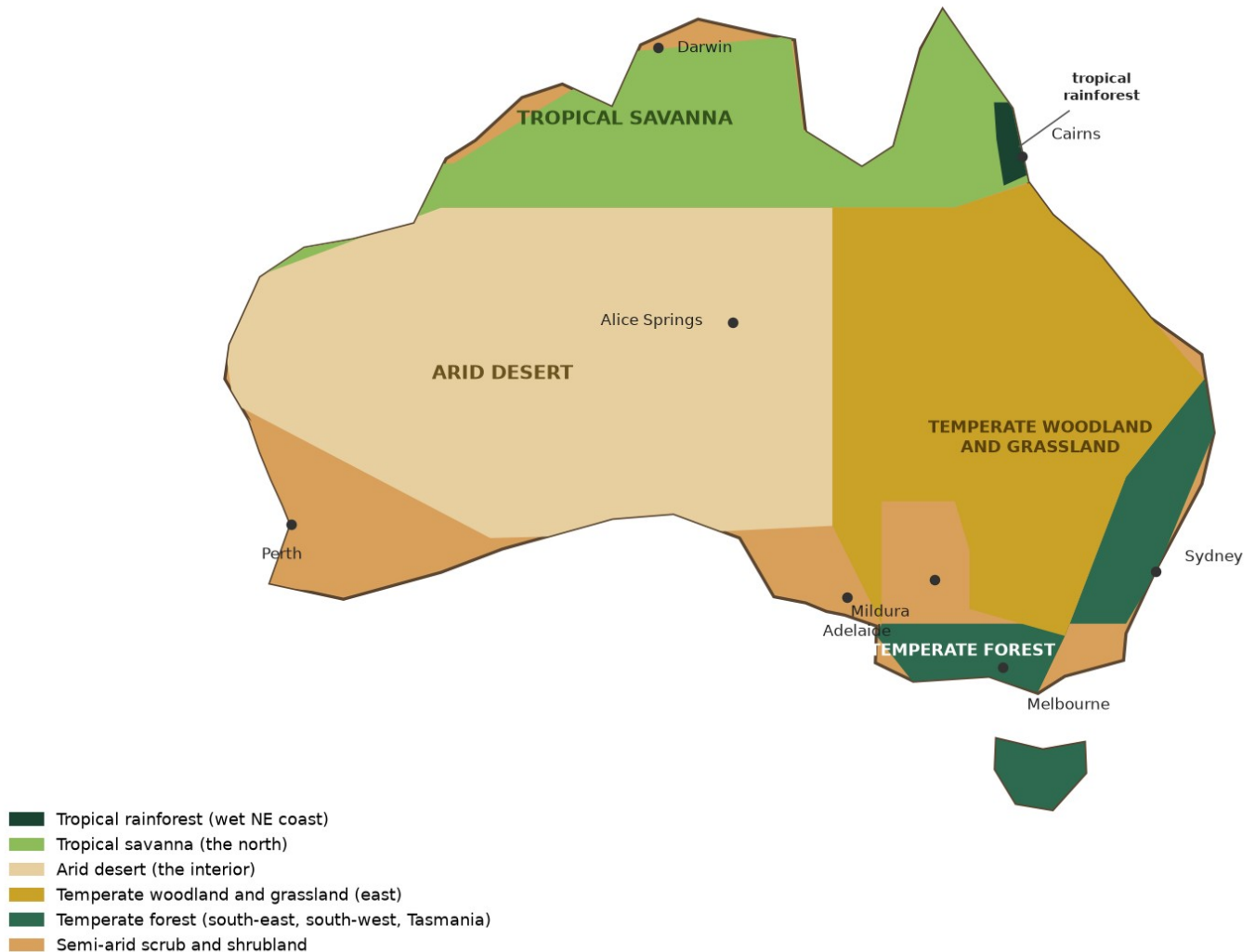
An idealised model of land biomes from the equator to the pole, showing latitude bands of tropical rainforest, tropical savanna, hot desert and semi-arid scrub, woodland shrubland and temperate grassland, temperate forest, boreal forest, and tundra and polar ice

Figure 2 — An idealised model. Real biome boundaries bend and grade into one another; maps of biomes are models, not fences.

Australia shows the same banding on a mostly dry continent (Figure 3). **Tropical savanna** (grassland with scattered trees) crosses the north around Darwin; a small patch of **tropical rainforest** clings to the wet north-east coast near Cairns; the interior around Alice Springs is **arid desert**, ringed by a wide belt of **semi-arid scrub**; the eastern inland plains are **temperate woodland and grassland**; and the wetter south-east and south-west corners, with Tasmania, carry **temperate forest**. Melbourne sits in the temperate forest biome; Mildura sits out in the semi-arid scrub of the Mallee, on the dry edge of the country's cropping belt.

A simplified model of Australia's major land biomes

Simplified coastline drawn for this section — a model for learning, not for navigation.



Original model map for this section, simplified from the idea of Australia's major vegetation groups. Biomes graded; boundaries are approximate.

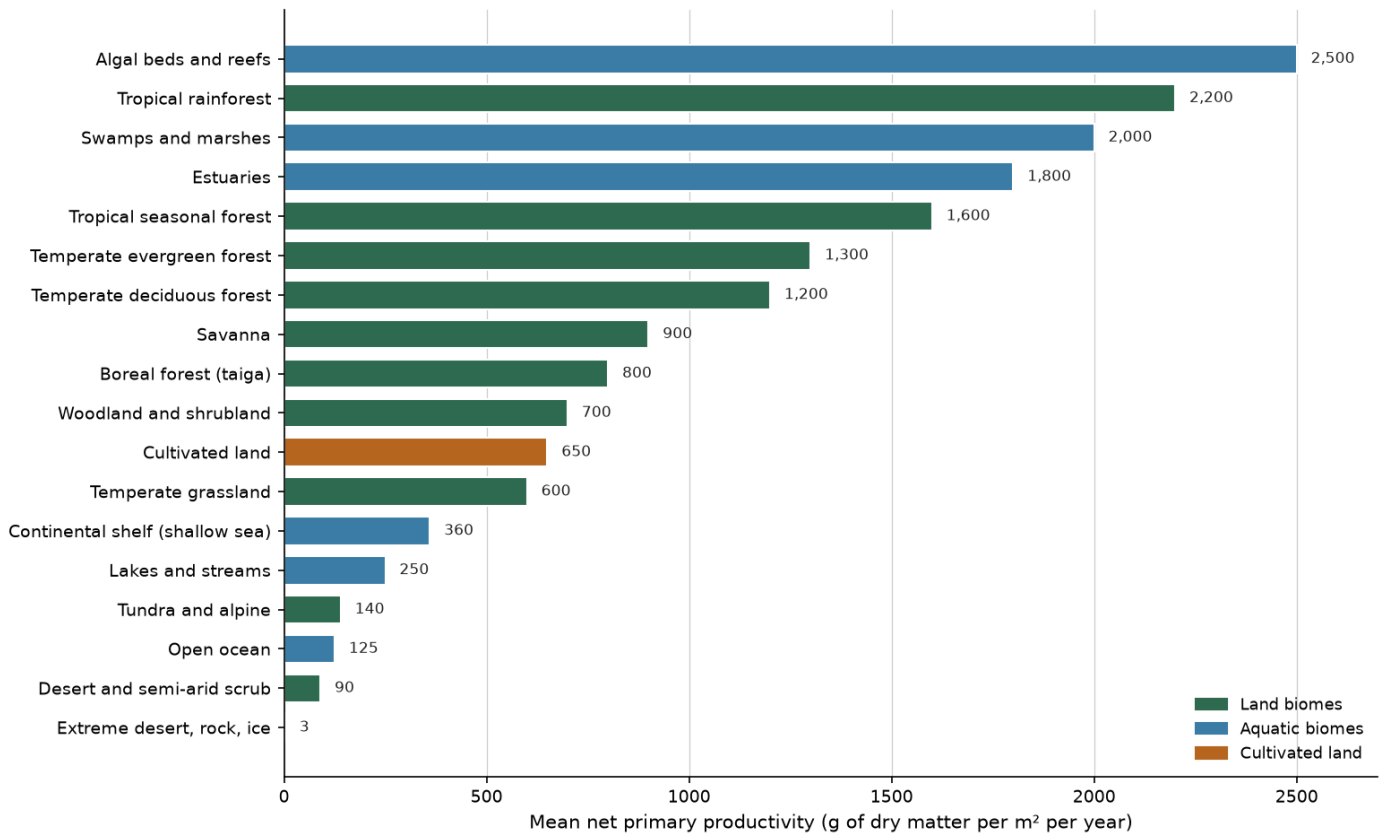
A simplified map of Australia's major land biomes with Darwin, Cairns, Alice Springs, Perth, Mildura, Adelaide, Melbourne and Sydney marked, showing tropical savanna across the north, tropical rainforest on the north-east coast, arid desert in the interior, semi-arid scrub around it, temperate woodland and grassland in the east, and temperate forest in the south-east, south-west and Tasmania

Figure 3 — Australia's major land biomes (simplified). The named cities are used throughout this section to connect biomes to real places.

(VC2HG10K01.E02)

How productive are the biomes? Figure 4 ranks the world's biomes by mean NPP. Warmth and water together mean high productivity: algal beds and reefs (shallow waters rich in seaweeds and corals; 2,500 g/m²/yr), tropical rainforest (2,200) and swamps and marshes (2,000) sit at the top, while the open ocean (125), deserts (90) and ice (3) sit at the bottom. Cultivated land — cropland — sits in the middle at about 650. Figure 5 changes the question from “how fast per square metre?” to “how much in total?”, because total NPP is mean NPP multiplied by the biome's area. The open ocean jumps to first place (about 41.5 billion tonnes of dry matter a year) even though each square metre does little, simply because the ocean is enormous; tropical rainforest is second (about 37.4), and the forest biomes together make up most of the land total.

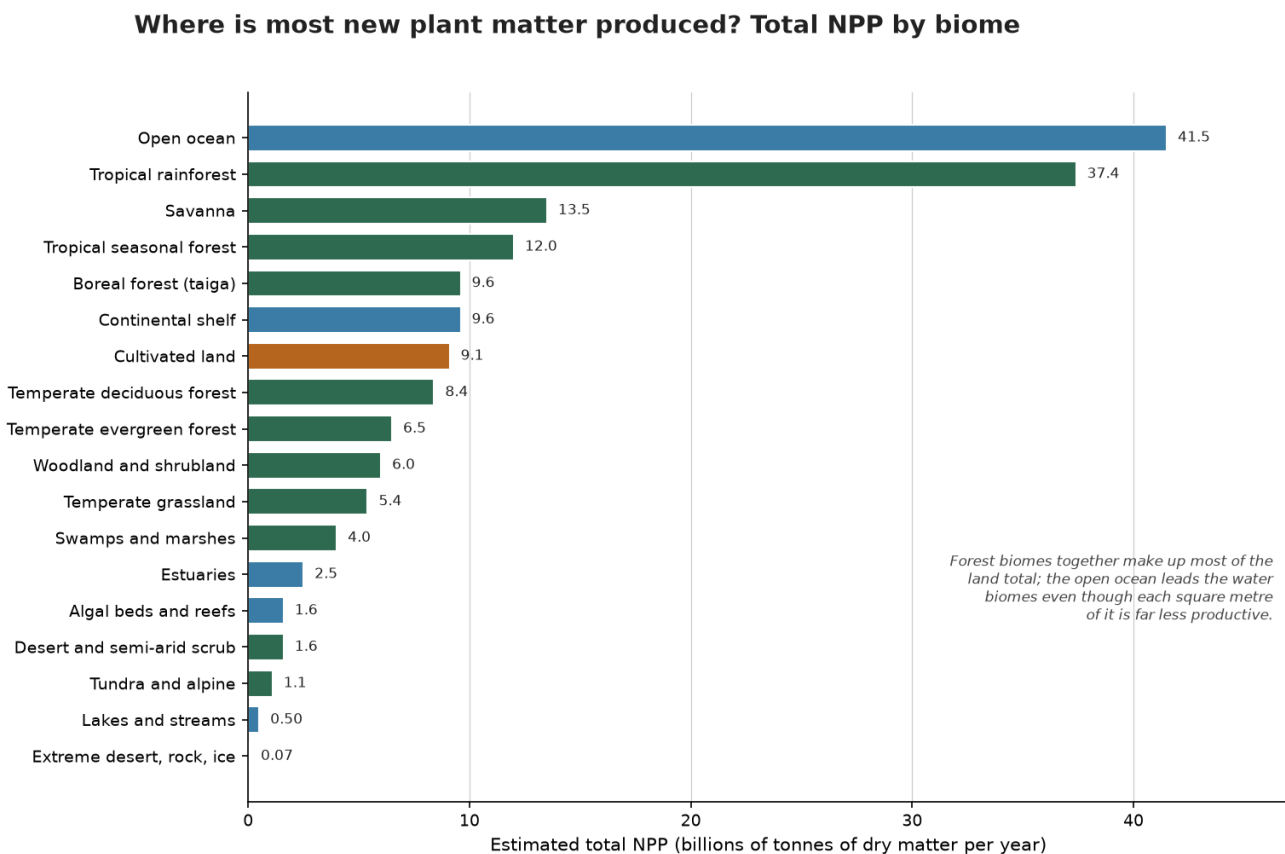
How productive are the world's biomes? Mean NPP by biome



Data: Whittaker, R.H. & Likens, G.E. (1975), 'Productivity of the biosphere', in Lieth & Whittaker (eds), *Primary Productivity of the Biosphere*, Springer-Verlag.

Bar chart of mean net primary productivity of the world's biomes in grams of dry matter per square metre per year, from algal beds and reefs at 2,500 down through tropical rainforest at 2,200 and cultivated land at 650 to extreme desert at 3

Figure 4 — Mean NPP by biome: how fast each square metre makes new plant matter.

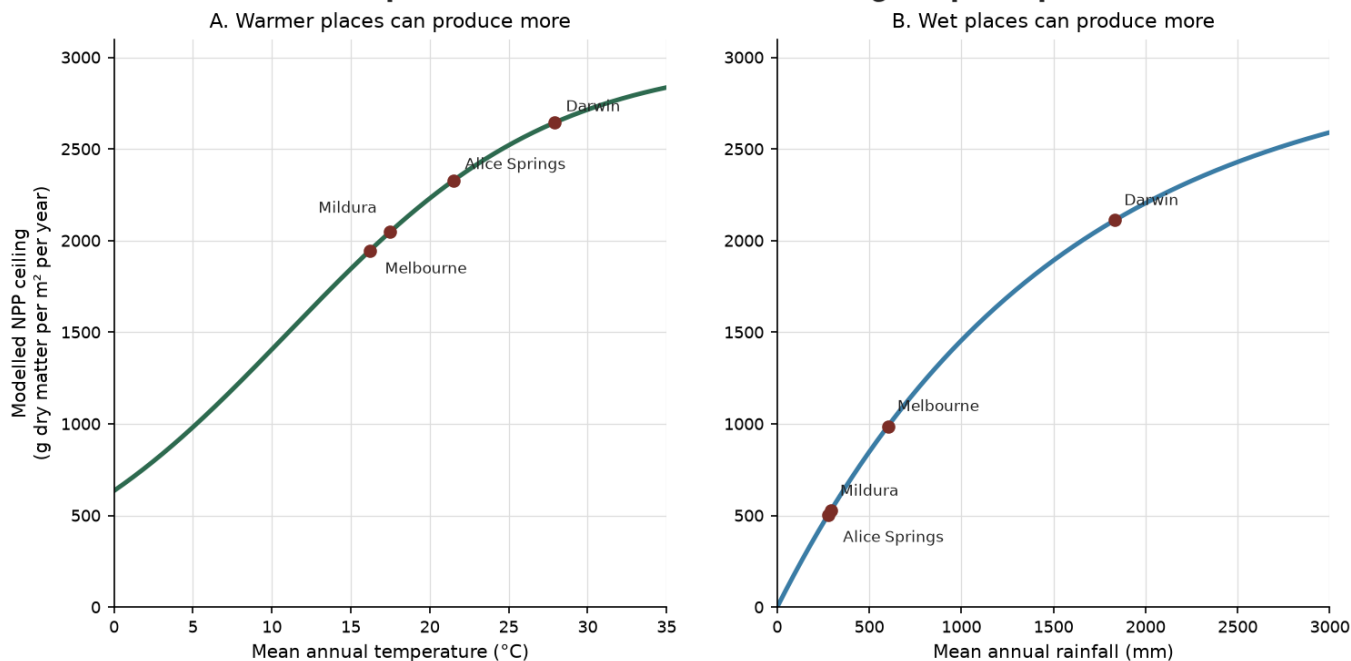


Bar chart of estimated total net primary productivity by biome in billions of tonnes of dry matter per year, with the open ocean first at 41.5, tropical rainforest second at 37.4, then savanna, tropical seasonal forest, boreal forest, continental shelf and cultivated land

Figure 5 — Total NPP by biome: mean rate $\times$ area. The open ocean wins on area, not on rate.

One simple model of climate control on NPP is the **Miami model** (Figure 6). It gives each place two ceilings — one set by mean annual temperature and one set by mean annual rainfall — and the place's modelled NPP is the lower of the two. Plotted with Bureau of Meteorology 1991–2020 averages, Darwin (hot and wet) models at about 2,100 g/m²/yr, Melbourne (warm and reliably wet) at about 990, and Mildura and Alice Springs (warm but dry) at only about 520 and 500. Over Australia, rainfall is nearly always the binding ceiling: Mildura is only slightly cooler than Melbourne, but with less than half the rain its natural biome is mallee scrub, not forest. Models like this are deliberate simplifications — soils, cloud cover, seasons and extreme days also matter — but the large pattern holds: warmth plus water sets the potential, and dryness caps it.

The Miami model: how temperature and rainfall set a ceiling for plant production



A place's modelled NPP is the LOWER of the two ceilings. Climate data: Bureau of Meteorology 1991-2020 averages.
Model: Lieth, H. (1975), 'Modeling the primary productivity of the world', in Lieth & Whittaker (eds), Primary Productivity of the Biosphere, Springer-Verlag.

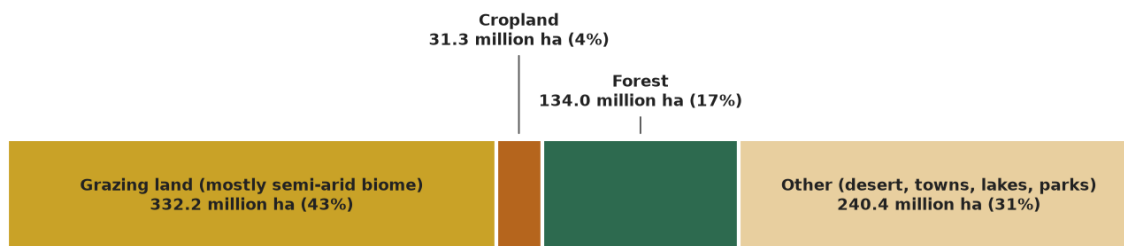
Two curves of the Miami model: modelled net primary productivity rising with mean annual temperature in panel A and with mean annual rainfall in panel B, with Darwin, Alice Springs, Melbourne and Mildura plotted on both curves from Bureau of Meteorology 1991 to 2020 averages

Figure 6 — The Miami model. A place's modelled NPP is the lower of its two ceilings, so in dry Australia the rainfall curve does the deciding.

(VC2HG10K01.E01, VC2HG10K01.E02)

Which biomes feed the world? The biomes that produce most of the world's food are not the most productive ones by nature — very little tropical rainforest or swamp is farmed — but the mid-ranking biomes that people have converted and managed: grasslands, woodlands and temperate forests turned into cropland and grazing land, plus the rich coastal waters and the irrigated patches of dry biomes. Figure 7 shows Australia's land budget for 2022: about 43% of the continent is grazing land, nearly all of it in dry, low-NPP biomes; only about 4% is cropland, concentrated in the better-watered parts of the temperate woodland and grassland biome (the wheat–sheep belt of the Murray–Darling basin and the Wimmera and Mallee edges) plus irrigated valleys such as the Murray at Mildura. Figure 8 shows the same pattern for the world: of roughly 4.9 billion hectares of farm land, pasture outweighs cropland by about 5 to 2, and the aquatic biomes add a second stream of food — 90.3 million tonnes of wild-caught fish and seafood, 87.5 million tonnes farmed in water (aquaculture), and 35.1 million tonnes of farmed seaweeds and algae (simple water plants) in 2020.

Australia's land budget, 2022: where food and fibre are produced



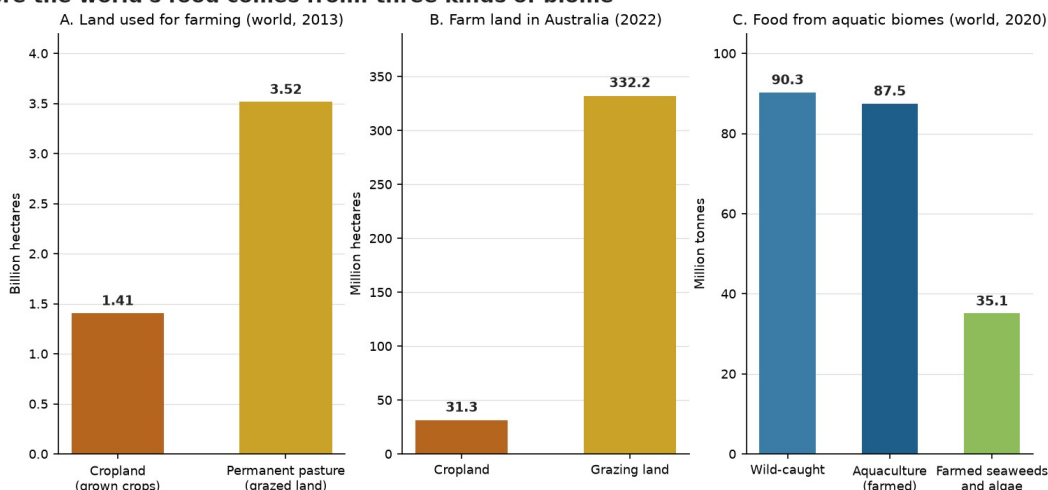
About half the continent (47%) is used for farming — but nearly all of it is grazing on dry land. Only about 4% of Australia is cropland, and it sits in the better-watered parts of the temperate woodland/grassland biome.

Data: World Bank, World Development Indicators (from FAO estimates): agricultural land, arable land and forest area, Australia, 2022; accessed 25 August 2026. Total land area 769.2 million ha.

Stacked bar of Australia's 2022 land budget: grazing land 332.2 million hectares or 43 per cent, cropland 31.3 million hectares or 4 per cent, forest 134.0 million hectares or 17 per cent, and other uses 240.4 million hectares or 31 per cent

Figure 7 — Australia's land budget, 2022. Farming covers about half the continent, but almost all of it is grazing on dry land; cropland is the small, well-watered sliver.

Where the world's food comes from: three kinds of biome



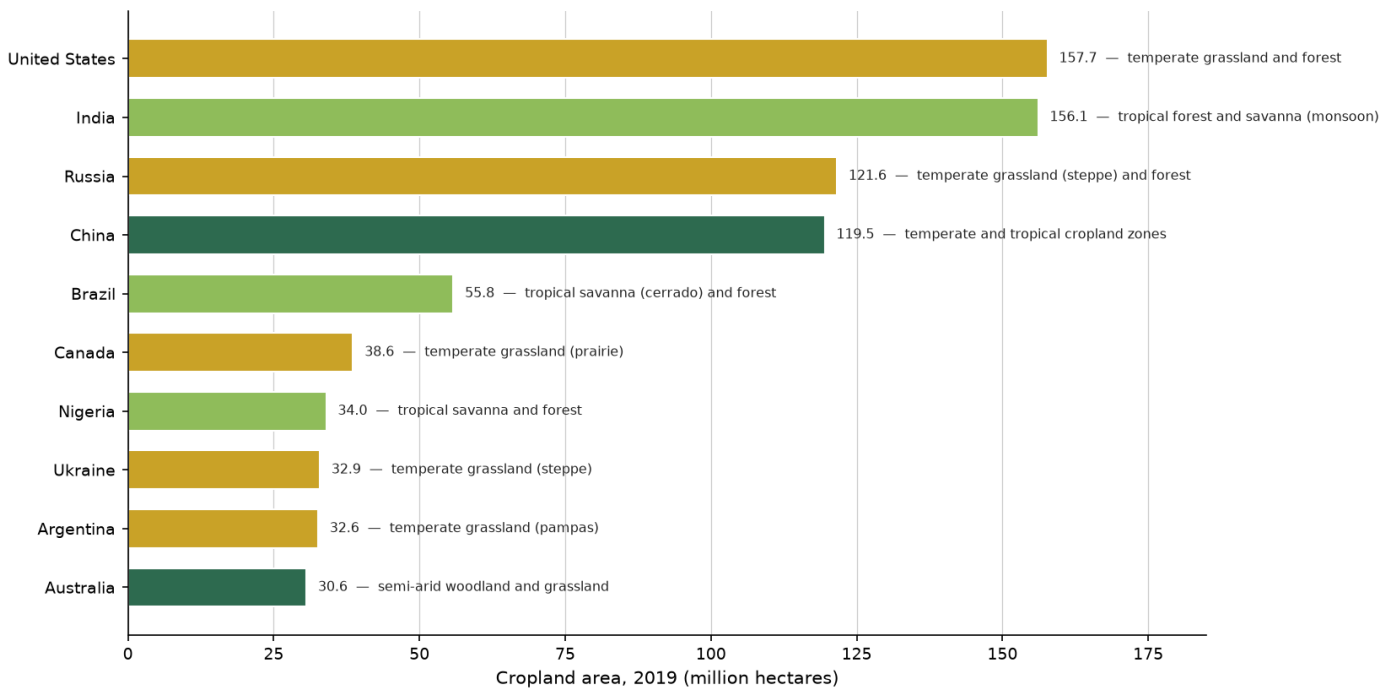
Data: A and B from FAO estimates via the World Bank and the FAO's 'Arable land' country data (cropland and pasture, 2013; Australia, 2022); C from FAO, The State of World Fisheries and Aquaculture 2022 (2020 totals). Accessed 25 August 2026.

Three bar charts: panel A, world farm land in 2013, cropland 1.41 billion hectares against permanent pasture 3.52; panel B, Australian farm land in 2022, cropland 31.3 million hectares against grazing land 332.2; panel C, food from aquatic biomes in 2020, wild-caught 90.3 million tonnes, aquaculture 87.5, and farmed seaweeds and algae 35.1

Figure 8 — Three streams of food: modified land biomes (crops and grazing) and aquatic biomes (wild-caught, farmed, and seaweeds).

The geography of cropland follows the grassland and forest biomes (Figure 9). The ten countries with the most cropland — the United States, India, Russia, China, Brazil, Canada, Nigeria, Ukraine, Argentina and Australia — mostly made it from temperate grassland (the North American prairie, the Eurasian steppe, the pampas), tropical savanna and forest, and Australia's from semi-arid woodland and grassland. Australia's 30.6 million hectares of cropland (2019) rank tenth in the world, and in good seasons it grows about 20–25 million tonnes of wheat a year — most of it exported. So the answer to “which biomes produce most of the world's food?” is: the mid-productivity grassland, woodland and temperate forest biomes, modified into cropland and pasture, together with the aquatic biomes and the irrigated green patches inside dry biomes.

The ten countries with the most cropland, and the biomes it was made from



Data: FAO country data, 2019, as compiled in the 'Arable land' reference list; accessed 25 August 2026. Biome labels are a general description of where each country's cropland sits.

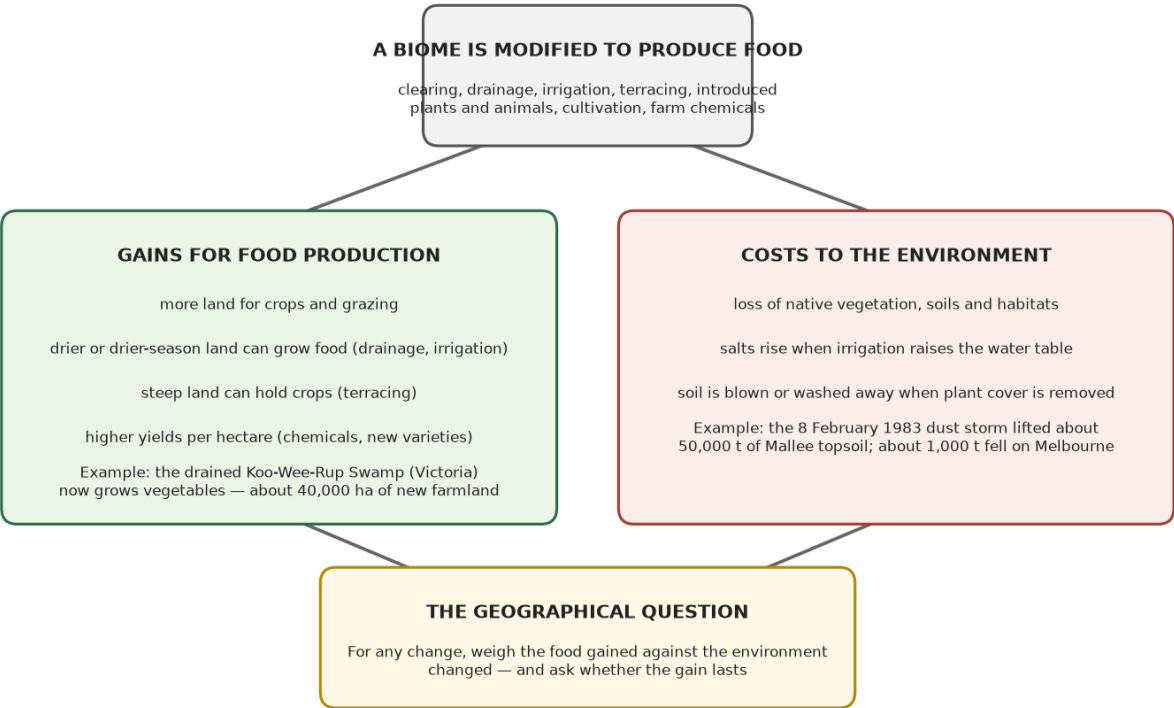
Bar chart of the ten countries with the most cropland in 2019 in million hectares — United States 157.7, India 156.1, Russia 121.6, China 119.5, Brazil 55.8, Canada 38.6, Nigeria 34.0, Ukraine 32.9, Argentina 32.6, Australia 30.6 — each labelled with the biome most of its cropland was made from

Figure 9 — The world's cropland sits where grassland and open forest used to be: flat, fertile, and workable by machines.

(VC2HG10K01.E03)

Changing biomes to produce food: gains and costs. People raise a biome's food output by changing it: clearing native vegetation, draining wetlands, irrigating dry land, terracing steep land, introducing new plants and animals, cultivating the soil, and applying agricultural chemicals such as fertilisers and pesticides. Every change buys a gain and pays a cost (Figure 10). Two Victorian stories show both sides of the ledger. The **Koo-Wee-Rup Swamp**, south-east of Melbourne, was one of the largest swamps in Australia — about 40,000 hectares of reed bed and floodplain. The first main drainage channel was cut in February 1876, larger drainage works followed under the engineer Carlo Catani in the 1890s, and despite setback floods in 1891, 1893, 1900 and 1934 the drained black peat soils became some of the richest market gardens in the country: the district became Victoria's potato capital and, by the early 2000s, grew about 95% of Australia's asparagus. The gain is real and lasting farmland; the cost is a wetland ecosystem that no longer exists, shrinking peat soils, and flood risk that drainage never fully removed. The **Mallee** tells the other story: semi-arid scrub was cleared for wheat from about 1904, yet a 1924 government report already found harvests of about a quarter of the yields farmers had expected; superphosphate (a phosphate fertiliser) and better wheat varieties later lifted yields, but on 8 February 1983 a dust storm lifted about 50,000 tonnes of Mallee topsoil, dropped about 1,000 tonnes on Melbourne and cut visibility in the city to about 100 metres — the price of clearing a dry biome and leaving the soil bare. The geographical question is never "change or no change?" but "what was gained, what was paid, and does the gain last?"

Changing biomes to produce food: gains on one side, costs on the other



Original diagram for this section. Examples: Koo-Wee-Rup Swamp drainage (1876 onwards); 1983 Melbourne dust storm, 8 February 1983.

Flow chart of modifying a biome to produce food, with a top box listing the changes (clearing, drainage, irrigation, terracing, introduced plants and animals, cultivation, farm chemicals) leading to two boxes, gains for food production on the left and costs to the environment on the right, using the drained Koo-Wee-Rup Swamp and the 8 February 1983 Mallee dust storm as examples, and a bottom box asking the geographical question of weighing food gained against environment changed

Figure 10 — The ledger of change. Gains and costs are dated and placed: drainage at Koo-Wee-Rup from 1876; the Mallee dust storm of 8 February 1983.

(VC2HG10K01.E04)

Worked examples

Example 1 — scaffolded

Use the Miami model and Bureau of Meteorology 1991–2020 averages to compare the modelled NPP of Melbourne (mean annual temperature 16.2 °C, rainfall 601 mm) and Mildura (17.5 °C, 290 mm).

Working	Comment
Melbourne, temperature ceiling $\approx 1,950\text{ g/m}^2\text{/yr}$; rainfall ceiling $\approx 990\text{ g/m}^2\text{/yr}$.	Read both ceilings from the two curves in Figure 6.
Melbourne modelled NPP = the lower ceiling $\approx 990\text{ g/m}^2\text{/yr}$.	The model takes the <i>lower</i> of the two ceilings: water, not warmth, limits Melbourne.
Mildura, temperature ceiling $\approx 2,050\text{ g/m}^2\text{/yr}$; rainfall ceiling $\approx 520\text{ g/m}^2\text{/yr}$.	Mildura is only slightly cooler than Melbourne, so its temperature ceiling is almost as high.

Working	Comment
Mildura modelled NPP = the lower ceiling $\approx 520 \text{ g/m}^2/\text{yr}$.	With less than half of Melbourne's rain, the rainfall ceiling collapses — roughly half the productivity for nearly the same temperature.
Interpretation: Mildura's natural biome is semi-arid mallee scrub; cropping there needs irrigation water from the Murray River or careful dryland farming.	The model explains the map: the biome boundary near Mildura is a rainfall boundary.

Example 2 — scaffolded

Read Australia's land budget (Figure 7). (a) What share of the continent is cropland? (b) How many times larger is grazing land than cropland? (c) Explain the contrast in one or two sentences.

Working	Comment
(a) $31.3 \div 769.2 \approx 0.04 \rightarrow$ about 4% .	Cropland $\div$ total land area.
(b) $332.2 \div 31.3 \approx$ 10.6 times .	Grazing land $\div$ cropland.
(c) Most of Australia is too dry for reliable cropping (low rainfall ceiling on NPP), but even dry land grows scattered grass and scrub that cattle and sheep can harvest themselves, so grazing spreads over about ten times more area than cropping.	Link the numbers back to climate control on NPP: animals collect sparse plant growth; crops need dependable water.

Practice questions

Scaffolded

Q1. (2 marks) In your own words, define *biome* and *biomass*.

Q2. (2 marks) Using Figure 2, name the land biome you would expect about 5° from the equator and the one about 25° from the equator.

Q3. (3 marks) Using Figure 3, name the biome at or nearest to (a) Darwin, (b) Alice Springs, (c) Melbourne.

Q4. (2 marks) Using Figure 4, name (a) the most productive biome shown, and (b) the least productive *land* biome shown.

Q5. (3 marks) Figure 6 shows Mildura and Melbourne with almost the same temperature ceiling but very different modelled NPP. Identify the factor that causes the difference and give the two modelled NPP values.

Q6. (4 marks) Using Figure 10 and the Theory, give two gains and two costs of draining the Koo-Wee-Rup Swamp.

Un scaffolded

Q7. (4 marks) The open ocean has the largest total NPP of any biome (Figure 5) yet one of the lowest mean NPP values (Figure 4). Explain this apparent contradiction.

Q8. (4 marks) "Most of the world's food comes from modified grassland, woodland and temperate forest biomes, not from the biomes most productive by nature." Use Figures 8 and 9 to support this claim.

Q9. (5 marks) The Mallee was cleared for wheat from about 1904; a 1924 report found yields of about a quarter of expectations, and the dust storm of 8 February 1983 carried Mallee topsoil to Melbourne. Use Figure 10 to evaluate whether clearing this biome for food was worth it.

Q10. (4 marks) Only about 4% of Australia is cropland, yet Australia is one of the world's large food exporters. Use Figure 7 and the idea of NPP to explain how both facts can be true.

Inquiry task

Your plate, your biomes (6 marks). Choose three foods you eat in a normal week that were grown or raised in Australia (supermarket labels and “grown in” stickers are data). For each food, build one row of a table with: (a) the region it most likely came from (a named place, e.g. Mildura, Koo-Wee-Rup, the Wimmera); (b) the biome of that region from Figure 3; (c) the biome’s natural NPP class from Figure 4 (high, middle or low); (d) one human change that makes production possible there (for example irrigation, drainage, clearing, cultivation or fertilisers); and (e) one gain and one cost of that change, in the style of Figure 10. Finish with one sentence answering: *which of your three foods comes from the biome least suited to producing it, and how is the biome being pushed past its natural ceiling?*

Answers

- Q1.** A biome is a large region with its own climate, vegetation and biomass productivity. Biomass is the mass of living plant and animal material in a region.
- Q2.** About 5°: tropical rainforest. About 25°: hot desert and semi-arid scrub.
- Q3.** (a) Tropical savanna. (b) Arid desert. (c) Temperate forest.
- Q4.** (a) Algal beds and reefs (2,500 g/m²/yr). (b) Extreme desert, rock and ice (3 g/m²/yr).
- Q5.** Rainfall. Melbourne ≈ 990 g/m²/yr; Mildura ≈ 520 g/m²/yr. Mildura's much lower rainfall sets a much lower rainfall ceiling, and the lower ceiling wins.
- Q6.** Gains (any two): about 40,000 ha of swamp became rich farmland; the district became Victoria's potato capital and grew about 95% of Australia's asparagus by the early 2000s. Costs (any two): the wetland ecosystem was destroyed; peat soils shrink once drained; flood risk remains (floods in 1891, 1893, 1900, 1934).
- Q7.** Total NPP = mean NPP × area. The open ocean's mean rate is tiny (about 125 g/m²/yr) but its area is enormous, so the product is the largest of any biome (about 41.5 billion tonnes/yr).
- Q8.** Figure 4 shows the most productive biomes (reefs, rainforest, swamps) are rarely farmed; cropland's own mean NPP (about 650) is mid-ranking. Figure 9 shows the top cropland countries sit on what was once grassland, steppe, prairie, pampas and open forest — flat, fertile, workable — so most food comes from those modified mid-NPP biomes plus grazing land and aquatic biomes (Figure 8).
- Q9.** Open evaluation; a sound answer weighs dated gains (wheat grown, farms and towns established, later improvements such as superphosphate and better varieties) against dated costs (quarter yields by 1924, lost scrub habitat, the 1983 dust storm's ~50,000 t of lifted topsoil and ~1,000 t dropped on Melbourne), and reaches a stated judgement about whether the gain lasts (for example: worth it only where farming keeps enough ground cover; on the driest margins, marginal).
- Q10.** Most Australian land is dry and low-NPP, so cropland is small and concentrated in the better-watered woodland/grassland biome and irrigated valleys; but even the dry biomes' sparse growth supports very large sheep and cattle herds (43% grazing), and the cropped 4% is farmed with machinery, fertilisers and irrigation that lift yields — so a small, well-run cropland plus vast grazing land produces a surplus far beyond what 26 million Australians eat.
- Inquiry task.** Tables will vary; markers look for a named place, a biome consistent with Figure 3, a correct NPP class, one plausible modification, one gain and one cost each, and a closing sentence that names the least-suited biome and the modification pushing past its natural ceiling (typically irrigation in the Mallee/Mildura or drainage on swamp soils).
-

Fully-worked solutions

- Q1 (2 marks).** 1 mark per definition. *Biome*: a large region of the Earth with its own distinctive climate, vegetation and biomass productivity. *Biomass*: the mass of living plant and animal material stored in a region's plants and animals.
- Q2 (2 marks).** Read latitude bands off Figure 2: 0–10° → tropical rainforest (1 mark); 20–30° → hot desert and semi-arid scrub (1 mark).
- Q3 (3 marks).** One mark each: (a) Darwin sits in the tropical savanna of the north; (b) Alice Springs sits in the arid desert interior; (c) Melbourne sits in the temperate forest of the south-east.
- Q4 (2 marks).** (a) Algal beds and reefs, 2,500 g/m²/yr (1 mark). (b) Extreme desert, rock and ice, 3 g/m²/yr (1 mark).
- Q5 (3 marks).** Factor: rainfall (1 mark). Values: Melbourne ≈ 990 g/m²/yr; Mildura ≈ 520 g/m²/yr (1 mark). Mechanism: the Miami model takes the lower of the temperature and rainfall ceilings; both cities are warm enough, but Mildura's ~290 mm of rain sets a rainfall ceiling about half of Melbourne's ~601 mm ceiling (1 mark).

Q6 (4 marks). One mark per distinct, correct point, two from each side. Gains: ~40,000 ha of swamp converted to highly productive market gardens; potato capital of Victoria; ~95% of Australia's asparagus by the early 2000s. Costs: wetland habitat and ecosystem lost; drained peat soils shrink and degrade; floods still struck (1891, 1893, 1900, 1934) and flood risk persists.

Q7 (4 marks). State the relationship $\text{total} = \text{mean} \times \text{area}$ (1 mark); give the ocean's low mean, ~125 g/m²/yr (1 mark); give its huge area / about 41.5 billion tonnes total (1 mark); conclude that area compensates for rate, whereas a small, fast biome (e.g. swamps, 2,000 g/m²/yr but tiny area) has a small total (1 mark).

Q8 (4 marks). Point 1: the highest-NPP biomes (reefs 2,500; rainforest 2,200; swamps 2,000) contribute little direct food because they are small, inaccessible or unsuited to machines, and rainforest soils are poor once cleared (1–2 marks). Point 2: Figure 9 shows the top-10 cropland countries sit on temperate grassland/steppe/prairie/pampas and tropical savanna and open forest — the biomes people actually convert (1 mark). Point 3: Figure 8 shows the food streams: 1.41 billion ha of cropland, 3.52 billion ha of pasture, plus 90.3 + 87.5 + 35.1 million tonnes from aquatic biomes (1 mark). Conclude with the claim restated in the student's own words.

Q9 (5 marks). Structure: dated gains (1 mark) — wheat land opened from ~1904, farms, towns and later yield gains from superphosphate and new varieties; dated costs (2 marks) — 1924 report of ~quarter yields on marginal land, native scrub lost, 8 February 1983 dust storm lifting ~50,000 t of topsoil with ~1,000 t falling on Melbourne and visibility ~100 m; evaluation (1 mark) — weighs the two sides using Figure 10's question "does the gain last?"; judgement (1 mark) — a stated, justified position (for example, worthwhile where ground cover and fallow protect the soil; not worthwhile on the driest margins where cropping fails and soil blows).

Q10 (4 marks). Point 1: 4% cropland because most of the continent is dry — rainfall sets a low NPP ceiling outside the better-watered woodland/grassland belt and irrigated valleys (1 mark). Point 2: the other 43% is grazing land: cattle and sheep harvest sparse natural growth over huge areas, turning low-NPP scrub into meat and wool (1 mark). Point 3: the small cropland is highly managed (machinery, fertilisers, irrigation — e.g. Mildura's horticulture) so yields per hectare beat the natural biome (1 mark). Point 4: with ~26 million people, the surplus from grazing plus cropping is exported, making Australia a major food exporter despite the tiny cropland share (1 mark).

Inquiry task (6 marks). 1 mark per completed row element across the three foods (place, biome, NPP class, modification, gain + cost) to 5 marks; 1 mark for a closing sentence that correctly names the least-suited biome and the modification (usually irrigation or drainage) lifting production past the natural climate ceiling.

Sources

- Victorian Curriculum F–10 Version 2.0, Geography, Levels 9–10: content description VC2HG10K01 and elaborations E01–E04.
- Whittaker, R.H. & Likens, G.E. (1975), 'The biosphere and man', in Lieth, H. & Whittaker, R.H. (eds), *Primary Productivity of the Biosphere*, Springer-Verlag — mean and total NPP by biome (Figures 4 and 5).
- Field, C.B., Behrenfeld, M.J., Randerson, J.T. & Falkowski, P. (1998), 'Primary production of the biosphere: integrating terrestrial and oceanic components', *Science*, 281(5374), 237–240 — modern cross-check that land and ocean NPP are of similar size.
- Lieth, H. (1975), 'Modeling the primary productivity of the world', in Lieth & Whittaker (eds), *Primary Productivity of the Biosphere*, Springer-Verlag — the Miami model (Figure 6).
- Bureau of Meteorology 1991–2020 climate normals for Darwin, Alice Springs, Melbourne and Mildura, as tabulated in the Wikipedia climate sections for those cities; accessed 25 August 2026.
- World Bank, World Development Indicators (sourced from FAO): agricultural land, arable land and forest area, Australia and world, 2022; accessed 25 August 2026 (Figures 7 and 8).
- FAO country data for cropland and permanent pasture (2013) and cropland by country (2019), as compiled in the 'Arable land' reference list, Wikipedia; accessed 25 August 2026 (Figures 8 and 9).
- FAO (2022), *The State of World Fisheries and Aquaculture* — 2020 totals for capture fisheries, aquaculture and algae (Figure 8).

- Koo-Wee-Rup Swamp drainage history (main channel February 1876; Catani works 1890s; floods 1891, 1893, 1900, 1934; potato and asparagus production), Wikipedia ‘Koo-Wee-Rup Swamp’; accessed 25 August 2026.
- Mallee settlement (~1904), the 1924 report of quarter yields, and the 8 February 1983 Melbourne dust storm (~50,000 t of topsoil lifted, ~1,000 t deposited on Melbourne, visibility ~100 m), Wikipedia ‘1983 Melbourne dust storm’ and related Mallee articles; accessed 25 August 2026.
- Australian wheat production (~20.9 Mt, 2018), FAO via Wikipedia ‘Wheat production in Australia’; accessed 25 August 2026.
- All figures in this section are original diagrams drawn for this book from the sources above.

Why crops grow where they do

Strand: Geographical Knowledge and Understanding · Sub-strand: Biomes and food security. Content description: VC2HG10K02, taught through its elaborations VC2HG10K02E01 to VC2HG10K02E05.

Section 1A showed that the world's food is grown in a handful of heavily modified biomes. This section asks the next question: **why is a crop grown in one place and not another, and why does the same crop produce more in some places and some years than in others?** The answer always comes from three families of factors — environmental, economic and technological — so we will keep that framework in view the whole way through, using wheat in Victoria and rice in Indonesia as our running case studies.

Theory

The three families of factors. Every explanation in this section fits into one of three groups (Figure 1):

- **Environmental factors** — the natural conditions a crop grows in: climate, soil, landforms and water resources. A crop cannot be grown where these are too far outside its limits.
- **Economic factors** — the money and market side: how far the farm is from markets and transport, the supply and cost of labour, the cost of inputs such as fuel and seed, and the price buyers will pay.
- **Technological factors** — the tools and knowledge that change what land can grow: irrigation systems, high-yielding varieties, fertilisers and pesticides, machinery and GPS guidance.

Two terms are used constantly in crop production, so we fix them now. The **yield** of a crop is the amount harvested from each unit of land, measured in **tonnes per hectare (t/ha)** — a hectare is about the size of a football field, so a yield of 3 t/ha means three tonnes of grain from each field-sized piece of land. **Dryland** farming relies on rainfall alone, while **irrigation** is the supply of water to crops through channels, pipes or driplines, on top of rain.

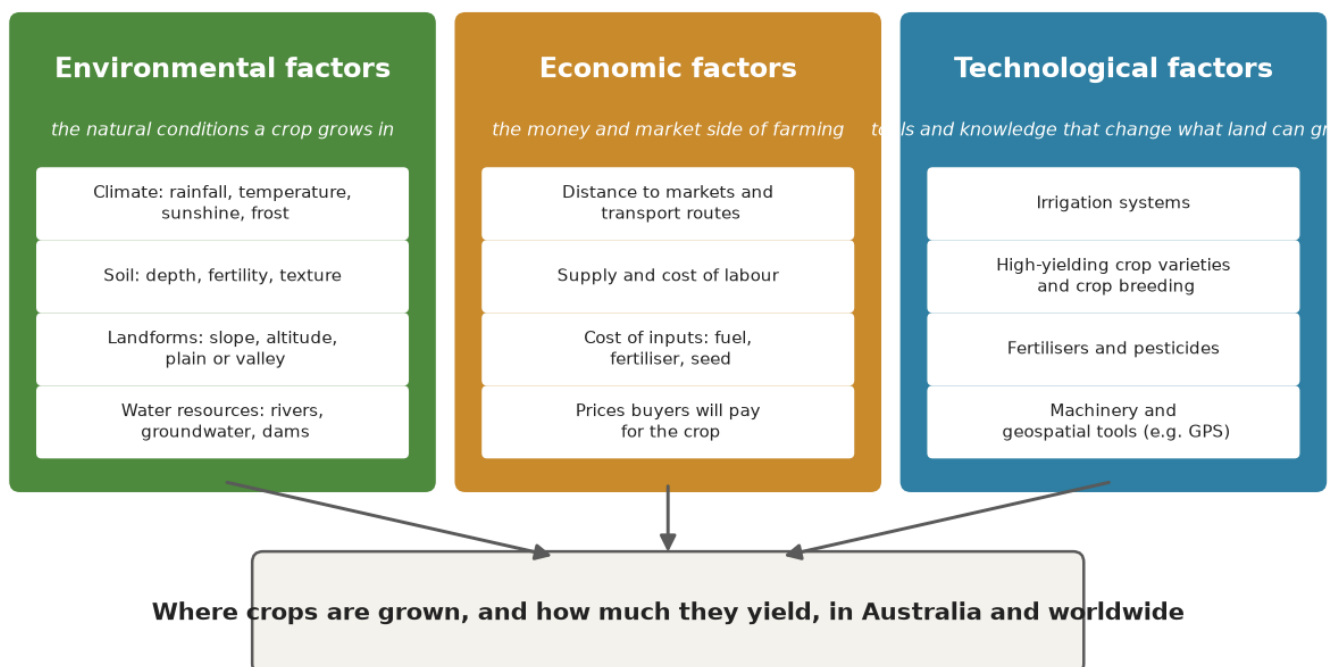


Figure 1 The three families of factors that influence crop production (model).

Three-column diagram sorting the factors that influence crop production into environmental, economic and technological families, each with an arrow to “where crops are grown and how much they yield”

Where our food and plant material comes from. The foods and plant materials consumed in Australia and Indonesia are produced in just a few regions (Figure 2). In Australia, wheat is a dryland winter crop of the Wimmera

and Mallee in Victoria and of the Western Australian wheatbelt; rice is a summer crop grown under irrigation in the Riverina of New South Wales; canola is another cool-season crop. In Indonesia — a country in Asia with which Australia has close trade ties — rice (*padi*) is the staple: it is grown on the volcanic soils of Java, where the wet season runs from November to April, and on terraced hillsides in Bali. East Java, Central Java and West Java were the top three rice provinces for the January–May 2025 harvest (BPS, 8 April 2025). In 2025 Indonesia harvested 11.32 million hectares of rice for 60.21 million tonnes of paddy — the harvested, unmilled rice — a yield of about 5.3 t/ha (BPS, 2 February 2026).

The two countries are joined by trade as well as by climate. Indonesia's hot, wet climate is perfect for rice but wrong for wheat, so Indonesia imports almost all of its wheat — and on average 35% of those imports came from Australia over 2013–14 to 2024–25 (ABARES, UN Comtrade data, September 2025; Figure 3). Wheat grown in the Australian biomes of Figure 2 ends up as noodles, bread and biscuits on Indonesian tables. This is **interconnection**: the environmental factors that stop Indonesia growing wheat create the market that Australian farms supply.

Key crops and where they are grown: Australia and Indonesia

AUSTRALIA

Crop	Where it is grown	Conditions that help
Wheat (winter crop, dryland)	Wimmera and Mallee, Victoria; wheatbelts of Western Australia and South Australia	Cool, semi-arid winters; Horsham averages 379.3 mm of rain a year. National crop: about 36 million tonnes in 2025–26
Rice (summer crop, irrigated)	Riverina irrigation areas, New South Wales (Murray and Murrumbidgee valleys)	Hot summers with irrigation water on demand; yields averaged 9.4–11.1 t/ha, 2020–21 to 2025–26 — about double Indonesia's 5.3 t/ha in 2025
Canola (winter crop)	Victoria: 540,000 hectares in 2025–26; also Western and South Australia	Cool-season crop; GM varieties have been approved for Australian growers since 2003

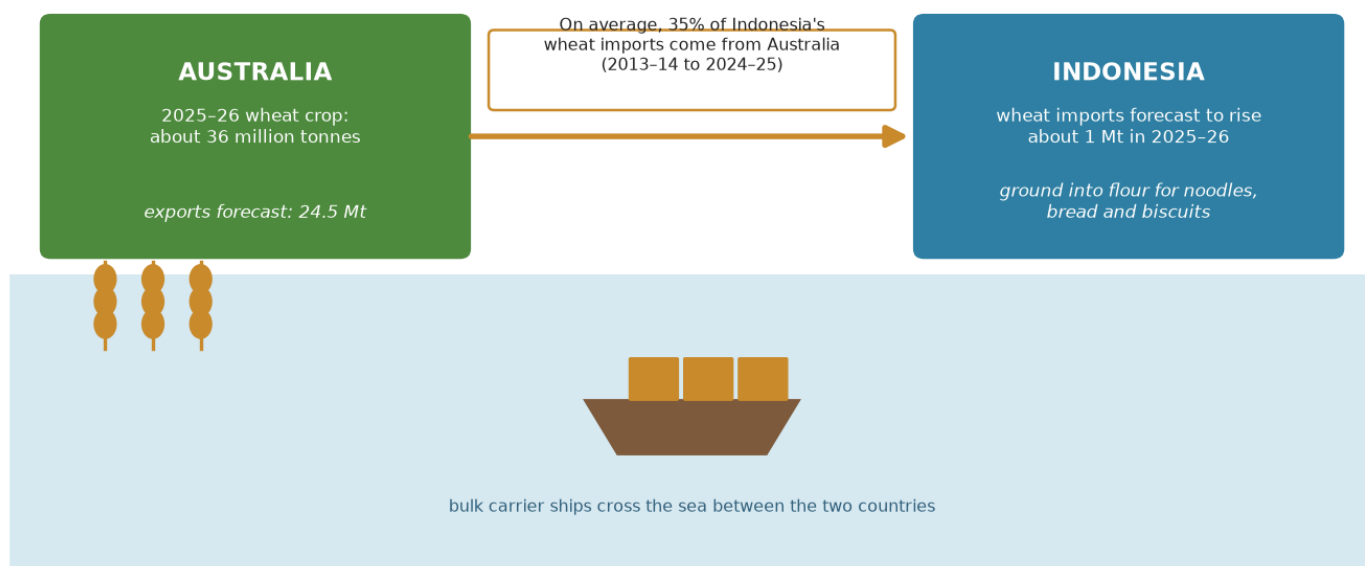
INDONESIA

Crop	Where it is grown	Conditions that help
Rice (padi — the staple food)	Java: East Java, Central Java and West Java were the top three provinces for the January–May 2025 harvest; terraced fields in Bali (subak system)	Volcanic soils; wet season rains from November to April. 2025: 11.32 million hectares harvested, 60.21 million tonnes of paddy (5.3 t/ha). Rice supplies more than half the calories in the average Indonesian diet

Figure 2 Key food crops and where they are grown in Australia and Indonesia (summary table).
Sources: ABARES, Australian Crop Report June 2026; BPS (Indonesia) 8 April 2025 and 2 February 2026; retrieved 25 August 2026.

Table of key food crops and the regions where they are grown in Australia (wheat, rice and canola) and Indonesia (rice)

Wheat flows from Australian farms to Indonesian tables



Indonesia grows almost no wheat — its climate suits rice — so it depends on imports.
Australia's dryland wheatbelt and nearby ports make it a natural supplier.

Figure 3 The Australia–Indonesia wheat trade (flow diagram). Source: ABARES, Agricultural Commodities Report, September 2025 (trade shares: UN Comtrade); retrieved 25 August 2026.

Flow diagram of the wheat trade from Australia to Indonesia, showing that on average 35% of Indonesia's wheat imports came from Australia between 2013–14 and 2024–25

Reading yields: the environment leaves fingerprints. Because yield measures how well the growing conditions went, a yield series is a record of the environment at work. Australian wheat yields move with the rains (Figure 4): in the drought year 2019–20 the average yield fell to 1.47 t/ha, while in the record 2022–23 season it reached 3.11 t/ha (ABARES, June 2026). Victoria's wheat is grown in a slightly wetter, cooler part of the wheatbelt, so in most years its average yield sits above the Australian average (Figure 5) — 3.60 t/ha against 3.11 t/ha in 2022–23 — though in a bad Victorian season, such as 2024–25, it can fall below. Compare any wheat year with irrigated rice (Figure 6): Australian rice yields of 9.4–11.1 t/ha are roughly three times the wheat figures, because water is supplied on demand instead of left to the sky. Even so, Australia's irrigated rice and Indonesia's rice (5.3 t/ha in 2025) show the same rule — where water, climate, soil and landforms suit the crop, yields are high.

Average wheat yield in Australia, 2019-20 to 2026-27

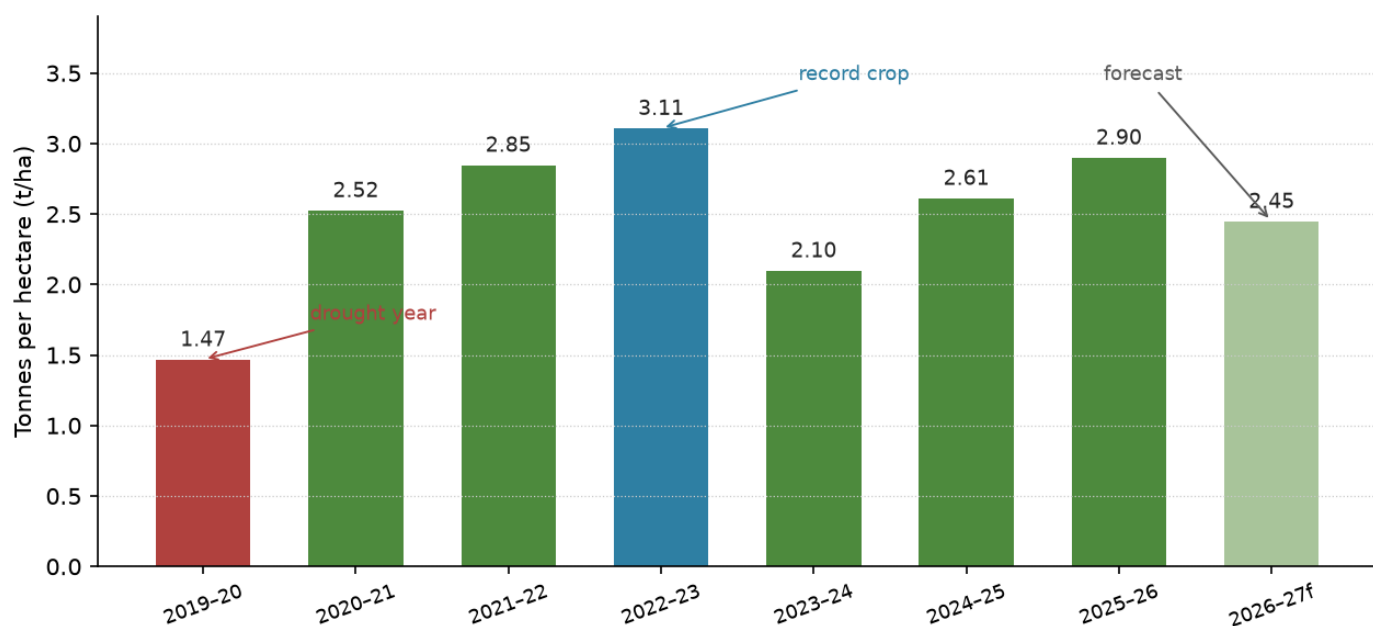


Figure 4 Average wheat yield in Australia, 2019-20 to 2026-27. A drought year, the record year and the forecast stand out.
Source: ABARES, Australian Crop Report, June 2026, No. 218 (yield = production ÷ area; retrieved 25 Aug 2026).

Bar chart of average wheat yield in Australia from 2019-20 to 2026-27, lowest at 1.47 tonnes per hectare in the drought year and highest at 3.11 in 2022-23

Average wheat yield: Victoria compared with Australia, 2020-21 to 2026-27

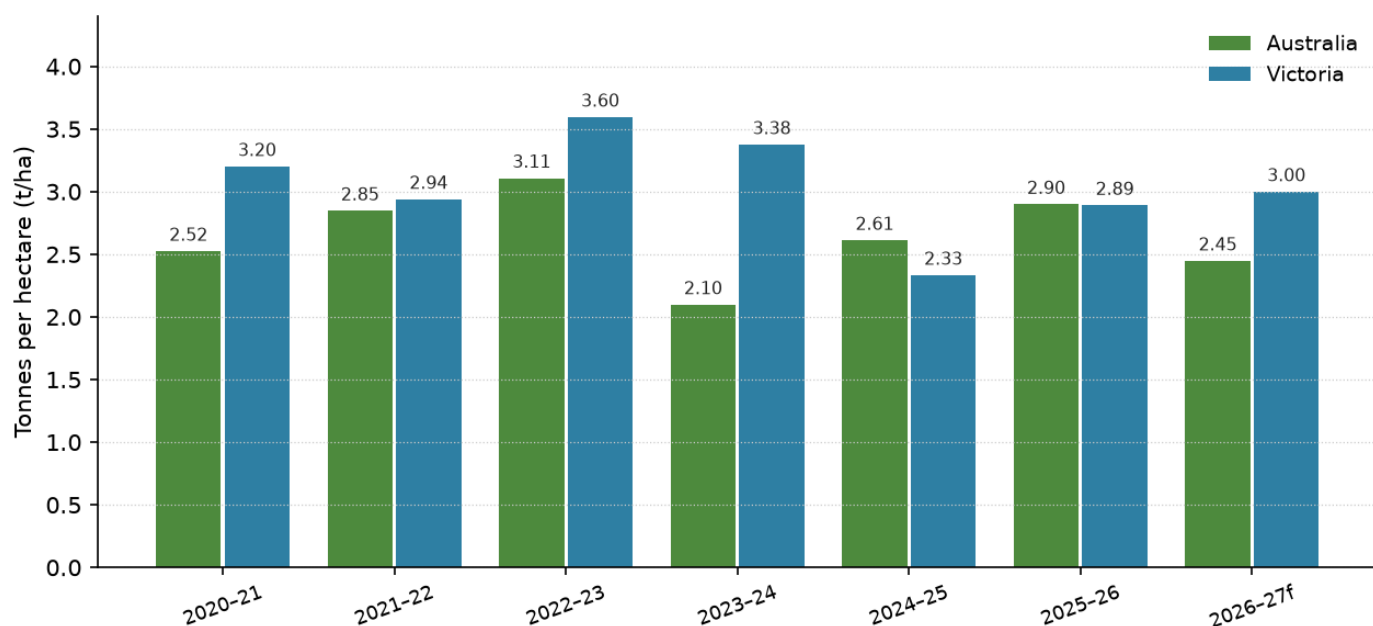


Figure 5 Average wheat yield in Victoria compared with the Australian average, 2020-21 to 2026-27.
Source: ABARES, Australian Crop Report, June 2026, No. 218 (yield = production ÷ area; retrieved 25 Aug 2026).

Grouped bar chart comparing average wheat yield in Victoria with the Australian average from 2020-21 to 2026-27, Victoria above the average in most years

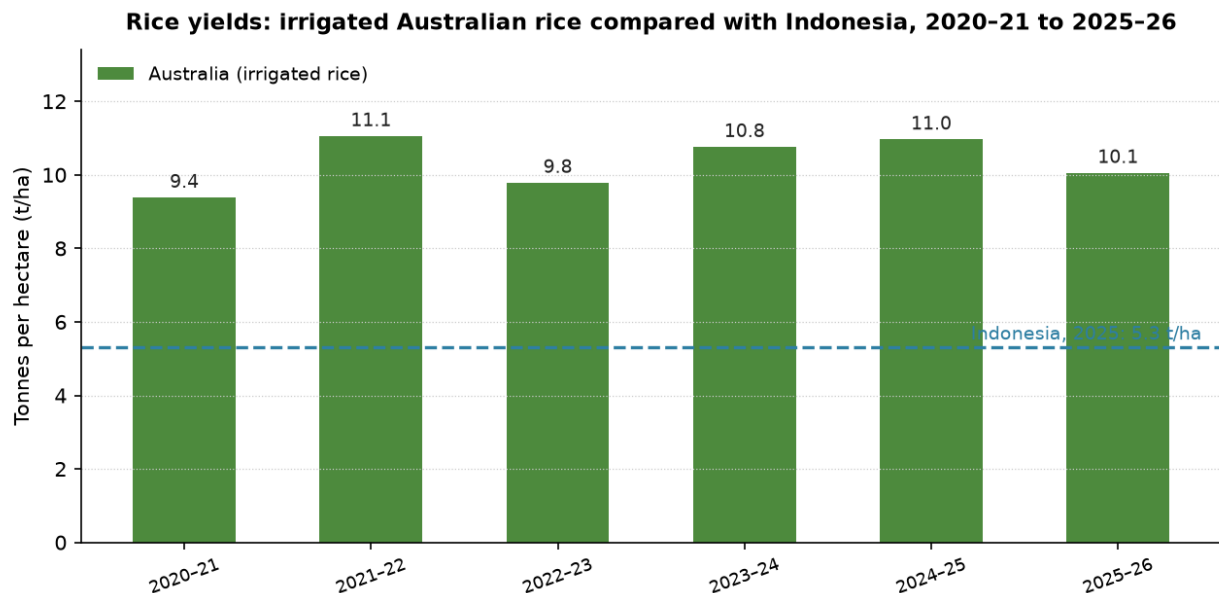


Figure 6 Rice yields: irrigated Australian rice compared with Indonesia's 2025 average.
Sources: ABARES, Australian Crop Report, June 2026, No. 218; BPS (Indonesia), 2 Feb 2026. Indonesia's figure is GKG paddy; both derived as production ÷ area. Retrieved 25 Aug 2026.

Bar chart of irrigated Australian rice yields of 9.4 to 11.1 tonnes per hectare beside a dashed line at Indonesia's 2025 average of 5.3 tonnes per hectare

The four environmental factors. Figure 7 is the model we will use for every place we study.

- **Climate** — how much rain falls and when, how hot or cold it gets, whether frost or heat waves strike, and how many sunshine hours the crop receives. Wheat near Horsham, in the Wimmera, grows in a cool semi-arid climate with only 379.3 mm of rain in an average year, so it is sown to catch the cool winter rain and harvested before the hot, dry summer. Rice on Java grows in the opposite climate: a wet-season monsoon from November to April brings from 900 mm on the east coast to more than 4,000 mm in the western highlands, plus the heat rice needs.
- **Soil** — its nutrients, depth, texture and how well it holds water. The sandy Mallee soils of Victoria were low in nutrients; wheat and barley only became reliable there after **fertilisers** — materials added to soil to feed the crop, such as superphosphate — were developed. Java's soils are the other story: ash from its many active volcanoes renews their fertility, which is one reason Java's rice lands are among the richest in the world.
- **Landforms** — flat plains suit machines and hold deeper soil; steep slopes shed water and soil, and are hard to work. The flat Wimmera plain is ideal for large-scale wheat farming, while Balinese farmers faced with steep hills built **terracing** — steps cut into a slope, each with a near-flat growing surface and an earth wall (Figure 9).
- **Water resources** — rivers, groundwater and dams that can back rainfall up. The Murray–Darling Basin covers about a seventh of Australia's land and grows about a third of its food; Goulburn–Murray Water supplies irrigation across roughly 68,000 km² of northern Victoria. It was irrigation water in the Riverina's Murray and Murrumbidgee valleys that introduced rice to Australia at all.

How the four environmental factors shape crop yield

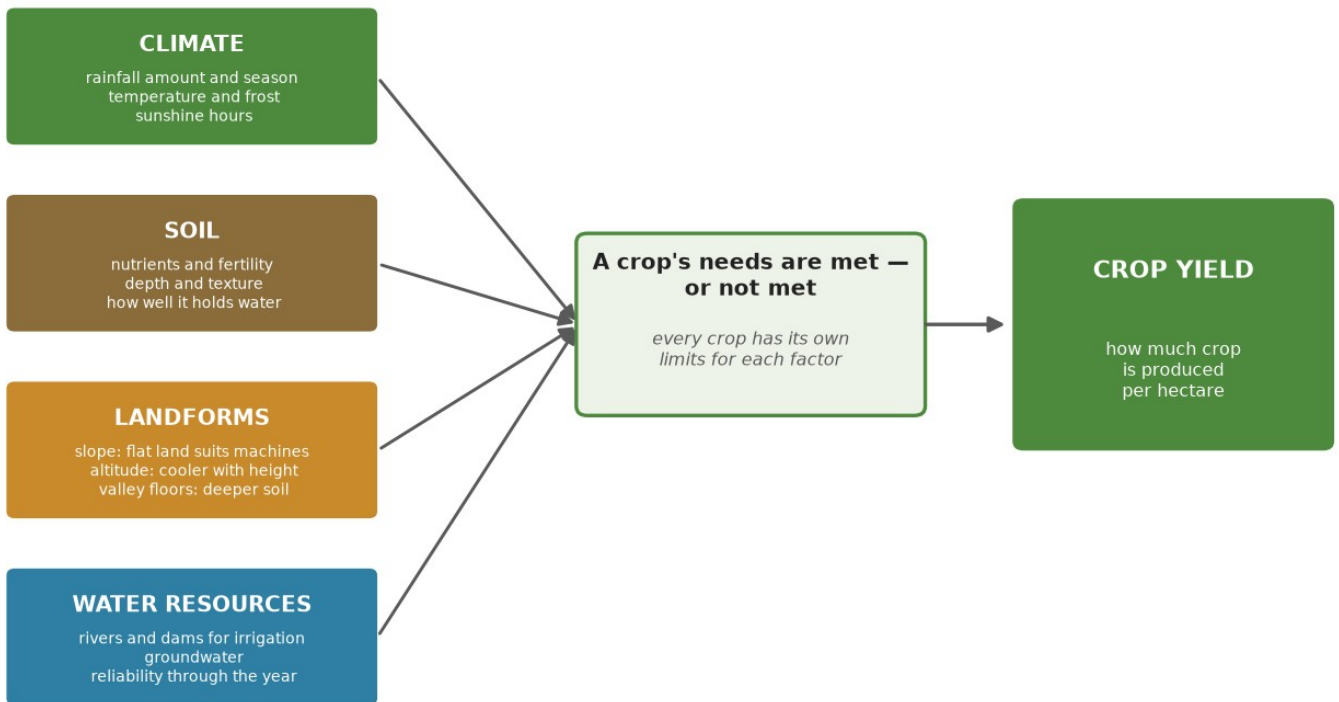


Figure 7 The four environmental factors (model). Yields are highest where all four suit the crop.

Flow model of the four environmental factors — climate, soil, landforms and water — feeding into whether a crop's needs are met, and therefore into crop yield

Economic and technological factors. Environmental factors set the outer limits, but economic and technological factors decide what actually gets grown, and how much.

- **Irrigation** is both: a technology (channels, sprays, driplines) with an economics (water costs money, and drought can cut allocations). It is the single biggest reason some Australian farms yield several times what dryland farms nearby achieve.
- **Accessibility** — how easily a farm can reach transport, markets and services. Bulk wheat only works because grain can be loaded onto road and rail, moved to export ports, and shipped to buyers such as Indonesia (Figure 3). A remote farm with poor roads faces higher costs at every step.
- **Labour supply** — crops must be planted and harvested in narrow windows, so the number and cost of workers matter. When border closures cut Australia's backpacker workforce from about 200,000 to about 52,000 in 2020, farm labour shortages caused losses estimated at \$22 million — a clear economic factor at work.
- **Agricultural technologies**, above all **high-yielding varieties** — crop varieties bred to produce more grain per hectare. The famous semi-dwarf rice IR8, released in Asia in November 1966, lifted yields from about 1–2 t/ha toward 4–5 t/ha where water and fertiliser were supplied, and modern breeding has kept raising the ceiling since. **Genetically modified (GM) crops** — crops given a new trait in the laboratory, rather than by crossing plants in the field — go a step further: GM canola has been approved for Australian growers since 2003, and 99.5% of Australian cotton growers plant GM cotton.

Human alteration of biomes: changing the limits. Farming has altered almost every food-producing biome on Earth, and those alterations are how the limits in Figure 7 get moved. Drip irrigation (Figure 8) delivers water slowly, close to the roots, so little is lost to evaporation or run-off — in Sunraysia, around Mildura, it supports grapes, citrus and stone fruit in a region too dry for rain-fed cropping. Fertilisers and **pesticides** — chemicals that control the pests and weeds that destroy crops — raised yields on poor soils. Terracing (Figure 9) turned eroding Balinese slopes into productive rice land, with water shared from terrace to terrace through the **subak**, the Balinese village system of water sharing recognised by UNESCO since 2012. Figure 10 summarises the pattern: for each environmental limit, an innovation that eases it.

Evaluating the innovations. Have these changes removed the environmental limits on food production? Not removed — *moved*. Crop breeding and irrigation changed what Australian land can grow: the Riverina grows rice in a semi-arid country, and Mallee soils that once carried only scrub carry wheat. But the limits push back. Irrigation depends on water that drought can take away — ABARES forecast the 2026–27 Australian wheat crop down to about 2.45 t/ha on the back of a Bureau of Meteorology outlook giving a 60–80% chance of below-average winter rain (May 2026). High-yielding varieties usually need more fertiliser and water to show their advantage. And every innovation has a cost a farmer must weigh against the price the crop will bring — which is exactly why the economic column of Figure 1 stands beside the other two. The sustainability of these alterations is the job of sections 1C and 1D; here the point is that farm output, in Australia and around the world, is the outcome of all three families acting together.

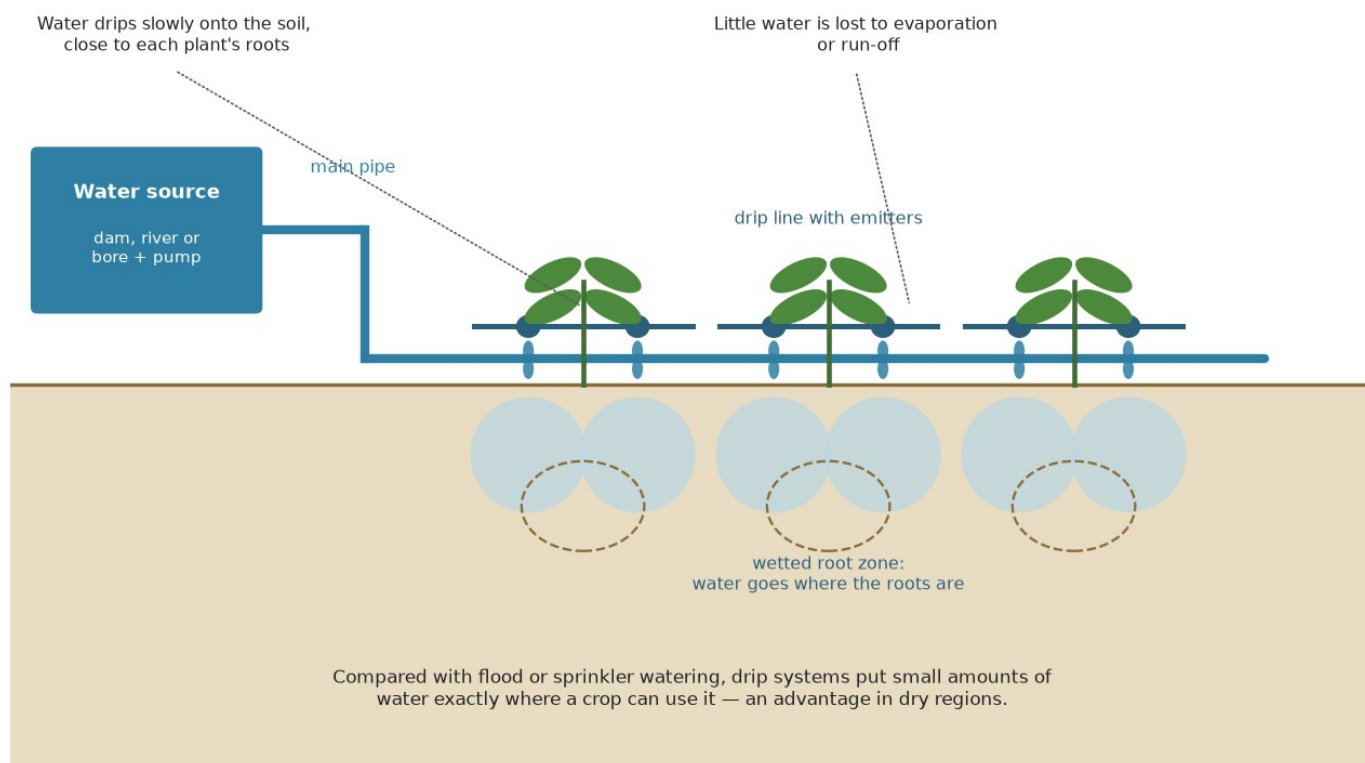


Figure 8 How a drip irrigation system works (labelled diagram).

Labelled cross-section of a drip irrigation system: a water source and main pipe feed drip lines whose emitters wet a small zone of soil around each plant's roots

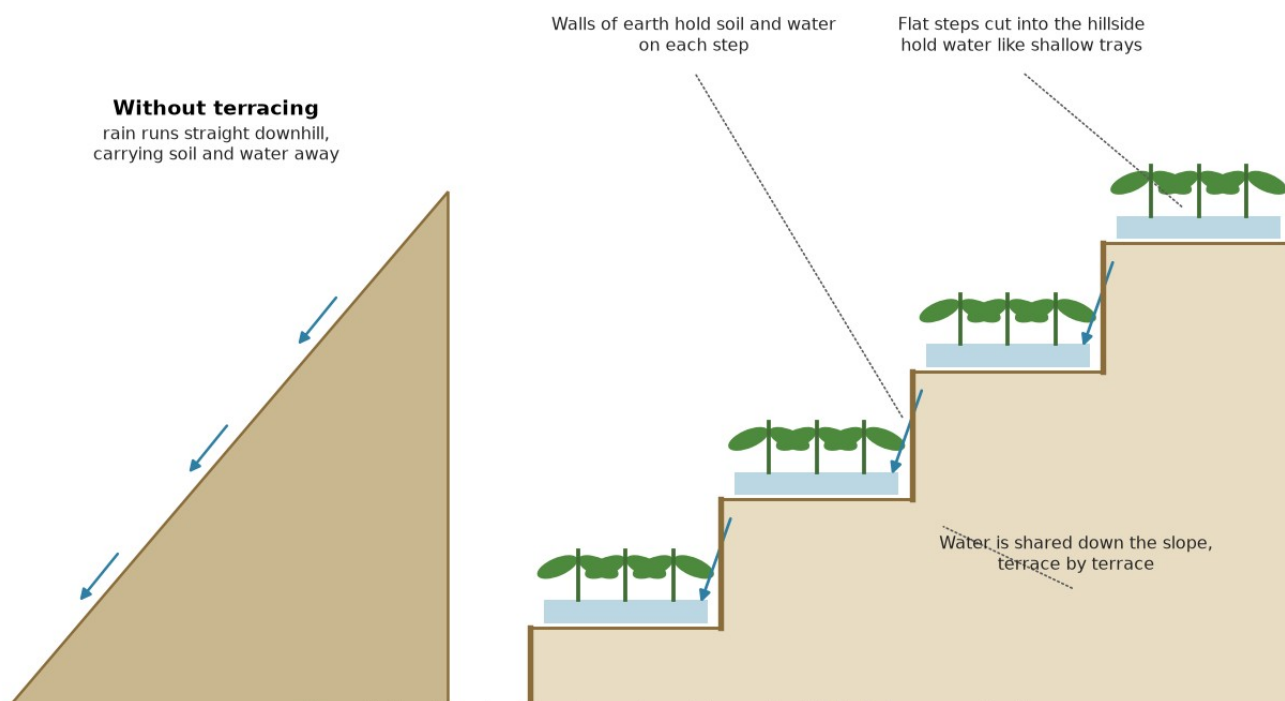


Figure 9 How terracing turns steep slopes into cropland (labelled cross-section).
Terraced rice fields like these support the Jatiluwih terraces in Bali, part of the subak water-sharing
system recognised by UNESCO since 2012.

Labelled cross-section comparing an un-terraced slope, where rain runs downhill carrying soil away, with terraced steps that hold water and soil for rice

Innovations that change environmental limits on crop production

Environmental limit	Innovation that overcomes it	Where you can see it
Water: rainfall is low and unreliable	Irrigation — channels and drip lines deliver river or stored water to the crop	Goulburn–Murray district waters about 68,000 km ² of northern Victoria; Sunraysia grows fruit and grapes around Mildura
Soil: old, worn soils lack nutrients	Fertilisers (e.g. superphosphate) and crop rotations add nutrients back	Mallee sandy loams in Victoria were opened up to wheat and barley once fertilisers were used
Landform: steep slopes lose water and soil	Terracing cuts flat steps into the slope; water is shared step by step (subak)	Jatiluwih rice terraces, Bali — part of the subak system recognised by UNESCO since 2012
Seed: older varieties produced little grain	High-yielding varieties from crop breeding programs	IR8 rice, released November 1966, lifted Asian rice yields from 1–2 toward 4–5 t/ha
Weeds and pests destroy part of every crop	Herbicides and pesticides; genetically modified (GM) crops bred for resistance	GM canola approved for Australian growers in 2003; 99.5% of cotton growers plant GM cotton

Figure 10 Five environmental limits on crops, and the innovations that overcome them (summary table).
Sources: section 1B source record, S1–S16, retrieved 25 August 2026.

Table matching five environmental limits on crops — water, soil, landform, seed and pests — with the innovation that overcomes each and a real Australian or Indonesian place to see it

Worked examples

Example 1 — scaffolded

Use Figures 4 and 5. (a) State the Australian average wheat yield in 2019–20 and in 2022–23. (b) Describe the pattern of Victorian yields relative to the Australian average over 2020–21 to 2026–27. (c) Explain the pattern in (a) using two environmental factors.

Working	Comment
(a) 2019–20: 1.47 t/ha. 2022–23: 3.11 t/ha.	Read the bar heights; the figure flags the drought year and the record year.
(b) Victoria’s yield is above the Australian average in five of the seven years shown (e.g. 3.60 vs 3.11 t/ha in 2022–23), level in 2025–26, and below in 2024–25 (2.33 vs 2.61 t/ha).	“Describe” means report the pattern with figures — no explaining yet.
(c) The 2019–20 to 2022–23 swing is mainly climate : wheat is dryland, so a drought year’s low rainfall gives little grain per hectare, while a wet season gives much more. Water resources is the second factor: without irrigation there is nothing to buffer the rain.	Match the pattern to the Figure 7 model: the factor that changed between the two years is the one doing the explaining.

Example 2 — unscaffolded

People’s alterations of biomes have lifted agricultural productivity in both Australia and Indonesia. Evaluate this claim using **two** alterations from this section — one Australian, one Indonesian.

Choose one alteration per country, and for each run the chain: *limit* → *alteration* → *effect* → *judgement*.

Australia — irrigation of the Riverina. The limit: a semi-arid to temperate climate whose rainfall alone suits dryland wheat at about 2–3 t/ha, not water-hungry rice. The alteration: irrigation channels drawing on the Murray and Murrumbidgee rivers introduced rice to the Riverina. The effect: irrigated Australian rice averaged 9.4–11.1 t/ha over 2020–21 to 2025–26 (Figure 6), several times dryland grain yields. The judgement: the alteration genuinely changed the water limit — but did not delete it, because the water is allocated from rivers that drought can run low, so the productivity gain stands or falls with the water supply.

Indonesia — terracing and subak water-sharing on Bali. The limit: steep slopes on which rain runs off, carrying soil and water away (Figure 9, left). The alteration: terraces cut flat, banded steps into the slopes, with the subak sharing water from terrace to terrace. The effect: land that could carry little beyond scrub produces rice in a wet-tropical climate, and the Jatiluwih terraces are productive enough to be recognised by UNESCO (since 2012). The judgement: terracing changed the landform and water limits at low technology cost, but it demands continuous labour to maintain the walls and channels — an economic factor that can erode the gain if workers move away.

Overall: the claim holds in both countries — human alteration raised productivity — yet every alteration substitutes one set of limits (water allocations, maintenance labour, input costs) for the raw environmental ones. That is what “evaluate” requires you to show.

Practice questions

Scaffolded

Q1. Sort each factor into the correct family of Figure 1 (environmental, economic or technological): (a) frost in the growing season; (b) the cost of diesel for the header; (c) GPS guidance on tractors; (d) distance from farm to export port; (e) soil depth; (f) the number of workers available at harvest.

Q2. Use Figure 2. (a) Name the three Indonesian provinces that led the January–May 2025 rice harvest. (b) Name the two Victorian regions given for wheat. (c) Of Australia and Indonesia, which country grows wheat as a dryland winter crop, and which must import most of its wheat?

Q3. Use Figure 4. (a) State the Australian average wheat yield in the drought year 2019–20 and in the record year 2022–23. (b) How many times larger was the record yield than the drought-year yield? (Give your answer to one decimal place.) (c) Name the environmental factor that most explains the difference between those two seasons.

Q4. Match each statement to the environmental factor it describes (climate, soil, landforms or water resources), as in Figure 7: (a) “379.3 mm of rain in an average year, most of it in winter”; (b) “ash from active volcanoes renews fertility”; (c) “a flat plain that suits large machines”; (d) “rivers and dams that can back up the rainfall”.

Q5. Use Figure 8. (a) Where does the water leave the drip line? (b) Why does a drip system lose less water than flood or sprinkler watering? (c) Explain in one sentence why drip irrigation is valuable in a dry region such as Sunraysia.

Q6. Use Figure 3. (a) On average, what share of Indonesia’s wheat imports over 2013–14 to 2024–25 came from Australia? (b) The wheat is shipped to a market far from the farm that grew it. Name the economic factor that makes this trade possible. (c) Give the environmental reason Indonesia grows almost no wheat of its own.

Unscaffolded

Q7. Compare the environmental setting for dryland wheat near Horsham with that for rice on Java. For each place, refer to at least one figure for climate and one for soil or water, and conclude which of the four environmental factors most limits each crop.

Q8. Use Figure 9. Explain how terracing at places such as Jatiluwih overcomes **two** environmental limits, and identify one economic factor a terraced farming system depends on.

Q9. Figure 5 shows Victoria’s average wheat yield above the Australian average in most years, but below it in 2024–25 (2.33 vs 2.61 t/ha). Using the Figure 7 model, give one reason a region’s yield can rank above the national average in most years yet fall below it in a particular season.

Q10. “High-yielding varieties eased the environmental limits on food production, but they did not remove them.” Discuss this statement with reference to IR8 rice in Asia **or** irrigated rice in the Riverina, using at least two figures or statistics from this section.

Inquiry task

One bowl of noodles, two countries. A popular Indonesian meal — wheat noodles — is made from flour milled from Australian-grown wheat. Using Figures 2, 3 and 6 and the sources printed on them, write a short account (about 150 words) that traces this interconnection and answers:

1. Which environmental factors make Australia suited to growing the wheat, and which make Indonesia suited to growing rice instead?
2. Which economic factor explains why the wheat is traded at all?
3. Name one technological factor that helps keep the trade flowing.

Close your account with one sentence stating which source you found most reliable and why. Cite each source you use, including its date (all were retrieved 25 August 2026).

Answers

Q1. (a) environmental; (b) economic; (c) technological; (d) economic; (e) environmental; (f) economic (labour supply). **Q2.** (a) East Java, Central Java, West Java. (b) The Wimmera and the Mallee. (c) Australia grows wheat as a dryland winter crop; Indonesia imports most of its wheat. **Q3.** (a) 1.47 t/ha; 3.11 t/ha. (b) About 2.1 times. (c) Rainfall (climate) — wheat is dryland, so the season's rain sets the yield. **Q4.** (a) climate; (b) soil; (c) landforms; (d) water resources. **Q5.** (a) At the emitters, close to each plant's roots. (b) Water drips slowly onto a small wetted zone, so little is lost to evaporation or run-off. (c) It lets a small amount of water grow a high-value crop where rainfall alone is far too low. **Q6.** (a) 35%. (b) Accessibility — transport (ships, ports) linking farms to a distant market. (c) Indonesia's hot, wet tropical climate suits rice; wheat needs a cooler, drier growing season. **Q7.** Horsham: cool semi-arid climate (379.3 mm a year) suits winter wheat but caps its yield; soil is workable but only fertile with fertiliser; water is the tightest limit (no irrigation). Java: monsoon climate (900 to over 4,000 mm, November–April wet season) and volcanic soils suit rice; on steep land, slope is the limit until terraced. Conclusion: water (its scarcity) most limits wheat near Horsham; on un-terraced Java hillsides, landforms (slope) most limit rice, while on the plains water control does. **Q8.** Terracing overcomes the landform limit (steep slope becomes flat steps) and the water/soil limit (each step holds rain and topsoil instead of shedding them). It depends on labour — an economic factor — to build and maintain walls and channels. **Q9.** A region can sit above the national average because its climate, soil and water suit wheat better in a typical year (e.g. Victoria's cooler, wetter wheatbelt). In a season when that region's rain fails while other states' holds up, the same climate factor pulls it below the average — yields respond to each season's conditions, not to reputation. **Q10.** For IR8: yields rose from about 1–2 t/ha toward 4–5 t/ha where water and fertiliser were supplied — the seed changed the yield limit but tied it to water and nutrient supply, so the environmental limits reappeared as conditions the variety demanded. Equally acceptable: Riverina rice at 9.4–11.1 t/ha shows breeding and irrigation lifting yields far above dryland crops, yet allocations in drought (and Figure 4's wheat story) show the water limit remains.

Inquiry task. Answers will vary. A sound account names: (1) Australia — cool semi-arid winter rain and large flat plains for dryland wheat; Indonesia — hot wet-season monsoon and volcanic soils for rice; (2) the economic factor of markets/accessibility — Indonesia's demand for wheat it cannot grow, met by Australian supply (35% average import share); (3) a technology such as high-yielding varieties, irrigation, or bulk shipping and grain handling. The reliability sentence should prefer the official statistics (ABARES; BPS) over general summaries and say why (named producer, dated, figures checkable).

Fully-worked solutions

Q1. (a) Frost is weather during the growing season — **environmental**. (b) Diesel is an input cost — **economic**. (c) GPS guidance is machinery and knowledge — **technological**. (d) Distance to port is about reaching markets — **economic** (accessibility). (e) Soil depth is a natural condition — **environmental**. (f) Harvest workers are the **economic** factor of labour supply.

Q2. (a) East Java, Central Java and West Java (BPS, 8 April 2025). (b) The Wimmera and the Mallee. (c) Australia grows wheat as a dryland winter crop; Indonesia's climate suits rice, so it imports most of its wheat — on average 35% of it from Australia.

Q3. (a) 2019–20: 1.47 t/ha (drought year). 2022–23: 3.11 t/ha (record crop). (b) $3.11 \div 1.47 \approx 2.1$. (c) Rainfall — the climate factor — because Australian wheat is dryland: the season's rain is the water supply, so a drought year's yield can be less than half a wet year's (1.47 vs 3.11 t/ha).

Q4. (a) Climate — it states rainfall amount and season. (b) Soil — fertility and nutrients. (c) Landforms — slope and the workability of the land. (d) Water resources — rivers and dams backing up rain.

Q5. (a) At the emitters spaced along the drip line, so water lands beside each plant's roots. (b) Because water is applied slowly to a small wetted root zone rather than sprayed or flooded over a whole field, evaporation and run-off losses are much smaller. (c) In a dry region the scarce input is water, and drip irrigation stretches each litre further, allowing high-value crops where rainfall alone could never grow them.

Q6. (a) 35% on average over 2013–14 to 2024–25. (b) Accessibility: bulk shipping, ports and rail make a distant market reachable at low enough cost. (c) Wheat needs a cool, relatively dry growing season; Indonesia's hot, wet tropical climate — ideal for rice — is wrong for wheat, so the environmental factor of climate rules it out.

Q7. *Horsham (Wimmera):* climate is cool semi-arid with 379.3 mm of rain a year — enough for winter wheat but never generous; soils need fertiliser to be fully productive; the landform (a flat plain) is the one factor working fully in the farmer's favour. Water is therefore the binding limit: with no irrigation, the crop lives on the season's rain, which is why national wheat yields swing from 1.47 to 3.11 t/ha (Figure 4). *Java:* climate delivers a November–April wet season with 900 to over 4,000 mm, and volcanic soils are fertile, so on the plains climate and soil favour rice strongly; the limit appears where the landform steepens, because un-terraced slope sheds water and soil (Figure 9). *Conclusion:* water scarcity most limits wheat at Horsham; slope (until terraced) most limits rice on Java's hills, with water control the key on its plains.

Q8. First limit: **landforms** — the steep natural slope is re-shaped into flat steps a crop can stand on and farmers can work. Second limit: **water and soil loss** — each step's earth wall holds rain on the field, and water is passed down the slope through the subak instead of racing off with the topsoil. The economic factor: labour — terraces only stay productive while people maintain the walls and channels and transplant and harvest the rice, so the system depends on a willing, affordable workforce.

Q9. Yield is set each season by that season's conditions (Figure 7). Victoria's wheatbelt is cooler and, in a typical year, better watered than much of the Australian wheatbelt, so its *average* rank is high (e.g. 3.60 vs 3.11 t/ha in 2022–23). But wheat is dryland in both: if in one season Victoria's growing-season rain fails harder than in other states — as in 2024–25, 2.33 vs 2.61 t/ha — the very climate factor that usually gives Victoria its lead instead drags it below the national average. Region-to-region and year-to-year differences in one factor, climate, explain both facts.

Q10. Take IR8. Before it, tropical Asian rice typically yielded 1–2 t/ha; IR8's stiff, short straw carried far more grain, lifting yields toward 4–5 t/ha where water and fertiliser were supplied — a real change in the production limit, and the start of the Green Revolution. Yet the variety did not remove environmental limits: it *raised* the demand for water and nutrients, so in a poor season or without irrigation the old limits returned; Figure 6 shows Indonesia's 2025 average at 5.3 t/ha — far above the pre-IR8 era, but still below what full water control achieves in the Riverina (9.4–11.1 t/ha). The same logic fits Australian rice: breeding plus irrigation moved the water and yield limits, but allocations in drought remind growers the limits were moved, not deleted. Hence the statement is correct: the limits were eased, not removed.

Inquiry task — one possible approach. *Noodles in Bandung begin as wheat on a Wimmera or Western Australian plain: a cool, semi-arid winter climate (Horsham averages 379.3 mm a year), flat land for machines, and varieties bred for dry conditions give Australia a surplus — about 36 million tonnes of wheat in 2025–26, of which 24.5 million tonnes is forecast for export. Indonesia's environment points the other way: a hot wet-season monsoon and volcanic soils grow rice (5.3 t/ha in 2025) but not wheat, so the economic factor of a market — Indonesian demand meeting Australian supply — trades the grain, with Australia taking on average 35% of Indonesia's wheat imports. The technological factor of bulk shipping (and high-yielding varieties on the farm) keeps the flow cheap enough to matter. Most reliable source: the ABARES report, because it is the named government producer of the trade and yield figures, its issue is dated (June 2026), and its numbers can be checked against its data tables.*

Can Australian farming keep going? Soils, incomes and communities

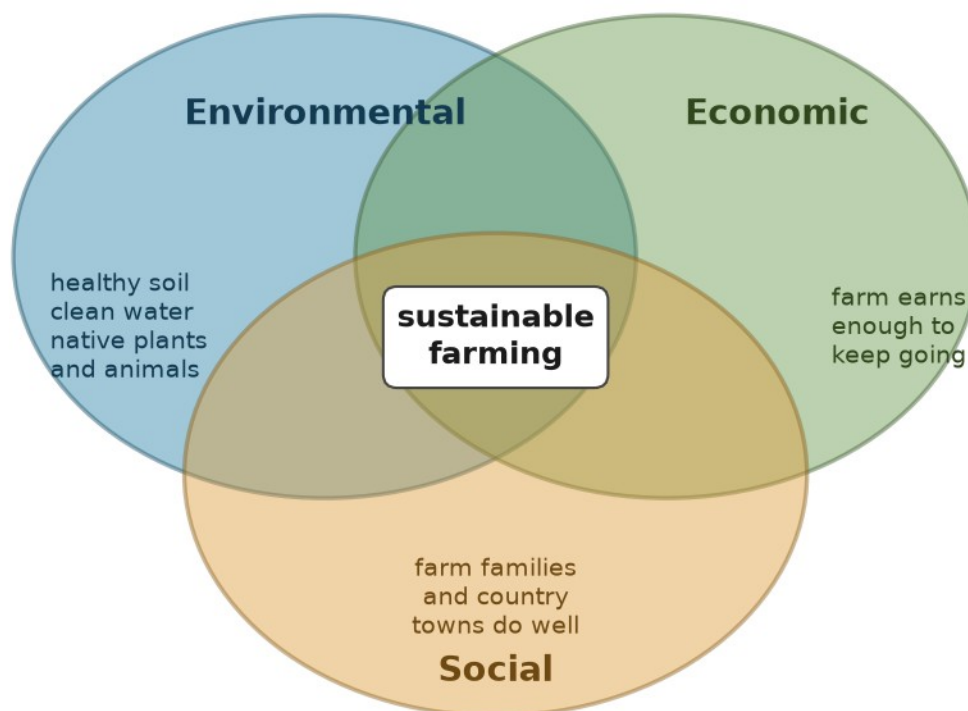
Strand: Geographical Knowledge and Understanding · Sub-strand: Biomes and food security. Content description: VC2HG10K03, taught through its elaborations VC2HG10K03E01, VC2HG10K03E02, VC2HG10K03E03 and VC2HG10K03E05.

Section 1A showed where the world's food is grown, and Section 1B showed why crops are grown in some places and not others. This section asks the next question: **can Australian farming keep going — in its soils, in its incomes and in its communities?** The key idea is *sustainability*, and because that word is used loosely in public life, we will define it carefully, then apply it with dated evidence to real Australian farming.

Theory

Defining sustainability — and owning the frame. *Sustainability* is a contested term: farmers, scientists, companies and protesters all use it, and they do not mean the same thing. Good geography therefore begins by stating the frame it will use. Ours is the one set in *Our Common Future*, the 1987 report of the World Commission on Environment and Development (the Brundtland Report): activity is sustainable when it meets the needs of people living now **without** damaging the ability of future generations to meet their own needs. Applied to a farm, that question splits into three dimensions (Figure 1): **environmental** (soil, water and native plants and animals stay healthy), **economic** (the farm earns enough to keep going) and **social** (farm families, workers and country towns do well). Calling farming sustainable is a judgement across all three at once — and because people weight the dimensions differently, two careful readers can disagree about the same farm. That is acceptable, as long as each shows their reasoning and their evidence. Showing that reasoning is what this section teaches.

The three dimensions of sustainability on a farm



Farming is called sustainable when all three dimensions are met at the same time.

Venn diagram of the three dimensions of sustainability on a farm: overlapping Environmental, Economic and Social circles with examples (healthy soil and clean water; the farm earning enough; farm families and country towns doing well) and “sustainable farming” labelled where all three overlap

Australian farming at a glance. In 2021-22, about 87,800 farm businesses worked 369 million hectares of agricultural land (ABS, Agricultural Commodities 2021-22). An earlier count put farmland at 393.8 million hectares — 51% of Australia’s 769.2 million hectares (ABS, Land Management 2016-17; Figure 2), most of it dry grazing country too low in rain for cropping. What the land produces is shown in Figure 3: in 2021-22 the biggest single item was **livestock disposals** — animals sold for slaughter — at \$25.0 billion, ahead of wheat at \$13.1 billion, livestock products (wool, milk, eggs) at \$9.1 billion, and canola, barley and cotton (ABS, Value of Agricultural Commodities 2021-22). Farms also feed the export account: rural goods exports were worth about \$19.6 billion in the single quarter January-March 2026 (ABS, Balance of Payments, March quarter 2026).

About half of Australia's land area is farmland (2016-17)

Total land area of Australia: 769.2 million hectares

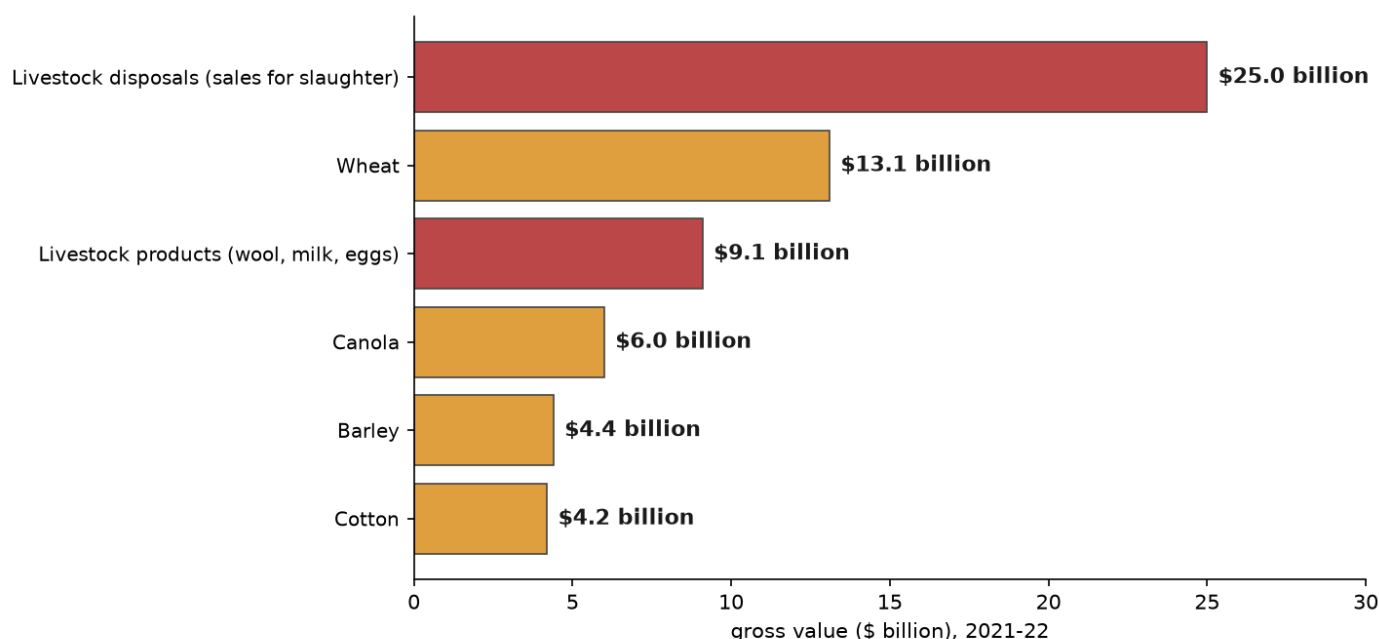


Agricultural land in 2021-22: 369 million hectares (ABS, Agricultural Commodities 2021-22)

Source: ABS, Land Management and Farming in Australia 2016-17, released 26 June 2018. Retrieved 25 August 2026.

Single horizontal stacked bar showing farmland, 393.8 million hectares, and other land, 375.4 million hectares, of Australia’s total 769.2 million hectares in 2016-17

What Australian farm goods were worth, 2021-22

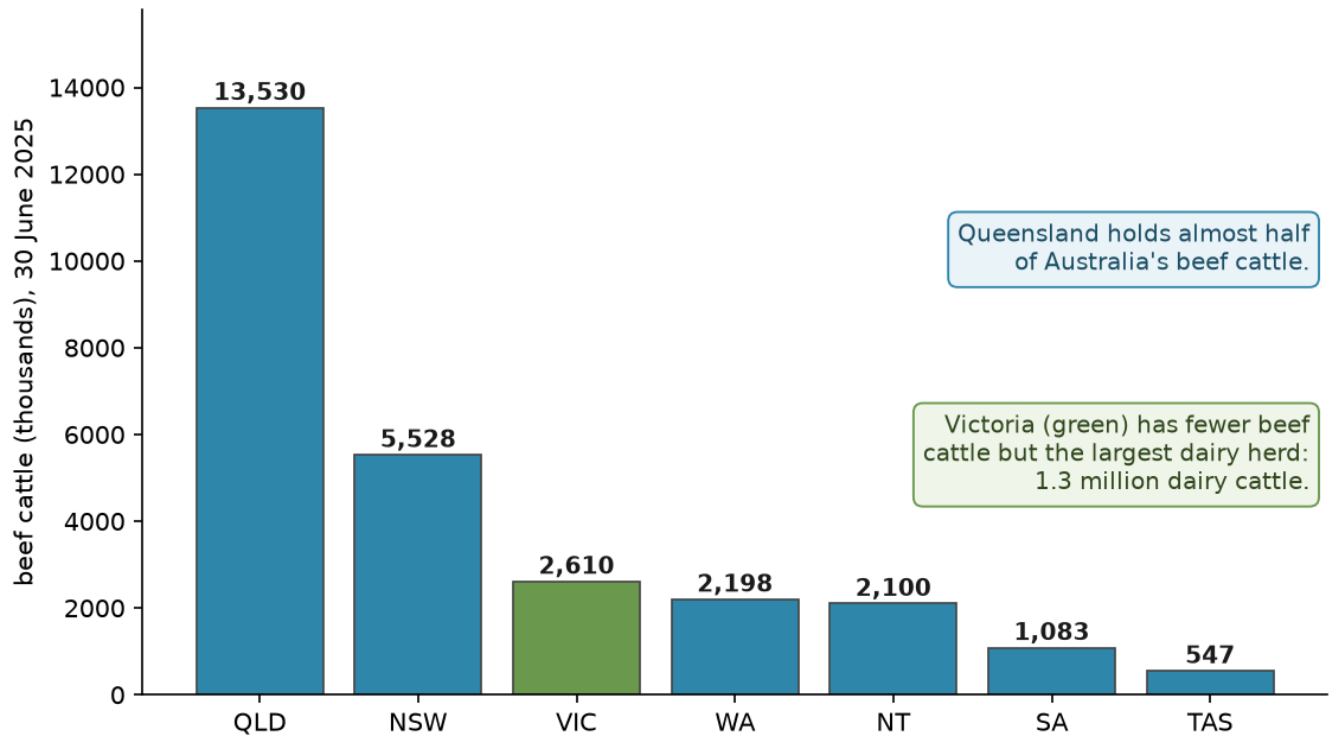


Source: ABS, Value of Agricultural Commodities Produced, Australia, 2021-22, released 17 January 2023. Retrieved 25 August 2026.

Horizontal bar chart of the gross value of Australian farm goods in 2021-22: livestock disposals \$25.0 billion, wheat \$13.1 billion, livestock products \$9.1 billion, canola \$6.0 billion, barley \$4.4 billion, cotton \$4.2 billion

Where things are raised matters to people as well as to soils. Figure 4 shows beef cattle numbers by state: Queensland carries about half the national herd, while Victoria’s strength is dairy — its 1.3 million dairy cattle are the largest herd in Australia (ABS, Livestock 2024-25). Farming like this is the backbone of many country towns: when farm incomes are good, the town’s shops, school and services do well, and when they are not, the town feels it. That farm-town link is the social dimension in action.

Where Australia's beef cattle are held



Source: ABS, Australian Agriculture: Livestock, 2024-25, released 28 April 2026. Retrieved 25 August 2026.

Bar chart of beef cattle numbers by Australian state and territory in 2024-25, Queensland largest at about 13.5 million head with Victoria highlighted, plus callouts noting Victoria has the largest dairy herd at 1.3 million

The method: criteria, indicators and a scorecard. How do we actually *assess* sustainability? We use a **criterion** — the question we judge against — and an **indicator** — the data we check to make the judgement. Figure 5 is the scorecard model this section will use: for each dimension, a criterion, an indicator, and a piece of dated Australian evidence. Keep this model in front of you: it is the skill the worked examples and tasks are built on.

Scorecard model: is Australian farming sustainable?

Dimension	Criterion (the question asked)	Indicator	Australian evidence
Environmental	Is the soil being protected?	share of crop area grown with no ploughing	79% of crop area had no cultivation apart from sowing (2016-17)
Environmental	Is water use under pressure?	where the irrigation water is used	the Murray-Darling Basin received 62% of irrigation water (2020-21)
Economic	Is production worth enough to keep going?	gross value of farm products	wheat \$13.1b; livestock disposals \$25.0b (2021-22)
Social	Are farming communities holding up?	number of farm businesses	87,800 agricultural businesses (2021-22)

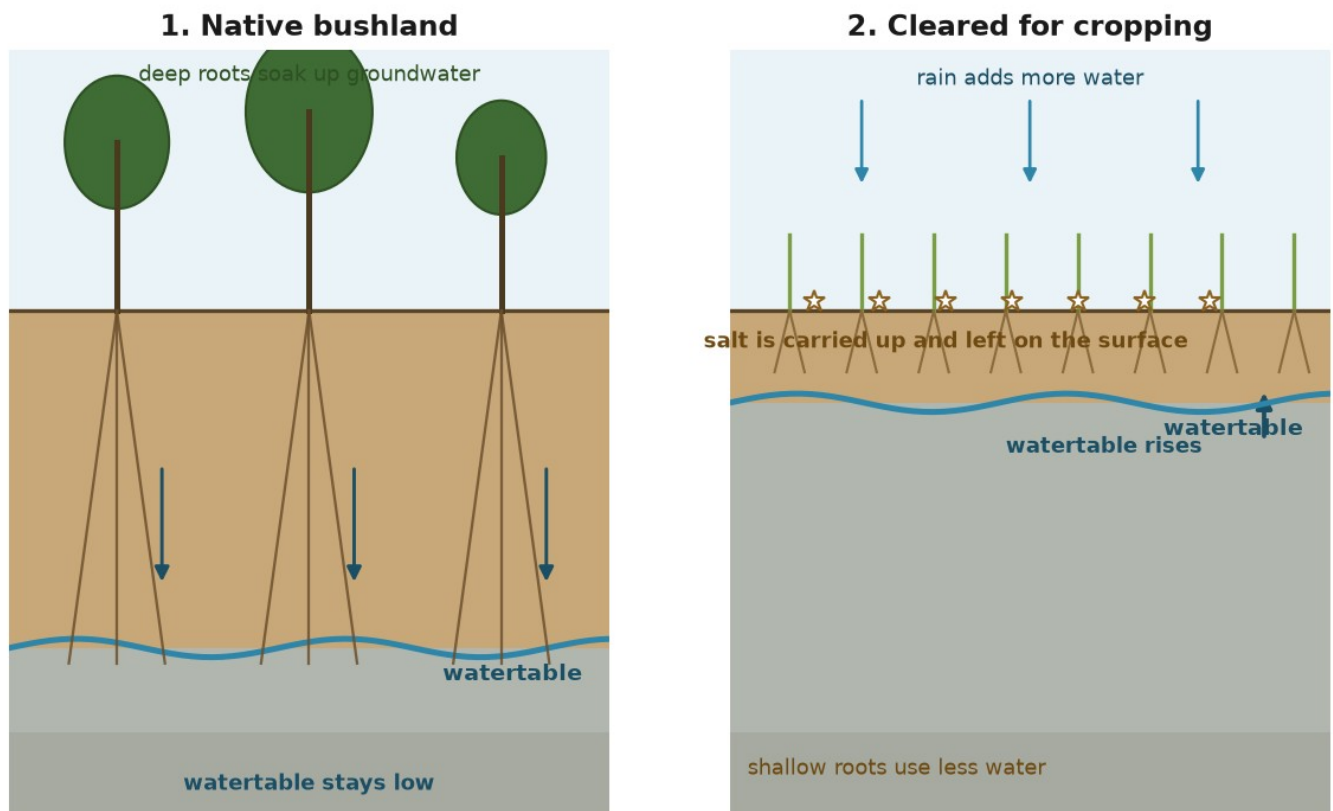
A criterion is a standard you judge against. An indicator is the data you check to make the judgement.

Scorecard table with four rows across the environmental, economic and social dimensions, each row giving a criterion, an indicator and dated Australian evidence, such as 79% of crop area grown with no cultivation apart from sowing in 2016-17

Environmental sustainability: soils and water under the scorecard. Soil is the slowest resource a farm owns — it can take hundreds of years to form one centimetre — so the environmental assessment of farming begins with it. The two big soil threats in Australia are **erosion** (wind and water carrying topsoil away) and **salinity**. Dryland salinity works the way Figure 6 shows: under native bushland, deep roots use most of the rain and the watertable — the top of the groundwater — stays deep; after clearing, shallow-rooted pastures and crops let rain leak past the roots, the watertable rises, and the salt it carries is brought up into the root zone and into streams, damaging soil and water. Both threats are worst where soil is left bare — which makes “how much cropping keeps its soil covered and unturned” a strong indicator of environmental sustainability.

On that indicator the news is genuinely good: in 2016-17, 79% of Australia’s crop area had no cultivation apart from sowing, and stubble — the straw left after harvest — was retained on 5.7 million hectares lying on the ground and 5.3 million hectares left standing (ABS, Land Management 2016-17). That spread of no-till sowing and stubble keeping is exactly the practice change that protects soils. The water indicator is more troubling: in 2020-21 Australian farms applied 7.8 million megalitres of irrigation water — a megalitre is one million litres — and the Murray-Darling Basin alone took 62% of it (ABS, Water Use on Farms 2020-21). A farm system that draws that much from one stressed basin is, by our criterion, under pressure. Fertiliser sits in between: 57,300 businesses applied 4.87 million tonnes in 2016-17 (ABS, Land Management 2016-17), which keeps soils fertile and yields up but can damage waterways where it runs off. Scorecard reading: the soil criterion is increasingly met; the water criterion is not yet.

How dryland salinity develops after native vegetation is cleared



Salt occurs naturally in many Australian soils and in groundwater. When the watertable rises, dissolved salt reaches the surface.

Two-panel cross-section comparing native bushland, where deep roots use most rain and the watertable stays deep, with cleared farmland, where shallow roots let water leak down so the watertable rises and brings salt into the root zone

Sustainable farming practices. Three named approaches come up often in Australia (Figure 7): **conservation farming**, **regenerative agriculture** and **biodynamic farming**. All three attack the same weakness of conventional farming — bare, turned, run-down soil — but in different ways and at different costs. Notice the shape of the trade-off in every row: the advantages are mostly environmental and long term, while the limitations are mostly economic and short term (new machinery, years of waiting, certification costs). That shape *is* the sustainability tension in one table, and it explains why many farmers mix methods rather than adopt one label.

Three sustainable farming practices used in Australia

Practice	What it means	Key methods	Possible advantages	Possible limitations
Conservation farming	Farming that keeps soil covered and disturbs it as little as possible	no-till sowing; stubble left on the surface; crop rotation	protects soil from erosion; holds in moisture	can need more weed control; new machinery costs a lot
Regenerative agriculture	Farming that aims to rebuild soil health and the life in it	rotational grazing; cover crops; compost; little or no ploughing	builds soil organic matter; fewer bought inputs over time	results take years; yields can dip while the soil recovers
Biodynamic farming	A certified way of farming that treats the farm as a living system	compost preparations; planned rotations; crops and stock together	recycles nutrients on the farm; no synthetic chemicals	careful records and certification; can cost more to run

This is a summary model. Real farms often mix methods from more than one practice.

Comparison table of conservation farming, regenerative agriculture and biodynamic farming, each with what it means, key methods, possible advantages and possible limitations

Economic and social sustainability. Economically, Australian farming is large — Figures 3 and 4 — but it is not steady. Section 1B showed wheat yields swinging from 1.47 t/ha in the drought year 2019-20 to 3.11 t/ha in 2022-23 (ABARES, June 2026); prices swing too. In 2024-25 the value of livestock sold for slaughter rose 27% to \$28.4 billion in a single year while the value of milk fell 4.3% to \$6.0 billion (ABS, Livestock 2024-25). A business whose income can jump or fall by a quarter in one year must still pay for fuel, water and fertiliser in the bad year — so the economic criterion (“does it earn enough to keep going?”) must be judged across a run of years, never on one.

On the social side, farming is the heartbeat of country Australia. The 87,800 farm businesses of 2021-22 (ABS, Agricultural Commodities 2021-22) are mostly family businesses, and their spending keeps small towns alive. Two slow social pressures sit on top of the income swings: when prices stay low for years, families leave a district and its school, services and clubs shrink; and when the next generation moves to the cities, “who will take over the farm?” becomes a question about the future of a whole community. A farm system that cannot keep families and towns going is not sustainable in its social dimension, however large its exports.

Innovations: reducing the environmental limits. Section 1B showed that environmental factors set limits, and that people alter them. The innovations named in VC2HG10K03E05 (Figure 8) are the same story from the sustainability side: high-yielding varieties and pest-resistant GM varieties — plants whose genes scientists have changed to give a useful trait, such as resisting an insect pest — lift production per hectare; drip irrigation delivers water to the roots instead of the sky; stubble mulching, crop rotation, intercropping and agroforestry keep soil covered and fed. Do they work? Compare two seasons: 2024-25 grew 34.8 million tonnes of wheat from 12.7 million hectares, against 28.0 million tonnes from 10.5 million hectares in 2023-24 (ABS, Broadacre Crops 2024-25) — more grain *and* more grain per hectare. Yet set either season beside the drought year 2019-20 and the honest reading is that innovations move the limits; they do not remove them. Rain still has the last word — which is exactly why the environmental dimension can never be handed over to the other two.

Innovations that reduce environmental limits on food production

Innovation	Environmental limit it reduces	How it helps	Australian example
High-yielding crop varieties	low rainfall, short seasons	breeding selects varieties that ripen faster and give more grain	wheat crops in the Wimmera, Victoria
Pest-resistant GM varieties	insect pests destroy crops	plants resist pests, cutting losses and some spray use	cotton in inland NSW and Queensland
Drip irrigation	water is scarce in dry regions	water drips to the roots, so far less is wasted	grapes and citrus in Sunraysia (Mildura), Victoria
Stubble mulching	bare soil dries out and blows away	crop residue left on the surface holds moisture and protects soil	grain farms across the Wimmera and Mallee
Crop rotation	soil nutrients run down; weeds build up	crops are grown in turn; legumes add nitrogen back to the soil	wheat and legume rotations in the Wimmera
Intercropping	bare ground between rows is exposed	two or more crops grown together keep ground covered	some vegetable and grain farms
Agroforestry	wind erosion; loss of shelter and habitat	tree rows among crops or grazing land shelter soil and stock	tree belts on farms in western Victoria

GM means genetically modified: the plant's genes have been changed to give it a useful trait.

Table of seven innovations — high-yielding varieties, pest-resistant GM varieties, drip irrigation, stubble mulching, crop rotation, intercropping and agroforestry — each with the environmental limit it reduces, how it helps and an Australian example

The best case on each side, and one judgement. Before judging, hear each side at its strongest. *For* “Australian farming is sustainable”: most cropping now sows without tillage and keeps its stubble, production and exports sit near record highs, and farm spending carries thousands of country towns. *Against*: soil threats such as erosion and salinity have not gone away, one stressed river basin carries 62% of irrigation water, and incomes — and towns — swing with prices and rain. Notice that both cases are true: they simply weight the dimensions differently. A good answer to “is it sustainable?” therefore never says only yes or no. It says *in which dimension, on what evidence, trending which way*.

Worked examples

Example 1 — scaffolded

Assess the environmental sustainability of Australian grain cropping using the scorecard (Figure 5).

Working	Comment
1. Criterion 1: is the soil being protected? Indicator: the share of crop area grown without ploughing.	A criterion is the question asked; the indicator is the data checked (Figure 5).
2. Evidence: 79% of crop area had no cultivation apart from sowing, and stubble was retained on 5.7 million hectares on the ground plus 5.3 million hectares standing (2016-17; ABS, Land Management 2016-17).	Dated, checkable evidence — never judge without one.
3. Reading: no-till sowing plus stubble means covered soil, less erosion and more stored moisture, so criterion 1 is largely met.	Evidence to meaning: this is the assessing move.
4. Criterion 2: is water use under pressure? Evidence: the Murray-Darling Basin took 62% of all irrigation	A second criterion stops a one-sided judgement.

water in 2020-21 (ABS, Water Use on Farms 2020-21).

5. Reading: one stressed basin carrying most of the irrigation load means the water criterion is not yet met.

Same move, opposite reading.

6. Judgement: the environmental sustainability of Australian grain cropping is *improving but not secured* — soil practice has shifted at scale in the right direction, while water use remains under pressure.

A sustainability judgement names the dimension, the trend and the evidence.

Example 2 — unscaffolded

Evaluate how sustainable Victorian dairy farming is in economic and social terms. A model response follows. Notice that every claim carries a dated source, and that the conclusion is a weighing, not a slogan.

Victoria keeps the largest dairy herd in Australia — 1.3 million cattle (ABS, Livestock 2024-25) — concentrated in irrigated valleys such as the Goulburn Valley and in Gippsland, and irrigated production is worth more in Victoria than in any other state: \$4.9 billion in 2017-18 (ABS, GVIAP 2017-18). Economically, dairy is valuable but exposed: the national value of milk fell 4.3% to \$6.0 billion in a single year (ABS, Livestock 2024-25) while the costs of water, feed and power kept climbing, so a district can be profitable one year and squeezed the next; the economic criterion is therefore met *at present* only in part, and the trend matters as much as the level. On the social side, the same herds support the towns of the dairy belt — the factories, truck drivers, schools and shops that live on farm spending — so when milk values fall, the pressure travels from paddock to main street, and where a dairy family leaves a district the loss is social as well as economic. Weighing the two dimensions together: Victorian dairy is presently sustainable in the sense that it keeps incomes, families and towns going, but it sits close to the edge of sustainability in both dimensions, because a price fall it does not control can tip either one. The reasoning, not the verdict, is what this skill is: dimension, criterion, dated evidence, weighing, judgement.

Practice questions

Scaffolded

Q1. The frame this section uses defines sustainability from *Our Common Future* (WCED, 1987). In your own words, complete the definition: “Farming is sustainable when it meets the needs of _____ without damaging the ability of _____ to meet their own.”

Q2. Use Figure 2. (a) How many million hectares of Australia were farmland in 2016-17? (b) Check the “about half” claim by dividing farmland by total land area. Give your answer as a percentage to the nearest whole number.

Q3. Use Figure 3. (a) Rank the top three Australian farm goods of 2021-22 by value. (b) Which four of the six bars are crops, and which two come from animals?

Q4. Figure 6 shows dryland salinity. Rearrange these steps into the correct order: (a) the watertable rises; (b) the land is cleared to shallow-rooted pastures and crops; (c) salt reaches the root zone and streams, damaging soil and water; (d) rain leaks past the roots into the groundwater; (e) native bushland with deep roots uses most of the rain.

Q5. Use Figure 7. Match each practice — conservation farming, regenerative agriculture, biodynamic farming — to its description: (a) rebuilds soil life with rotational grazing, cover crops and compost; (b) keeps soil covered using no-till sowing and stubble; (c) a certified system that runs the whole farm as one living system with compost and planned rotations.

Q6. Use Figure 8. (a) Name two innovations that keep soil covered. (b) Which innovation delivers water straight to the roots, and in which Victorian region is it widely used on grapes and citrus?

Unscaffolded

Q7. “79% of crop area had no cultivation apart from sowing (2016-17).” Explain why that figure is evidence of environmental sustainability — and give one reason it is not enough on its own.

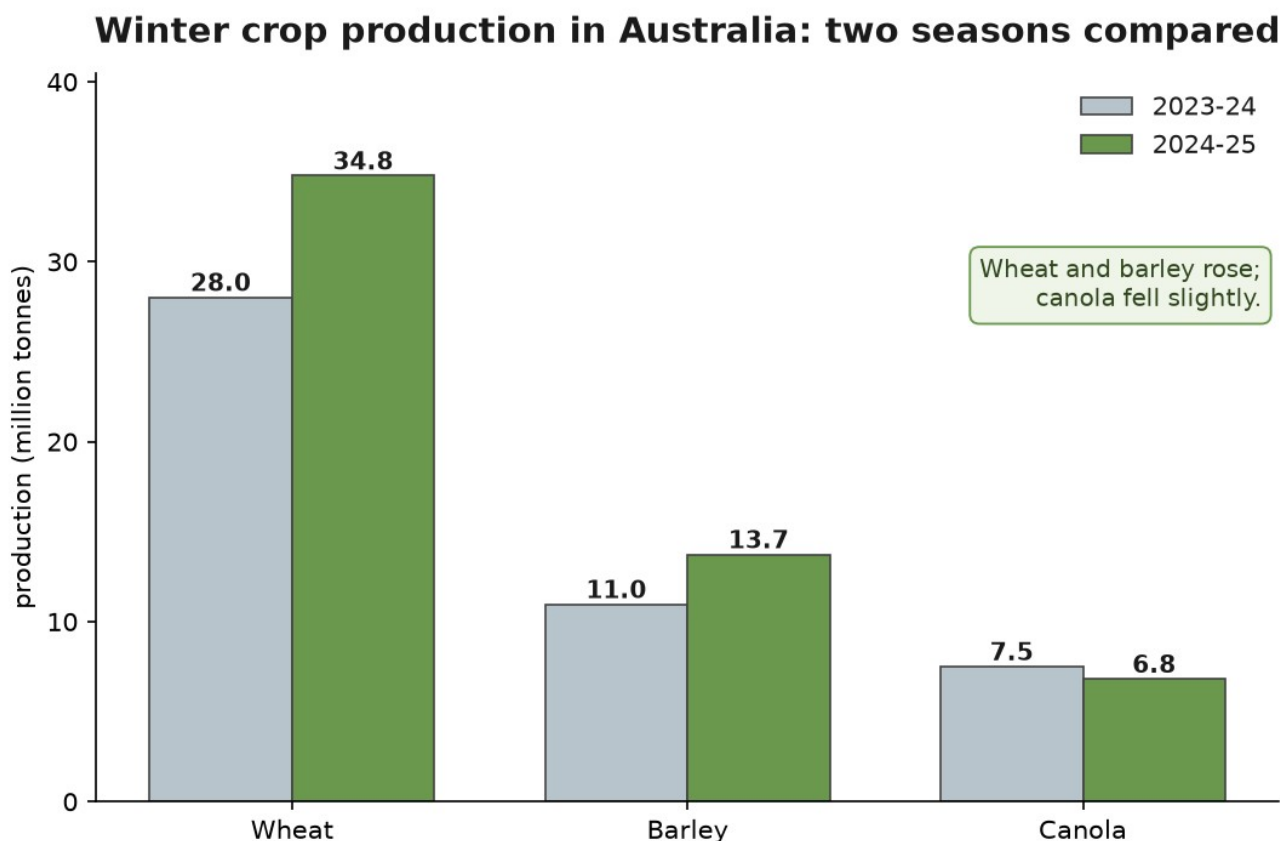
Q8. “A farm can be sustainable in one year and not the next.” Argue for this claim using **two** dated figures from this section.

Q9. Figure 4 shows Queensland carrying about half of Australia’s beef cattle. Explain how a Queensland drought can become a *social* sustainability problem for a country town, not only an environmental and economic one.

Q10. “Australian farming is sustainable.” Judge this claim across all three dimensions, using at least one piece of dated evidence per dimension, and show your weighing.

Inquiry task

Two seasons of winter crops. Figure 9 shows Australian production of wheat, barley and canola in 2023-24 and 2024-25 (ABS, Broadacre Crops 2024-25, retrieved 25 August 2026). Wheat was grown on 10.5 million hectares in 2023-24 and 12.7 million hectares in 2024-25 (same source).



Source: ABS, Australian Agriculture: Broadacre Crops, 2024-25, released 30 June 2026. Retrieved 25 August 2026.

Grouped bar chart comparing Australian winter crop production in 2023-24 and 2024-25: wheat 28.0 then 34.8 million tonnes, barley 11.0 then 13.7, canola 7.5 then 6.8

- Describe the change in production of each crop between the two seasons.
- Calculate the change in wheat production, in million tonnes and as a percentage.
- Calculate the wheat yield (production divided by area) for each season, to two decimal places.
- Apply this section’s model: is the stronger 2024-25 season, on its own, evidence that wheat farming is economically sustainable? Write six to eight lines that name the dimension, the criterion and the evidence with its source, and give one reason a single good season is thin evidence.

Answers

Q1. ...people living now...; ...future generations...

Q2. (a) 393.8 million hectares. (b) $393.8 / 769.2 = 0.512$, so 51%.

Q3. (a) Livestock disposals (\$25.0b), wheat (\$13.1b), livestock products (\$9.1b). (b) Crops: wheat, canola, barley, cotton. Animals: livestock disposals and livestock products.

Q4. e, b, d, a, c.

Q5. (a) regenerative agriculture; (b) conservation farming; (c) biodynamic farming.

Q6. (a) Stubble mulching and intercropping (agroforestry also shelters soil — accept). (b) Drip irrigation; Sunraysia, centred on Mildura, in Victoria's north-west.

Q7. Covered, unturned soil resists erosion, stores moisture and protects the soil life that fertility depends on — a direct environmental gain. But it is not enough alone: sustainability also needs the water, economic and social criteria to be met, and a no-till farm can still draw heavily on a stressed river basin or fail to earn enough to keep going.

Q8. Example pair: the value of livestock disposals rose 27% to \$28.4 billion in 2024-25 while the value of milk fell 4.3% to \$6.0 billion in the same year (ABS, Livestock 2024-25) — one dimension of farm income booming while another slips. Equally, wheat yields swung from 1.47 t/ha in drought 2019-20 to 3.11 t/ha in 2022-23 (ABARES, June 2026, as in Section 1B). A single year is a snapshot, not a trend, so sustainability must be judged across years.

Q9. Drought dries the pastures, so cattle are sold early and herds shrink; farm incomes fall; the town's sale yards, transport firms, shops and school then lose the spending they live on; families may leave; the town's services and community thin out. The environmental shock has become a social one.

Q10. Answers will vary. A sound response judges each dimension separately with dated evidence — e.g. environmental: 79% of crop area sown without cultivation (2016-17) but 62% of irrigation drawn from the Murray-Darling Basin (2020-21); economic: wheat worth \$13.1 billion (2021-22) but incomes swing year to year; social: 87,800 farm businesses (2021-22) carrying country towns, but low-price years push families out — then weighs them and states a reasoned position.

Inquiry task. (a) Wheat up (28.0 to 34.8 Mt), barley up (11.0 to 13.7 Mt), canola down (7.5 to 6.8 Mt). (b) +6.8 Mt; $6.8 / 28.0 = 24\%$ (to 2 s.f.). (c) 2023-24: $28.0 / 10.5 = 2.67$ t/ha; 2024-25: $34.8 / 12.7 = 2.74$ t/ha. (d) Answers will vary — see the fully-worked solution.

Fully-worked solutions

Q1. The 1987 frame: farming is sustainable when it meets the needs of **people living now** without damaging the ability of **future generations** to meet their own needs. The two gaps are the whole point — now *and* later.

Q2. (a) 393.8 million hectares (ABS, Land Management 2016-17). (b) $393.8 / 769.2 = 0.512 = 51\%$ — the “about half” claim in Figure 2 checks out.

Q3. (a) Livestock disposals \$25.0b, then wheat \$13.1b, then livestock products \$9.1b (ABS, Value of Agricultural Commodities 2021-22). (b) The four crop bars are wheat, canola, barley and cotton; the two animal bars are livestock disposals and livestock products.

Q4. e, b, d, a, c. Native bushland with deep roots uses most rain (e); clearing replaces it with shallow roots (b); rain then leaks past the roots into the groundwater (d); the watertable rises (a); salt reaches the root zone and streams (c).

Q5. (a) **Regenerative agriculture** — rebuilding soil life is its signature. (b) **Conservation farming** — no-till sowing and stubble cover. (c) **Biodynamic farming** — certification and the farm-as-living-system idea mark it out.

Q6. (a) **Stubble mulching** (residue left on the surface) and **intercropping** (two crops keep ground covered); agroforestry's tree belts also shelter soil, so accept it with a reason. (b) **Drip irrigation**, widely used on grapes and citrus around Mildura in **Sunraysia**, Victoria.

Q7. The figure shows most cropping keeps its soil covered and unturned, which cuts erosion, holds moisture and protects soil life — so on the soil criterion, environmental sustainability is strong and improving. It is not enough alone because sustainability has other criteria: the same no-till farms may still draw heavily on the Murray-Darling Basin (62% of irrigation water, 2020-21), and a farm that protects its soil can still fail the economic or social test. One indicator never settles a three-dimension judgement.

Q8. Take two dated figures from the same release: in 2024-25 the value of livestock disposals rose 27% to \$28.4 billion while the value of milk fell 4.3% to \$6.0 billion (ABS, Livestock 2024-25). Beef regions were having a sustainable-income year while dairy regions were slipping in the same twelve months — and each will swap places in other years as prices move. Add the yield swing of Section 1B (1.47 t/ha in 2019-20 against 3.11 t/ha in 2022-23, ABARES June 2026) and the argument is complete: sustainability is a property of a run of years, so a farm can pass in one year and fail in the next.

Q9. Chain the dimensions. Environmentally, drought dries pastures and stresses water. Economically, producers sell early, herds shrink and incomes fall. On the social side — the step the question wants — the town's sale yards, transport firms, fuel stop, shops and school lose the spending they depend on; services contract; families may leave; the community thins. The town's social sustainability was tied to the region's environmental sustainability the whole time, which is exactly the farm-town link of Figure 4.

Q10. Model weighing. *Environmental*: soil practice is strong (79% of crop area with no cultivation apart from sowing, 2016-17; ABS Land Management 2016-17) but water is under pressure (62% of irrigation from the Murray-Darling Basin, 2020-21; ABS Water Use on Farms 2020-21) — improving, not secured. *Economic*: large values (livestock disposals \$25.0b and wheat \$13.1b in 2021-22; ABS Value of Agricultural Commodities 2021-22; rural exports about \$19.6b in one quarter of 2026; ABS Balance of Payments) but incomes swing hard year to year — strong in good years, vulnerable in bad. *Social*: 87,800 farm businesses (2021-22; ABS Agricultural Commodities 2021-22) carry country towns, yet low-price years push families out and raise the hand-over question. Weighing: no dimension fails outright and one (soil) is clearly improving, but two (water, income stability) sit under pressure — so the claim is best answered as “yes in part, and trending differently by dimension”, which is the honest shape of a sustainability judgement.

Inquiry task — one possible approach. (a) Wheat and barley rose strongly (wheat 28.0 to 34.8 Mt; barley 11.0 to 13.7 Mt) while canola fell slightly (7.5 to 6.8 Mt). (b) $34.8 - 28.0 = 6.8$ Mt; $6.8 / 28.0 = 0.243$, a rise of about 24%. (c) 2023-24: $28.0 / 10.5 = 2.67$ t/ha; 2024-25: $34.8 / 12.7 = 2.74$ t/ha — a small yield gain on top of the large area gain. (d) The dimension is economic; the criterion is “earns enough to keep going across a run of years”; the evidence is the 2024-25 wheat crop of 34.8 Mt worth about \$10.1 billion (ABS, Broadacre Crops 2024-25, retrieved 25 August 2026). A single strong season is thin evidence because one good price-and-rain year can mask bad ones either side of it — Section 1B's drought yield of 1.47 t/ha (2019-20) sits inside the same decade — and because economic sustainability also needs costs, debt and the social dimension to hold up. The 2024-25 season is evidence of a good year, not of a sustainable system; it becomes part of a sustainability judgement only when set beside other seasons and the other two dimensions.

Feeding a growing world: limits, climate change and food security

Curriculum focus — Victorian Curriculum 2.0, Geography, Levels 9–10 content description

VC2HG10K04. This section draws on elaborations VC2HG10K04.E01, .E02, .E03, .E04, .E05 and .E06.

In this section

You will learn to:

- explain why feeding a growing world population is a geographic problem, and define **food security** using its four pillars (E01, E02)
- discuss **extensification** and **intensification** as two ways of increasing food production, and evaluate how sustainable each one is (E01)
- evaluate the environmental constraints on what the world can grow from here on: degraded land, industrial pollution, scarce water and a changing climate (E02)
- evaluate how competing uses of land — cities, mining, biofuel crops, livestock and tourism — squeeze food output (E03)
- reflect on the ways poverty, policy, conflict and barriers to trade can hurt world food output and leave more people food-insecure (E04)
- explain the management strategies that can bring quality and variety back to Australian agriculture (E05)
- generate your own ideas for lifting farm production in Australia (E06)

Key words: food security, availability, access, utilisation, stability, extensification, intensification, sustainable intensification, land degradation, soil erosion, salinity, acidification, water scarcity, trade barrier, tariff, export ban, biofuel, natural biome, anthropogenic biome, no-till

Defining our terms

Food security is the core idea of this section. The definition used by the Food and Agriculture Organization of the United Nations (FAO) comes from the 1996 World Food Summit:

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Geographers break this long definition into four pillars, shown in Figure 2. If any one pillar fails, people are food-insecure.

What food security means

Food security exists when:
all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

the four pillars of food security



Definition: World Food Summit (1996), as used by the FAO; pillars as set out by the FAO. Retrieved 25 August 2026.

The definition of food security above four labelled pillars: availability (enough food is grown or brought in), access (people can get to it and afford it), utilisation (food is safe and nourishing) and stability (the food keeps coming, year after year)

Figure 2. Food security and its four pillars. Definition: World Food Summit (1996), as used by the FAO; retrieved 25 August 2026.

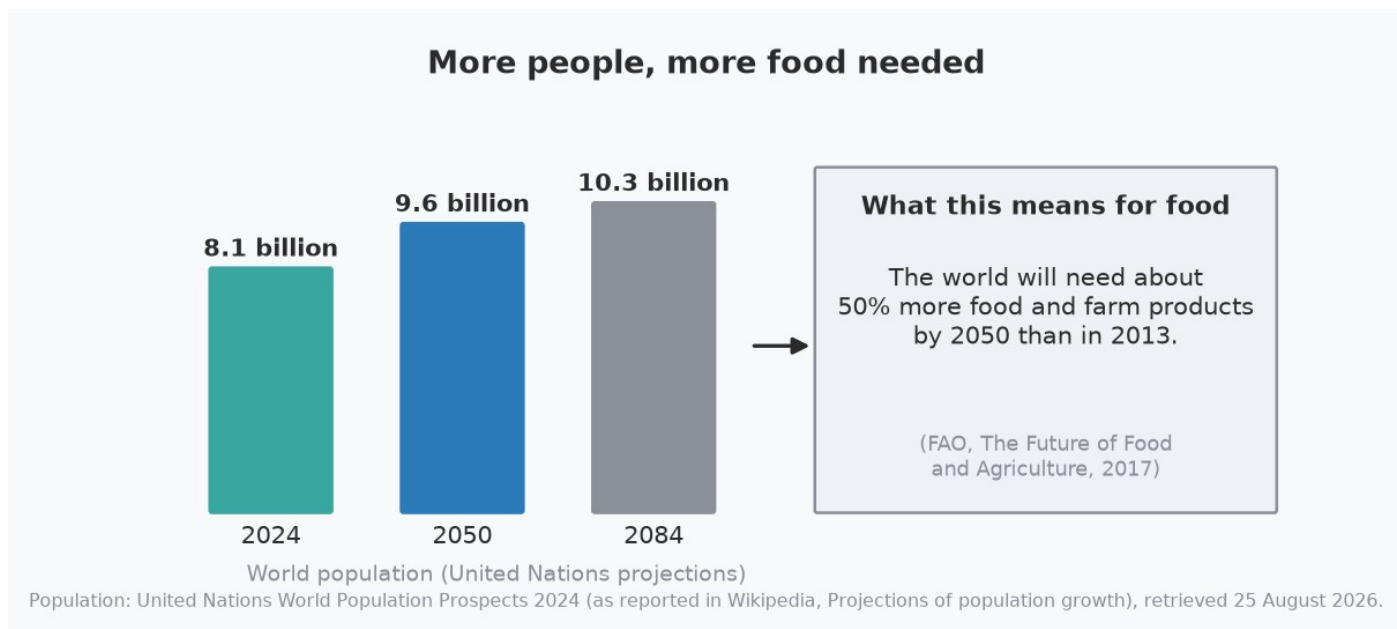
Two more terms are **contested** — people argue about them, so we define them carefully:

- **Sustainability**, in this section, means meeting today's food needs without damaging the ability of future generations to meet theirs. We test it with three questions: Is it good for the **environment** (soil, water, biomes)? Does it **economically** work for farmers and food buyers? Is it fair for **society** (workers, communities, future generations)? A pathway that passes all three tests is more sustainable than one that fails a test.
- **Anthropogenic biomes** (from the Greek *anthropos*, "human") are ecosystems shaped by long-term human use, such as cropping land and grazing land; **natural biomes** are ecosystems that are mostly self-managed, such as forests and native grasslands. Both terms appeared in Section 1A of this book.

One boundary for this section: *why* the climate is changing is science content (VC2 Science 9–10, VC2S10U10 and VC2S10U11) and is not taught here. We take the measured changes as our starting point and ask what they do to food production.

1 The challenge: more people, more food

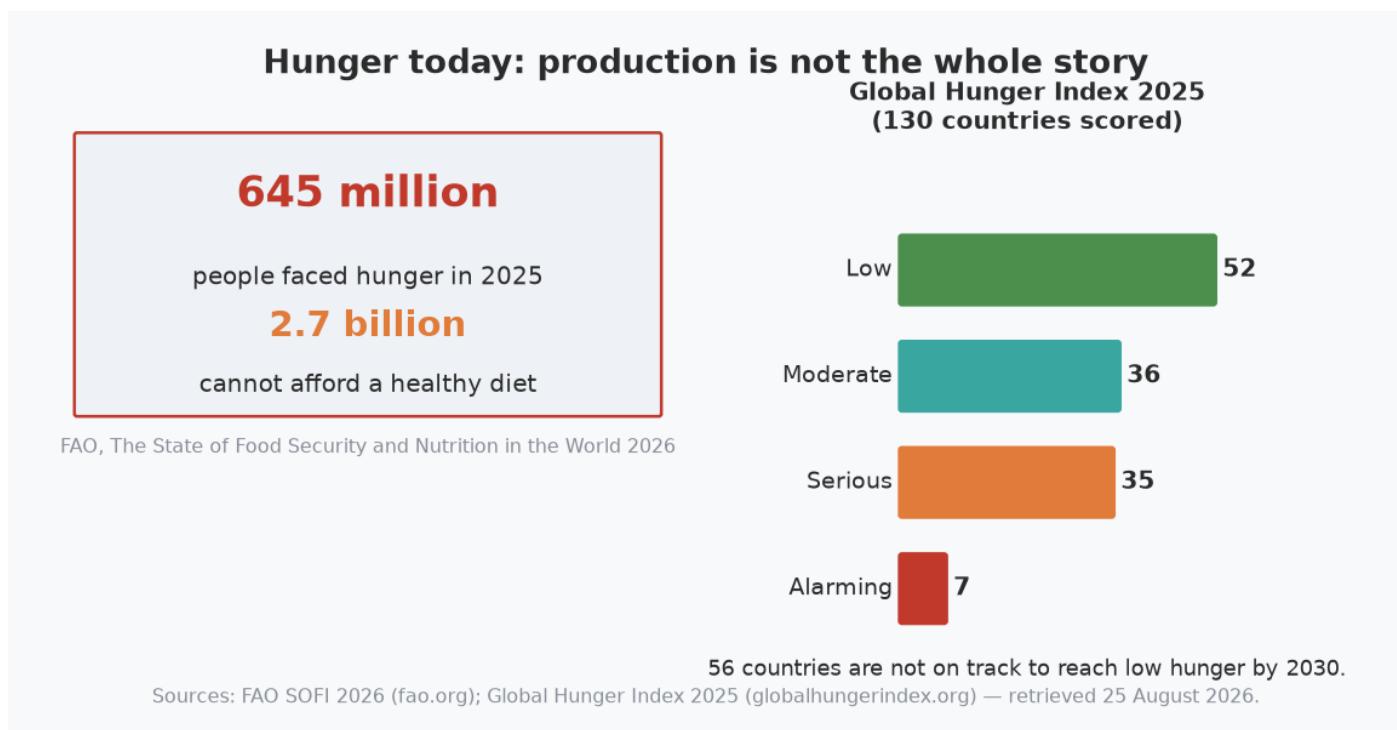
The world's population reached about 8.1 billion in 2024. United Nations projections put it at about 9.6 billion in 2050, peaking at about 10.3 billion in the 2080s. More people means more mouths to feed — and, as incomes rise in some countries, more demand for meat and dairy as well. The FAO estimates that by 2050 the world will need about 50% more food and farm products than it produced in 2013 (Figure 1).



Three bars showing world population: 8.1 billion in 2024, 9.6 billion projected in 2050 and 10.3 billion projected in 2084, beside a panel stating the world will need about 50% more food and farm products by 2050 than in 2013

Figure 1. Projected world population and food demand. Population: United Nations World Population Prospects 2024; demand: FAO, The Future of Food and Agriculture (2017); retrieved 25 August 2026.

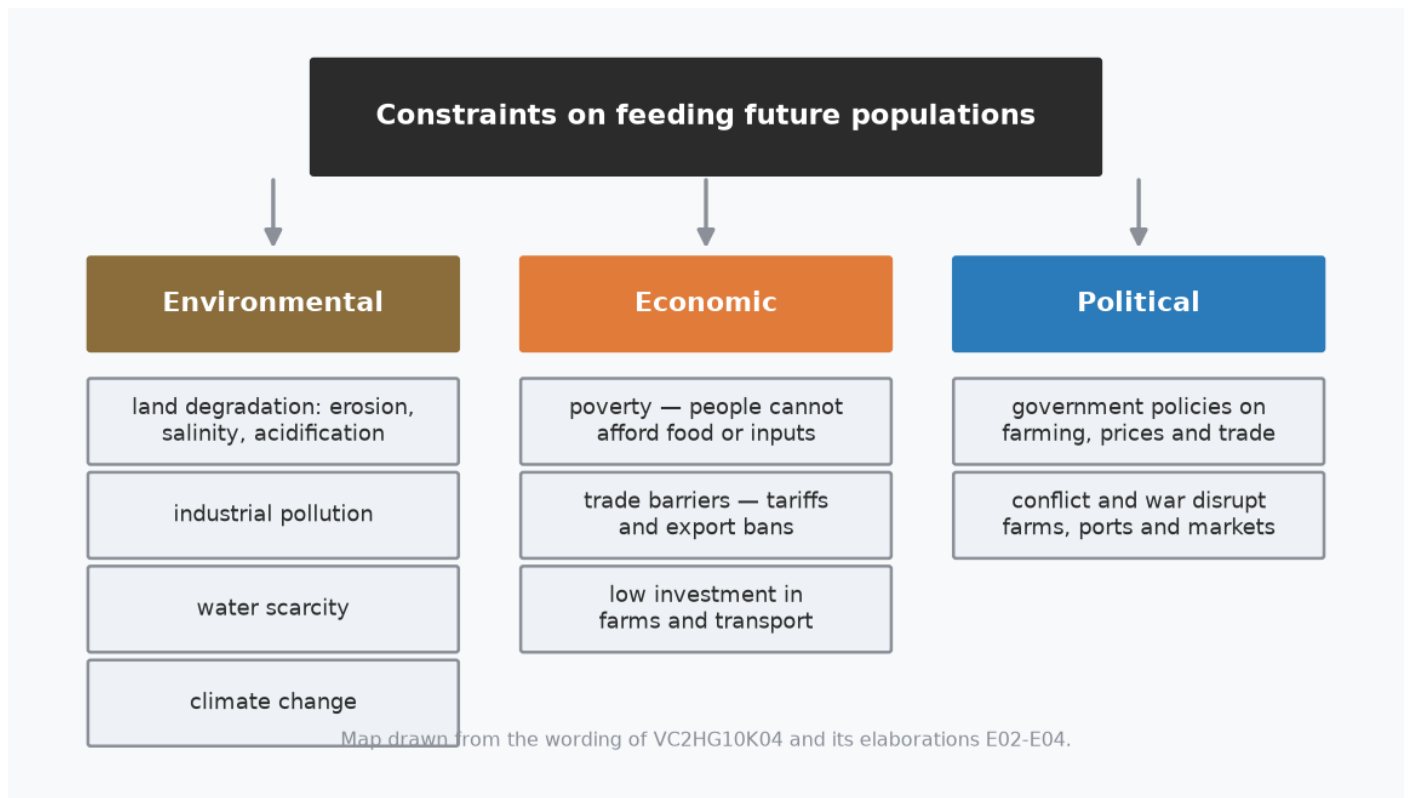
Here is the surprise for many students: the world already grows enough food to feed everyone. The problem is that not everyone can reach it or afford it. In 2025, about 645 million people faced hunger, and about 2.7 billion people could not afford a healthy diet (Figure 3). So feeding future populations is not only a production problem. It is also a distribution, poverty and policy problem — which is exactly why the curriculum bundles environmental, economic and political constraints together.



Left panel: 645 million people faced hunger in 2025 and 2.7 billion cannot afford a healthy diet. Right panel: Global Hunger Index 2025 bars for 130 countries — 52 low, 36 moderate, 35 serious, 7 alarming — with the note that 56 countries are not on track to reach low hunger by 2030

Figure 3. Hunger today. Sources: FAO, The State of Food Security and Nutrition in the World 2026; Global Hunger Index 2025; retrieved 25 August 2026.

Figure 4 maps the constraints this section studies, straight from the curriculum’s own list. Work through them in order: two pathways (Topic 2), environmental constraints (Topic 3), competing land uses (Topic 4), and the economic and political side (Topic 5). Then look at what Australia can do about it (Topics 6–7).



A concept map: “Constraints on feeding future populations” branches into three families — Environmental (land degradation: erosion, salinity, acidification; industrial pollution; water scarcity; climate change), Economic (poverty; trade barriers; low investment) and Political (government policies; conflict and war)

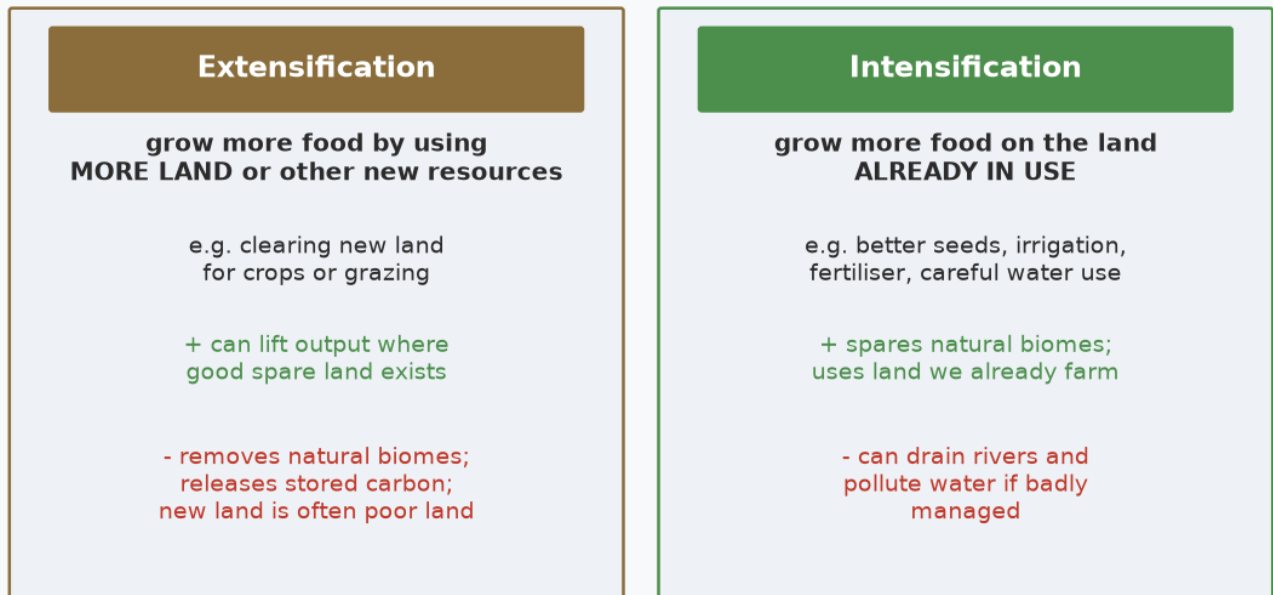
Figure 4. The three families of constraints in this section, drawn from the wording of VC2HG10K04 and elaborations E02–E04.

2 Two pathways: extensification and intensification

To close the gap between today’s food and 2050’s food, producers can take two pathways (Figure 5).

- **Extensification** means growing more food by bringing *more land and other new resources* into production — for example, clearing native vegetation for new cropping paddocks or new grazing land.
- **Intensification** means growing more food *on the land already in use* — for example, improved seeds, irrigation, fertiliser and more careful water management.

Two ways to grow more food



Concept diagram drawn for this section; the two terms come from curriculum elaboration VC2HG10K04.E01.

Two side-by-side panels. *Extensification*: grow more food by using more land or other new resources; plus, can lift output where good spare land exists; minus, removes natural biomes, releases stored carbon and new land is often poor land. *Intensification*: grow more food on the land already in use; plus, spares natural biomes and uses land we already farm; minus, can drain rivers and pollute water if badly managed

Figure 5. The two pathways, with one strength and one risk each. Concept diagram drawn for this section from elaboration VC2HG10K04.E01.

Steelmanning the two pathways. Before evaluating, set out the strongest case for each pathway.

- *The best case for extensification*: where a country genuinely has spare, suitable land, extending the farm area is the fastest, lowest-technology way to add food and farm income. It needs no expensive inputs and can use existing machines and skills.
- *The best case for intensification*: the planet's spare land is mostly forest and grassland that store carbon and host biodiversity, so the kindest way to add food is to lift yields on land we have already cleared. Done well, it spares natural biomes entirely.

Now evaluate with the three sustainability tests from "Defining our terms". Extensification usually fails the environmental test: clearing natural biomes removes habitat and releases stored carbon, and the last land cleared is often the worst land, so yields disappoint. Intensification passes the environmental test *only if* it is managed carefully: unmanaged intensification can drain rivers (water scarcity) and pollute waterways with fertiliser and salt. Geographers therefore talk about **sustainable intensification** — lifting yields on existing farmland while actively caring for soil, water and biomes. That is the pathway tested in Worked example 2 and practised in Question 7.

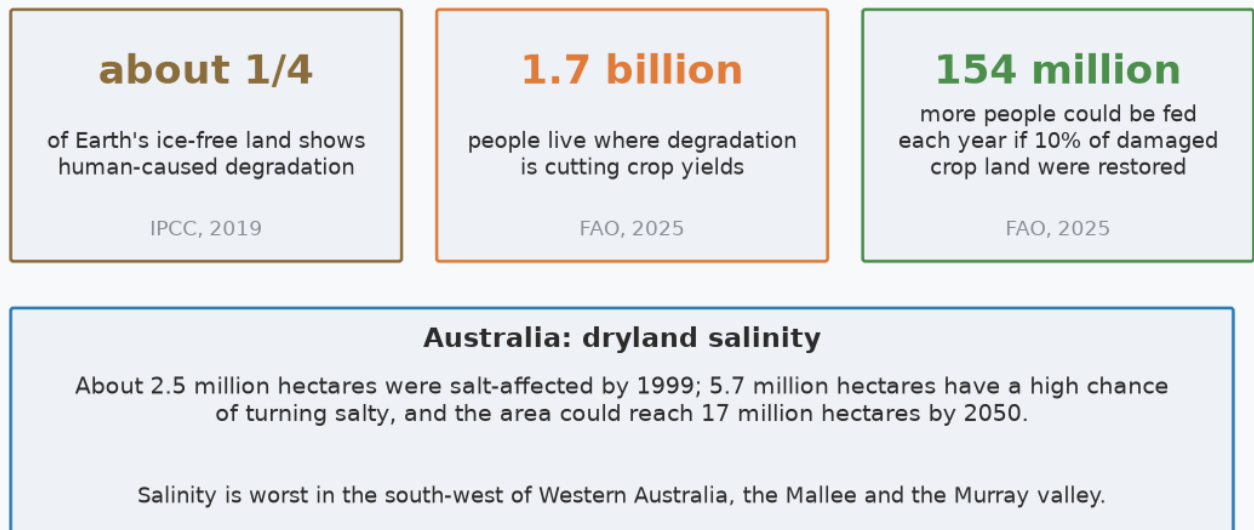
3 Environmental constraints on feeding future populations

3a Land degradation. Soil is a slow resource: it can take centuries to build a few centimetres, and it can be lost in one bad season. The 2019 special report of the IPCC found that roughly a quarter of the Earth's ice-free land is already degraded by human activity. The FAO reported in 2025 that 1.7 billion people live where degradation is cutting crop yields, and that restoring just 10% of damaged crop land could feed 154 million more people each year (Figure 6). Degradation takes several forms named in the curriculum:

- **soil erosion** — wind and water carrying topsoil away, worst on bare, cultivated slopes;
- **salinity** — salt building up in the soil surface until plants struggle, often after deep tree roots are replaced by shallow crops and the watertable rises;

- **acidification** — soils turning more acid over time, in part from some nitrogen fertilisers, which locks up nutrients plant roots need.

Land degradation: how big is the problem?



Sources: Wikipedia, Land degradation and Salinity in Australia (each citing IPCC and FAO reports), retrieved 25 August 2026.

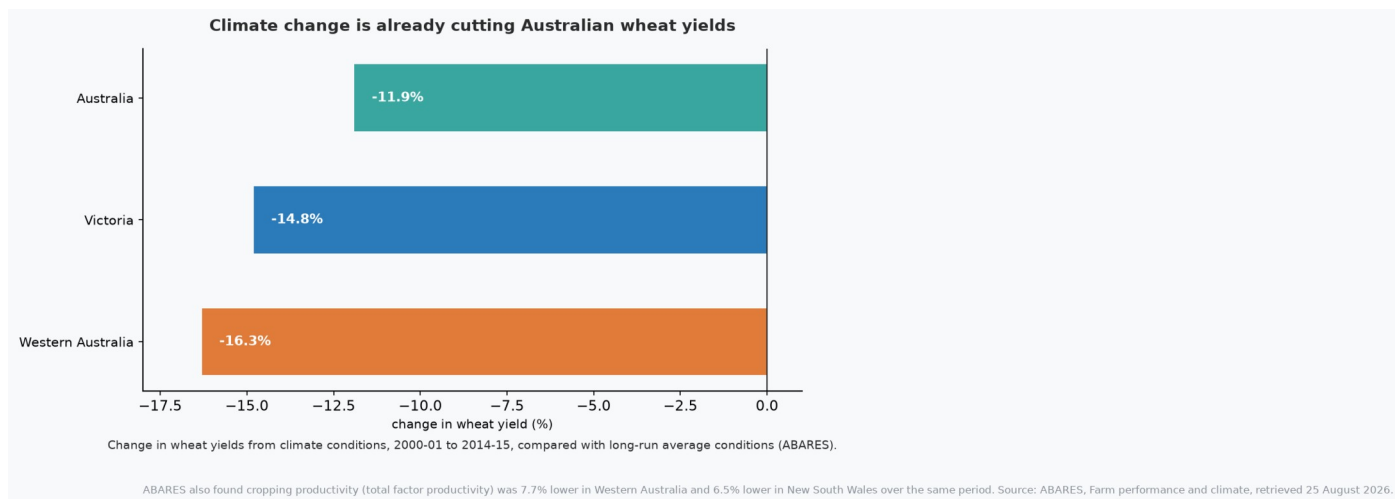
Three tiles: about a quarter of Earth's ice-free land shows human-caused degradation (IPCC, 2019); 1.7 billion people live where degradation is cutting crop yields (FAO, 2025); 154 million more people could be fed each year if 10% of damaged crop land were restored (FAO, 2025). Below: an Australia panel stating about 2.5 million hectares were salt-affected by 1999, 5.7 million hectares have a high chance of turning salty, and the area could reach 17 million hectares by 2050, worst in south-west Western Australia, the Mallee and the Murray valley

Figure 6. Land degradation worldwide and dryland salinity in Australia. Sources: IPCC (2019) and FAO (2025), as reported in Wikipedia, "Land degradation" and "Salinity in Australia"; retrieved 25 August 2026.

Australia is a dry continent with old, fragile soils, so degradation bites hard here. By 1999 about 2.5 million hectares of Australian land were salt-affected; 5.7 million hectares carry a high salinity risk; and without action the area could reach 17 million hectares by 2050 — including the Mallee and the Murray valley, two of the country's most important food regions.

3b Water scarcity. Farming is by far the largest user of fresh water: agriculture takes about 69% of the water humans withdraw worldwide. **Water scarcity** means demand for water outruns the supply that rainfall, rivers and aquifers can renew. In Australia the map of scarcity and the map of food production overlap: the Murray–Darling Basin (1,061,469 km², about a seventh of the country) grows roughly a third of Australia's food, yet its flows change hugely from drought to flood. Every extra megalitre diverted for irrigation is a megalitre not in a wetland or a downstream town — so water scarcity constrains *both* how much food can be grown and how sustainably it can be grown.

3c Climate change. A changing climate is not a future risk for Australian farmers; it has already measured in. ABARES compared farm results in 2000–01 to 2014–15 against the long-run climate and found that the shift in climate conditions cut wheat yields by about 11.9% nationally — 14.8% in Victoria and 16.3% in Western Australia (Figure 7). Hotter, drier seasons shrink the area where rain-fed cropping works, push droughts deeper, and add heat stress to livestock and horticulture. Climate change also acts as a *multiplier* on the other constraints: it worsens water scarcity, speeds erosion in drought-then-flood cycles, and raises the salinity risk in irrigated valleys.



Horizontal bar chart of the change in wheat yields from climate conditions, 2000-01 to 2014-15, compared with long-run average conditions: Australia minus 11.9%, Victoria minus 14.8%, Western Australia minus 16.3%. A note adds that cropping productivity was 7.7% lower in Western Australia and 6.5% lower in New South Wales

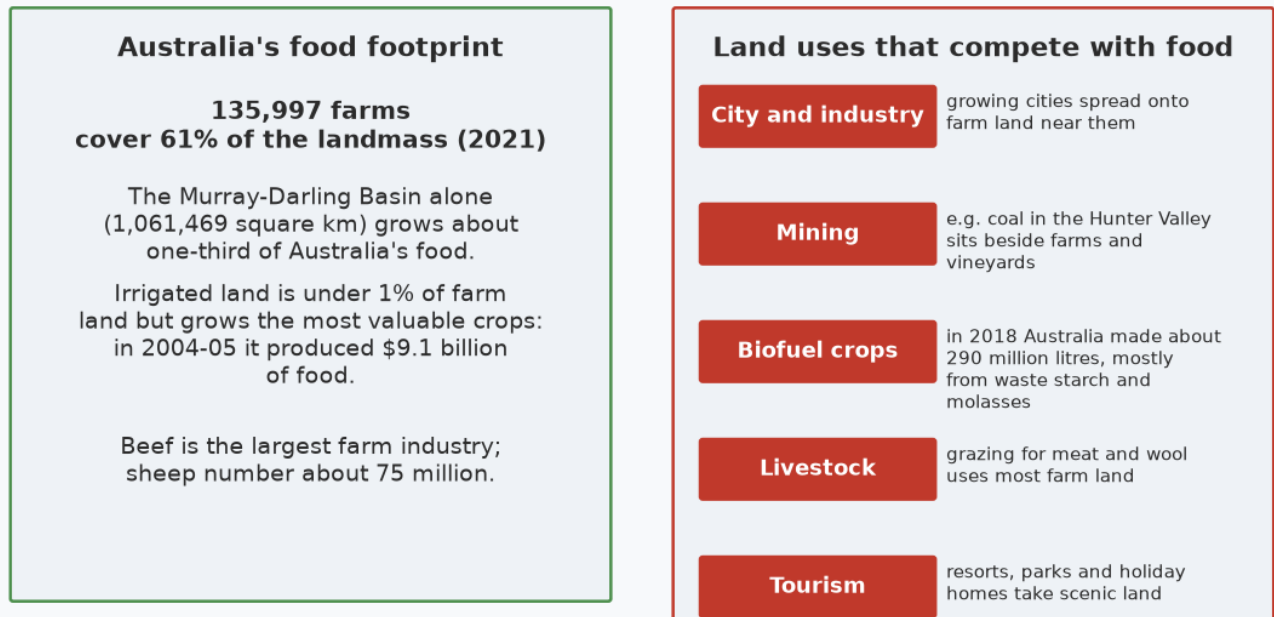
Figure 7. Measured climate impact on Australian wheat yields. Source: ABARES, Farm performance and climate; retrieved 25 August 2026.

3d Industrial pollution. Pollution constrains food production in two directions. Industrial waste, spills and air pollution can damage soils, water and crops directly — food land near badly managed industry loses quality or is taken out of production. And food systems themselves can pollute: runoff carrying fertiliser and manure degrades rivers and coastal water. Either way, pollution reduces the *quality* of the land and water that future food depends on.

4 Competing land uses

Food does not automatically win the competition for land. The curriculum lists the rivals (Figure 8): **urban and industrial growth, mining, biofuel crops, livestock, and tourism.**

Food must share Australia's land with other uses



Sources: Wikipedia, Agriculture in Australia; Murray-Darling Basin; Biofuel in Australia; Hunter Valley — retrieved 25 August 2026.

Left panel, Australia's food footprint: 135,997 farms cover 61% of the landmass (2021); the Murray-Darling Basin alone grows about one-third of Australia's food; irrigated land is under 1% of farm land but grew the most valuable crops; beef is the largest farm industry and sheep number about 75 million. Right panel, land uses that compete with food: city and industry, mining (e.g. coal in the Hunter Valley sits beside farms and vineyards), biofuel crops (about 290 million litres made in Australia in 2018, mostly from waste starch and molasses), livestock and tourism

Figure 8. Australia's food footprint and the uses that compete with it. Sources: Wikipedia, "Agriculture in Australia", "Murray-Darling Basin", "Biofuel in Australia" and "Hunter Valley"; retrieved 25 August 2026.

Two Australian cases make the competition concrete.

- **Mining versus farming in the Hunter Valley (NSW).** The Hunter is one of Australia's biggest coal regions — mining and coal exports are the valley's most important economic activity — yet the same valley is also a valued farming and wine region, producing around 3% of Australia's wine. Mines and vineyards compete for the same land, water and community support, and a mine approval can remove food land for decades.
- **Biofuels.** Using crops or crop waste for fuel puts food and fuel in competition for land. Australia has mostly avoided the food-versus-fuel clash by making its small biofuel output (about 290 million litres in 2018) from waste wheat starch, sorghum and molasses rather than from dedicated fuel crops — but in other countries, maize and palm oil grown for fuel directly displaces food.

A third rival is quieter but permanent: **cities**. Urban growth is concentrated on some of the best-watered, most fertile land — the flat, well-serviced land that food production also wants. Once a paddock becomes a suburb, it almost never returns to food production.

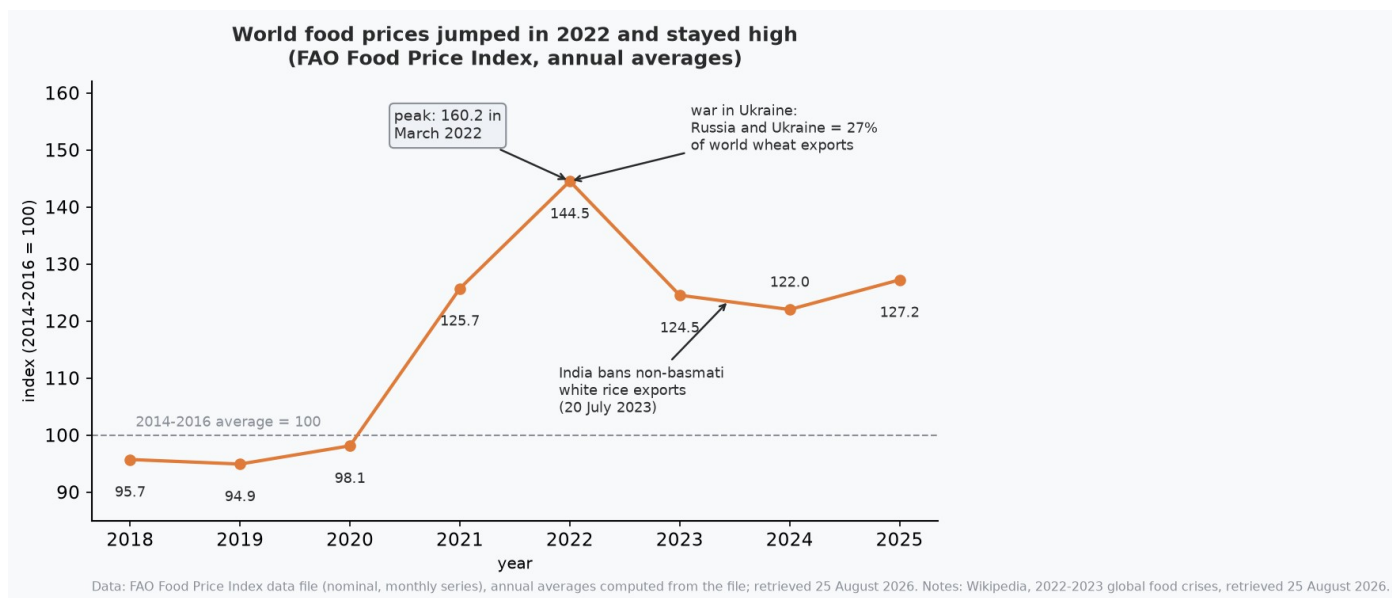
5 Poverty, policy, conflict and trade

Poverty. Figure 3 showed that hunger tracks money more closely than it tracks harvests. A poor household, and a poor country, can face full markets and still go hungry because food is unaffordable. Poverty also constrains *production*: smallholder farmers who cannot afford seeds, fertiliser, irrigation pumps or transport are stuck at low yields, so the countries with the fastest-growing populations often have the slowest-growing farm output.

Government policies. Policies can feed or starve a food system. Subsidies (government payments) can make an unprofitable crop viable, or can encourage over-use of water and fertiliser. Pricing rules, investment in roads and research, and drought support all shift what farmers can produce. Badly designed policy does the reverse — taxing farmers too hard or fixing food prices too low has repeatedly squeezed farm investment and cut future production.

Conflict. War destroys farms, blocks ports, sends farm workers to the front line, and makes insurance and credit vanish. The 2022 escalation of the war in Ukraine showed how quickly a conflict in two breadbasket countries becomes a global food problem: Russia and Ukraine together supplied about 27% of world wheat exports and about half of world sunflower oil exports, and the FAO's food price index jumped about 40% in a few months, peaking at 160.2 in March 2022 (Figure 9).

Trade barriers. When prices spike, governments reach for **trade barriers**: tariffs (taxes on imports) and **export bans**. In 2022–23, India banned wheat exports (13 May 2022), then non-basmati white rice exports (20 July 2023), and added a 20% duty on parboiled rice (25 August 2023); other countries restricted palm oil and meat at different moments. Each ban protected some people in the exporting country — and raised prices for importing countries that depend on bought food, destabilising their pillar of *stability*.



Line graph of the FAO Food Price Index, annual averages 2018 to 2025 (index 2014-2016 = 100): 95.7, 94.9, 98.1, 125.7, 144.5, 124.5, 122.0, 127.2, with notes marking the March 2022 peak of 160.2, the war in Ukraine (Russia and Ukraine = 27% of world wheat exports) and India's non-basmati white rice export ban of 20 July 2023

Figure 9. World food prices, 2018–2025. Data: FAO Food Price Index data file, annual averages computed from the file; event notes: Wikipedia, “2022–2023 global food crises”; retrieved 25 August 2026.

A contested trade question — steelmanned both ways. *Should a country ban food exports when world prices spike?* The strongest case **for** bans: a government's first duty is to its own people, and letting staple foods leave during a price spike can price out the poor at home; bans keep local shelves stocked and local prices down. The strongest case **against** bans: importing countries — often poorer — plan their meals around traded food; sudden bans spike their prices, punish their poor, and teach everyone to hoard and distrust trade, which makes the next crisis worse. There is no tidy answer; examiners reward students who can run both cases before judging (see Worked example 1 and Question 9).

Worked example 1

The question models elaboration E04: reflect on how a government policy can affect global food production and food security.

In July 2023, India banned exports of non-basmati white rice. Evaluate this policy using the four pillars of food security. (4 marks)

Working

Step 1 — Name the policy and its aim. India, the world's biggest rice exporter, stopped selling non-basmati white rice overseas to keep domestic prices down after poor monsoon seasons.

Step 2 — Run the pillars for people *inside* India.

Comment

Always anchor the evaluation in a real, dated decision (D9): 20 July 2023.

A policy can strengthen two pillars for one group...

Availability and **access** improve at home: more rice stays in the country and prices rise more slowly, protecting poor households.

Step 3 — Run the pillars for people *outside* India.

Stability fails for rice-importing countries: contracts break, prices jump, and poor buyers (including aid programs) scramble. **Access** worsens for their poorest people.

Step 4 — Judge with a balance sentence. The ban was rational for India's own food security but exported insecurity to others; if every exporter copies it, global **stability** collapses and future production is discouraged (farmers overseas cannot trust the market they invested for).

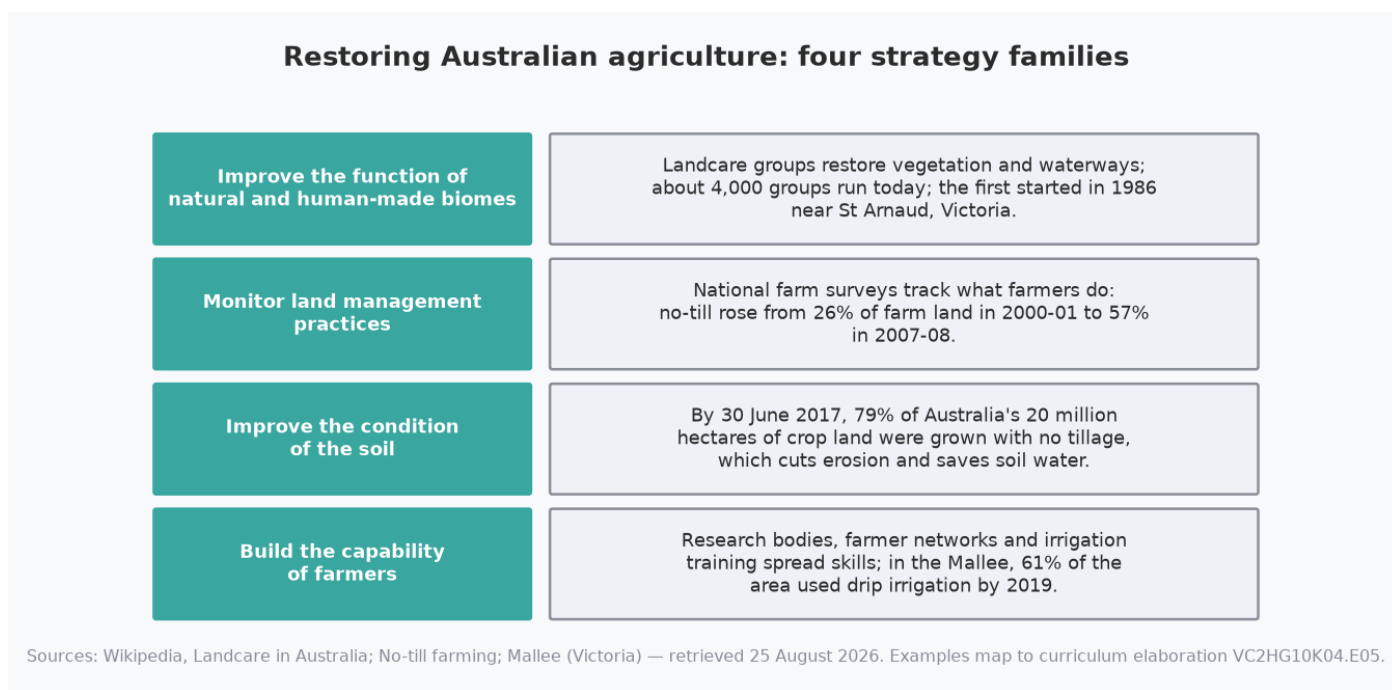
...while weakening pillars for another group. Naming *which* group wins and loses is the difference between describing and evaluating.

End with a reasoned judgement, not a vibe. The steelman from Topic 5 supplies both sides.

Model answer (exam length): The ban strengthened availability and access for India's own consumers by keeping rice at home during a price spike (1 mark). It weakened stability and access for importing countries, whose poorest buyers faced sudden price rises (1 mark). It was defensible as a duty to India's own food security (1 mark), but if repeated by many exporters it discourages farm investment and makes global food security less stable, so on balance it protects some people today at a cost to others tomorrow (1 mark).

6 Management strategies that restore Australian agriculture

The curriculum (E05) lists four families of strategy. Figure 10 pairs each with a real Australian example.



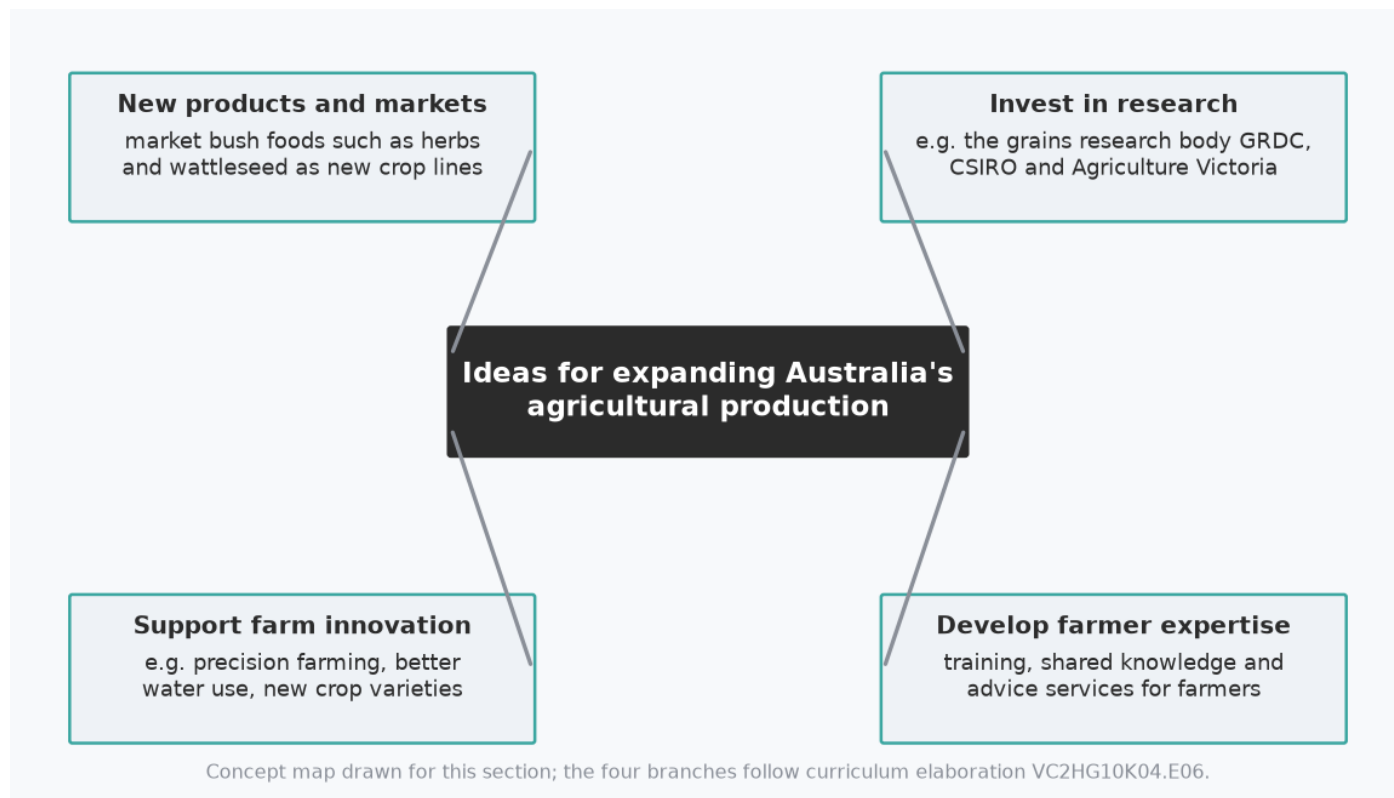
Four rows pairing strategy families with Australian examples: improve the function of natural and human-made biomes — Landcare groups restore vegetation and waterways, about 4,000 groups today, the first started in 1986 near St Arnaud, Victoria; monitor land management practices — national farm surveys track what farmers do, no-till rose from 26% of farm land in 2000-01 to 57% in 2007-08; improve the condition of the soil — by 30 June 2017, 79% of Australia's 20 million hectares of crop land were sown with no tillage, cutting erosion and saving soil water; build the capability of farmers — research bodies, farmer networks and irrigation training spread skills, and in the Mallee 61% of the area used drip irrigation by 2019

Figure 10. Four strategy families with Australian examples. Sources: Wikipedia, "Landcare in Australia", "No-till farming" and "Mallee (Victoria)"; ABARES farm surveys; retrieved 25 August 2026.

Notice what the examples have in common: they **restore** rather than **expand**. Landcare (born near St Arnaud, Victoria, in 1986 and now about 4,000 groups) repairs vegetation and waterways on private land, improving the function of both natural biomes and the anthropogenic biomes of farms. National monitoring of what farmers actually do — like the rise of no-till from 26% of crop land in 2000–01 to 79% by 2017 — lets governments and farmers see degradation early and change practice. No-till itself is the soil story: leaving stubble in place cuts wind and water erosion and traps scarce rainfall. And capability-building — training, research networks, irrigation skills — is why a dry region like the Mallee could move 61% of its irrigated area onto drip irrigation by 2019, growing more food per megalitre than flood irrigation ever did.

7 Expanding Australian production: generating ideas

E06 asks you to *generate* ideas, not just receive them. Figure 11 maps the four idea families the curriculum names, with Australian hooks for each.



A concept map with “Ideas for expanding Australia’s agricultural production” at the centre and four branches: new products and markets (market bush foods such as herbs and wattleseed as new crop lines); invest in research (e.g. the grains research body GRDC, CSIRO and Agriculture Victoria); support farm innovation (e.g. precision farming, better water use, new crop varieties); develop farmer expertise (training, shared knowledge and advice services for farmers)

Figure 11. Four idea families for expanding Australian production, following elaboration VC2HG10K04.E06. Concept map drawn for this section.

- **New products and markets.** The curriculum’s own example is marketing bush foods — native plants such as wattleseed and native herbs — as commercial crop lines for new markets. Other examples in the same family: premium “clean and green” beef, wine and dairy sold into Asian middle-class markets.
- **Invest in research.** Australian grain growers levy themselves to fund the GRDC; CSIRO and Agriculture Victoria breed heat- and drought-tolerant varieties. Research is how a drying climate (Figure 7) is answered with better plants, not just bigger inputs.
- **Support farm innovation.** Precision farming — soil sensors, satellite mapping, drip lines that water plants not paddocks — lifts yields while cutting water and fertiliser waste, i.e. sustainable intensification in practice.
- **Develop farmer expertise.** Training and peer networks spread the skills that make every other strategy work; a drip system in untrained hands saves little.

A good generated idea always names **who** does it (farmers, companies, governments), **what** it changes (land, water, soil, skills, markets), and **which sustainability test** it improves. Question 10 and the inquiry task ask you to do exactly this.

Worked example 2

The question models elaboration E01: discuss extensification and intensification, and evaluate their sustainability, using a scorecard (Figure 12).

A wheat–sheep farm in the Victorian Mallee (average rainfall about 268 mm at Mildura) wants to lift production. Option A is to clear 200 hectares of remaining mallee scrub. Option B is to keep the same farm area but adopt no-till cropping, stubble retention and drip irrigation. Use the scorecard in Figure 12 to evaluate which option is the more sustainable pathway. (5 marks)

Model scorecard: which pathway is more sustainable?			
Test	Extensification	Intensification	Sustainable intensification
Adds enough food?	only where spare land exists	yes, on current farm land	yes, on current farm land
Pressure on natural biomes?	high — new clearing	low — no new clearing	low — no new clearing
Pressure on soil and water?	depends on the new land	high if badly managed	lower — careful water, soil care
Cost?	land and clearing are costly	inputs (seeds, fertiliser) cost	research and training cost
Jobs and communities?	few, spread thin	keeps farm regions working	keeps farm regions working

A model for you to test, not a finished verdict: scores are typical judgements, and real cases vary by place.
 Concept table drawn for this section (sustainability criteria: environmental, economic, social).

A model scorecard table comparing extensification, intensification and sustainable intensification across five tests: adds enough food; pressure on natural biomes; pressure on soil and water; cost; jobs and communities. A caption notes it is a model for students to test, not a finished verdict

Figure 12. A model scorecard for evaluating the pathways. Concept table drawn for this section using the three sustainability tests.

Working	Comment
Step 1 — Classify the options. Option A (clearing scrub) is extensification ; Option B (no-till + drip on existing land) is sustainable intensification .	Naming the pathway is the E01 skill.
Step 2 — Environmental test. A fails it: mallee scrub is a natural biome with its own habitat and stored carbon, and cleared marginal land in a 268 mm rainfall zone is high-risk for erosion and salinity. B passes it: no-till cuts erosion and drip irrigation wastes little water.	Use <i>measured</i> constraints from Topic 3: rainfall, salinity, erosion — not vague worry.
Step 3 — Economic test. A looks cheap but buys risky land: ABARES' climate figures (Figure 7) show the driest regions lost the most yield, so marginal new paddocks fail first in drought. B costs more upfront (equipment, training) but lifts output per hectare and per	The economic test is about <i>long-run</i> viability, not the first invoice.

Working	Comment
megalitres on land the farm already knows. Step 4 — Social test. Both keep the family farm and district jobs running, but B builds skills (capability) that transfer to the next generation, while A leaves the district with degraded scrub land it cannot hand on intact. Step 5 — Verdict. Option B is the more sustainable pathway: it adds food on existing land, protects the natural biome, and fits a drying climate; its weakness (upfront cost) is manageable with research and training support (Topic 7).	The social test includes future generations — that is the “sustainably” in the CD. A verdict with one acknowledged weakness scores higher than a one-sided cheer.

Practice — scaffolded

Q1 (Figure 1). Read Figure 1. (a) State the projected world population in 2050. (b) How many *more* people is that than in 2024? (c) The FAO says food demand will rise about 50% by 2050 from 2013 levels. Give one reason, besides population growth, why demand rises. (3 marks)

Q2 (Figure 5). Using Figure 5, complete the sentence pair in your own words: “Extensification adds food by ..., while intensification adds food by ...”. Then state the single biggest environmental risk of each pathway. (3 marks)

Q3 (Figure 4). Sort these five constraints into the three families of Figure 4: (a) a war closes a grain port; (b) the watertable rises and salts the paddock; (c) a government taxes imported fertiliser so heavily that farmers stop buying it; (d) a river system is over-allocated in drought; (e) a new export ban on wheat. (5 marks)

Q4 (Figure 7). (a) Which jurisdiction in Figure 7 lost the most wheat yield to changed climate conditions? (b) A Victorian wheat farmer says, “My district lost about 14.8% of yield to the climate shift.” Explain in one sentence what is being compared. (c) Name one other constraint from Topic 3 that climate change makes worse. (3 marks)

Q5 (Figure 2). Assign each scenario to the pillar of food security it most directly damages: (a) a drought halves the local harvest; (b) bread prices double and low-income families switch to cheaper, poorer food; (c) unsafe storage contaminates grain with mould; (d) a fuel blockade stops trucks reaching a city for a month. (4 marks)

Q6 (Figure 10). Match each Australian example to its E05 strategy family: (a) a Landcare group replants creek lines on member farms; (b) a national survey reports no-till on 79% of crop land; (c) Mallee irrigators retrain to run drip systems; (d) a district adopts stubble retention to stop wind erosion. (4 marks)

Practice — unscaffolded

Q7. “Extensification is the cheaper way to feed the future because the land is already there.” Evaluate this claim using evidence from Topics 2 and 3 and one named Australian place. (4 marks)

Q8. Explain, using Figures 3 and 9, why geographers say hunger is more a problem of *poverty and policy* than of *production*. (4 marks)

Q9. In 2022–23 several countries restricted food exports (Topic 5). Steelman the case *for* export bans and the case *against* them, then give your own reasoned judgement using at least two pillars of food security. (5 marks)

Q10. The Hunter Valley (NSW) hosts both coal mining and valued farmland and vineyards. A company applies to mine 800 hectares of currently farmed land. Generate one strategy that would let the valley *expand* food production in another part of the district to offset the loss, naming who leads it and which sustainability test it improves. (4 marks)

Inquiry task

Task: “Enough food, wrong pockets?” — a data inquiry into production versus access (E02, E04).

You are a junior policy analyst. Your minister asks: *If the world grows enough food, why do 645 million people still face hunger — and what should our food-export policy be?*

1. **Question.** Restate the minister's question as two testable sub-questions: one about production, one about access.
2. **Data.** Use Figure 3 (SOFI 2026 and Global Hunger Index 2025) and Figure 9 (FAO Food Price Index). Record: (a) how many people faced hunger in 2025; (b) how many cannot afford a healthy diet; (c) what happened to world food prices in 2022 and why.
3. **Pattern.** Decide, with reasons, whether the hunger data correlate more closely with *low production* or with *poverty and price shocks*. Cite one country or region from the Global Hunger Index map categories to support your pattern.
4. **Policy memo (150–200 words).** Recommend one thing an exporting country like Australia should do in the next price spike — and steelman the objection to your own recommendation before answering it.
5. **Limitations.** State one limitation of using a price index and one limitation of country-group hunger data as evidence.

Present as a one-page memo with one small table or chart of your own.

Answers

Scaffolded

- **Q1.** (a) About 9.6 billion. (b) About 1.5 billion more. (c) Any one: rising incomes buy more meat/dairy per person; more demand for biofuels; less waste tolerance — accept any reasoned demand-side factor.
- **Q2.** Extensification adds food by bringing more land/new resources into production; intensification adds food by lifting yields on land already farmed. Risks: extensification — clearing destroys natural biomes (habitat loss, stored carbon released); intensification — badly managed input use drains rivers and pollutes water.
- **Q3.** (a) political (conflict); (b) environmental (salinity); (c) economic/political (policy as a trade barrier — accept either with a reason); (d) environmental (water scarcity); (e) political/economic (trade barrier — accept either with a reason).
- **Q4.** (a) Western Australia (−16.3%). (b) Yields in 2000–01 to 2014–15 under the *observed* (changed) climate are compared with what the long-run average climate would have given. (c) Any one: water scarcity (drier seasons), erosion (drought-then-flood), salinity (irrigation under hotter conditions).
- **Q5.** (a) availability; (b) access; (c) utilisation; (d) stability.
- **Q6.** (a) improve the function of natural/anthropogenic biomes; (b) monitor land management practices; (c) build the capability of farmers; (d) improve the condition of the soil.

Unscaffolded — what a good response includes

- **Q7.** Names the pathway (extensification); challenges “cheaper” with evidence — new land is often poor land, clearing costs money and removes the biome services (habitat, carbon, shelter) that protect farms; names a place (e.g. Mallee salinity risk, or WA’s −16.3% climate hit on marginal cropping land); concludes with a weighed judgement, not a slogan.
- **Q8.** Uses Figure 3: hunger persists while production suffices; 2.7 billion cannot afford a healthy diet → access/poverty; uses Figure 9: 2022 price spike came from war and export bans (policy/conflict), not from empty fields; concludes that distribution, poverty and policy decide who eats.
- **Q9.** For: government’s first duty; keeps domestic supply up and prices down for the local poor. Against: hurts poorer importers; breaks stability; invites copycat bans and hoarding; discourages farm investment. Judgement: reasoned, citing at least two pillars (typically access vs stability).
- **Q10.** A strategy that *expands* production in another part of the district (e.g. fund precision irrigation training for neighbouring farms; convert a retired flood-irrigation paddock to high-value drip horticulture; a research partnership on drought-tolerant varieties); names the lead (farmers’ body, company, state government); names the sustainability test improved.

Inquiry — memo checklist: two testable sub-questions; the three data points recorded accurately (645 million; about 2.7 billion; 2022 spike to 144.5 annual average / 160.2 peak, driven by the Ukraine war and export restrictions); a pattern claim tying hunger to poverty/price shocks with a named country or GHI category; a recommendation plus a steelmanned objection answered; two limitations (index averages hide national differences; country groups hide within-country inequality).

Teaching notes (for the teacher)

- **Sequencing.** Run Topics 1–2 before the constraints so students evaluate pathways with the constraints still ahead of them; keep Figures 4–9 on the wall as the “evidence bench” for every later judgement.
- **Climate boundary.** Do not teach greenhouse mechanics here — that is VC2 Science 9–10 (VC2S10U10, VC2S10U11), a same-year dependency. The geography job is the measured impact on production (Figure 7) and the multiplier effect on other constraints.
- **Contested terms.** Sustainability is operationalised as three tests (environmental, economic, social); mark on the quality of reasoning, not on which pathway a student prefers (CONTESTED_TERMS Rules 4–5). The export-ban debate in Topic 5 and Q9 is the symmetry showcase: require both steelmans before the judgement.
- **First Nations content.** Excluded from this book by policy; E06’s “bush food” example is presented only as the curriculum’s commercial-marketing illustration, without cultural content.
- **Common misconceptions.** “The world doesn’t grow enough food” (Figures 3 + 9 correct this); “intensification is automatically sustainable” (the scorecard’s middle column is a warning, not a verdict);

“Australia has plenty of spare farm land” (Figure 8: spare land is mostly biome, and the driest margins lost the most yield, Figure 7).

- **Assessment.** Scaffolded items test retrieval and matching; unscaffolded items and the inquiry test evaluation and generation (E01, E04, E06). The scorecard (Figure 12) is a model to be tested, not a marking key.

Sources and retrieval dates

All sources retrieved 25 August 2026.

- Victorian Curriculum 2.0, Geography, Levels 9–10 — VC2HG10K04 and elaborations E01–E06 (curriculum is the scope authority; codes kept for linkage).
- United Nations, World Population Prospects 2024 (8.1 billion in 2024; about 9.6 billion in 2050; peak about 10.3 billion in the 2080s), as reported in Wikipedia, “Projections of population growth”.
- FAO, *The Future of Food and Agriculture* (2017) — agricultural demand about 50% higher by 2050 than 2013.
- FAO, *The State of Food Security and Nutrition in the World 2026* — 645 million faced hunger in 2025; about 2.7 billion cannot afford a healthy diet.
- Global Hunger Index 2025 — 130 countries scored: 52 low, 36 moderate, 35 serious, 7 alarming; 56 countries not on track for low hunger by 2030.
- FAO Food Price Index data file (2014–2016 = 100) — annual averages 2018: 95.7; 2019: 94.9; 2020: 98.1; 2021: 125.7; 2022: 144.5; 2023: 124.5; 2024: 122.0; 2025: 127.2; peak March 2022: 160.2.
- Wikipedia, “2022–2023 global food crises” — Russia + Ukraine about 27% of world wheat exports and about half of sunflower oil exports; FAO index +40% by March 2022; India wheat export ban 13 May 2022; non-basmati white rice ban 20 July 2023; 20% parboiled rice duty 25 August 2023.
- ABARES, *Farm performance and climate* — climate shift 2000–01 to 2014–15 cut wheat yields about 11.9% nationally (Victoria –14.8%, Western Australia –16.3%); cropping productivity –7.7% WA, –6.5% NSW.
- Wikipedia, “Agriculture in Australia” — 135,997 farms covering 61% of the landmass (2021); no-till on 79% of 20 million hectares of crop land at 30 June 2017 (26% in 2000–01, 57% in 2007–08); about 75 million sheep.
- Wikipedia, “Salinity in Australia” — about 2.5 million hectares salt-affected by 1999; 5.7 million hectares high risk; up to 17 million hectares by 2050; Mallee and Murray valley affected.
- Wikipedia, “Land degradation” — IPCC (2019) about a quarter of ice-free land degraded; FAO (2025) 1.7 billion people where degradation cuts yields; restoring 10% of damaged crop land could feed 154 million more a year.
- Wikipedia, “Water use” — agriculture about 69% of global freshwater withdrawals (FAO).
- Wikipedia, “Murray–Darling Basin” — 1,061,469 km²; about a third of Australia’s food.
- Wikipedia, “Landcare in Australia” — first group 1986 near St Arnaud, Victoria; about 4,000 groups.
- Wikipedia, “Mallee (Victoria)” — Mildura average rainfall 267.9 mm a year; 61% drip irrigation by 2019.
- Wikipedia, “Biofuel in Australia” — about 290 million litres in 2018, mostly from waste wheat starch, sorghum and molasses.
- Wikipedia, “Hunter Valley” — coal the valley’s most important economic activity; valued wine region (about 3% of Australian wine).
- World Food Summit (1996) food-security definition, as used by the FAO (via Wikipedia, “Food security”).

Glossary

- **access** (pillar): people can get to food and afford it.
- **anthropogenic biome**: an ecosystem shaped by long-term human use, such as cropping or grazing land.
- **availability** (pillar): enough food is grown, stored or brought in.
- **biofuel**: fuel made from plants or plant waste, e.g. ethanol from wheat starch or molasses.

- **export ban:** a government order stopping a product from being sold overseas.
- **extensification:** increasing food production by using more land or other new resources.
- **food security:** when all people, at all times, have physical and economic access to sufficient, safe and nutritious food (World Food Summit, 1996).
- **intensification:** increasing food production on the land already in use.
- **land degradation:** decline in land quality, e.g. through soil erosion, salinity or acidification.
- **natural biome:** an ecosystem mostly self-managed, e.g. forest or native grassland.
- **no-till:** cropping without ploughing; stubble stays on the surface to hold soil and water.
- **salinity:** salt building up in soil or water until plants and ecosystems suffer.
- **stability** (pillar): the food keeps coming in all seasons and through shocks.
- **sustainable intensification:** lifting yields on existing farmland while caring for soil, water and biomes.
- **tariff:** a tax on imported goods.
- **trade barrier:** a policy (tariff, quota, ban) that restricts trade between countries.
- **utilisation** (pillar): food is safe, nutritious and used well by the body.
- **water scarcity:** demand for fresh water outruns the supply that rainfall and rivers renew.