UNIT 1 BIOMES AND FOOD SECURITY

TOPIC 3
How can we feed the world?

3.1 Overview
Numerous videos and interactivities are embedded just where you need them, at the point of learning, in your learnON title at www.jacplus.com.au. They will help you to learn the content and concepts covered in this topic.

3.1.1 Introduction
Food dominates every person’s life. For many people, what to have for breakfast, lunch and dinner can be a constant thought and sometimes a worry.

Starter questions
1. Have you ever thought about where the food you eat is actually produced? Do you know how much is produced in Australia and how much is imported? Check the labels of various foods in your pantry or fridge to work out the sources of your favourite or most consumed foods.
2. Do you think there is enough food in the world for everybody? Why? How do you know?
3. If you had to, could you grow fruit and vegetables in your home garden? Does your family have a garden and, if so, does your family grow its own food? Conduct a class discussion to establish how many students in your class grow their own food.
3.2 How can we feed the world?

3.2.1 What are our food problems?

At the beginning of the twentieth century, the entire world population was less than 2 billion people. Today, the current world population is more than 7 billion. Earth’s population is projected to rise to 9 billion people by 2050, and we all need food. What can we do to ensure there is enough food for everyone?

The map in figure 1 shows that crops occupy half the available agricultural land space. Almost all future population growth will occur in the developing world. This increased population, combined with higher standards of living in developing countries, will create enormous strains on land, water, energy and other natural resources.

There is currently about one-sixth of a hectare of arable land per capita in East and South Asia. With population growth, and almost no additional land available for agricultural expansion, arable land per capita will continue to decline.

3.2.2 Food production increases

Agricultural yields vary widely around the world owing to climate, management practices and the types of crops grown. Globally, 15 million square kilometres of land are used for growing crops — altogether, that’s about the size of South America. Approximately 32 million square kilometres of land around the world are used for pasture — an area about the size of Africa. Across the Earth, most land that is suitable for agriculture is already used for that purpose and, in the past 50 years, we have increased our food production.

According to the Food and Agriculture Organization (FAO), the three main factors that have affected recent increases in world crop food production are:

- increased cropland and rangeland area
- increased yield per unit area
- greater cropping intensity.

Current FAO projections suggest that cereal demand will increase by almost 50 per cent by 2050. This can either be obtained by increasing yields, expanding cropland through conversion of natural habitats, or growing crops more efficiently. Figure 2 shows the growth in crop yields from 1961 to what is proposed in 2030. Rice, maize and wheat have had significant increases in yield.
Agricultural innovations have also changed and increased global food production. They have boosted crop yields through advanced seed genetics; agronomic practices (scientific production of food plants); and product innovations that help farmers maximise productivity and quality. In this way, the nutritional content of crops can be increased (see figure 3).

3.2.3 We could do more

It should be possible to get more food out of the land we are already using. Figure 1 shows the places where maize yields could increase and become more sustainable by improving nutrient and water management, seed types and markets.
3.2 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Refer to figure 1 and describe the distribution of places in the world with pasture and grasslands.
2. How could crop production be increased in places such as Eastern Europe or Western Africa?

Explain
3. Explain the impact of an increasing population on world environments.
4. Explain why agricultural innovations can change food production.

Discover
5. Research the reasons why the environments of Canada, Northern Africa and Central Australia, shown on figure 1, do not produce any crops.
6. Figure 1 shows where more crops could be grown. Investigate how Mexico or a country in West Africa or Eastern Europe could improve the sustainability of its agriculture.

Predict
7. With reference to specific places, suggest how increasing population densities might influence future crop production.
8. Figure 1 refers to the potential increase in maize crop yields. Suggest how this could be of benefit to a future world population.

Think
9. Should countries in the developed world be supporting those who struggle to produce their own food?
10. Would food production be secure if we grew fewer crops better?
3.3 What does the world eat?

3.3.1 The major food staples

Staple foods are those that are eaten regularly and in such quantities that they constitute a dominant portion of a diet. They form part of the normal, everyday meals of the people living in a particular place or country. They are called staples because they are easy to access and are grown or produced locally.

The world has over 50,000 edible plants. Staple foods vary from place to place, but are typically inexpensive or readily available. The staple food of an area is normally interconnected to the climate of that area and the type of land.

Most staple foods are cereals, such as wheat, barley, rye, oats, maize and rice; or root vegetables, such as potatoes, yams, taro and cassava. Rice, maize and wheat provide 60 per cent of the world’s food energy intake; 4 billion people rely on them as their staple food.

Other staple foods include legumes, such as soya beans and sago; fruits, such as breadfruit and plantains (a type of banana); and fish.

**FIGURE 1** Staple foods around the world

Source: Data from FAO.
3.3.2 Wheat, maize and fish

Wheat is a cereal grain that is cultivated across the world. In 2015, world production of wheat was 715.90 million tonnes, making it the third most produced cereal after maize (1018.1 million tonnes) and rice (740.9 million tonnes). World trade in wheat is greater than for all other crops combined. In terms of total production tonnage, it is currently second to rice as the main human food crop and ahead of maize, after allowing for maize’s more extensive use as an animal feed.

Wheat was one of the first crops to be easily cultivated on a large scale, and had the added advantage of yielding a harvest that could be stored for a long time. Wheat covers more land area than any other commercial crop, and is the most important staple food for humans.

Maize, or corn, was commonly grown throughout the Americas in the late fifteenth and early sixteenth centuries. Explorers and traders carried maize back to Europe and introduced it to other countries. It then spread to the rest of the world, owing to its ability to grow in different environments. Sugar-rich varieties called sweet corn are usually grown for human consumption, while field corn varieties are used for animal feed and biofuel. Maize is the most widely grown grain crop in the Americas, with 361 million metric tonnes grown annually in the United States alone.

Fish is a staple food in some societies. The oceans provide an irreplaceable, renewable source of food

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**TABLE 1** Top 10 maize producers, 2015

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (million tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>363</td>
</tr>
<tr>
<td>China</td>
<td>229</td>
</tr>
<tr>
<td>Brazil</td>
<td>77</td>
</tr>
<tr>
<td>European Union</td>
<td>65</td>
</tr>
<tr>
<td>Ukraine</td>
<td>26</td>
</tr>
<tr>
<td>Argentina</td>
<td>25</td>
</tr>
<tr>
<td>India</td>
<td>23</td>
</tr>
<tr>
<td>Mexico</td>
<td>23</td>
</tr>
<tr>
<td>South Africa</td>
<td>13</td>
</tr>
<tr>
<td>Russia</td>
<td>12</td>
</tr>
</tbody>
</table>

and nutrition essential to good health. According to the United Nations Food and Agriculture Organization, about 75 per cent of fish caught is used for human consumption. The remainder is converted into fishmeal and oil, used mainly for animal feed and farmed fish.

In general, people in developing countries, especially those in coastal areas, are much more dependent on fish as a staple food than those in the developed world. About 1 billion people rely on fish as their primary source of animal protein.

Use the United Nations Food and Agriculture Organisation (UN FAO) weblink in the Resources tab to find out what is being done to promote sustainable aquatic biomes.

FIGURE 4 A fish haul in Bali, Indonesia

3.3 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Make a list of the main staple foods of the world and the places (continents) where they are grown.
2. What is biofuel?

Explain
3. Explain why plants, rather than animals, dominate as the major staple foods of the world.
4. Australia is a major exporter of wheat. Why is Australia able to produce such a surplus?

Predict
5. With the increase in world population and greater pressure on fish stocks, what could be done to sustain fish stocks in oceans and lakes?
6. Maize is currently used as a feed for animals, as biofuel and as food for humans. Why might this be an unsustainable environmental practice in future?

Think
7. Although fish may be seen as a staple food for many people, why is it not possible for fish to be a staple food for everyone?
8. Referring to table 1, why do you think countries other than those in the Americas are producing large quantities of maize?
3.4 How does traditional agriculture produce food?

3.4.1 Subsistence agriculture

In the more developed countries of the world, people have easy access to food in stores such as supermarkets. However, many people in developing nations are still tied to subsistence agriculture and visits to local markets to buy and exchange food.

For many people, changes in technology and the development of sophisticated agricultural practices have, over millennia, removed the need to hunt and gather food. With modern forms of transport, there is now enormous movement of food stocks around the world. Nevertheless, many people around the world still practise traditional agriculture.

![Map of world agricultural practices and food production](image)

**Source:** FAO.
3.4.2 Hunters and gatherers: the San people

Today, about 50,000 San people (or Kalahari Bushmen) live in the Kalahari Desert in southern Africa. Approximately 6 per cent still live in the traditional way.

Traditionally nomadic San people travel in small family groups, roaming over regions of up to 1000 square kilometres. They have no pack animals, and carry few possessions — only spears, bows and arrows, bowls and water bags. The bushmen’s San people’s clothes are made from animal skins. When needed, they construct dome-shaped shelters of sticks that are thatched with grass.

The San people are experts at finding water and tracking animals. The men hunt antelope and wildebeest, while the women hunt small game such as lizards, frogs and tortoises, and gather roots, berries and grubs. When the waterholes are full, empty ostrich shells are filled with water, and buried in the sand for times of drought.

3.4.3 Nomadic herders: the Bedouin people

Bedouin people are nomads who live mainly in Syria, Iraq, Jordan, the countries of the Arabian Peninsula, and the Sahara. Some groups are camel herders who live in the inner desert regions. Others herd sheep and goats on the desert fringes, where more water is available. Unless Bedouin communities find a good piece of grazing land, they rarely stay in one place longer than a week.

Bedouin camel-herding families can survive on as few as 15 camels. The camels provide not only transportation but also milk — the main staple of the Bedouin diet. Camel meat is sometimes eaten, and dried camel dung is used as fuel. Camel hair is collected and woven into rugs and tent cloth.
3.4.4 Shifting agriculture: the Huli people

The Huli people live in the rainforests of the Papua New Guinea highlands. Many still lead a traditional way of life. The land on which they live has steep hillsides and dense rainforest.

The Huli people today use a farming system known as shifting agriculture. This means that land is used for food production until its fertility declines; it is then abandoned until its fertility returns naturally. The Huli people clear a patch of rainforest and plant crops of sweet potato, sugar cane, corn, taro and green vegetables. It is the role of the women to tend these gardens, and their individual huts are built next to the gardens. The men live together in a communal house.

When the soil of the garden no longer produces good crops, a new patch of rainforest is cleared, leaving the old one to recover naturally. The garden crops are supplemented by food that the men have hunted. Wild and domesticated pigs are a common source of meat.

While most Huli people still live in their traditional lands, they wear some items of Western-style clothing, and knives, cooking utensils and mirrors are common.
3.5 How did Indigenous Australian peoples achieve food security?

3.5.1 Introduction

Since the beginning of the Dreamings Aboriginal and Torres Strait Islander peoples established management practices of their lands, waterways, lakes and marine environments to ensure food security. At the time of European occupation in 1788 most Aboriginal and Torres Strait Islander peoples were hunters and gatherers. However, some nations had abundant food supplies in their regions and were able to settle in one place. In all cases their deep knowledge and close association with the land allowed for sustainable management of the ecosystems and biomes in which they lived. The ‘world view’ that describes this sustainable lifestyle is called an ‘earth-centred’ approach. This means people’s interaction with the environment is one of a caring stewardship.

3.5.2 Aboriginal and Torres Strait Islander peoples’ food sourcing

Aboriginal and Torres Strait Islander peoples sourced their foods from a wide range of uncultivated plants and wild animals, with some estimates suggesting there were up to 7000 different sources of food. The composition of the food was greatly influenced by both the season and geographic location of the community region.

In Aboriginal and Torres Strait Islander communities there was a division of labour among men, women and children. Food sources based on cereals, fruits and vegetables were collected or gathered daily by women and children. Men were involved more in hunting for game and fishing, as well as wider scale land management using fire.
To ensure food security, communities developed a range of food-gathering techniques that were sustainable. For example, some seeds from gathered plants were left behind to allow for new growth, and a few eggs were always left in nests to hatch. This ensured that species would survive and communities could expect to find food in the same place in the future. See figure 1 for details of food types from both tropical and temperate regions of Australia, including arid and desert regions.

3.5.3 Torres Strait Islander people

Torres Strait Islander peoples’ food sources, both historically and today, are based on fishing, horticulture and inter-island trading activities. Torres Strait Islander peoples have a profound understanding of the sea, including its tides and sea life. While their food sources vary from island to island, their lifestyle can be best described as subsistence agriculture with seafood, garden foods and other produce stored and preserved for both local use and trade. See figure 2.

3.5.4 The use of fire

The use of fire was a significant aspect of the Indigenous Australian peoples’ land management. What has been described as the ‘park like’ landscape of the Australian bush was purposely created by clearing forest in a controlled burn using fire sticks. After the fires, new plant growth with tender shoots attracted all types of birds and animals to the area. The grassland areas that resulted from the controlled burning of the landscape became ideal places to

FIGURE 1 A generalised selection of different foods and water resources

<table>
<thead>
<tr>
<th>Water:</th>
<th>Water was obtained from rivers, lakes, rock holes, soaks, beds of intermittent creeks and dew deposits on surfaces. Moisture obtained from foods such as tree roots and leaves also provided water.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cereal foods:</td>
<td>Grass seeds from the clover fern were ground to form flour for damper. Many other seed types were similarly treated.</td>
</tr>
<tr>
<td>Fruit and vegetables:</td>
<td>Fruits, berries, orchids and pods were available, depending on the region and seasonal availability (for example, sow thistle, lilly pilly, pigface fruit, kangaroo apple, wild raspberry, quandong and native cherry) as well as wild figs, plums, grapes and gooseberries. Also eaten were plant roots such as bull rushes, yams and bulbs; the heart of the tree fern and the pith of the grass tree; and the blister gum from wattles, native truffles and mushrooms.</td>
</tr>
<tr>
<td>Eggs:</td>
<td>Emu, duck, pelican and many other birds’ eggs were eaten.</td>
</tr>
<tr>
<td>Meat:</td>
<td>Meats included insects such as the larval stage of the cossid moth or witchetty grub and the Bogong moth, honey ants, native bees and their honey and scale insects; animals such as kangaroos, eels, crocodiles, sea turtles, snakes, goannas and other lizards; and birds such as ducks, gulls and pelicans.</td>
</tr>
<tr>
<td>Fish and shellfish:</td>
<td>Freshwater fish such as perch, yabbies and mussels in creeks and rock holes as well as saltwater fish of all varieties were caught.</td>
</tr>
<tr>
<td>Medicines:</td>
<td>Over 120 native plants were used as sedatives, ointments, diarrhoea remedies, and cough and cold palliatives as well as for many other known treatments.</td>
</tr>
</tbody>
</table>

FIGURE 2 Cooking bush food in a traditional Kup Murrie or ground oven
hunt kangaroos. Burning also caused animals to be flushed out into the open where they could be speared. The Indigenous Australian peoples’ use of fire had to be carefully managed as part of their efforts to ensure food security and as such was a sustainable practice based on a sound knowledge of fire control. See figure 3.

3.5.5 The arrival of Europeans
Since European occupation, Aboriginal and Torres Strait Islander peoples have been displaced from their lands and traditional methods of sourcing food have mostly ceased. This is because government policies forced Indigenous communities to move to missions and as a consequence there was a denial of access to their lands. However, some methods of food sourcing continued up until recent times in areas the Europeans hadn’t yet occupied, including in remote and and desert areas and in the sparsely settled northern parts of Australia.

Today, many Aboriginal and Torres Strait Islander peoples, particularly in remote areas, are suffering from food insecurity due to the forced move away from nutritious bush tucker and historical government policies. This, among other things, has led to health issues such as low life expectancy, and related issues such as poor education and reduced work opportunities.

More recently, with the introduction of the Native Title Act (1993) and involvement of state governments, members of Indigenous communities have been able to re-establish connections with their lands through collaborative land and water management projects.
3.5.6 The Bogong moth: a past food source

While there were many other sources of food for Indigenous communities that lived near the south-eastern Australian highlands, the Bogong moth was a particularly important seasonal speciality. The Bogong moth, which lived in the ground as larvae in Queensland, migrated in millions to the south-eastern highlands to seek out cool, rocky overhangs and crevices where they could sleep through the long, hot summer months, surviving off the fat in their bodies. See figure 4.

The Bogong moths were a rich source of fat and protein for Indigenous Australian peoples who lived adjacent to the highlands of Victoria and New South Wales. Many culture groups would migrate from the valleys and foothills into the highlands and set up camps for the feasting ceremony. They would smoke out the moths, which they called ‘cori’, collecting them by the thousands to be cooked over hot rocks for feasting. In addition to savouring this important seasonal food source, making the annual pilgrimage to the high country presented these groups with an important opportunity to interact socially, participate in ceremonies and to arrange inter-community marriages.

3.5.7 Eel farming by the Gunditjmara people

The home of the Gunditjmara people, the Budj Bim National Heritage Landscape, is the site of one of Australia’s largest ancient aquaculture systems. This area, which is part of the Mount Eccles National Park near Portland in Victoria, shows evidence of a large, permanent settlement of stone huts and channels used for farming and the local trade of eels. The Gunditjmara people managed this landscape by digging channels and constructing weirs to bring water and young eels from Darlot Creek to local ponds and wetlands. Woven baskets placed at the weirs were used to harvest the mature eels. The area provided an abundance of food, ensuring food security for all. See figure 5.

Following European occupation of the area in the 1830s, the Gunditjmara people fought for their lands in the Eumerella Wars, which lasted for more than 20 years. By the 1860s the remaining Gunditjmara people were displaced to a government mission at Lake Condah. The mission lands were returned to the Gunditjmara people in 1987 and thereafter the Deen Maar Indigenous Protected Area (IPA) was declared in 1999 and the area was listed on the Australian National Heritage register in 2004.

Today the Gunditjmara people, as part of the Winda-Mara Aboriginal Corporation, manage the 248-hectare Darlots Creek (Killara), which flows from Lake Condah in the Budj Bim National Heritage Landscape. They aim to reinstate the wetlands and manna gum woodlands and re-establish the eel aquaculture industry as a sustainable business prospect. Further works are in progress to control weeds and feral animals and to expand tourism by building visitor boardwalks and information signage.
3.5 Activities
To answer questions online and to receive **immediate feedback** and **sample responses** for every question, go to your learnON title at www.jacplus.com.au. **Note:** Question numbers may vary slightly.

**Remember**
1. What was the division of labour for men, women and children when sourcing food?
2. How did Indigenous Australian peoples use fire to source food?
3. Who are the traditional owners of the Budj Bim region of Victoria?

**Explain**
4. Why did Aboriginal and Torres Strait Islander peoples lose access to ‘bush tucker’ after European occupation?
5. How did the Indigenous Australian peoples access the Bogong moth as a food source?

**Predict**
6. How might the re-establishment of eel farming help the economic opportunities of the Gunditjmara people?

**Think**
7. What lessons could be learned from the way the Budj Bim National Heritage Landscape is managed and applied to a national park with which you are familiar?
8. Which foods that Aboriginal and Torres Strait Islander peoples sourced could be utilised in cooking today? Have you tried any of the wide range of traditional food types? If so, how tasty or appetite satisfying were they to you?

3.6 SkillBuilder: Constructing ternary graphs

**WHAT ARE TERNARY GRAPHS?**
Ternary graphs are triangular graphs that show the relationship or interconnection between three features. They are particularly useful when a feature has three components and the three components add up to 100 per cent. Ternary graphs are most often used to show soil types, employment structures and age structures.

**Go online to access:**
- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

**FIGURE 1** Economic activity in selected countries

[Diagram of a ternary graph showing economic activity in selected countries with labels for Industry, Agriculture, and Services.]

**learnON RESOURCES — ONLINE ONLY**

- **Watch this eLesson:** Watch this video to learn more about how to construct ternary graphs.
  Searchlight ID: eles-1728
- **Try out this interactivity:** Use this interactivity to learn how to construct ternary graphs.
  Searchlight ID: int-3346
3.7 How have we increased our food?

3.7.1 How does food increase come about?

World food production has grown substantially over the past century. Increased fertiliser application and more water usage through irrigation have been responsible for over 70 per cent of crop yield increases. The Second Agricultural Revolution in developed countries after World War II, and the Green Revolution in developing countries in the mid 1960s, transformed agricultural practices and raised crop yields dramatically.

Since the 1960s agriculture has been more productive, with world per capita agricultural production increasing by 25 per cent in response to a doubling of the world population.

3.7.2 Environmental factors

In the past, growth in food production resulted mainly from increased crop yields per unit of land and to a lesser extent from expansion of cropland. From the early 1960s, total world cropland increased by only 9 per cent, but total agricultural production grew nearly 60 per cent. Increases in yields of crops, such as sweet potatoes and cereals, were brought about by a combination of:

- increased agricultural inputs
- more intensive use of land
- the spread of improved crop varieties.

In some places, such as parts of Africa and South-East Asia, increases in fisheries (areas where boats are used to catch fish) and expansion of cropland areas were the main reasons for the increase in food supply. In addition, cattle herds became larger. In many regions — such as in the savanna grasslands of Africa, the Andes, and the mountains of Central Asia — livestock is a primary factor in food security today. Fertilisers have increased agricultural outputs and enabled more intensive use of the land. Global fertiliser use is likely to rise to above 200.5 million tonnes in 2018, 25 per cent higher than recorded in 2008.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Fertiliser use, 1959–60, 1989–90 and 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed countries</td>
<td>24.7</td>
</tr>
<tr>
<td>Developing countries</td>
<td>2.7</td>
</tr>
<tr>
<td>East Asia</td>
<td>1.2</td>
</tr>
<tr>
<td>South Asia</td>
<td>0.4</td>
</tr>
<tr>
<td>West Asia/North Africa</td>
<td>0.3</td>
</tr>
<tr>
<td>Latin America</td>
<td>0.7</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>0.1</td>
</tr>
<tr>
<td>World total</td>
<td>27.4</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>9.5</td>
</tr>
<tr>
<td>Phosphate</td>
<td>9.7</td>
</tr>
<tr>
<td>Potash</td>
<td>8.1</td>
</tr>
</tbody>
</table>


3.7.3 Trade factors and economic factors

From the 1960s onwards, there has been significant growth of world trade in food and agriculture. Food imports to developing countries have grown, together with imports of fertilisers, thus reducing the likelihood of developing countries suffering from famine.

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3.7.4 What was the Green Revolution?

The Green Revolution was a result of the development and planting of new hybrids of rice and wheat, which saw greatly increased yields. There have been a number of green revolutions since the 1950s, including those in:

- the United States, Europe and Australia in the 1950s and 1960s
- New Zealand, Mexico and many Asian countries in the late 1960s, 1970s and 1980s.

With its high-yield varieties of cereals, chemical fertilisers and pesticides, and irrigation, the Green Revolution has had a very positive effect on global food production.

What happened?

The Green Revolution saw a rapid increase in the output of cereal crops — the main source of calories in developing countries. Farmers in Asia and Latin America widely adopted high-yielding varieties. Governments, especially in Asia, introduced policies that supported agricultural development. In the 2000s, cereal harvests in developing countries were triple those of 40 years earlier, while the population was a little over twice as large. Yield gains accounted for much of the increase in cereal output and calorie availability. Planting of these varieties coincided with expanded irrigation areas and fertiliser use, as seen in figure 1, where fertiliser is being spread in the Punjab.

### TABLE 2 Share of crop production increases 1961–2030

<table>
<thead>
<tr>
<th></th>
<th>Arable land expansion (1)</th>
<th>Increases in cropping intensity (2)</th>
<th>Harvested land expansion (1+2)</th>
<th>Yield increases</th>
</tr>
</thead>
<tbody>
<tr>
<td>All developing countries</td>
<td>23</td>
<td>21</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>South Asia</td>
<td>6</td>
<td>6</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>East Asia</td>
<td>26</td>
<td>5</td>
<td>−5</td>
<td>14</td>
</tr>
<tr>
<td>Near East/North Africa</td>
<td>14</td>
<td>13</td>
<td>14</td>
<td>19</td>
</tr>
<tr>
<td>Latin America and the Caribbean</td>
<td>46</td>
<td>33</td>
<td>−1</td>
<td>21</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>35</td>
<td>27</td>
<td>31</td>
<td>12</td>
</tr>
<tr>
<td>World</td>
<td>15</td>
<td>7</td>
<td>22</td>
<td>78</td>
</tr>
</tbody>
</table>

### FIGURE 1 Spreading fertiliser in the Punjab, India, during the Green Revolution
3.8 How are biomes modified for agriculture?

3.8.1 How do we use technology for food production?

In the twentieth century, rapid global population growth gave rise to serious concerns about the ability of agriculture to feed humanity. However, additional gains to food production have come from newer processes and technology.

Across the world, humans have modified biomes to produce food through the application of innovative technologies. In general, the focus of agriculture is to modify water, climate, soils, land and crops.

FIGURE 1 False-colour satellite image of greenhouses in the Almeria region.

Source: American Geophysical Union and Google Maps.
3.8.2 How do we modify climate?

Irrigation is the artificial application of water to the land or soil to supplement natural rainfall. It is used to assist in the growing of agricultural crops to increase food production in dry areas and during periods of inadequate rainfall.

In flood irrigation, water is applied and distributed over the soil surface by gravity. It is by far the most common form of irrigation throughout the world, and has been practised in many areas, virtually unchanged, for thousands of years.

Modern irrigation methods include computer-controlled drip systems that deliver precise amounts of water to a plant’s root zone.

Another way of modifying climate is with the use of greenhouses (or glasshouses) used for growing flowers, vegetables, fruits and tobacco (see figure 2). Greenhouses provide an artificial biotic environment to protect crops from heat and cold and to keep out pests. Light and temperature control allows greenhouses to turn non-arable land into arable land, thereby improving food production in marginal environments. Greenhouses allow crops to be grown throughout the year, making them especially important in high-latitude countries.

The largest expanse of plastic greenhouses in the world is around Almeria, in south-east Spain. Here, since the 1970s, semiarid pasture land has been replaced by greenhouse horticulture (see figures 1 and 2). Today, Almeria has become Europe’s market garden. To grow food all year round, the region has about 26,000 hectares of greenhouses.

3.8.3 How do we modify soils?

Fertilisers are organic or inorganic materials that are added to soils to supply one or more essential plant nutrients. Fertilisers are essential for high-yield harvests, and it is estimated that about 40 to 60 per cent of crop yields are due to fertiliser use. It is estimated that almost half the people on Earth are currently fed as a result of adding fertiliser to food crops.
3.8.4 How do we modify landscapes?

People change landscapes in order to produce food. Undulating land can be flattened, steep slopes terraced, or stepped, and wetlands drained. Land reclamation is the process of creating new land from seas, rivers or lakes. In addition, it can involve turning previously unfarmed land, or degraded land, into arable land by fixing major deficiencies in the soil’s structure, drainage or fertility.

In the Netherlands, the Dutch have tackled huge reclamation schemes to add land area to their country. One such scheme is the IJsselmeer (see figure 3), where four large areas (polders) have been reclaimed from the sea, adding an extra 1650 square kilometres for cultivation. This has increased the food supply in the Netherlands and created an overspill town for Amsterdam.

3.9 How is food produced in Australia?

3.9.1 Why are farms found in certain locations?

Modern food production in Australia can be described as commercial agricultural practices that produce food for local and global markets. Farms may produce single crops, such as sugar cane, or they may be mixed farms that produce sheep and cereals, for example. Farms use sophisticated technology, and in many cases are managed by large corporations with an agribusiness approach.

There is a wide range of types of agriculture in Australia, as shown in figure 1. These types occupy spaces across all biomes found in Australia, from the tropics to the temperate zones.

The location of farms in Australia shows that there is a change in the pattern of farming types, from the well-watered urban coastal regions towards the arid interior. Because much of Australia’s inland rainfall is less than 250 millimetres, farm types in these places are limited to open-range cattle and sheep farming.

The pattern of land use and transition of farm types is shown in figure 2. It indicates that intensive farms, which produce perishables such as fruit and vegetables, are located on high-cost land close to urban

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3.8 Activities

To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember

1. What changes to the environment are made by land reclamation?

Explain

2. Refer to figure 3. Use the scale to calculate the approximate area of new land created in Flevoland.

Discover

3. How is land that is reclaimed from the sea, such as the Netherlands’ polders, made productive for farming and food production?

Predict

4. Refer to figures 1 and 2. How do greenhouses modify spaces and places on the Earth’s surface?
5. Refer to figure 3. What might be the purpose of the pumping stations?

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Try out this interactivity: Changing nature: Use this interactivity to further your understanding of how we change environments to produce food.
Searchlight ID: int-3321
markets. At the other extreme, the extensive farms, which manage cattle, sheep and cereals, are found on the less expensive lands distant from the market.

3.9.2 Some farm types in Australia

Extensive farming of sheep or cattle

Sometimes known as livestock farming or grazing, sheep and cattle stations are found in semi-arid and desert grassland biomes, with rainfall of less than 250 millimetres. In 2015 Australia’s 70 million sheep and 27 million cattle were found mainly in Queensland, Victoria and New South Wales. Farms are large in scale, covering hundreds of square kilometres. These days, they have very few employees, and often use helicopters and motor vehicles for mustering. Meat and wool products go to both local and overseas markets for cash returns.

**FIGURE 1** Types of agriculture in Australia

![Map of Australia showing types of agriculture](image)

*Key*

<table>
<thead>
<tr>
<th>Extensive grazing</th>
<th>Intensive cropping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle for meat</td>
<td>Cereal grains</td>
</tr>
<tr>
<td>Sheep for wool</td>
<td>Fruit, grapes and vegetables</td>
</tr>
<tr>
<td>Sheep for meat and wool</td>
<td>Sugarcane</td>
</tr>
<tr>
<td>Cattle for milk</td>
<td>Cotton, tobacco, nuts and other crops</td>
</tr>
<tr>
<td>Sheep for wool and cereal</td>
<td>Rice</td>
</tr>
<tr>
<td>grains</td>
<td>Non-agricultural use</td>
</tr>
</tbody>
</table>

*Desert region*

- 250 mm
- < 250 mm rainfall

*Source:* © Commonwealth of Australia (Geoscience Australia) 2013.
Wheat farms
About 25,000 farms in Australia grow wheat as a major crop, and the average farm size is 910 hectares, or just over 9 square kilometres. Wheat production in Australia for 2015 was estimated at 23 million tonnes. As in other areas of the world, extensive wheat farming is found in mid latitude temperate climates that have warm summers and cool winters, and annual rainfall of approximately 500 millimetres. In Australia, these conditions occur away from the coast in the semi-arid zone. The biome associated with this form of food production is generally open grassland, mallee or savanna that has been cleared for the planting of crops.

Soils can be improved by the application of fertilisers, and crop yields increased by the use of disease-resistant, fast-growing seed varieties. Wheat farms are highly mechanised, using large machinery for ploughing, planting and harvesting. The farm produce, which can amount to 2 tonnes per hectare, is sold to large corporations in local and international markets.

Mixed farms
Mixed farms combine both grazing and cropping practices. They are located closer to markets in the wetter areas, and are generally small in scale, but operate in much the same way as cattle and sheep farms.
Intensive farming
Intensive farms are close to urban centres, producing dairy, horticulture and market gardening crops. They produce milk, fruit, vegetables and flowers, all of which are perishable, sometimes bulky, and expensive to transport. The market gardens are capital- and labour-intensive, because the cost of land near the city is high, and many workers are required for harvesting.

Plantation farming
This form of agriculture is often found in warm, well-watered tropical places. Plantations produce a wide range of produce such as coffee, sugar cane, cocoa, bananas, rubber, tobacco and palm oil. Farm sizes can be 50 hectares or more in size. Although many such farms in Australia are family owned, in other parts of the world they are often operated by large multinational companies. Biomes that contain plantations are mainly tropical forests or savanna, and require large-scale clearing to allow for farming. Cash returns are high, and markets are both local and global.

3.9 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Which type of agricultural land use is closest to urban centres, and which is the furthest away?
2. How does the environment in the centre of Australia affect farming types?
3. What is the interconnection between climate and farm type in Australia? (Hint: Refer to a climate map in your atlas for other ideas.)

Explain
4. Explain why extensive, large-scale cattle and sheep farms are typically located in remote and arid regions of Australia.
5. Using the map of farm production in Australia, describe and explain the location of:
   (a) wheat farms
   (b) dairy farms.

Discover
6. Investigate which foods are grown closest to you.
7. Collect information on the percentage of land used for the different forms of farming in Australia, and then show this data in a graph. Comment on the details shown in your graph.
8. One of the growing plantation industries is that of palm oil. It often has great impacts on tropical biomes; loss of habitat is one such impact. On a world map, locate major palm oil production areas and explain the implications of loss of habitat in those areas.

9. Various plantations in Queensland (such as pineapple, sugar cane and banana plantations) are associated with fertiliser run-off, which is affecting the Great Barrier Reef. Find out what effects fertiliser has on these aquatic environments.

Predict
10. What would be the impact of flood or drought on any of the commercial methods of food production?
11. Predict the impact of the growth of Australian capital cities on the sustainability of surrounding market gardens.

Think
12. Why is much of Australia’s food production available for export?
13. It used to be said that Australia’s economy ‘rode on the sheep’s back’. What do you think this means, and do you think it is still true today?

3.10 What does a farming area look like?

3.10.1 Creating farmland areas

Modern-day food production relies heavily on technology to create ideal farming conditions. This may involve reshaping the land to allow for large agricultural machinery and for the even distribution and drainage of water. Uneven or unreliable rainfall can be supplemented by irrigation. As a result of such changes, large areas can become important farmland.

CASE STUDY

Griffith

Griffith, located in the Western Riverina of New South Wales, is an important agricultural and food-processing centre for the region, generating more than $1.9 billion dollars’ worth of food. It is responsible for 60 per cent of the oranges, 44 per cent of the rice and 51 per cent of the wine produced in New South Wales.

The first European explorer to the area was John Oxley, who described the region as ‘uninhabitable and useless to civilised man’. This was largely due to the lack of a suitable water supply. The construction of irrigation canals in 1906 established a reliable source of water that could be used in food production. The region has become an important food centre owing to the large-scale use of irrigation combined with suitable flat land, fertile soils and a mild climate.

To investigate the area in a little more detail, study the topographic map shown in figure 2, and complete the tasks.

Figure 1 Orange trees growing in an orchard near Griffith, New South Wales
FIGURE 2 Topographic map extract, Griffith, New South Wales

Source: Commonwealth of Australia (Geoscience Australia).

SCALE 1:250 000
3.10 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Discover
1. What types of environment might have existed in the Griffith area when Oxley first arrived?
2. Identify and name a possible source for irrigation water on the map in figure 2.
3. How is water moved around this area? (Hint: Follow the blue lines.)
4. Using the contour lines and spot heights as a guide, estimate the average elevation of the map area.
5. What is the importance of topography (the shape of the land) to irrigation?
6. What types of farming are found at the following places?
   (a) GR410195
   (b) GR413220
7. Approximately what percentage of the map area is irrigated?

Explain
8. Are orchards and vineyards an example of intensive or extensive farming? Explain.
9. Compare the pattern of irrigation channels and buildings in AR3919 and AR4220. Suggest a reason for the differences you can see.

Think
10. Within Griffith there are many factories that process raw materials, such as rice mills, wineries and juice factories. What would be the advantages and disadvantages of locating processing factories close to growing areas?

3.11 SkillBuilder: Describing patterns and correlations on a topographic map

WHAT ARE PATTERNS AND CORRELATIONS ON A TOPOGRAPHIC MAP?
A pattern is the way in which features are distributed or spread. A correlation shows how two or more features are interconnected—that is, the relationship between the features. Patterns and correlations in a topographic map can show us cause-and-effect connections.

Go online to access:
- a clear step-by-step explanation to help you master the skill
- a model of what you are aiming for
- a checklist of key aspects of the skill
- a series of questions to help you apply the skill and to check your understanding.

learnON RESOURCES — ONLINE ONLY

Watch this eLesson: Watch this video to learn more about how to describe patterns and correlations on a topographic map.
Searchlight ID: eles-1729

Try out this interactivity: Use this interactivity to learn how to describe patterns and correlations on a topographic map.
Searchlight ID: int-3347
3.12 Why is rice an important food crop?

3.12.1 The importance of rice

Rice is the seed of a semi-aquatic grass. In warm climates, in more than 100 countries, it is cultivated extensively for its edible grain. Rice is one of the most important staple foods of more than half of the world’s population, and it influences the livelihoods and economies of several billion people. In Asia, rice provides about 49 per cent of the calories and 39 per cent of the protein in people’s diet. In 2010, approximately 154 million hectares of rice were harvested worldwide, and 95 kilograms were produced for each person on Earth.

Figure 1 shows that the largest concentration of rice is grown in Asia. About 132 million hectares are cultivated with this crop, producing 88 per cent of the world’s rice. Of this, 48 million hectares and 31 per cent of the global rice crop are in South-East Asia alone.

Countries with the largest areas under rice cultivation are India, China, Indonesia, Bangladesh, Thailand, Vietnam, Myanmar (Burma) and the Philippines, with 80 per cent of the total rice area.

3.12.2 Factors affecting rice production in Asia

Climate and topography

Rice can be grown in a range of environments that are hot or cool, wet or dry. It can be grown at sea level on coastal plains and at high altitudes in the Himalayas. However, ideal conditions in South-East Asia are high temperatures, large amounts of water, flat land and fertile soil.

In Yunnan Province, China, the mountain slopes have been cultivated in terraced rice paddies by the Hani people for at least 1300 years (see figure 2). The terraces stop erosion and surface run-off.
Irrigation

Traditional rice cultivation involves flooding the paddy fields (*padi* meaning ‘rice plant’ in Malay) for part of the year. These fields are small, and earth embankments (*bunds*) surround them. Rice farmers usually plant the seeds first in little seedbeds and transfer them into flooded paddy fields, which are already ploughed. Canals carry water to and from the fields. Houses and settlements are often located on embankments or raised islands near the rice fields.

Approximately 45 per cent of the rice area in South-East Asia is irrigated, with the largest areas being found in Indonesia, Vietnam, the Philippines and Thailand. High-yielding areas of irrigated rice can also be found in China, Japan and the Republic of Korea. Because water is available for most of the year in these places, farmers can grow rice all year long. This intensive scale of farming can produce two and sometimes three crops a year.

Upland rice is grown where there is not enough moisture to nurture the crops; an example of such cultivation takes place in Laos. This method produces fewer rice varieties, since only a small amount of nutrients are available compared to rice grown in paddy fields.

Pests and diseases

Rice yields can be limited if any of the following conditions exist:

- poor production management
- losses caused by weeds (biotic factor)
- pests and diseases (biotic factor)
- inadequate land formation and irrigation water
- inadequate drainage that leads to a build-up of salinity and alkalinity.

Technology

Agricultural biotechnology, especially in China, has produced rice that is resistant to pests. There are also genes for herbicide resistance, disease resistance, salt and drought tolerance, grain quality and photosynthetic efficiency. Genetic engineering may be the way of the future in rice cultivation in some parts of the world.

However, in the Philippines, a new strain of rice has been developed that grows well in soils lacking phosphorus. This could change crop yields considerably, and has been a result of cross breeding rather than genetic engineering.
Environmental issues

Increasing temperatures, due to global warming, may be causing a drop in rice production in Asia, where more than 90 per cent of the world’s rice is produced and consumed. The Food and Agriculture Organization of the United Nations (FAO) has found that in six of Asia’s most important rice-producing countries — China, India, Indonesia, the Philippines, Thailand and Vietnam — rising temperatures over the past 25 years have led to a 10–20 per cent decline in rice output.

Scientists state that if rice production methods cannot be changed, or if new rice strains able to withstand higher temperatures cannot be developed, there will be a loss in rice production over the next few decades as days and nights get hotter. People may need to turn to a new staple crop.

Rice growing is eco-friendly and has a positive impact on the environment. Rice fields create a wetland habitat for many species of birds, mammals and reptiles. Without rice farming, wetland environments created by flooded rice fields would be vastly reduced.

3.12.3 Factors affecting rice production in Australia

Climate and topography

Eighty per cent of rice produced in Australia consists of temperate varieties that suit climates with high summer temperatures and low humidity. Rice is grown in the Murrumbidgee valleys of New South Wales and the Murray valleys of New South Wales and Victoria. The scale of production is sophisticated.

Sowing and irrigation

In Australia, rice grows as an irrigated summer crop from September to March. Most of it is sown by aircraft rather than planted by hand. Experienced agricultural pilots use satellite guidance technology to broadcast seed accurately over the fields.

Before sowing, the seed is soaked for 24 hours and drained for 24 hours, leaving a tiny shoot visible on the seed. Once sown, it slowly settles in the soft mud, and within three to four days each plant develops a substantial root system and leaf shoot. After planting, fresh water is released from irrigation supply channels to flow across each paddy field until the rice plants are well established.

Most countries grow rice as a monoculture, whereas Australian rice grows as part of a unique farming system.
Farmers use a crop rotation cycle across the whole farm over four to five years. This means that the growers have other agricultural enterprises on the farm as well as rice. This system, designed for efficiency, sustainability and safety, means Australian growers maintain water savings, and have increased soil nutrients, higher yields and much healthier crops.

Once Australian rice growers harvest their rice, they use the subsoil moisture remaining in the soil to plant another crop — either a wheat crop or pasture for animals. This form of rotation is the most efficient in natural resource use and agricultural terms.

Pests and diseases
Rice bays (areas contained by embankments — see figure 5) are treated with a chemical application, which prevents damage by pests and weeds. Without this treatment, crop losses would be extensive. In the last 100 days before harvesting, the rice plant has no chemical applications, so that when it is harvested, it is virtually chemical free.

Technology
Most farms use laser-guided land levelling techniques to prepare the ground for production. This gives farmers precise control over the flow of water on and off the land. Such measurement strategies have contributed to a 60 per cent improvement in water efficiency. Most of the equipment used on rice farms is fitted with computer-aided devices, such as GPS (global positioning systems), CAD (computerised whole farm design), GIS (geographical information systems) and remote sensing. Australian rice growers are the most efficient and productive in the world.

Environmental issues
The rice industry encourages biodiversity enhancement and greenhouse gas reduction strategies. Some farms in southern New South Wales are avoiding the use of chemical fertilisers and pesticides by converting farms to biodynamic practices, and have avoided salinity by planting red gums.

3.12 Activities
To answer questions online and to receive immediate feedback and sample responses for every question, go to your learnON title at www.jacplus.com.au. Note: Question numbers may vary slightly.

Remember
1. Refer to figure 1. Which countries produce most of the world's rice?
2. What is meant by the term monoculture?

Explain
3. Explain why places in Asia are ideally suited to rice growing.
4. Use the Terraced rice weblink in to explain how the terraced rice fields shown in figure 2 have been formed.
5. Explain the environmental issues that may affect future rice production.
6. Describe and explain the similarities and differences between the rice cultivation methods used in Asia and Australia.

Discover
7. Investigate two different rice growing places in Asia and describe the reasons for the different environments.
8. Investigate an example of an Australian rice farm and outline its yearly rice-growing cycle.
9. Research the interconnection between rice-growing and the Murray River for ensuring a sustainable environment.

Predict
10. Predict how technology will influence changes to rice cultivation in both Asia and Australia.
3.13 Why is cacao a special food crop?

3.14 Daly River: a sustainable ecosystem?

3.15 How can aquaculture improve food security for Indigenous Australian peoples?

3.16 Review

3.16.1 Review
The Review section contains a range of different questions and activities to help you revise and recall what you have learned, especially prior to a topic test.

3.16.2 Reflect
The Reflect section provides you with an opportunity to apply and extend your learning.