4.2.4 - Environmental Sustainability of Primary Food Production

Key Knowledge 4.2.4

The environmental sustainability of primary food production in Australia, including use of fertilisers, pesticides and water, choices of crops and animals for farming, and risks associated with biosecurity, climate change and loss of Biodiversity.

Key Skills 4.2.2

Evaluate contributions of innovations and technologies to food security in terms of ethics and sustainability.

Key Skills 4.2.6

Examine an array of issues and evaluate pathways to improve environmental sustainability within the food systems.

Key Skills 4.2.8

Apply a range of practical food skills to demonstrate understanding of sociocultural, sustainable and ethical food choices and preparation.

Terms and Definitions

Biosecurity is the term used to describe measures taken to prevent the introduction, establishment or spread of harmful organisms that transmit disease to animals and plants in a given area.

Biodiversity is the number and variety of species living in or occupying a specific location.

Climate change refers to a change in a particular region's climate and weather conditions over a long period.

Ecosystems consist of animals, plants, and other organisms that live in a specific area and interact with each other.

Environmental sustainability is the practice of conserving natural resources and protecting our ecosystems both now and in the future.

A **fertiliser** is any substance added to soil or applied to a plant containing nutrients to promote plant growth and nourishment. They also improve the richness of soils and replace nutrients in the ground taken up by plant crops.

Fossil fuels are organic matter from fossilised plants and animals that were formed on Earth millions of years ago. Energy in the form of coal, kerosene, natural gas, oil, and propane can be extracted from fossil fuels.

Global warming is a process that increases the temperature of the Earth.

The **greenhouse effect** occurs when certain gases in the Earth's atmosphere trap heat.

Invasive species are organisms that are not indigenous or native to a specific area.

Pesticides are substances that destroy or repel insects and weeds (pests).

Primary food production refers to the cultivation and harvesting of crops and the rearing and slaughtering of livestock.

Non-renewable resources are natural resources that cannot be replenished at the rate that it is being used. Fossil fuels are an example of non-renewable resources.

Renewable resources are natural resources for which there is an endless or unlimited supply. Rain, sunshine, and wind are all considered renewable resources.

Environmental Sustainability of Primary Food Production

In this area of the study, we will explore the crucial topic of environmental sustainability in primary food production in Australia. With a focus on factors such as the use of fertilisers, pesticides, and water, choices of crops and animals for farming, as well as the risks associated with biosecurity, climate change, and loss of biodiversity, we will delve into the challenges and potential solutions for achieving sustainable food production.

Sustainability in Primary Food Production

Environmental sustainability refers to the responsible use and management of natural resources in a way that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. In primary food production, environmental sustainability involves minimising negative impacts on ecosystems, conserving biodiversity, and ensuring long-term agricultural productivity.

Primary food production, including agriculture and livestock farming, has a significant impact on the environment. It is crucial to adopt sustainable practices to mitigate negative environmental effects and preserve ecosystems, while also meeting the growing demand for food.

There are a range of sustainable farming methods that are being used in Australia with a view to working towards sustainability. The following are just a few examples of sustainable farming methods. Each approach offers unique benefits and can be adapted to different farming systems and environmental conditions. By adopting these practices, farmers can minimise environmental impacts, conserve resources, and promote long-term agricultural sustainability.

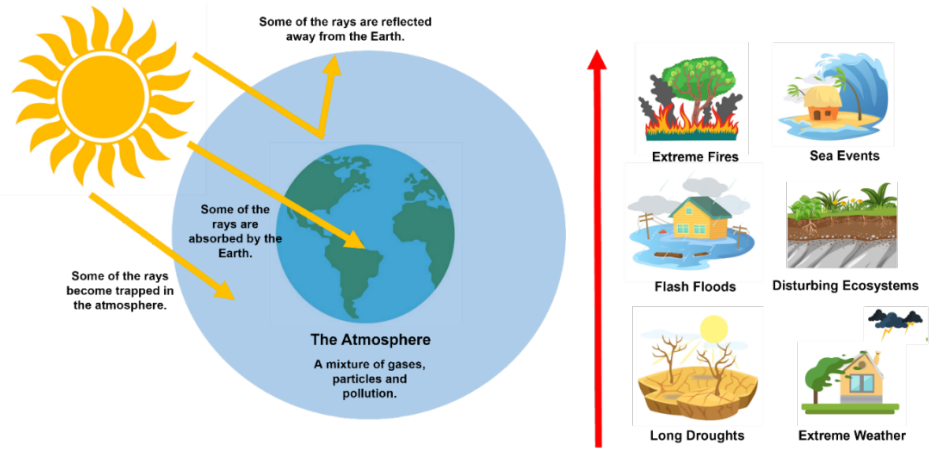
- Minimum tillage farming, also known as conservation tillage or reduced tillage, is a farming practice that reduces soil disturbance during seedbed preparation and planting. Instead of conventional ploughing or intensive tillage, minimum tillage involves leaving crop residues on the soil surface and using specialised equipment to create small planting furrows or slots. Once the slots are created, seeds or seedlings are placed directly into them, and the soil is gently pressed or covered to ensure proper seed-to-soil contact. The benefits of minimum tillage include improved soil health, reduced soil erosion, enhanced water infiltration and retention, increased organic matter content, reduced fuel and labour costs, and decreased greenhouse gas emissions. This practice promotes sustainable agriculture by preserving soil structure and biodiversity while maintaining or improving crop yields.
- Pasture cropping is a sustainable farming practice that involves sowing crops directly into existing pastures without clearing or plowing the land. It combines grazing and cropping in the same area. This means that both livestock grazing and crop cultivation occur within the same piece of land or field. The grazing livestock in the area add nutrients back to the soil from their manure and the crops, benefit from the improved soil fertility resulting in improved yields.
- Crop rotation is a farming practice that involves alternating the type of crops grown in a specific area over different growing seasons. A key aspect of crop rotation is including legumes in the rotation, as they have the unique ability to add nitrogen back into the soil, reducing the need for synthetic nitrogen fertilisers. The idea behind crop rotation is that different crops have varying nutrient requirements and capacities to give back nutrients to the soil. By rotating crops, farmers can optimise nutrient cycling, prevent nutrient depletion and improve soil fertility. This farming technique contributes to a more sustainable and resilient agricultural system while supporting long-term soil health and crop productivity.
- Organic farming focuses on building and maintaining healthy soil through practices such as composting, crop rotation, and the use of organic matter. It reduces the use of synthetic chemicals, reducing pollution of soil, water, and air. It promotes biodiversity, preserves ecosystems, and protects natural resources. It promotes the use of natural sources of nutrients, such as compost and manure, to nourish crops and maintain soil fertility, reducing reliance on synthetic fertilisers. Organic farming uses natural methods of pest management and places a strong emphasis on the humane treatment of animals.

Climate Change

The Earth is surrounded by the atmosphere, which consists of layers of gases. These gases help to keep the Earth warm. The Earth needs some warmth to maintain its average temperature at around 14 - 15°C. Unfortunately, certain gases are being produced that trap heat, creating a greenhouse effect and increasing the Earth's temperature. This phenomenon is called global warming.

Global warming is changing the climate and weather patterns worldwide. Climate change describes the changes to our climate and weather patterns that result from global warming. Climate change is making it challenging to sustain food production. Environmental sustainability is needed to secure a consistent and reliable food supply.

The diagram below shows how global warming occurs and impacts our environment.



Carbon dioxide, methane, and nitrous oxide are three greenhouse gases that become trapped in the Earth's atmosphere. Dust and pollution in the atmosphere can also contribute to global warming.

The table below lists activities related to food consumption and production that impact the amount of carbon dioxide, methane, and nitrous oxide in the atmosphere.

Carbon dioxide	Methane	Nitrous oxide
Carbon dioxide is released from bacteria when insects and plants decompose. Carbon dioxide is released when energy, in the form of electricity, gas, and petrol, is extracted from fossil fuels. When they breathe, animals, humans, and plants release carbon dioxide. The amount of carbon dioxide in the atmosphere increases due to deforestation because trees can no longer absorb carbon dioxide. The amount of carbon dioxide in the atmosphere decreases when soils absorb it.	Cows and sheep release methane when they burp and, to a lesser extent, when they pass wind. Methane is released from food waste, manure, and urine when there is no oxygen available to enable it to decompose. Methane-producing bacteria are present when rice paddies are flooded. Methane is produced when fossil fuels like coal are extracted from the Earth.	Nitrous oxide is released when nitrogen-based fertilisers are added to crops and pastures. Nitrous oxide forms when fuel in vehicles is used. A particular type of bacteria that feeds off human and plant waste releases nitrate into the atmosphere.

Risks Associated with Climate Change

Global warming is causing the climate to change in various ways. Australia is experiencing more bushfires, droughts, floods, and intense storms. These changing climate and weather conditions can have a negative impact on farming in Australia and impact the quality and quantity of Australia's food supply. Ultimately, it affects food security both in Australia and overseas.

Bushfires

Over time, Australia has recorded significant decreases in rainfall and increased hot weather. The rising temperatures make the ground dry and vegetation more flammable. Bushfires can start as a result of human activity or as a result of lightning striking in a summer storm.

Bushfires have a drastic effect on food production.

- Crops, buildings, farm infrastructure and machinery, feed supplies, pastures, and livestock can all be ruined.
- Farmers may be unable to feed livestock that survive or treat their injuries.
- Power outages can impact dairy farmers as they cannot milk their cows.
- Milk and other fresh produce can spoil because road closures prevent trucks from accessing properties.
- The cost of farm produce may also increase due to a lack of availability.

Watch this video to learn more about the impact of bushfires on farms: https://youtu.be/dAEDCMmxFEI

Floods and Storms

Climate change is causing more intense and frequent floods.

The atmosphere around the world is getting warmer; a warmer atmosphere can hold more water. This water is released when it rains, resulting in heavier rainfall that lasts a long time. This causes flooding in some areas, particularly in low sea-level regions or areas with significant deforestation. With no trees to absorb the rainwater, floods often occur.

The Earth's warmer temperature causes the ice-caps to melt and the water in the oceans to expand, resulting in rising sea levels. Combined with cyclones, high winds, or stormy weather, these higher sea levels can cause coastal flooding.

As the oceans are getting warmer, the storms are getting stronger. The heat energy from the warm water is absorbed by storms and creates air moisture. The warmer the water, the more air moisture occurs, leading to more powerful storms.

Floods and severe storms can devastate farmers.

- Irrigation equipment can be damaged.
- Lack of topsoil increases farmers' production costs as they have to apply extra lime and nutrients to the soil before planting their crops.
- Livestock can drown or become stranded in the water.
- Road closures can mean that produce cannot be transported and sold to markets.
- The cultivation and harvesting of crops and pastures can be delayed due to waterlogged land.
- Topsoil that contains nutrients for plant growth can be washed away, causing erosion.
- Water can destroy paddocks where animal fodder is being grown.

On a positive note, as long as irrigation equipment has not been damaged, dams can refill with water and soils can be irrigated again.

Watch this video to learn about the impact of flooding on farm produce: https://youtu.be/mbbKG8Ks694

Droughts

The number and severity of droughts in Australia are increasing. The rising temperatures result in increased moisture evaporating from the soil and drier areas receiving less rainfall. A lack of trees in an area can contribute to the problem.

During a drought, there is little water for animals to drink. A lack of water also decreases the amount of pasture available for livestock grazing. Farmers often have to resort to buying water for their animals. This puts increased financial pressure on farmers. Farmers who can grow crops in a drought often find their crops are of inferior quality and can only be used as animal feed.

When farmers eventually overcome droughts and start producing food again, it can be challenging to sell their produce as their buyers have had to source produce from other markets.

Heatwaves

The duration and frequency of more intense heat waves have increased in Australia. As temperatures rise, some regions in Australia will become unsuitable for growing crops or raising animals. Hotter temperatures also increase carbon dioxide levels in the atmosphere, resulting in plants with lower levels of minerals and protein. Crops such as maize, rice, and wheat produce less yield in temperatures higher than 30°C. High temperatures may also have a

negative impact on livestock; farmers may need to select cattle that can cope in hot conditions but do not produce good quality meat. It is also possible that dairy cows may produce less milk in hotter climates.

Watch these videos about the drought and its impact on primary food production in Australia:

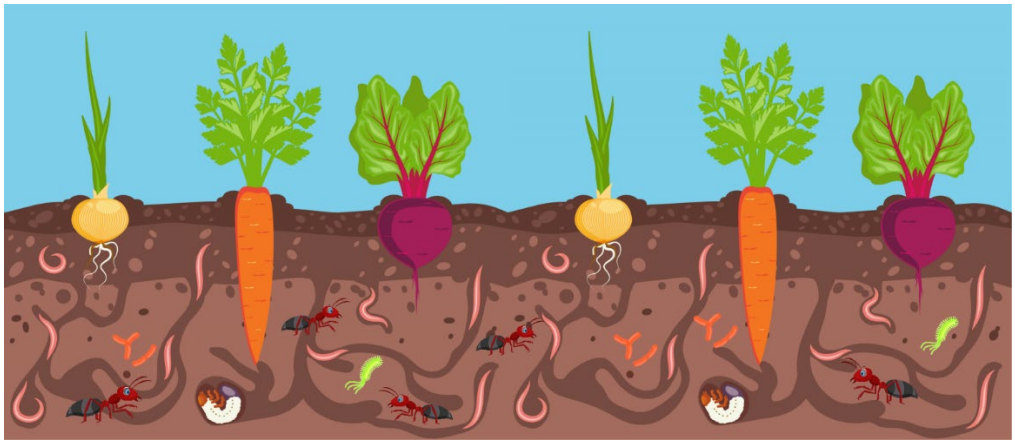
https://youtu.be/SzXxYiloUsg or https://youtu.be/FD3G_am5Vjo

Biodiversity

Biodiversity is a term used to describe the amount and variety of a species living in or occupying a specific location. These organisms contribute to and help make up the ecosystem. Ecosystems need biodiversity in order to function effectively and help maintain the environment. Biodiversity creates balance in ecosystems.

A significant amount of biodiversity can be found in good quality soils. Living organisms such as animals, bacteria, earthworms, and insects can be found in soil. These organisms feed off animal and plant residue, releasing waste that contains nutrients into the soil. Crops and plants absorb these soil nutrients. Animals and humans consume the crops and plants that contain these nutrients.

The image below highlights the interaction of organisms in the soil.



Factors that contribute to a lack of biodiversity include:

- Climate change and global warming: A lack of biodiversity can make it challenging for ecosystems to recover after events such as intense bushfires, droughts, heatwaves, floods, and storms, caused by climate change and global warming.
- Erosion:The top layer of soil contains a lot of nutrients and living organisms; it is where the most biodiversity in the soil exists. Erosion occurs when the top layer of soil is blown away by the wind, thus a significant portion of biodiverse soil is lost.
- Land clearing and urbanisation: Land clearing and urbanisation decrease the amount of natural habitat on farms for animals, plants, and other living organisms, thereby decreasing biodiversity.
- Lack of crop diversity: Currently, around 60% of crop production comes from the intense agriculture of only nine crops. Improving biodiversity in agriculture will assist in creating an ecosystem that can recover and adapt to the impact of climate change.
- Use of pesticides: The use of pesticides on crops not only kills pests but can destroy helpful insects that contribute to an area's biodiversity. For example, bees and butterflies are responsible for the pollination (fertilisation) of crops and plants. Using pesticides can destroy bees and butterflies; this decreases or eliminates pollination and contributes to a lack of biodiversity.

Watch these videos to learn more about the importance of biodiversity: https://youtu.be/b6Ua_zWDH6U

https://youtu.be/GlWNuzrqe7U

The Risks Associated with Loss of Biodiversity

A lack of biodiversity could contribute to poor quality crops and plants depleted of nutrients. This could further contribute to a lack of food security.

The information below provides an account of the risks associated with a loss of biodiversity and the problems that this causes.

Risk	Explanation
Animals and plants move to other habitats or face extinction	When there is less biodiversity in an area, animal and plant life find it more challenging to adapt to an environment that has changed or is new. In this situation, animals and plants move to another habitat or face extinction.
Habitats and ecosystems take a long time to recover	Ecosystems with more significant numbers of diverse species are more resilient. They can cope with changes to the ecosystem more effectively. This is because more species can respond to and repair the environment. Whereas areas where there is less diversity take longer to recover.
Poor quality crops and plants can be depleted of nutrients	A lack of biodiversity in the soil can lead to inadequate amounts of soil nutrients for plant and crop growth. Consequently, poor quality crops and plants are produced.
Invasion by pests	Planting a limited variety of crops and plants in an area may result in a particular crop or plant attracting a specific type of pest. This pest could decimate an entire crop. Planting different crops and plants may decrease the likelihood of this happening.

Use of Fertilisers

The soil quality in Australia is an issue of concern in primary food production. Healthy soils absorb carbon, contribute to biodiversity, retain water, and store nutrients. By taking care of the soil, farmers preserve the environment and ensure that future generations can continue to use the land for farming. The soil in Australia is old, susceptible to erosion, and low in nutrients. Australian farmers are under pressure to produce more food using poor quality soils. For this reason, they often resort to adding fertilisers to the soil.

A fertiliser is any substance containing nutrients that is added to soil or applied to a plant to promote plant growth and nourishment. They improve fertility by adding nutrients to the soil for crops and plants to absorb. There are two types of fertilisers: synthetic or man-made fertilisers and organic fertilisers.

Synthetic fertilisers contain a mix of nutrients made from chemicals. Organic fertilisers are of natural origin, for example, crushed fish, dried blood, ground bone, manure, rock minerals, shells, small rocks, and wood chippings. Both types of fertilisers contain nitrogen and phosphorus, which are essential for producing a quality crop with a high yield and strong growth.

While fertiliser increases crop and plant quality and yield, it could also negatively impact the environment.

The Risks Associated with the Use of Fertilisers

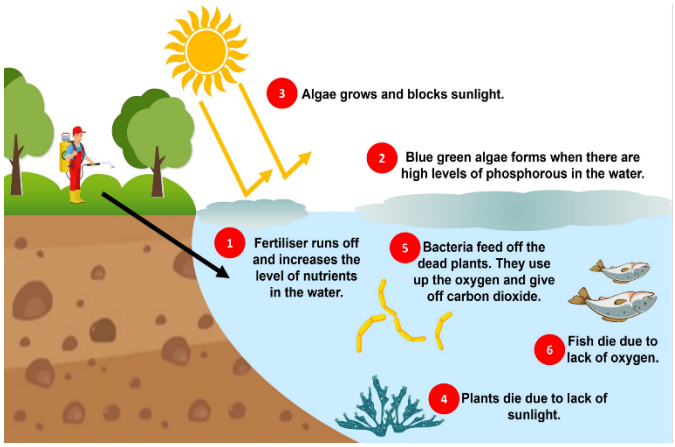
The following risks are associated with the use of fertilisers:

Risk	Explanation

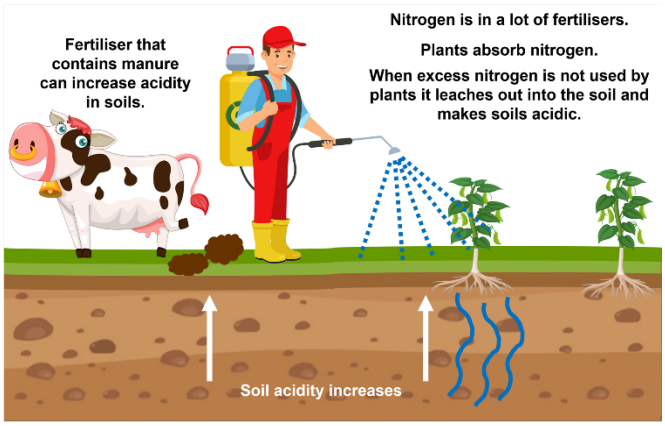
Increase in gas emissions	Gas emissions are produced during the production, transportation, and application of fertilisers. Bacteria in the soil also produce gas emissions when they break down the fertiliser in the ground.
Groundwater pollution	If high concentrations of fertiliser are used, then nitrate in fertilisers can move through the soil and enter groundwater supplies. This could harm people's health if the groundwater is intended for domestic use.
Eutrophication	Fertilisers contain phosphorous. This phosphorous can run off fertilised crops and pastures into waterways. Blue-green algae are produced when phosphorous reaches a certain level in the water. Increased amounts of these algae may be toxic to animals and humans and contaminate water supplies.
Soil acidification	Adding excessive amounts of fertiliser that contain nitrogen to soil can cause acidification. Excess nitrogen not absorbed by plants leaches into the soil. This makes the soil acidic. The acidic soil decreases the availability of nutrients and causes a dramatic decline in crop and plant production.

The images below provide an overview of how eutrophication and soil acidification occurs.

Eutrophication



Soil Acidification



Use of Pesticides

Around 8000 pesticide products have been approved as safe by the Australian Government; approximately 75% are used in agriculture. A significant number of crops in Australia are grown using pesticides.

Pesticides can be made from bacteria, chemicals, and viruses. They work by making crops taste awful or killing the organisms that attack crops.

Farmers spray crops with pesticides to:

- control insects, pests, and weeds;
- decrease labour costs – farmers do not have to pay people to manage pest infestations;
- gain profit;
- improve plant growth and reduce blemishes;
- increase crop yields;
- prevent disease and infestations; and
- reduce food wastage, as crops affected by pests are often discarded.

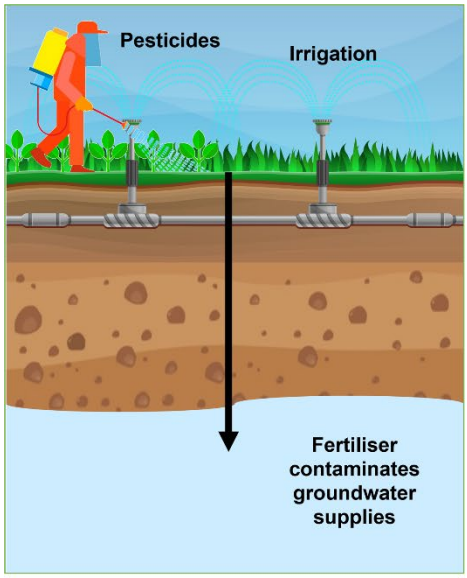
The Risks Associated with the Use of Pesticides

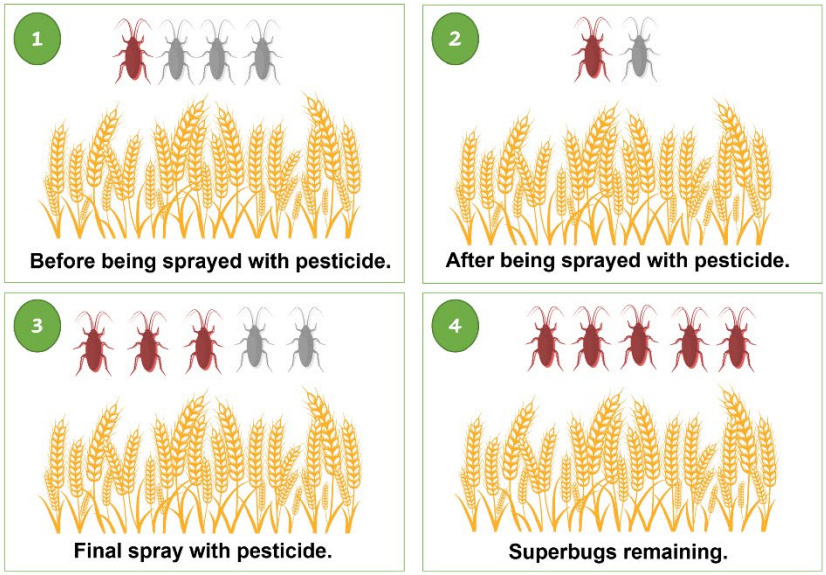
While pesticides have many benefits, including increasing food availability and improving food security, they can also negatively impact the environment.

The following risks are associated with using pesticides:

Risk	Explanation
Create superbugs	While pesticides kill most of the insects targeted, some of these insects can become immune to pesticides. They can pass this gene to their offspring, who then become resistant to pesticide sprays.
Decrease biodiversity and destroy non-targeted species	Pesticides can kill the target pests and beneficial insects like bees and butterflies, birds, fish, and plants.
Human health	There is concern that pesticide residue remains in food, which may harm human health.
Pollute groundwater	When applied to crops, pesticides can wash off in the rain or make their way into groundwater or water systems that provide people with their drinking water.

The images below provide an overview of how pesticides can contaminate groundwater supplies and how superbugs can develop through pesticide use.





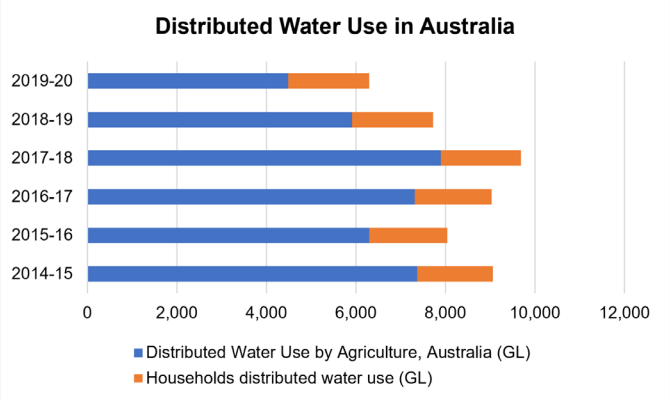
Watch this video to learn about fertiliser and pesticide use in agriculture: https://youtu.be/GLIlZ-qiXJA

Use of Water

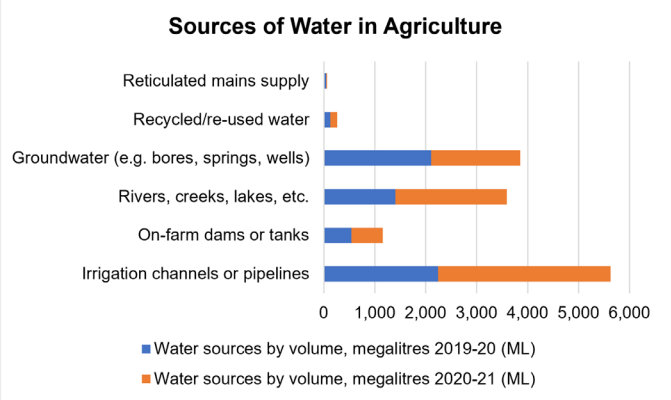
Australia is the driest continent in the world and one of the most significant water users worldwide. As Australia's population increases, so will the need for food and water. The amount of water that Australia needs is expected to double by 2050. As indicated in the table below, a significant amount of water is used throughout Australia through agricultural and household use; all Australians must use water responsibly.

The Australian Bureau of Statistics released this data in 2022.

Comparison of the use of water in agriculture compared to domestic household use.



Comparison of sources of water in agriculture.



Click here to access data about water use on Australian farms.

- Farmers need water to:
- apply pesticides and fertilisers;
- clean farm buildings, equipment, and animals;
- grow crops; and
- supply drinking water to animals and humans.

As identified in the above graph, farmers have access to water from various sources such as dams, pipelines, groundwater supplies, rivers, streams, rainwater, and recycled water on their farms. However, most farm water is accessed via irrigation channels or pipelines.

A significant number of crops grown in Australia use irrigated water. Irrigation is the term used to describe the process of adding water to crops or plants.

Watch this video to find out more about irrigation: https://youtu.be/amrCMakolKA

The Risks Associated with the Use of Water

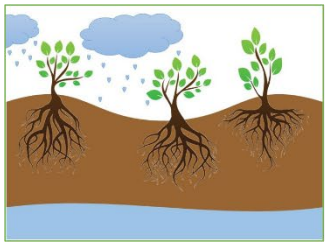
Irrigation and Salinity

Salinity occurs when there is an increased salt concentration in the soil or water table. Overuse of irrigation in Australia has contributed to increased salinity. Excess water from irrigation has moved down to the water table and caused the water table to rise, bringing along the salt. The salt remains in the soil and the water table after the surface water has evaporated. Salinity is a massive problem for farmers. Salinity can impact the water quality on a farm; it can cause poor plant growth and lower crop yields. The salt can kill plants, leaving bare soil prone to erosion.

- Salinity causes a range of environmental problems, including:
- decreased biodiversity by endangering wildlife, e.g. loss of habitat, food and water;
- disturbed ecosystems, i.e. salt contamination in waterways and freshwater habitats, e.g. wetlands become more acidic;
- land degradation, e.g. erosion;
- damage to infrastructure, e.g. buildings, roads, and underground pipelines and grassy areas like sporting fields;
- poor water quality, e.g. drinking water supplies and irrigation water; and
- reduced quality and quantity of crop yields.

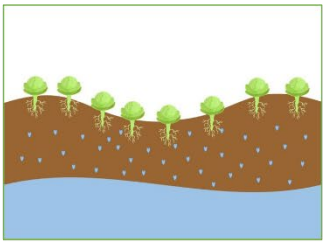
Watch this video to learn about salinity in Australia: https://youtu.be/P4pX5W_WwU4

The diagram below explains how salinity occurs due to adding too much water to farmland.

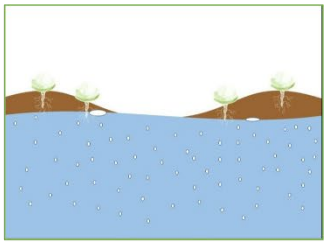


Before land clearing and European farming, rainwater moved down through the soil to the water table. Native trees and plants had long root systems and would absorb the rainwater before it entered the water table. This resulted in the water table staying at the same level.

Europeans then cleared the native vegetation to build their cities and towns. They planted non-native crops and plants.



The crops that Europeans planted had shallow roots and only grew for a short time each year. This resulted in less rainwater and irrigation water being absorbed and therefore more surface water entered the water table.



As surface water enters water table, the water table rises. It brings salt with it that eventually covers the land. Crops and plants struggle to grow in the salty soil. Topsoil is blown away, causing erosion. Salty deposits form on the land.

The Murray–Darling Basin

The Murray–Darling Basin spreads across four states, including Queensland, New South Wales, Victoria, and South Australia. Over 50% of irrigation in Australia occurs in the Murray–Darling Basin. It is called a basin because it acts like a bowl that collects water before it flows into two major rivers, the Murray River and the Darling River. Hence, the name Murray–Darling Basin.

The land around the Murray–Darling Basin is very fertile. In 2022, the Murray–Darling Basin Authority reported that the area contributed $22 billion worth of food and fibre to the Australian economy annually and significantly to national and international food supplies. This agricultural area is responsible for producing canola, cereal crops, cotton, fruits, grapevines, pastures for animal feed, vegetables, and, more recently, biofuels.

The heavy reliance on irrigation in the Murray–Darling Basin has caused havoc on ecosystems that rely on the water in surrounding areas.

Attempts to manage salinity in this area by improving farming systems and irrigation practices as well as diverting salt away from the rivers are being employed.

Farmers are now more aware of the negative impacts of irrigation, and many are trying to improve their water management on farms. Some strategies used by the farmers include:

- regularly testing and monitoring salinity levels;
- regular maintenance of irrigation equipment to ensure no leakages;
- use of GPS navigation, drones, and computerised drip irrigation systems to deliver the right amount of water to crops at the right times; and
- use of recycled water from other farm production activities and reuse of excess irrigation water.

Watch this video to learn about over-irrigation and how it has impacted an ecosystem in a small South Australian town: https://youtu.be/H1sTXv14Hgg

Watch this video about how water is managed on a farm: https://youtu.be/f19zSAXz-qY

Choice of Crops for Farming

The increasing duration and intensity of droughts, floods, storms, and rising temperatures in Australia mean that food production levels could decrease. Changing the type of crops grown or the animals raised so they are more sustainable may help Australian farmers continue providing national and overseas markets with good quality food in sufficient quantities.

Australia's most common food crops include barley, canola, fruits, lentils, nuts, oats, sugar cane, vegetables, wheat, and wine grapes. Research on these crops aims to increase their ability to grow in changing climate and weather conditions, produce bigger and better quality yields, and support environmental sustainability.

Sugarcane

Australia is the second largest exporter of sugarcane worldwide; around 80–85% of sugar is exported annually. Unfortunately, sugarcane production can have a significant environmental impact.

Sugarcane is mainly grown in Queensland, where pesticides are applied to reduce the likelihood of pests and weeds ruining crops. Water containing pesticide residue is making its way to the Great Barrier Reef, threatening the area's marine life and water quality.

CSRIO has developed an App to assist farmers in managing the amount of water and chemicals they add to their sugarcane crops. They have supported farmers in using drones to track crop performance and determine if crops require fertiliser and pesticides.

They have also bred a specific type of sugarcane, known as SRA28. This new breed of sugarcane is more disease resilient and requires less pesticide application. While it is slower to begin growing, extensive trials reveal that this variety produces an excellent canopy cover, which helps to reduce weed growth and the need for fertiliser and pesticides. It also grows tall and straight, making it easier to harvest.

Saltbush

Crops are not only grown for human consumption but also for animal feed. Saltbush is a native plant that farmers use as animal fodder. It grows well in Australia's acidic, dry and salty soils, doesn't require fertiliser or pesticides, and is drought resilient. Also, it is high in energy and protein and does not cause digestive problems in animals. Planting saltbush varieties also improves the condition of the soil and assists in lowering water table levels, which decreases the impact of salination.

Many farmers have also reported positive outcomes on sheep production. Sheep feeding on the saltbush produce an average of 20–25% more wool and gain more weight than sheep fed on conventional fodder. The saltbush is also higher in vitamin E and other minerals, resulting in sheep with improved fertility and meat with a longer shelf-life.

Watch this video to learn how CSIRO is helping to reduce the environmental impact of sugarcane production: https://youtu.be/gNhetvF5Hsw

Watch this video to learn more about the benefits of saltbush as a crop: https://youtu.be/K8YaPLBGTFE

Seaweed

Seaweed can be used to produce animal feed, biofuels, fertiliser, food, and pharmaceuticals. For this reason, seaweed farms are increasing in popularity in Australia. Using seaweed as a source of animal fodder has significant benefits. Additional water is not needed to grow seaweed; therefore, there is little dependency on water supplies. When fed a conventional diet, cattle emit around 15% of the world's greenhouse gases, but when given seaweed, the methane produced by cattle decreased by 99%. This has the potential to significantly reduce the amount of global warming associated with the beef industry.

Watch this video about the environmental benefits of seaweed as a crop: https://youtu.be/Z6am9JUhyno

Choice of Animals

On average, Australians consume 34 kg of beef and 13 kg of lamb annually. Cattle and sheep farming occupies a significant proportion of the land in Australia; for this reason, it is important they use sustainable methods to rear

their livestock. Australians are also beginning to farm other animals to increase the supply of protein for human consumption that have minimal environmental impact.

Australia White Meat Sheep

Australian White is a large, white breed of Australian meat sheep developed for the Australian climate and environment. This new breed has been bred from four sheep types: White Dorper, Van Rooy, Poll Dorset, and Texel.

The White Meat sheep are fast becoming a popular breed of sheep for a variety of reasons. They are easy to maintain as they do not develop wool. They are highly adaptable; they grow a layer of down in colder temperatures to keep them warm. In warmer climates, they shed the down and return to just having hair. They mature early at around 10–12 months of age, making them suitable for breeding and meat production. The lamb has a subtle flavour and a low melting point, enhancing its flavour, juiciness, and tenderness – creating a melt-in-the-mouth experience.

Watch this video to learn more about Australian White Meat Sheep: https://youtu.be/kFrxv3h6P_s

Alpacas

Some farmers in Australia are choosing to farm alpacas to profit from both their fleece and meat. The Australian climate and environment are ideal for alpacas. They also have less environmental impact than other agricultural animals. Very little pressure is applied to the ground when they walk and causes only minor damage to the root system of the grasses that they eat. Alpaca also graze on a range of grasses and weeds. This helps to boost the regrowth of native vegetation and reduce the risk of erosion. Manure from alpacas does not need to be treated like manure from other animals; it can be applied directly to a garden because it slowly releases nitrogen, potassium, and phosphorous, improving overall soil health.

Watch these videos about the benefits of raising alpacas compared to other domesticated livestock: https://youtu.be/svz2RESTz-U and https://youtu.be/quXELeJI7bc

Emus

Emus are native to Australia and have a range of characteristics that make them a potentially good choice of livestock in certain situations. Here are some reasons why emus can be considered a suitable choice for farming in Australia:

- Adaptability: Emus are well adapted to the harsh Australian climate, including arid and semi-arid regions. They have evolved to withstand extreme temperatures, ranging from scorching heat to cold nights, making them resilient to environmental fluctuations.
- Low water requirements: Emus are able to survive and thrive on relatively low water intake. They can obtain most of their hydration from the vegetation they consume.
- Grazing habits: Emus primarily feed on grasses, plants, seeds, fruits, and insects. Their grazing habits are less destructive to the land compared to other livestock, as they do not pull up entire plants or graze them down to the roots. This can help reduce soil erosion and preserve vegetation cover.
- Economic opportunities: Emus can provide various economic opportunities. Their meat is considered lean and healthy, containing low levels of fat and cholesterol, which can be marketed as a niche product. Emu oil, derived from their fat, is used in various cosmetic and therapeutic products. Additionally, emu feathers, eggs, and even live birds can be sold for different purposes.
- Sustainable farming: Emus have a relatively low impact on the environment compared to traditional livestock. They produce less greenhouse gas emissions and require less land and water resources.

Insect Farming in Australia

Indigenous Australians have been known to consume up to 60 varieties of insects. The global insect market in Australia is expected to increase significantly in the next few years. While insects are being bred for human consumption, most insects from farms are used for animal fodder.

Insects are highly nutritious; they contain significant amounts of folic acid, iron, Omega-D fatty acids, and vitamins B12, C, and E. As a protein source, they could play a vital role in reducing food insecurity with little environmental

impact. They produce less greenhouse gases than other protein sources, can be farmed in urban areas, and use less land and water than other livestock.

Watch this video to find out more about emu farming: https://youtu.be/ppZiSJ2YNAU

Watch this video to find out more about insect farms: https://youtu.be/h1pzHZw0IjI

Biosecurity

Biosecurity is the term used to describe measures taken to prevent the introduction, establishment or spread of harmful organisms that transmit disease to animals and plants in a given area. Biosecurity in Australia aims to protect the biodiversity of our unique and fragile ecosystems. Introducing foreign invasive species could have a devastating impact on Australia's environment.

Watch this video about biosecurity in Australia: https://youtu.be/Ed_ESd8R-uM and https://youtu.be/G_1OgTaLFAo

The Risks Associated with Biosecurity

Introducing invasive species can alter an ecosystem so much that it threatens the survival of many native animals, plants, and other organisms. Invasive species could not only significantly harm the biodiversity of Australia's species but also decimate the agricultural industry.

CSIRO has stated that invasive species threaten biodiversity more than habitat destruction and climate change in Australia. Invasive species reproduce quickly and out-compete native plants and animals for food, water, and space. This is why having strict biosecurity at our borders is so important.

Risks to Agriculture and Agricultural Industry

The Department of Agriculture is responsible for preventing invasive species entering Australia. If these pests go undetected in Australia, businesses, human health, the economy, and the environment may suffer.

Many species are a biosecurity risk for Australia. The fall armyworm, which was first detected in Australia in 2020, is causing a considerable problem. This pest is known to destroy 350 plant species, including maize, sorghum, wheat, and fruit and vegetable crops.

Watch this video that explains how the fall armyworm could impact crops: https://youtu.be/ntdxvFoDENs

Watch this video about a possible outbreak of foot-and-mouth disease in Australia: https://youtu.be/_0dKNxqFnEI

Watch this video to find out more about the risks to biosecurity in Australia: https://youtu.be/P1gMhemWJPE

Innovation and Technology in Primary Food Production

Technological advancements are revolutionising the primary food production, offering a more efficient, sustainable, and safe approach to food production. From IoT applications, big data analysis, AI interventions, to automation, these innovations promise to reshape the landscape of food production, bolstering efficiency, reducing waste, and ensuring safety.

Internet of Things (IoT)

The term "Internet of Things (IoT) refers to the connection of devices (beyond traditional items like computers and smartphones) to the internet, allowing them to collect, send, and receive data.

Farmers are increasingly adopting Internet of Things (IoT) technologies to help increase productivity, efficiency, and sustainability on their farms.

These devices usually connect to the internet through a variety of means such as Wi-Fi, cellular networks, or even satellite connections in more remote locations. The data they generate can be accessed on computers or smartphones, often through specialised agricultural software or apps.

The table below shows examples of devices on farms that might connect to the internet:

The Internet of Things	Description
Smart Sensors	These devices can be placed in fields to monitor various conditions such as soil moisture, temperature, pH level, and nutrient levels. They can send this data to a cloud-based system where it can be accessed and analysed in real-time, helping farmers make timely decisions about irrigation, and pest control.
Drones	Drones equipped with cameras and sensors can provide aerial imagery of fields, helping farmers monitor crop health, identify pest infestations or disease outbreaks, and assess the impacts of weather events.
Automated Irrigation Systems	These systems use sensors to monitor soil moisture levels and automatically provide water to crops as needed, which can help conserve water and improve crop yields.
RFID Tags	Used in livestock farming, these tags can track the location and movements of individual animals. Some tags can also monitor health indicators such as temperature and heart rate.
Automated Milking Systems	In dairy farming, these systems can milk cows automatically, and monitor milk quality and quantity. They can also track data related to cow health and productivity.
GPS-enabled Machinery	Tractors and other farm machinery equipped with GPS can perform tasks like planting, fertilizing, and harvesting with great precision, which can save time, reduce waste, and improve yields.
Weather Stations	On-farm weather stations can collect data about local weather conditions like temperature, humidity, rainfall, wind speed, and solar radiation, which can help farmers plan their farming activities more effectively.
Smart Greenhouses	In these systems, sensors and actuators control the environment inside the greenhouse, adjusting factors like temperature, humidity, and light to optimal levels, and even watering plants when necessary.
Surveillance Cameras	These can be used for security purposes, but also to remotely monitor crops and livestock.

Use of Big Data and Artificial Intelligence (AI)

Big Data refers to extremely large data sets that can be analysed computationally to reveal patterns, trends, and associations, especially relating to human behaviour and interactions. Big Data comes from many different sources such as social media, business transactions, machine-to-machine data, and more. Artificial Intelligence (AI), on the other hand, is the capability of a machine or a computer program to mimic human intelligence and perform tasks that normally require human intellect such as understanding natural language, recognizing patterns, learning from experience, and making decisions.

Australian farmers are using Big Data and Artificial Intelligence (AI) to manage their farms, increase productivity, and reduce environmental impact.

Use of Big Data and Artificial Intelligence (AI)	Description
Precision Agriculture	Big Data and AI are crucial in precision agriculture which involves using GPS technology. For example, GPS-enabled machinery can apply the exact amount of water, seed, and fertiliser needed for specific parts of a field, reducing waste, and improving yield. This approach relies on big data gathered from various sources, including sensors, drones, and satellite images, and AI algorithms to analyse data and provide advice to farmers.
Crop Health Monitoring	AI algorithms, often using machine learning, can analyse data collected by drones or satellites to monitor crop health. These algorithms can detect early signs of disease, pest infestation, or other issues. This allows farmers to act before the problem causes significant crop loss.
Yield Prediction	By analysing historical yield data, weather patterns, soil conditions, and other factors, AI can help predict crop yields with greater accuracy.
Livestock Management	In livestock farming, wearable devices can collect data about each animal's location, movement, and health indicators. AI can analyse this data to monitor the wellbeing of the animals, detect signs of illness early, and even predict breeding periods.
Farm Management Systems	AI-powered farm management systems can help farmers make data-driven decisions. These systems collect data from various sources, analyse it, and provide insights about when to plant, irrigate, and harvest crops, how to manage pests, and other aspects of farm management.

Robotics and Automation

This is another technology that's transforming food production. Robots are now used for various tasks, including planting, harvesting, and packing. They can work round the clock, thereby increasing productivity. Moreover, they can perform tasks with a high level of precision, reducing waste.

Vertical Farming and Hydroponics

These innovative farming methods use technology to grow food in urban environments. Vertical farms stack plants vertically to maximise production in a limited space and use LED lights to provide the optimal light spectrum for plant growth. Hydroponics, on the other hand, grows plants in nutrient-rich water instead of soil. Both methods can be automated and monitored using IoT and AI.

Genetic Engineering

Genetic engineering or editing of plant and animal products, often referred to as genetically modified organisms (GMOs), involves altering the DNA of an organism in a way that does not occur naturally. These techniques allow scientists to add, delete, or change specific traits to improve the organism's characteristics or performance.

The use of genetic engineering in food production is a subject of debate due to potential risks and ethical considerations. These can include environmental concerns, such as the impact of genetically modified organisms on biodiversity, and health concerns about the safety of consuming genetically modified foods.

Here are some ways that genetic engineering is being used in the production of food:

Genetic Engineering	Description
Improving Nutrient Content	Genetic engineering can be used to enhance the nutritional content of food. For example, "Golden Rice" is a genetically modified variety of rice that contains beta-carotene, a source of Vitamin A. This rice was developed to help combat Vitamin A deficiency in regions where rice is a dietary staple.
Increasing Yield	Certain crops have been genetically modified to increase their yield. For example, some varieties of corn, soybean, and cotton have been engineered to be resistant to pests or diseases, resulting in higher yields.
Enhancing Stress Tolerance	Genetic engineering can make plants more resistant to environmental stresses like drought, cold, or high salinity. This can enable crops to grow in conditions where they might not otherwise survive, potentially increasing food production in challenging environments.
Reducing Reliance on Pesticides	Some crops have been genetically modified to be resistant to certain pests, reducing the need for chemical pesticides.

Written Activity One

Design Your Own Farm

You are a new farmer in Australia and have just purchased a piece of land to start your farm. The land includes a mixture of crop fields, livestock pastures, and even an available area for a greenhouse. Your mission is to design a farm that uses the latest technology for efficiency, sustainability, and productivity. Remember, you are starting in Australia, a continent known for its diverse climate ranging from tropical rainforests to arid deserts and cool mountainous regions. Your farm design should consider these environmental factors.

Annotate the image on the next page.

Describe where your farm is located.

- Where in Australia is your farm located?
- What type of crops will you grow?
- What type of livestock will you keep, if any?

Overcoming Challenges and Application of Technology

What potential challenges or problems might your farm face (considering location, crops, livestock, climate change, etc.)?

- List and describe the technologies you will incorporate into your farm.
  Choose at least three from the following categories:
  - Internet of Things (IoT)
  - Big Data and Artificial Intelligence (AI)
  - Robotics and Automation
  - Vertical Farming and Hydroponics
  - Genetic Engineering
- Explain why you have chosen each technology and how it will benefit your farm in terms of productivity, sustainability, and efficiency.

Ethical Considerations

Discuss any potential ethical considerations or controversies related to the crops, animals, or technological innovations you use on your farm. How will you address these concerns?

Design Sketch

Draw a rough sketch of your farm layout. Show where and how each chosen technology will be implemented on your farm.

Remember, the goal of this activity is to create a sustainable, efficient, and productive farm by using the latest technology. Be creative, and remember to justify your choices based on the location of your farm and the types of crops and livestock you plan to produce.

Good luck, future farmers!

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Written Activity Two

Question Time

Sustainable Farming

1. What is one method of farming that contributes to environmental sustainability in primary food production? Why is this method considered sustainable?

Climate Change

2. How do human activities related to food production influence the levels of greenhouse gases in the atmosphere and potentially impact global warming?

3. How does global warming and climate change impact primary food production in Australia?

Biodiversity

4. What is meant by the term "biodiversity"?

5. Why is biodiversity important for the health of soil?

6. What factors contribute to a decrease in biodiversity?

7. How can improving biodiversity in agriculture assist in addressing the impact of climate change?

8. How have health and nutrition concerns influenced the availability of different types of food in the market? Provide examples of specific food options that have emerged as a result of these concerns.

Use of Fertilisers

9. What are the two types of fertilisers, and what are they made from?

10. How does the use of fertilisers impact the environment?

Use of Pesticides

11. What are some of the main reasons farmers use pesticides?

12. What are the potential environmental risks associated with using pesticides?

Use of Water

13. Why is water essential for farmers?

14. What is irrigation, and how does it contribute to salinity?

15. What environmental problems are associated with salinity?

16. What strategies are farmers using in the Murray–Darling Basin to manage salinity and improve water management?

Choice of Crops

17. How is climate change influencing the choice of crops for farming in Australia?

18. What are some environmental impacts of sugarcane production in Australia?

19. How is technology aiding in the management of sugarcane crops in Australia?

20. What are the benefits of growing and using saltbush as animal fodder?

21. How can seaweed farming potentially reduce the environmental impact of the beef industry?

Biosecurity

22. What is biosecurity, and why is it important in Australia?

23. Why can invasive species threaten biodiversity more than habitat destruction and climate change in Australia?

24. What risks can invasive species pose to the agricultural industry in Australia?

Written Activity Three

Australian Agriculture and Climate Change: Two-Way Street

Read the article at this link:

https://www.science.org.au/curious/policy-features/australian-agriculture-and-climate-change-two-way-street

1. How does climate change impact Australian agriculture and its ability to feed the nation?

2. What environmental issues are associated with livestock production in Australia, and why are consumers seeking alternative protein sources?

3. How does Australian agriculture contribute to climate change, and what are some examples of activities that lead to greenhouse gas emissions?

4. What strategies do Australian farmers use to reduce the effects of climate change on agriculture, and how do these strategies benefit the environment and reduce costs?

5. How do climate change and rainfall trends affect food prices in Australia, and how does it impact the availability and quality of certain foods?

6. What changes in culinary preferences have been observed among Australian consumers in response to the negative impact of agriculture on climate change?

7. How are researchers addressing the impacts of climate change on Australian agriculture, and what innovative technologies and processes are being developed?

8. How can genomics and biotechnology tools be used to breed crop varieties and livestock that are more climate resilient?

9. How can sensors be utilised in agriculture to optimise water and nutrient usage?

10. What is the significance of investigating traditional Aboriginal food production systems in Australia for developing climate-adapted crops?

11. What alternative food sources are being explored to replace animal-derived proteins, and how are they produced?

12. How can technology, such as digital and biotechnologies, artificial intelligence, and robotics, contribute to mitigating the impact of climate change on agriculture?

13. How can innovations and technologies in agriculture improve environmental sustainability within the food system, considering ethics and sustainability factors?

Written Activity Four

Australia has relied on Agricultural Innovation

Read the article at this link:

https://theconversation.com/australia-has-relied-on-agricultural-innovation-to-farm-our-dry-land-well-need-more-for-the-uncertain-years-ahead-188597

1. What are some environmental risks associated with primary food production in Australia?

2. How do farmers in Australia make choices about crops and animals for farming?

3. What are the potential risks and impacts of excessive use of fertilisers, pesticides, and water in primary food production?

4. How do innovations and technologies contribute to food security in Australia?

5. Evaluate the ethical and sustainability aspects of high-tech farming practices mentioned in the article.

6. What are the current challenges to achieving environmental sustainability in Australia's food systems?

7. Evaluate the potential of vertical farming as a pathway to improve environmental sustainability in food production.

Practical Activity One

Let's do the Bus Stop!

In this activity, there are some stations set up, each featuring a different activity related to sustainable food production. You will work in small groups and rotate through the stations, completing various activities.

You may find that you can use some of these activities in your Research Inquiry Report.

Activity 1: Carbon Footprint Calculator

1. **Visit** the website: https://myemissions.green/food-carbon-footprint-calculator/
2. **Follow** the prompts to enter the ingredients listed below at this station into the calculator.
3. **Enter** one ingredient at a time and then select the tab "Compare Ingredients" to determine the carbon footprint of each ingredient one at a time.
4. **Calculate** the carbon footprint of each ingredient and list them in the table below.

Quantity	Ingredient	Cost	Carbon Rating gCO_2e per serving
100g	Beef mince		
100g	Chicken Breast		
100g	Tofu		
100g	Canned Peaches		
100g	Peaches		
100g	Milk – Cow's		
100g	Milk - Soy		

Group Discussion Questions:

- Which ingredients had the highest carbon footprint? Why do you think these ingredients had a higher carbon footprint?
- What technological innovations could be used to decrease the carbon rating of these ingredients?
- Which ingredients had the lowest carbon footprint? Why do you think these ingredients had the lowest carbon footprints?
- How do you think ingredients with a lower carbon footprint could be used as a solution to reducing the impact of food production on sustainability?

Activity 2: Nutritional Analysis – Meat versus Plant-Based

1. Study the labels of the products at this station.
2. Record the nutritional value of the different food products per 100g in the table below:

Food	Energy	Protein	Fat (total)	Saturated	Carbohydr-ate (total)	Sugars	Sodium	How many ingredients are listed?	Cost
Beef									
Plant-based Beef									
Chicken Nugget									
Plant-based nuggets									
Tofu									
Chickpeas									

Group Discussion Questions:

- Compare the nutritional information between the animal-based protein source and the plant-based protein source. What similarities and differences do you notice?
- Which source has a higher energy content? How might this impact someone's dietary choices?
- Discuss the differences in fat content between the two sources. What are the potential health implications of consuming different types of fats?
- Examine the sodium content. Which source is higher in sodium?
- Compare the cost of the animal-based protein source to the plant-based protein source. Are there any significant cost differences? How might this impact individuals' food choices?
- Based on the nutritional information and cost, which source do you think is a more nutritious and accessible option? Explain your reasoning.
- How might this information influence individuals' choices regarding environmental sustainability, considering the impact of animal agriculture and plant-based alternatives?

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Activity 3: Creating and Responding to a Design Brief - Biosecurity Measures

Select one of the Design Briefs below and create a solution to the problem.

You are encouraged to use the internet to help you find a solution.

Design Brief One: Wheat Woes

In rural New South Wales, a new strain of wheat stem rust has appeared. The disease, caused by a fungus, is quickly spreading through wheat fields, threatening to devastate the local economy.

Guiding Questions:

- What steps can farmers take to isolate affected crops?
- How might farmers work with scientists to identify possible treatments or resistant wheat varieties?
- How could farmers change their practices to prevent future outbreaks?

Design Brief Two: Fruit Fly Fright

Fruit farmers in South Australia are alarmed as a new species of invasive fruit fly is discovered. The fly is causing significant damage to apple and pear orchards, with potential to harm other fruit crops as well.

Guiding Questions:

- What are some methods to trap or deter fruit flies?
- How could farmers modify the environment or their practices to make it less attractive to fruit flies?
- Could introducing natural predators help control the fruit fly population?

Design Brief Three: Poultry Peril

A chicken farm in Victoria is hit by an unfamiliar strain of avian influenza. The virus is highly infectious and could spell disaster for Australia's poultry industry if not quickly contained.

Guiding Questions:

- What measures can be taken to isolate the infected birds?
- How can the farm be sanitised to prevent further spread?
- What changes could be made to the housing or care of chickens to reduce the risk of future infections?

Design Brief Four: Cattle Conundrum

Queensland cattle farmers are facing a new parasitic threat. An invasive tick species has been found, causing serious illness in cattle, and there's fear it could spread throughout the livestock industry.

Guiding Questions:

- What can farmers do to control ticks in their cattle?
- How could changes to grazing patterns or pasture management help?
- Are there any treatments or preventative measures that could be applied to the cattle to protect them from ticks?

Activity 4: Dietary Analysis – Which Diet is Best?

In this activity, your group will select one of the plant-based daily diets and one of the meat-based diets listed below. You will then compare these diets using the SWOT analysis activity provided.

Meal	Plant-based Diets			
	Vegan Day's Eating Plan	**Pescatarian Day's Eating Plan**	**Vegetarian Day's Eating Plan**	**Flexitarian**
Breakfast	Overnight oats with almond milk, chia seeds, and fresh fruit	Smoked salmon on whole-grain toast with cream cheese	Whole grain toast with avocado and a side of mixed berries	Whole grain toast topped with avocado and poached egg
Lunch	Lentil soup with a side of whole-grain bread	Grilled shrimp salad with olive oil and lemon dressing	Quinoa salad with roasted veggies and feta cheese	Lentil and vegetable soup with a side of whole-grain bread
Snack	A handful of mixed nuts and an apple	Greek yogurt with mixed berries	Hummus with carrot and celery sticks	A handful of mixed nuts and a piece of fresh fruit
Dinner	Stir-fried tofu with vegetables and quinoa	Grilled fish with a side of steamed vegetables and brown rice	Chickpea curry with brown rice	Stir-fried vegetables with tofu and brown rice
Meal	**Meat-based Diets**			
	Traditional Western Day's Eating Plan	**Paleo Day's Eating Plan**	**Keto Day's Eating Plan**	**Mediterranean Day's Eating Plan**
Breakfast	Scrambled eggs with bacon, and a glass of orange juice	Omelette with vegetables and a side of fresh fruits	Avocado and bacon omelette	Greek yogurt with honey and walnuts
Lunch	Cheeseburger with a side of fries	Grilled chicken salad with olive oil dressing	Steak salad with blue cheese dressing	Grilled fish with a salad of mixed greens, tomatoes, cucumbers, and feta cheese
Snack	A packet of potato chips	A handful of almonds and an apple	Celery sticks with cream cheese	A handful of olives and a piece of fresh fruit
Dinner	Grilled chicken with mashed potatoes and green beans	Pan-seared salmon with a side of roasted vegetables	Pork chops with a side of asparagus sautéed in butter	Grilled chicken kebab with a side of tabbouleh salad

As a group, conduct a SWOT analysis on the diets that you have chosen by answering the following questions about each diet that you have chosen:

SWOT Analysis	**Plant-Based Diet**	**Meat-Based Diet**
Strengths What are the health benefits of this diet? How does this diet contribute to environmental sustainability? Are there any economic advantages to this diet (e.g., cost savings)?		
Weaknesses What potential health risks or nutritional deficiencies could this diet pose? Are there any environmental concerns associated with this diet? Could this diet be more expensive or difficult to adhere to than others?		
Opportunities How could variations or modifications improve the sustainability or health benefits of this diet? Are there emerging trends, technologies, or research findings that could enhance the benefits or reduce the drawbacks of this diet? Could broader adoption of this diet benefit other sociocultural groups?		
Threats Are there challenges or barriers that could prevent people from adopting this diet? Could climate change, biodiversity loss, or other environmental factors threaten the viability of this diet? Are there ethical or sociocultural concerns related to this diet?		

Activity 5: Science Experiment - Fertilisers and Soil Health

In this task, you will conduct one simple experiment to understand the effects of different fertilisers (organic, synthetic) on soil health.

Select one of the experiments below to undertake.

At this station, you will find three glass jars containing different soil samples.

Use the samples of soil to conduct Experiment One, Assessing the Biodiversity of the Soil, or Experiment Two, Assessing the pH and moisture content of the soil.

Sample A	Sample B	Sample C
Organic Soil	**Farm with Pesticides and Fertilisers**	**Control Soil**
This soil sample is from an area where organic farming practices are followed.	This soil sample is from an area where pesticides and fertilisers are regularly used.	This soil sample is from an area where little, if any, pesticides or fertilisers have been used at all.

Experiment One - Assessing the Biodiversity of the Soil

1. Conduct a visual observation of the organisms in the soil by spreading out each soil sample on a clean surface such as a tray or a table. Look closely at the soil samples and observe any visible differences in colour, texture, or presence of organic matter. Make notes of your observations.
2. Conduct a macrofauna observation using a fork or spoon, gently sift through each soil sample and look for visible organisms such as earthworms, insects, or other macrofauna. Take note of the presence and abundance of these organisms in each soil sample.
3. Conduct a microbial observation by taking a small amount of each soil sample and placing it in separate transparent containers, such as clear plastic cups or jars. Add a small amount of water to each container to create a muddy consistency. Observe the containers under a magnifying glass or microscope (if available) and look for signs of microbial activity, such as tiny organisms or movement.

Results

Record your results in the table below:

Soil Samples	Visual Observation	Macrofauna Observation	Microbial observation
Organic Soil			
Farm with Pesticides and Fertilisers			
Control Soil			

Group Discussion Questions:

- What were the observable differences in visual characteristics, macrofauna exploration, and microbial activity among the soil samples collected from different properties (organic soil, farm with pesticides and fertilisers, and the control soil)?
- How might these differences reflect the potential impact of fertilizers and pesticides on soil biodiversity?

Experiment Two - Assessing the pH and Moisture Content of the Soil

1. Prepare the soil samples by removing any debris or stones from the soil samples and ensuring they are well-mixed.
2. Follow the directions of the moisture meter to take a moisture reading. You do not need to wet the soil to take a moisture reading. Record the results in the table below.

   You could use a pH and moisture meter like the one on this website: Aussie Gardener
3. Clean and dry the probes on the meter between uses.
4. Follow the directions of the pH and moisture meter to access the pH content of the soil. The pH range of 5.5–6.5 is optimal for plant growth as the availability of nutrients is optimal. This is also the case for most soil microbes. Record the results in the table below.

Results

Record your results in the table below:

Soil Samples	Moisture Reading	pH Reading
Organic Soil		
Farm with Pesticides and Fertilisers		
Control Soil		

Group Discussion Questions:

- What are the potential implications of the different moisture levels in the soil samples? How might soil moisture affect plant growth and the overall health of the soil ecosystem?
- Considering the optimal pH range for plant growth and soil microbial activity, which soil sample(s) appear most conducive to supporting healthy plant growth?
- How might these findings influence decisions regarding soil management and selecting suitable plants for different soil types?
- Discuss the potential factors that could contribute to variations in pH and moisture content among the soil samples.
- How might the results of this activity inform sustainable soil management practices?
- What steps can be taken to optimize pH levels and moisture content in order to promote healthy soil ecosystems and enhance plant growth?

Activity 5: Survey with Focus Group

In this activity, you will conduct a survey with your group about sustainable food choices. The data collected will help you understand the barriers to sustainable eating and how to promote environmental sustainability.

Conduct the survey below and make a graph of the results you obtained.

1. How often do you make food choices based on their environmental impact?

   ☐ Always ☐ Often ☐ Sometimes ☐ Rarely ☐ Never

2. What factors influence your food choices? (Select all that apply)

   ☐ Taste ☐ Price ☐ Health

   ☐ Convenience ☐ Environmental impact ☐ Animal welfare

3. Are you aware of the environmental impact of the following aspects of food production?

Use of fertilisers and pesticides	☐ Yes	☐ No
Water use in agriculture	☐ Yes	☐ No
Choice of crops and animals for farming	☐ Yes	☐ No
Risks associated with biosecurity	☐ Yes	☐ No
Climate change impacts on agriculture	☐ Yes	☐ No
Loss of biodiversity due to farming practices	☐ Yes	☐ No

4. Do you feel you have enough information to make sustainable food choices?

   ☐ Yes ☐ Somewhat ☐ No

5. What barriers prevent you from making more sustainable food choices? (Select all that apply)

   ☐ Higher cost of sustainable products ☐ Limited availability of sustainable products ☐ Taste preferences

   ☐ Lack of preparation time ☐ Lack of knowledge or misleading information ☐ Other _____

6. Would you be willing to modify your diet for the sake of environmental sustainability (e.g., eating less meat, choosing locally sourced foods)?

   ☐ Yes ☐ Maybe ☐ No

Group Discussion Questions:

- What were the most common barriers to sustainable eating identified in the survey? Why do you think these are significant?
- How might these barriers be addressed? What role could individuals, schools, governments, or businesses play in overcoming these barriers?
- What are some practical ways we can promote sustainable eating in our school/community?
- How do our personal food choices impact the broader food system and the environment? Can individual actions make a significant difference?
- Based on the survey responses, how might we tailor education or advocacy efforts to promote sustainable eating?

Activity 6: Product Analysis and Demonstration

In this activity, you will be tasked with analysing the packaging of a product that claims to be sustainable or ethical.

Research the certifications, labels, and claims on the packaging.

Use reliable sources to research each label or claim you listed.

- Present a demonstration to your group members of your findings by addressing the following:
- What certifications, labels, or claims were on the packaging?
- What does the label or claim mean?
- Who is behind this label or certification? Find out which organization is responsible for the label or certification and write a short description about them.
- How is it verified? Describe the process that a product or company goes through to get the label or certification.
- Does this product] contribute to sustainability and food security? Explain how.
- Based on what you've learned, do you believe your product is as sustainable or ethical as it claims to be? Why or why not?

Activity 7: Lamb Sensory Testing

1. Conduct a sensory testing on each of the meatballs listed below.
2. Rate each of the meatballs listed. (1 = poor and 5 = excellent).
3. Record your responses in the table below.

Meatball Variety	Appearance	Taste	Texture	Aroma	Total Rating
Conventional lamb					
Organic Lamb					
Lamb fed saltbush					

Group Discussion Questions:

- Compare and contrast the flavour, texture, and overall sensory experiences of the three types of lamb meatballs. Did you notice any significant differences? If so, what were they?
- Reflect on the concept of organic farming and the use of saltbush as lamb feed. How might these factors contribute to the differences in sensory properties observed in the meatballs?
- Consider the potential environmental and sustainability implications of each type of lamb meatball. Discuss the factors that may influence your personal preferences when choosing between conventional, organic, or saltbush-fed lamb products.

Activity 8: Organic Versus Conventional

1. Conduct sensory testing on food products on display.
2. In the table below, record which item you think is organic and which is conventional.

   Let your teacher know when you are ready for the big reveal – the right answers!

Food Item	Is this organic?	Is this conventional?	Am I right?
Carrot A			
Carrot B			
Egg A			
Egg B			
Milk A			
Milk B			
Apple A			
Apple B			

Group Discussion Questions:

- What were some common sensory differences noted between the organic and conventional versions of the food items?
- Did the sensory properties of the organic and conventional foods align with your expectations?
- Discuss the potential reasons behind any taste differences, such as farming methods, pesticide use, or processing techniques.
- Compare the costs of organic and conventional foods. Were there any significant differences in pricing?
- Discuss the broader implications of choosing organic or conventional foods, including environmental sustainability, health considerations, and accessibility.

Practical Activity Two

Reducing the Carbon Footprint, One Bite at a Time!

In this activity, you will have the opportunity to calculate the carbon footprint of a the burger recipe below using an online carbon footprint calculator. You will then analyse the ingredients to identify those with the highest carbon footprint and modify the recipe to make it more environmentally friendly by reducing its carbon footprint.

1. Visit the website: https://myemissions.green/food-carbon-footprint-calculator/
2. Familiarise yourself with the carbon footprint calculator and its features.
3. Enter the ingredients of the original meat-based burger recipe into the calculator, following the provided instructions.
4. Calculate the carbon footprint of the dish using the calculator.
5. Once you have obtained the carbon footprint, navigate to the "Compare Ingredients" tab on the calculator to identify the ingredients contributing the most to the carbon footprint of the dish.
6. Analyse the results and consider alternative ingredients that have a lower carbon footprint.
7. Modify the recipe by replacing the ingredients with lower carbon footprints, while still ensuring a tasty and appealing burger.
8. Use the calculator to calculate the new carbon footprint of the modified recipe.

Beefy Burger for Two

Ingredients:

150 grams beef mince
50 grams breadcrumbs
50g bacon rashers
1 egg
10 grams onion, finely chopped
5 grams fresh parsley, chopped
5 grams Worcestershire sauce
2 grams salt
2 grams black pepper
2 grams garlic powder
30 grams cheddar cheese, sliced
2 burger buns
Lettuce leaves
Tomato slices
Pickles (optional)
Ketchup and mustard (optional)

Instructions:

1. In a mixing bowl, combine the beef, breadcrumbs, egg, chopped onion, parsley, Worcestershire sauce, salt, black pepper, and garlic powder. Mix well until all the ingredients are combined.
2. Divide the mixture into two equal portions and shape each portion into a patty.
3. Heat a frypan over medium heat. Cook the bacon and then remove.
4. Using the same frypan. Place the burger patties on the pan and cook for about 4-5 minutes on each side, or until they reach your desired level of doneness.
5. In the last minute of cooking, top each patty with a slice of cheddar cheese and allow it to melt.
6. While the patties are cooking, slice the burger buns in half and lightly toast the cut sides.
7. Assemble the burgers by placing a lettuce leaf on the bottom half of the buns, followed by a tomato slice and the cooked burger patty with melted cheese on top. Add pickles if desired.
8. Spread ketchup and mustard on the top half of the bun, then place it on top of the burger.
9. Serve the burger while it's still warm and enjoy!

Class Discussion Questions:

- Which ingredients in the original recipe had the highest carbon footprint?
- What changes did you make to your recipes to reduce their carbon footprint?
- What were the carbon footprints of the modified recipes compared to the original?
- Do you think the modified recipes were more sustainable and environmentally friendly? Why or why not?
- How could you further improve the recipe to reduce its carbon footprint?

Summary Activity

Sustainability in Primary Food Production

Part A – Climate Change, Biodiversity and Biosecurity

What is the main idea about this key knowledge & key skill? (Two or three sentences in your own words)	
What is sustainable agriculture?	
What is one key sustainable farming practice used in Australia?	
What does the term "climate change" refer to and why is it occurring?	
What are the impacts of the following on primary food production in Australia?	
Bushfires	

Floods and Storms	
Droughts	
Heatwaves	

What factors contribute to a lack of biodiversity?
What are the risks in primary food production associated with a loss of biodiversity?
What role does biodiversity play in ecosystem resilience and adaptation to environmental changes?
In what way do biosecurity measures protect biodiversity in food production?
Why do invasive species pose risks to the biodiversity of the agricultural industry in Australia?

Part B – Use of Fertilisers, Pesticides and Water

What are fertilisers and why are they used in primary food production?	
What are the potential risks associated with the use of fertilisers regarding each of the following?	
Gas emissions	
Groundwater Pollution	
Eutrophication	
Soil acidification	
What are pesticides and why are they used in primary food production?	
What are the potential risks associated with the use of pesticides with regard to each of the following?	
Pesticide-resistant insects	

Non-targeted species	
Human health concerns	
Pollution of water supplies	
In what ways do farmers use water in their agricultural practices?	
How do the following impact the environment and crop production?	
Irrigation	
Salinity	
List two ways farmers could use innovation and technology to use water wisely in primary production.	

Part C – Choices of Crops and Animals

How can the choice of crops ensure sustainable food production in Australia?	
List two ways farmers could use innovation and technology in crop production.	
Identify four animals and explain how the choice of animals ensures sustainable food production in Australia.	

List two ways farmers could use innovation and technology in animal production.	

Exam Preparation

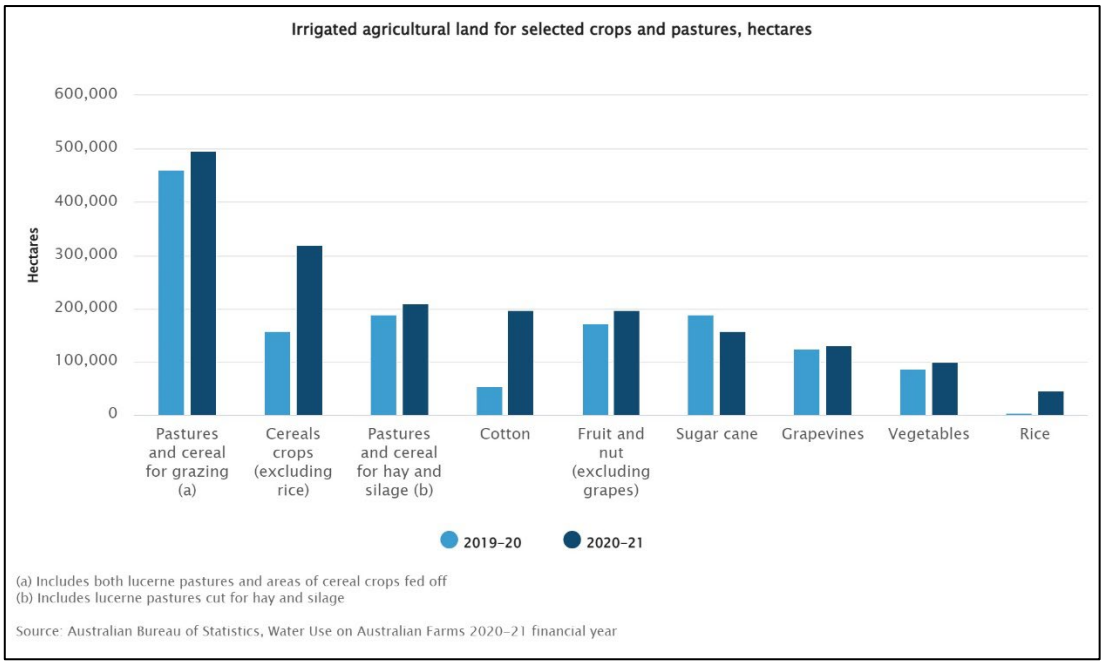
Multiple-Choice Questions (5 marks)

Choose the response that is correct or that **best answers** the question.

1. How does climate change impact crop production in Australia?
   a. Increased crop yields due to longer growing seasons.
   b. Decreased crop yields due to reduced water availability.
   c. Enhanced pest resistance resulting in improved crop productivity.
   d. Higher nutrient content in crops due to elevated atmospheric CO_2 levels.

2. Which of the following options best defines biosecurity?
   a. The practice of ensuring the security of biological research laboratories.
   b. The protection of biodiversity in natural ecosystems.
   c. The management of risks posed by biodiversity.
   d. The prevention, control, and response to the introduction or spread of harmful organisms.

3. Study the graph below:



   Which innovation in technology would help address the issue raised in the graph above,
   a. Drones for crop monitoring
   b. Virtual reality headsets for farmers
   c. Smart irrigation systems
   d. GPS directed, self-driving tractors

4. All of the following promote biodiversity in the soil except:
   a. Mulching and composting
   b. Crop rotation
   c. Pesticide use
   d. Intercropping

5. The Angus cow is a black, medium-sized breed known for its exceptional meat quality. It has a calm temperament, adaptability to various climates, high fertility, and efficient feed conversion. It is widely used in beef production worldwide.

   Which of the following characteristics makes Angus cows a suitable breed for farming amidst rising global temperatures?
   a. Angus cows have a black coat colour, which helps reflect sunlight and reduce heat absorption.
   b. Angus cows possess a genetic adaptation that enables them to withstand higher temperatures.
   c. Angus cows have a reduced metabolic rate, allowing them to cope with increased heat stress.
   d. Angus cows require less water compared to other breeds, making them more resilient in water-scarce conditions.

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Short Answer Questions (15 marks)

Question 1 (3 marks)

Identify one climatic and weather condition that occurs because of climate change and explain its impact on food production in primary food production.

Question 2 (2 marks)

Describe two important characteristics to consider when selecting livestock.

Question 2 (4 marks)

Sugarcane cultivation often involves the application of fertilisers to ensure high yields and promote plant growth.

a. Explain how the one impact of the overuse of fertiliser on the environment. 2 marks

b. Explain how innovation and technology could be used to improve sustainability in primary food production. 2 marks

Question 4 (6 marks)

Examine the relationship between biosecurity in Australia and biodiversity, highlighting their interconnectedness and the importance of maintaining both. 6 marks