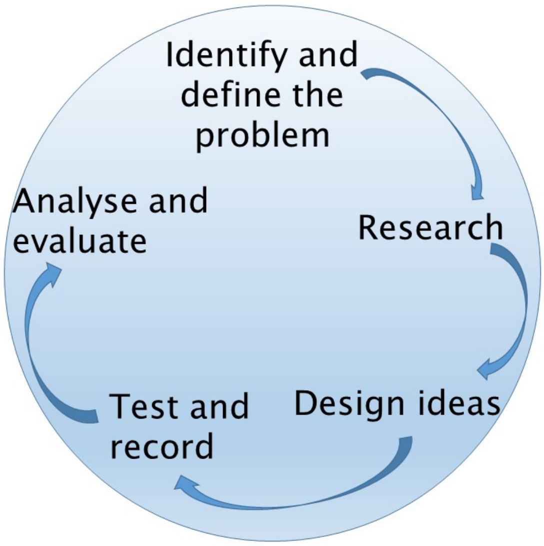
Farming for Food – Student Booklet

The Challenge

As the global population increases more food will be required but there will be less space to grow/produce it. To cope with the demand, farmers currently do things like add fertilisers to their soils, to produce a larger yield. However, fertilisers can leach into the groundwater and be carried long distances, effecting much more than just the intended area. To cope with the demands for space, methods such as vertical farming and the use of hydroponics systems are being utilised more and more.

Your task is to investigate the impacts of these methods of farming and to evaluate their suitability for use in your local area considering social, environmental and economic issues.



Background Information

You will be familiar with the equation for photosynthesis:

carbon dioxide + water → glucose + oxygen

$$6CO_2 + 6H_2O \xrightarrow[\text{(sunlight energy)}]{} C_6H_{12}O_6 + 6O_2$$

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For plants to grow successfully they also need many nutrients, including nitrogen and phosphorus. Naturally plants get these nutrients through the phosphorus and nitrogen cycle. The nitrogen cycle is shown below.

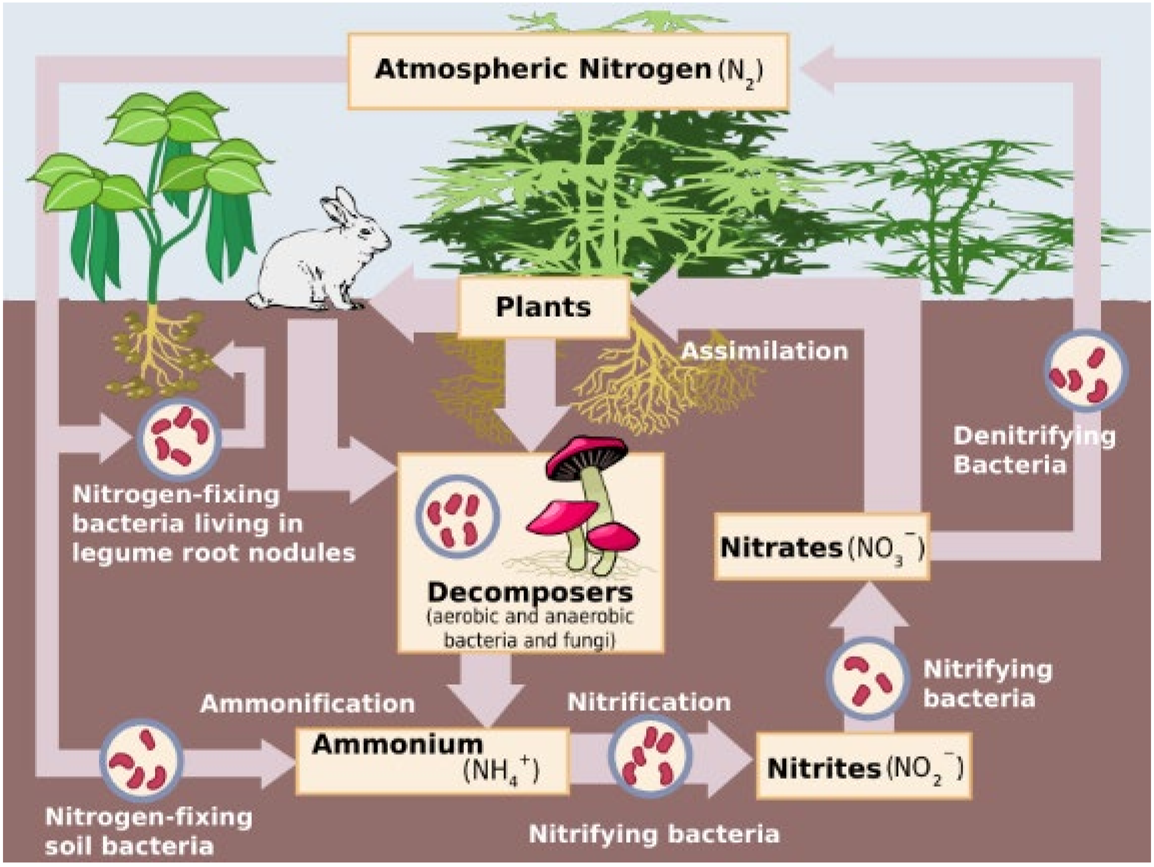

Figure 1: The nitrogen cycle.

Prior to the Industrial Revolution, the majority of farming was subsistence farming, where people grew enough only for their families. To ensure enough food for the year and maintain healthy soil as well as a varied diet, people would use crop rotation methods (changing the crop that was growing on the land over seasons or even from year to year). As different plants required different nutrients, this allowed time for the soil to replenish in the nutrients that had been used by a previous crop. However with industrialisation, farmers greatly increased the size of fields and scale of crops. As a result, it was more economical to grow the same crop as it required less machinery and specialisation than varied crops. However, this led to depleted soils and farmers began to add fertilisers to maintain the nutrients needed for crops to grow.

Most commonly, synthetic fertilisers are used as they provide predictable and efficient sources of nutrients and farmers can select how much they need of each type. In comparison, natural fertilisers, such as animal manure, have relative amounts of nutrients that are unknown. The addition of synthetic fertilisers to soils can lead to higher yield harvests and

also speed up growth rates of some crops. They are also much easier to transport than organic fertilisers, which could possibly reduce fuel costs and CO_2 emissions.
A problem with using synthetic fertilisers is that many of them contain high amounts of acidic chemicals, which can be a health hazard. With a period of heavy rain the fertilisers run-off, entering water bodies. As they are high in nitrogen they can cause algal blooms (algae are plants after all!) and enter the groundwater, carrying toxins that can be poisonous to animals and humans.

Different methods of farming are being introduced around the world to minimise the amounts of fertiliser being used, as well as to cut down on water and land usage. These include small scale hydroponic farms, vertical farms and the farming of genetically modified (GM) crops (which can be seen as controversial). Technologies are also being used more frequently by farmers to measure nutrient and water levels in the soil, ensuring that any additions are actually necessary and making the process more efficient and cost effective.

Background Research

1. Which crops are grown by farmers in your local area?

____

____

2. List some common fertilisers that are used for farming that fit the following criteria:

   a. Organic: ____

   b. Synthetic: ____

3. What are the dangers of synthetic fertilisers?

____

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____

____

4. What are some of the disadvantages of using organic fertilisers?

____

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5. Complete the table below outlining the features of a range of common fertilisers.

Fertiliser	***Price (per 100g or 100mL)**	**Organic or synthetic?**
Osmocote Controlled Release All		
Seasol Hose On Complete Garden Health		
Hortico Organic Garden Fertiliser		

*You will need to do some mathematical calculations here

6. Which nutrient cycles are impacted by fertiliser use?

____

____

7. What are algal blooms and why are they a problem?

____

____

____

____

8. Outline some alternative solutions to using fertilisers.

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Testing Fertilisers

Objective

To investigate the effects of different fertilisers on plant growth.

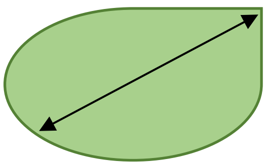
Your class will be divided into groups, and each group will use a different fertiliser for this experiment. Ensure that your group labels their plants clearly.

Equipment

- 4 x wide test tubes or cups
- Test tube holder
- Stickers and markers to label test tubes
- Black paper
- 4 x seedlings
- Cotton wool
- 4 x drinking straws
- Pre-mixed fertiliser solution
- Ruler

Method

1. Cover four wide test tubes with black paper (this will block the light from the roots of the plants, protecting them).
2. Label your test tubes (group name, fertiliser solution name and plant number). Fill test tube one to ¾ with water and then two to four to ¾ with your pre-mixed fertiliser solution.
   Why is it important to use more than one seedling when the same solution is being used?
   ____
3. Place a seedling and straw in each test tube. Pack the cotton wool into the mouth of the test tube to hold them in place. Ensure the seedling's roots are in the solution, with the rest of it above, and the straw is under the surface of the solution.
4. Put the tubes into a test tube holder and place in a well-lit area.
5. Measure the length of the longest leaf for each plant and record this in the table every lesson. Note: Once you have chosen the longest leaf on each plant continue to measure this leaf only.



6. Blow into the straw daily for around 20 seconds to ensure the solution is kept fresh.

BE VERY CAREFUL NOT TO SUCK ANY OF THE SOLUTION UP AS YOU DO THIS

Results and Analysis

1. Record your results in the table below

Day	**Leaf Length (mm)**				
	Plant 1 (water only)	**Plant 2**	**Plant 3**	**Plant 4**	**Average (for plants 2-4 only)**
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

2. Calculate the increase in leaf length each day. Create a table below to display your results in.

3. Calculate the percentage increase in leaf length and complete the table below:

% increase = Increase ÷ Original Number × 100

Day	Percentage Increase in Leaf Length				
	Plant 1 (water only)	Plant 2	Plant 3	Plant 4	Average (for plants 2-4 only)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

4. Create a scatter plot for the class results showing average % growth of the largest leaf each day for different fertilisers. Use a different colour or symbol to represent each fertiliser. Collect the class results for plant 1 (water only) to calculate an average growth and plot this too.
5. Using the class results determine the quartiles and interquartile range for the average percentage increase in largest leaf length for day 10 and create box plots to represent the spread of data.

6. Which fertiliser produced the largest increase in leaf length from day 1 to 10?

____

7. Which fertiliser produced the smallest increase in leaf length from day 1 to 10?

____

8. Which fertiliser resulted in the largest percentage increase in leaf length on average?

____

9. How did the plants that grew in just water compare to others?

Research

10. What is the cost (per 100mL or 100g) for each of the fertilisers used?

11. Calculate the cost per mm growth for each fertiliser used.

12. Was there a relationship between the cost of a fertiliser and the average increase in leaf length?

13. Which fertiliser was the best value in terms of cost per mm growth?

14. Which fertiliser would you recommend and why? Ensure you use data from your research to back up your answer.

Evaluation

1. Were there any potential sources of error in your investigation?

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2. How could you improve this investigation?

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Fertilised Algae

Objective

To investigate the effect of different concentrations of fertilisers on the growth rate of algae. Then to relate your findings to algal blooms.

Hypothesis

As the concentration of fertiliser increases, the amount of algae present will____________.

This is because ____.

Equipment

- 4 x petri dishes
- 1 x pipette
- Algal culture
- Fertiliser
- Water sourced from an area known to contain algae
- 4 x 100 mL beaker
- Green paint colour chart from hardware store
- Light sensor (if available)
- Camera

Method

Develop a method to investigate the effect of different concentrations of fertilisers on the growth rate of algae using the equipment listed above. Show this method to your teacher, for approval, before conducting this investigation.

Results and Analysis

1. Complete the table below. Include photos, observations of colour and growth of the algae and measurements from the light sensor (if available).

Petri Dish	Day 1	Day 2	Day 3	Day 4	Day 5
1					
2					
3					
4					

2. Create a scatter graph to show the percentage of algae present against time for each concentration of fertiliser.
3. If you were able to use a light sensor create a scatter plot for the data collected.
4. Which fertiliser concentration resulted in the most algal growth?

5. If you also measured the light intensity transmitting through your samples (using a light sensor), did this graph show similar trend lines to the one for percentage of algae present?

6. How did the algae that grew in just water compare to others?
   We hope you remembered to have a control (just water) sample!

7. Does your data support the idea that increased fertiliser use can lead to algal blooms? What could this mean for aquatic ecosystems that are close to farms? Use data to back up your conclusions

Evaluation

1. Were there any potential sources of error in your investigation?

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2. How could you improve this investigation?

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Investigating the Health of Your Local Waterway

Objective

To use abiotic and biotic water quality parameters to investigate the health of your local waterway, as well as to explore if human influence is affecting its health.

Background Information

A healthy waterway will have a large number of different types of macroinvertebrates present with no one type dominating the system. A polluted waterway will have only a few different types of macroinvertebrates present, often in large numbers, and will generally include things like aquatic worms, water fleas and non-biting midge larvae (Government of Western Australia, Department of Water and Environmental Regulation, 2017)

Equipment

- 1 x bamboo stick/broom handle/long pole
- 1 x bottle with wide opening, or sturdy cup
- Electrical tape or large cable ties
- Petri dish
- Thermometer
- Microscope
- Laminated macroinvertebrate identification chart
- Computer/device with internet connection
- pH paper or meter
- Optional: camera, light sensor, oxygen meter, turbidity meter, ammonia and phosphate test kits and waders/wellington boots.

Safety

For this activity you must be very aware of your surroundings, ensuring you keep to paths and avoid disturbing wildlife. Watch out for snakes and follow your teacher's instructions.

Method

Before you leave the classroom

1. Research which of the following macroinvertebrates are pollution intolerant, somewhat pollution tolerant and pollution tolerant:
   mayflies, scuds, aquatic worms, dragonfly nymphs, water fleas, stoneflies, damselfly nymphs, caddisflies and mosquito larvae.
2. Find out more about signs that might indicate fertilisers have entered a waterway.

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3. Make a water sampler by securing the bottle/cup to one end of the bamboo stick/broom handle/long pole using electrical tape/cable ties. Take this with you, as well as a thermometer and any optional equipment you may have

At the waterway

4. Make observations of the flora and fauna surrounding the waterway, taking note of what you have seen, and if possible the number of each species. You may need to take photos so that you can identify things later. Record these in the table.
5. Carefully dip your sampling cup into the water, lightly tap the bottom of the lake to collect some sediments and macroinvertebrates from the bottom of the waterway.

   ⚠ **Do not enter the water unless you are wearing waders gum boots and have teacher permission!**
6. Slowly lift your sampling cup out of the water.
7. Use the thermometer to measure the temperature of the water and record it in your table.
8. If you have an oxygen meter measure the dissolved oxygen percentage and record this also.
9. Put a lid on your sample and return to the lab.

Back in the lab

10. Pour some of your sample into a petri dish and using the microscope systematically make observations of the sample recording the number of each type of macroinvertebrate you can identify. Note: you may need to do this multiple times as you will have collected more water than will fit in a single petri dish.
11. Using pH paper, or by taking a small sample of the water (that doesn't contain macroinvertebrates), test and record the pH of the water.
12. If you have any of the other testing kits (ammonia or nitrogen tests or a turbidity meter) they will have directions specific to the brand. Follow the directions given to test these parameters.

Results and Analysis

1. Complete the table below adding in fauna and flora that you observed around the water way.

Species name					
Number of times observed					

2. Complete the table below adding in additional rows for any other measurements you took.

Water temperature	
Oxygen level	
pH	

3. Create frequency tables for the macroinvertebrates you observed in the lab under the microscope.

4. Share your data with the class to create whole class results and record them below.

5. Using the full class data set create pie charts to show the percentage of each macroinvertebrate identified. Colour code your pie chart so that pollution sensitive species are coloured green, somewhat pollution tolerant species are orange and very pollution tolerant species are red.
6. Which macroinvertebrate was most frequently observed in **your** sample?

____

7. Which macroinvertebrate was most frequently observed in the class data set?

____

8. What percentage of your pie chart is green, orange and red?

____

9. Calculate the average pH for the full class data set (show your working)

____

____

10. How does the pH of the lake compare to the pH of a healthy waterway? (Healthy waterways should score between 6.5 – 8.5)

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11. If you also measured other parameters, how do they compare to that of a healthy lake?

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12. Overall how healthy is your local waterway? Use data from your investigation to support your conclusion.

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Evaluation

1. Were there any potential sources of error in your investigation?

2. How could you improve this investigation?

3. Does your investigation give a fair reflection of the health of your waterway? If not, why not? What other information is needed to make this assessment?

4. Is there evidence that fertiliser run has affected the health of the lake?

5. What further investigations could you do to find out more about the health of the lake?

Modern Methods of Farming

Objective

To explain the principles behind modern farming methods and discuss the pros and cons of each farming type for use in your local area.

Method

Research the following methods of farming and produce a table/other appropriate representation to summarise what it is, give an example (or case study) and to outline the pros and cons:

Hydroponics, aeroponics, aquaponics, vertical farming and precision farming.

Results and Analysis

1. Which type of farming would be most suitable for your local area? Explain your choice.

2. Which type of farming would be least suitable for your area? Explain why.

3. Which type of farming would likely have the lowest impact on natural nutrient cycles?