Farming for Food – Teacher Resource

Intended Use of Resources

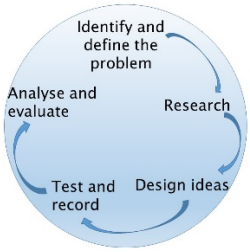
This project has been designed so that teachers from different STEM areas can pick and choose sections relevant to their subject area to work on. All activities in this package do not need to be completed to get value from the package – each activity can be completed as a stand-alone or can be approached, as a team, as a larger project. The package has potential to be extended into a much longer project to include curriculum points from different STEM subjects.

There are three **student workbooks - Open, Guided and Scaffolded,** that go alongside this resource; all have the same suggestions for activities, however, they have been written and edited to provide differentiated learning options to support good teaching practice**.** Teachers may pick and choose which versions they give which students, and may wish to edit them further to address their learning needs. Due to the differentiation of the workbooks, the **Open** activities will enable more syllabus links to be addressed, which is why each activity has its own syllabus links key. However, if you wish to give a truly open-ended investigation then you could just give the students the challenge and background information section of the Student Booklet.

The Woodside Australian Science Project (WASP) STEM resources aim to be accessible and supportive for teachers and students, please contact us if you have questions, feedback, require assistance or would like to arrange an incursion or a professional development workshop - www.wasp.edu.au.

The Student 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.



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Background Information

You will be familiar with the equation for photosynthesis:

carbon dioxide + water → glucose + oxygen

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

(sunlight energy)

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.

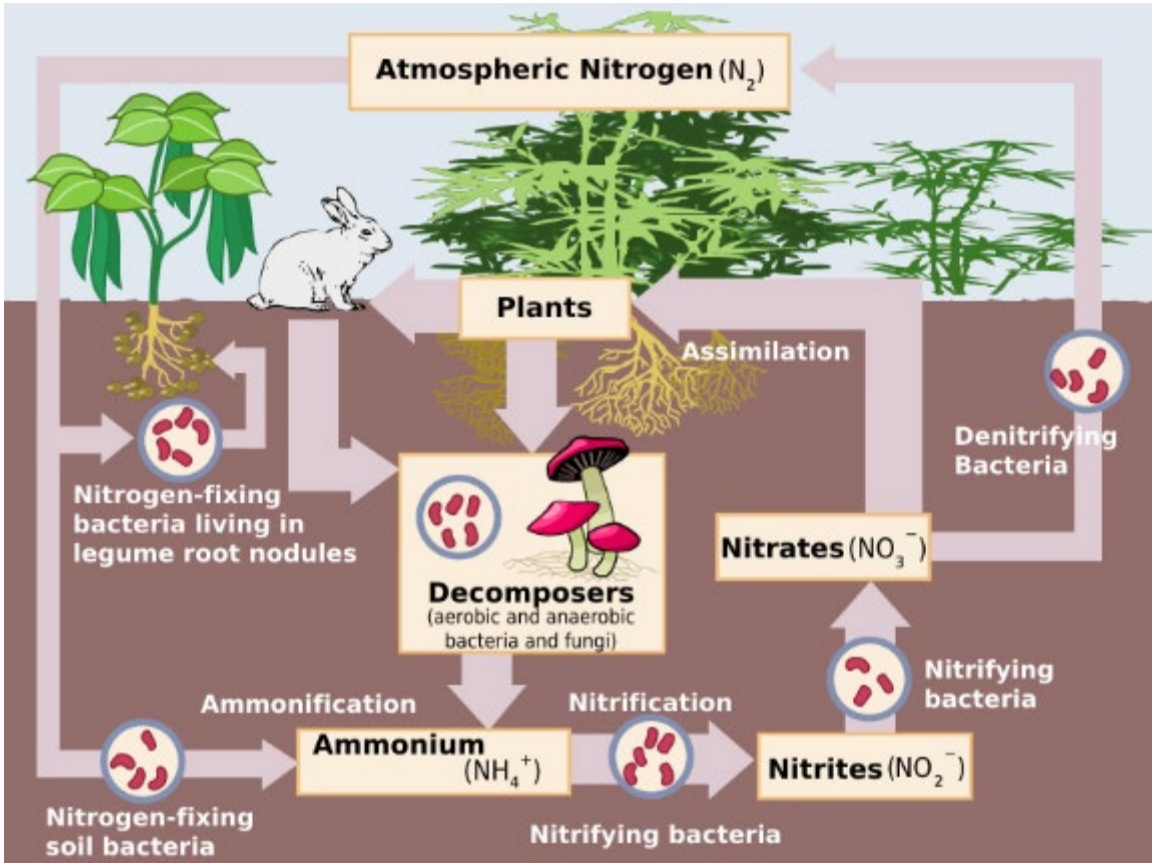

Figure 1: The nitrogen cycle.

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.

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Activities

This booklet contains extra information on each activity, including syllabus links the overall activity objective, suggestions for recommended equipment or alternative ways to run investigations as well as useful resources and website links. Please note that any reference websites provided in the entirety of our resource documents were current at the time of publication. Please advise if links are no longer accessible.

The curriculum links have been colour coded – please see the colour key below:

Covered in Scaffolded, guided and Open student workbook
Covered in Guided and Open Student workbook
Covered in Open student workbook
Italics – Only in WA curriculum

List of Activities

**Please note that any reference websites provided were accessed in May 2019 therefore these addresses may have changed slightly. We would be grateful if you could let us know if these sites are no longer accessible.*

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Background Research

Objective

Students will gain a general understanding of why fertilisers are used, the different types of fertilisers available and the problems with using fertilisers. They will gain an overview into alternatives to using fertilisers.

The background questions should lead them to start thinking about further investigations they could do to find out more about the effects of fertilisers and possible alternatives to using fertilisers. They are "teaser" questions about which students will be able to find out more through the other activities. Therefore, if you do not have time to complete all the activities you may wish to add to the background questions.

Particularly in Western Australia where the soils are very old and depleted, students will find that it is very difficult to grow crops without the use of fertilisers. They may come across the fact that Australia is one of the few countries globally that grows genetically modified (GM) foods for human consumption. These foods can be designed to require less water, fertiliser and/or pesticides. They should also gain an understanding of farming methods that are possible in smaller areas, such as vertical farming. These are becoming more popular as they can be used in places of high population density. This means fresher foods and less fuel use (less transportation).

	Australian Syllabus Links
Science	ACSSU189 Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. ACSHE230 Values and the needs of contemporary society can influence the focus of scientific research.
Design and Technology	ACTDEK040 Social, ethical and sustainability considerations that impact on designed solutions, complexity of design, and production processes involved ACTDEK041 Impact of emerging technologies on design decisions, and/ or economic, environmental and social sustainability.

Useful resources and websites:

- ABC educational video clip on scientists and farmers: http://education.abc.net.au/home#!/media/86240/scientists-working-with-farmers
- ABC education video clip on organic farming: http://education.abc.net.au/home#!/media/2350743/different-views-on-organic-farming
- Department of Water and Environment Regulation information on eutrophication: http://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/statewide-river-assessment

Testing Fertilisers

Objective

Students will investigate the effects of different fertilisers on plant growth. Recommended seed types for this activity are geranium or barley, which will need to be germinated 1 to 2 weeks beforehand. To enable them to grow after germination and avoid the roots getting covered in soil, the germinated seeds can be covered by damp cotton wool and connected to a pop stick with an elastic band. They can then be placed vertically into a test tube/cup with the bottom end in water, allowing the plant to grow upright. You may wish to use fertilisers that are on sale at hardware stores, so that students can compare ones they could access themselves. This allows them to make an economic comparison as well. Many of these will have instructions on how much should be added to water to make the solution. This may need to be scaled down for the experiment, which is an excellent application of mathematics. By using store bought fertilisers, the experiment is more relevant to student's daily lives, as they can then use the results if they have a vegetable garden at home or school.

Otherwise solutions can be made up in advance, by adding varying volumes of potassium sulphate, sodium phosphate, ammonium nitrate, and potassium phosphate. Each group should have a control, where only water is used on the plant.

During the evaluation, students can discuss the reliability of the techniques and measuring

If students wish to take photos of the plants they should ensure that a scale is placed next to the plant. Paint colour charts could be a useful way for students to compare the colour of their plant and note changes in colour of the leaves. Measurements of the height of the plant above the water line, as well as leaf size can be used – these can then be plotted on scatter graphs of time versus increased growth (either in mm or as a percentage of original size, or both).

Students will find that plotting each individual plant will make the graphs too disorganised. Plotting the averages will give a better overall view of the effectiveness of each fertiliser.

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	Australian Syllabus Links
Science	ACSSU189 Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. ACSIS199 Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; asses risk and address ethical issues associated with these methods. ACSIS200 Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately ACSIS203 Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies ACSIS204 Use knowledge of scientific concepts to draw conclusions that are consistent with evidence ACSIS205 Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of data.
Digital Technologies	WATPPS64 Apply design thinking, creativity, enterprise skills and innovation to develop, modify and communicate design ideas of increasing sophistication. WATPPS66 Select, justify and safely implement and test appropriate technologies and processes, to make solutions WATPP68 Work independently, and collaboratively to manage projects, using digital technology and an iterative and collaborative approach. Consider time, cost, risk, safety, production processes, sustainability and legal responsibilities.
Mathematics	ACMSP251 Use scatter plots to investigate and comment on relationships between two numerical variables ACMSP248 Determine quartiles and interquartile range ACMSP249 Construct and interpret box plots and use them to compare data sets

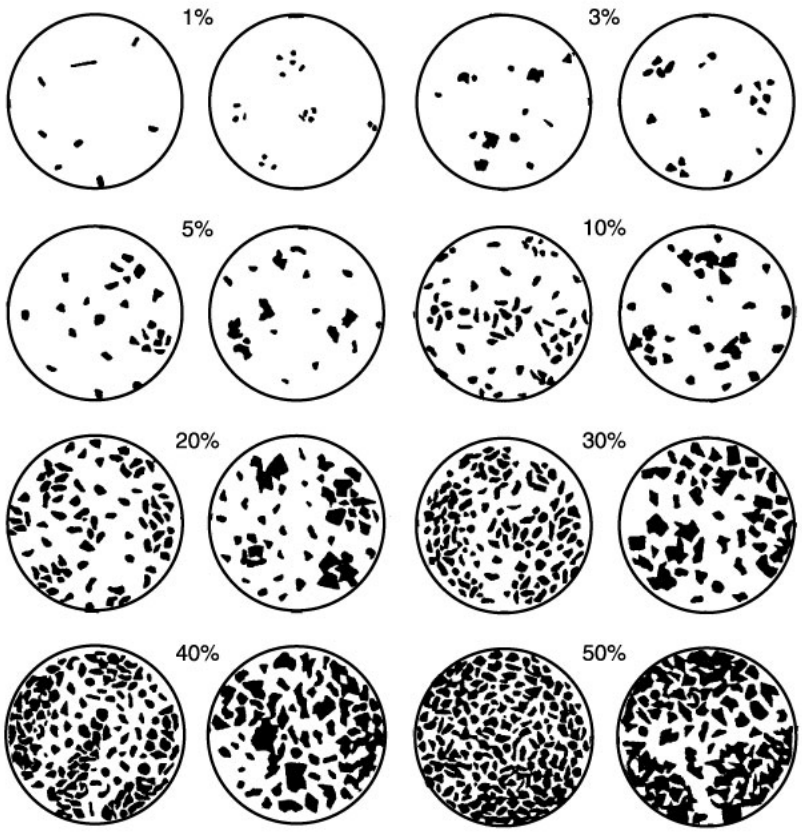
Fertilised Algae

Objective

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

If the school does not have petri dishes then glass jars or clear plastic cups are also fine to grow the algae in, provided they are transparent and each group uses the same sized vessel. They may even be better than petri dishes if it is very warm and there is a possibility that the water the algae is in will evaporate.

If an algal culture is difficult to get hold of duckweed is also very quick to grow. In this instance, they will not need to match the colour change but will make percentage estimates. Or you could ask them to count the exact number of duckweed plants each day. This may be easier to do from a photograph as they can mark crosses on the plants as they count them, so they do not recount. The chart below enables percentage estimates to be made and could be a useful tool.



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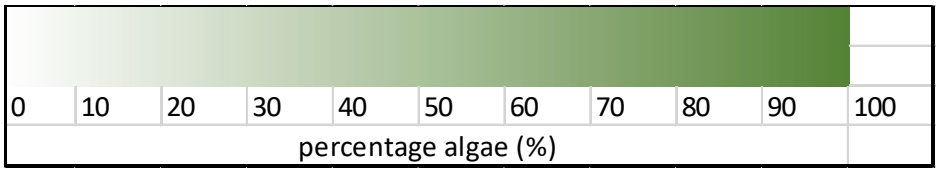
The fertiliser can be store bought, or pre-made solutions of potassium sulphate, sodium phosphate, ammonium nitrate, and potassium phosphate

Results collection suggestions

You can make your own colour charts in Excel if you can't find a paint chart to suit, see example below:



	day																			
	1				2				3				4				5			
	dish 1	dish 2	dish 3	dish 4	dish 1	dish 2	dish 3	dish 4	dish 1	dish 2	dish 3	dish 4	dish 1	dish 2	dish 3	dish 4	dish 1	dish 2	dish 3	dish 4
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	Australian Syllabus Links
Science	ACSSU189 Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. ACSSU187 Different types of chemical reactions are used to produce a range of products and can occur at different rates. ACSIS199 Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; asses risk and address ethical issues associated with these methods.

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	Australian Syllabus Links
Science	ACSIS200 Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately ACSIS203 Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies ACSIS204 Use knowledge of scientific concepts to draw conclusions that are consistent with evidence ACSIS205 Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of data.
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Mathematics	ACMSP251 Use scatter plots to investigate and comment on relationships between two numerical variables

Useful websites and resources:

- High level resource on algal blooms in the Swan River from DPWA: https://www.dpaw.wa.gov.au/images/documents/conservation-management/riverpark/fact-sheets/River%20Science%203%20-%20Algal%20Blooms.pdf
- Department of Water and Environmental Regulation information on algal blooms: http://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/algal-blooms
- Benefits of using duckweed – this article highlights the difference between duckweed and algae if you do intend to use duckweed instead of algae: https://owlcation.com/stem/duckweed

Investigating the Health of Your Local Waterway

Objective

Students will use abiotic and biotic water quality parameters to investigate the health of their local waterway, and explore if human influence is affecting its health. They will conduct a series of investigations, exploring which parameters are important to identify the health of the waterway.

Before running this activity you should ensure you have already visited your local waterway and have seen where it is safe to take samples from. Ensure you are well aware of any health or safety issues and have completed a risk assessment. The teachers resource guide to studying macroinvertebrates in the links below, covers much of this. It also contains invertebrate ID charts and frequency tables.

Taking photos and recording the different types of fauna and flora may take students a long time. You could either set a time limit or get them to focus on particular species, such as mayflies and pond skaters which are useful indicators of the water's pollution levels, and which they may not successfully catch in their sampling cup. Or create a table with pictures of particular fauna and flora you want them to look for and they can have a tally next to each picture as they count how many they see. You could even turn it into a bingo game (they could take photos to prove their sightings).

When students are looking under the microscope, if you use some grid paper underneath the petri dish this could be a good introduction to quadrat sampling methods.

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 generally include things like aquatic worms, water fleas and non-biting midge larvae

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Useful websites and resources:

- List of some species you would expect to find in health waterways in Western Australia: http://www.water.wa.gov.au/water-topics/waterways/values-of-our-waterways/threats-to-our-rivers
- File with pictures and information about different macroinvertebrates you could expect to find in lakes depending on their health (NB: this is from the US so some species may not be found in Western Australia): http://wupcenter.mtu.edu/education/stream/Macroinvertebrate.pdf
- Teacher resource guide to studying macroinvertebrates: http://www.atmosedu.com/ENVS109/WaterQualityandMacroinvertabrates.pdf

Modern Methods of Farming

Objective

Students will be able to explain the principles behind modern farming methods and to evaluate their suitability for use in their local area, considering environmental and economic issues.

This activity is research based but can be extended by suggesting that the students design a garden for their school. This could involve a lot of further research such as how to measure light levels, moisture content and nutrients in the soil. Then researching which plants would grow well in that area or if fertilisers will need to be added. If the time and resources are available, you may wish to get the students to set up an aquaponics system. Visits to farms which are using more modern methods of farming could also be engaging for the students.

	Australian Syllabus Links
Science	ACSSU189 Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere. ACSHE230 Values and the needs of contemporary society can influence the focus of scientific research.
Design and Technology	ACTDEK040 Social, ethical and sustainability considerations that impact on designed solutions, complexity of design, and production processes involved ACTDEK041 Impact of emerging technologies on design decisions, and/ or economic, environmental and social sustainability. ACTDEK044 The role of emerging research and technology in the design of ethical and sustainable products.

Useful websites and resources

- Activity from Science and Plants for Schools – building hydroponics systems in school: http://www.saps.org.uk/secondary/teaching-resources/847-hydroponics

Testing the Water

Bonus activity not included in the student booklets.

Devices such as CSIRO's Chameleon are being welcomed by farmers, who can use them to measure the water and nutrient content of soils. This enables them to determine how regularly their crops need watering and amount and type of fertilisers to add. Not only is this saving them time and money, but it is also helping protect the environment.

CSIRO's chameleon device - a simple hand-held sensor which allows water and nutrients levels to be measured.

Objective

To build and test a device that will be able to monitor the water content in soil and evaluate its effectiveness, discussing if and how it could be used to assist crop growth.

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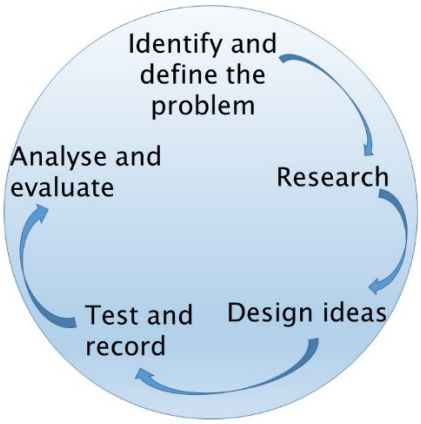

Step 1.

Research different soil moisture measurement devices and find instructions on how to create your own. (Websites such as instructables have many different designs)

Step 2.

Compare the different devices and their instructions, highlighting the strengths and weaknesses of each. Consider factors such as:

- Ease of use
- Materials required (cost and ease of access)
- How clear the instructions are (do you think you will be able to follow them?)
- Time needed to make the device

Step 3.

Decide on which device you will make and create a ***project plan*** outlining:

- Equipment you need
- Who will be responsible for what
- A timeline of task completions
- Risk assessment
- How you will test the device
- Any changes to the instructions which you will make

Show this to your teacher and gain approval before making the device.

Step 4

Testing the device. How will you test the device? Do you have any other devices that you can compare the results with? How will you know if it is working and how well it is working?

Step 5.

Analyse and evaluate the design, instructions and your project plan.

- How well does the device work? – How you know and what improvements can you make.
- How clear were the instructions? Were you able to follow them completely or did you have to give up or make up your own? Rewrite them with any improvements you think will make it easier for others to follow.
- How effective was the project plan? Were there health and safety issues that you had not thought of and came up as you were following the plan? Did you manage to stick to the timeframes you set?
- If you were to do this again would you do it differently, if so how?
- How useful would this device be for farmers?
- How could you improve the device to make it even better?

Bibliography

Figure 1: Nitrogen Cycle, Wikipedia, accessed at https://en.wikipedia.org/wiki/Nitrogen_cycle, accessed on 6/5/19