COMMONWEALTH CLASS

Global Food Security
How can we feed a growing population?

In collaboration with

BRITISH COUNCIL

THE ROYAL SOCIETY

The Commonwealth

Introduction

Commonwealth Values: Sustainable development; Protecting the environment; Access to health, education, food and shelter

Curriculum links: Science; mathematics; English, design and technology; personal, social and health education; geography; citizenship

Core skills: Communication and collaboration; Critical thinking and problem solving; Digital literacy; Global citizenship and civic responsibility; Student leadership

The rapid increase of the world's population, combined with unprecedented levels of human consumption, present profound challenges to our health, wellbeing and the natural environment.

Producing enough food for our growing global population comes with the added challenge of changing consumption patterns, as well as the need to cope with the dramatic effects of climate change and the increasing scarcity of water and land. In addition to sustaining populations around the world, food production methods must help preserve the environment and natural resources, and also support the livelihoods of farmers.

One of the UN's Sustainable Development Goals is to end hunger, achieve food security and improved nutrition and promote sustainable agriculture.

Contents

OVERVIEW

Why is it important?

The global population currently stands at around 7 billion and is still growing. In 2010 alone, 1 billion people did not consume the minimum recommended daily allowance of calories, while other parts of the world saw very high levels of consumption. Although the factors behind this imbalance are complex, science has a crucial part to play in alleviating malnutrition and managing the implications of food production for our finite planet.

What is certain is that the global population and levels of consumption will continue to rise over the next half-century. Consequently, food production will need to increase by at least 50% if it is to meet our future needs and must primarily take place on existing agricultural land.

Scientific background to the problem

Following the Green Revolution (1930s to mid-1960s), which saw the application of science to food production methods, the amount of food produced grew from 1.84 billion tonnes in 1961 to 4.38 billion tonnes in 2007. The Green Revolution encompassed changes to crop varieties (e.g. growing crops in all seasons, producing bigger fruit or seeds, making crops disease-resistant), changes to agricultural practices (e.g. using fertilisers, pesticides and water management systems), as well as broader social, economic and political changes. Nowadays, new scientific techniques and technologies are produced to help feed and mitigate the impact of our rising global population.

The types of plants and animals raised for food differ according to region, particularly between industrialised and developing countries. The kind of foods available depends both on what the country is capable of growing itself and on what it can import from other parts of the world. Maintaining a consistent supply of food is often referred to as 'food security' – this is dependent on the social, economic and political context of the country itself, that of the countries it buys its food from, as well as on how food is stored and distributed.

How successful food production methods are depends on things such as the inputs required to grow plants or raise animals (e.g. water, fertiliser, soil), the impact of pests and diseases, and on how well suited the plants and animals are to food production.

The rising demand for food means that a number of inputs into the food production process, such as the availability of fresh water, are going to come under pressure. In the future, it will be especially important to reduce the amount of water needed, such as by growing plants that require less water or improving irrigation systems.

Furthermore, due to the need to reduce greenhouse gas emissions and reach zero carbon by the second half of the century (as per the 2015 Paris Agreement on climate change), agriculture will have to become less reliant on the sources of non-renewable energy derived from fossil fuels.

Soils are another essential but non-renewable resource needed for crop production. Consequently, it will also be vitally important that we maintain the ability of soil to support plant growth by ensuring it is healthy and has the right nutrients.

Pests and diseases can also have a detrimental effect on food production, as they often result in the loss of plants and animals. Although dealing with pests and diseases can require a lot of time and financial resources, reducing these losses is one of the most accessible means we have of increasing food supplies.

In most parts of the world, climate change can also affect food production. It often reduces the amount of food plants can produce and, in extreme cases, stops them from producing food altogether. Equally, because climate change is likely to impact on weather patterns, it can also lead to less rain, putting greater pressure on the need to supply water through irrigation systems.

The concept of sustainability in the context of agriculture and food production is central to any new technologies. A system is unsustainable if it depends on non-renewable inputs, is unable to consistently and predictably deliver desired outputs, or can only do this by cultivating more land and/or causing adverse, irreversible environmental damage which threatens critical ecological functions.

Addressing all of these problems requires a diversity of approaches. Due to the scale of the challenge, no technology should be ruled out and different strategies may need to be employed to suit different regions and circumstances. With this in mind, research to develop new technologies and improve existing ones is crucial.

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Possible solutions

As there are multiple inputs to the farming process, there are a number of ways to improve its overall efficiency.

It is possible to address some of the issues by looking at the balance of plant and animal farming. Meat consumption contributes to greenhouse gases, both through the excretions of animals and through the destruction of forested land for grazing and growing other food for livestock. One possible solution would be for individuals to cut down on meat consumption and, in doing so, help reduce the harmful impacts of climate change. Additionally, reducing meat consumption can potentially free up land for growing cereals or biofuels.

It is also possible to improve how well suited plants and animals are to food production by modifying their genetics, either through breeding or using techniques in the lab to alter them. These techniques are typically referred to as genetic modification (GM) and are among the approaches which could help address the challenges of food security. For instance, it has been proven that plants that have been modified through GM have delivered benefits for food production including resistance to insects, viruses and herbicides. These innovations have reduced the loss of crops to pests and diseases, minimised insecticide use and helped prevent damage to the soil from deep ploughing. While there is no evidence to suggest any ill effects linked to eating approved GM crops, GM remains a contentious subject in a number of countries. There are also broader socioeconomic issues to consider, including the availability and pricing of food, politics and transport, as well as issues of trust in businesses and politicians.

The environment crops are grown in can also make a difference to the efficiency of the food production process. Indeed, many crops around the world are now grown with added protection against environmental extremes. This often entails a plastic film fashioned into a simple tunnel structure being placed over crops to protect them from the weather (see image below). The structure will often lead to an increase in crop quality and can also greatly increase water use efficiency. This is known as 'protected cropping'.

Finally, as there is great inequality in terms of where food is produced, another especially important way of increasing the efficiency of the food production process is by working to decrease food waste and improve food distribution.

ACTIVITY 1: WHAT TYPES OF FARMING ARE MOST COMMON IN YOUR COUNTRY?

Overview

This activity will allow your students to investigate the most common farming methods, crops and animals in their local area. Students should research online and in books, ask questions and share their findings with schools in other countries.

Activity

Different parts of the world have different climates. Even within a single country, changes in altitude, latitude, proximity to the sea, and many other factors, can lead to distinct sets of conditions which each suit different types of farming, animals and crops.

Ask your students to investigate the farming methods that can be found in their country and local area. If your school has a farm or allotment nearby, you could take your students on a field trip so they can witness these local methods first hand.

Points to consider might include:

- Which crops are most commonly grown?
- Which animals are most common? Are they raised for eating meat, eggs, or milk?
- Is this the same across the whole of your country or is there a lot of variation?
- What is the average rainfall in your country per year?
- How much land is occupied by farming in your country?
- What challenges do farmers face in your country today?

Sharing your results

Results should be shared and discussed with other countries via the teacher forum on Schools Online or through your links with partner schools.

ACTIVITY 2: SALTY SEEDS

Overview

Through this activity, students will learn how the germination of seeds is dependent on the environment.

Learning objectives

In some parts of the world, big problems are caused by irrigation and water shortages. Irrigation (applying water to soil in areas that are very dry or have periods of low rainfall) results in salinised soils (those with increased salt content), as salt that has accumulated in the soil layers is drawn up towards the surface.

This activity asks students to test how different levels of salt affect the germination of seeds and to investigate how other environmental factors could impact on the process. The activity has been adapted from a set of resources called 'The Crunch' by the Wellcome Trust.

Activity

1. Start by organising your class into small mixed ability groups and give each group a copy of Appendix A.
2. Explain to students that they are going to carry out an experiment soaking tomato seeds in salt water before sowing them. They will then observe the germination and growth of their seeds over a five-week period. Ask each group to follow the instructions on Appendix A.
3. Encourage students to select their own amounts of salt for the other three test tubes. These may need to be made up in beakers and transferred to test tubes before adding the seeds.
4. The soil needs to be kept moist but not over-watered. However, once the seeds germinate they will need more water. Demonstrate how to safely remove a plant from a pot so as not to damage its roots.
5. Once the plants have developed at least two true leaves, ask students to carefully remove each plant from their pots and measure the lengths of the roots. They should record the longest from each pot.

The stressed seeds (with additional salt) germinate and grow faster than the control seeds (with no extra salt). This is because they are trying to quickly produce roots that will reach down below the hostile environment (salty soil) to the more suitable soil below.

You may wish to ask your students to think about and discuss the following questions when planning their investigation:

- How will you keep all variables, apart from the amount of salt, the same?
- Once the seeds have been sown each plant pot must be treated the same. Why do you think that is?
- What do you think would happen if you put more or less salt into the solution?

Extension exercise

Discuss the variables students could change in this experiment to investigate other things. For example:

- Could the activity be repeated using different concentrations of salt?
- What would happen to plants grown in sandy soil? Can students predict whether the outcome would be the same as or different to the outcome for plants grown in salty soil?

ACTIVITY 3: FLOATING GARDENS

Overview

In this activity, students will build a basic floating garden using a range of construction materials and explore the potential positive and negative aspects of the structure. The activity has been inspired by the Floating Garden Challenge by Practical Action.

Activity

Lead a class discussion around how flooding could affect food production. Explain that more rain is falling now than ever before due to climate change and this has led to an increase in flooding. If land used to grow crops gets flooded on a regular basis, this then contributes to food shortages.

One answer to the problem is floating gardens. These are rafts made of natural resources, normally water hyacinth, soil and cow dung. Crops are grown on the rafts, which then float when flooding occurs.

Floating water hyacinth is collected and spread on bamboo poles which outline the structure of the raft. These are then woven together to build the raft and, once it is secure, the bamboo is removed. A thick layer of soil, compost and cow dung is then added on top to plant the seeds in.

Explain to students that although new rafts have to be made every year, old rafts can be used as fertiliser.

Organise your students into small groups and tell them that they are going to build their own floating gardens. Instructions can be found in Appendix B – you may want to print and hand this out to your class.

Ask students to think about the following points:

- Are the materials readily available?
- How might you dispose of the raft when it can no longer be used? Can it be recycled or used for compost?
- What size will it need to be and how well does it float?

The rafts can be tested in a sink or washing up bowl.

Extension exercise

1. If your school has a pond or a similar water feature close by, students could build a larger version of the most successful design and test it in the water.
2. If you have suitable seeds to hand (e.g. cress seeds), students could try and grow plants on their floating gardens. They will need to ensure sufficient nutrients are available for the plants to grow.

CROSS-CURRICULAR ACTIVITIES

Overview

This activity encourages students to explore how far their food has travelled and the environmental impact importing foods and their ingredients can have.

Activity

Ask your students to look at the labels on foods in their cupboards and fridges at home and record the name of the food and its country and/or place of origin. In class, ask them to locate these countries on a map and record the approximate distance these foods have travelled to their home using atlases or a food miles calculator.

Discuss with your class which products have travelled the furthest and ask them why they think certain foods are grown in specific locations.

Some questions to consider:

- What might the energy costs of transporting these foods to you be?
- What do we mean by someone's 'carbon footprint'?
- Why is it important to try and buy local products to reduce your carbon footprint?

Students could then go on to try and estimate the total food miles travelled by all the items in their school lunch.

Extension exercise

Scientists at the Royal Botanic Gardens in Kew, UK, state that 'all life depends on plants.' Discuss this statement and the scientific principles that lie behind it with your class.

Now set your students the additional challenge of trying to trace the origin of each element of their lunch back to a plant. For example, the ingredients of a chicken sandwich might be traced back as follows:

- bread (wheat)
- butter (made from milk from a cow, which is fed on grass)
- chicken (fed on grain).

Is it possible for students to find an item in their lunch that cannot be traced back to a plant?

CROSS-CURRICULAR ACTIVITIES

ACTIVITY A

- You could encourage your students to try and grow different healthy foods in containers or garden beds in your school and then harvest the produce for cooking and eating. Which are your students' most successful crops?
- If you have a partner school, why not both grow the same plants and compare how well they grow in different climates? A primary school in Japan worked with their UK partner school to find out how different climates affect the growth of traditional food products. Both schools grew daikon seeds (a Japanese radish) to investigate how well this traditional Japanese product grew in a different climate and compared the results. In Japan the radishes that were harvested were much larger than those grown in the UK. Why might this be?

ACTIVITY B

Go a step further and show your class the Rocket Science experiment launched by the British astronaut Tim Peake. The experiment is designed to see how well seeds that have been in space grow compared with seeds that have been stored on Earth. The aim of the project is to explore the effect of weightlessness and radiation on seeds in order to develop plant varieties that can be grown on long space missions.

The rocket seeds were in space for six months and then sent to the 10,000 UK schools participating in the project. Each school received 100 seeds in red and blue packets, but were not told which packet contained which seeds. Students are currently comparing the growth of the two types of seeds and suggesting possible explanations for their results.

For more information on the experiment, visit the Rocket Science experiment page on the Royal Horticultural Society website.

Dr Libby Jackson from the UK Space Agency explained why it was important to test whether astronauts could grow their own food: 'Should we ever want to send astronauts back to the Moon or on to Mars they will need fresh food. At the moment astronaut food is freeze dried and not very exciting. We would like to have astronauts growing their own food. It would be healthier, psychologically better for them and it would mean that they would not need to take so much with them.'

If you are working with a partner school you could:

- Exchange information about your country's food and farming methods and the challenges faced by farmers in your country
- Share the data and photographs of your cultivation experiments and floating gardens
- Swap recipes that are popular in your local area.

APPENDICES

Appendix A: Salty seeds Activity Sheet 1

Scientists are trying to find ways of increasing food production in desert areas. One way of doing this is by soaking seeds in salted water before sowing them. This process is known as 'stressing' the seeds.

Equipment:

- test tubes and stoppers
- tomato seeds
- water
- table salt
- labels and pens
- beakers
- plant pots
- soil
- ruler.

Instructions:

Prepare the seeds

1. Put 100 ml of water into each of the five test tubes.
2. Put a stopper in one of the test tubes. Write '0 salt' on a label and stick the label on the test tube. This is your control sample.
3. Put 1/8 of a teaspoon of salt into the second test tube. Put a stopper in it. Write '1/8 salt' on a label and stick the label on the test tube. Shake it until all the salt has dissolved.
4. Decide how much salt you are going to put into each of the other three test tubes. Make up each salt solution in a beaker then transfer it to a test tube. Label each test tube with the amount of salt in it. Do not use more than two teaspoons of salt.
5. Put five seeds into each of the five test tubes and leave them to soak for two to twenty four hours.

Sow the seeds and grow the plants

6. Label five plant pots with the amount of salt used in the five test tubes. Put compost in each pot.
7. Sow the five seeds in each pot, making sure that you sow the seeds in the pot with the same label as the test tube.
8. Watch the containers over the next few days and note how many in each pot germinate each day.

Gather the results

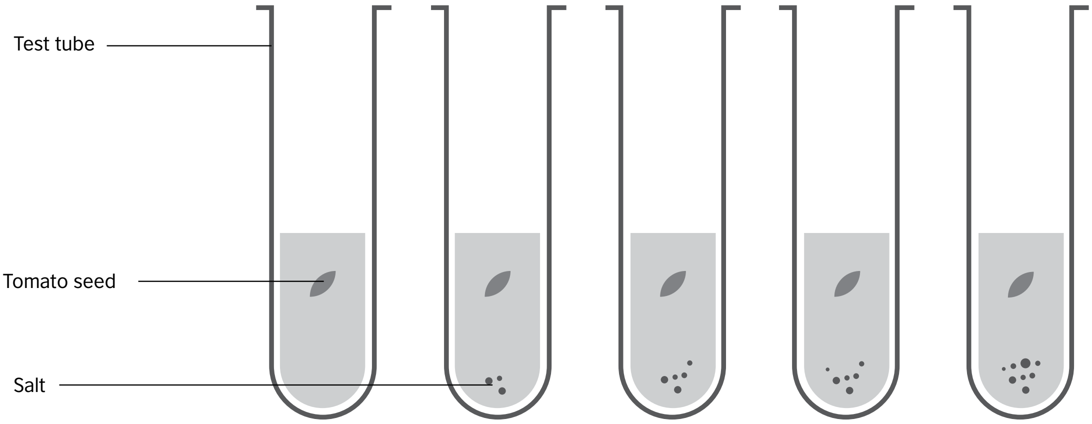
9. When the seedlings have at least two true leaves, take them out of the compost.
10. Record and compare the lengths of their roots.
11. Re-pot the individual seedlings and continue to grow them to compare their growth rates.

Share your results

Compare the results for the amount of salt you chose with the results of other groups.

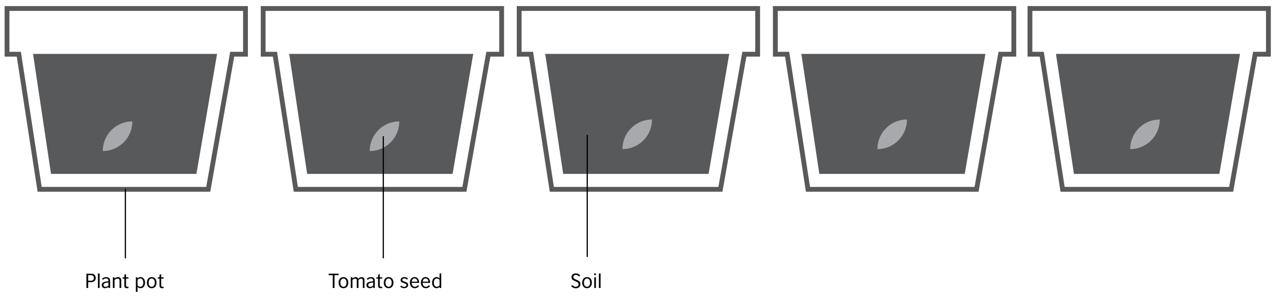
Prepare the seeds

Soak the seeds in solutions with different amounts of salt. Don't forget to label your test tubes.



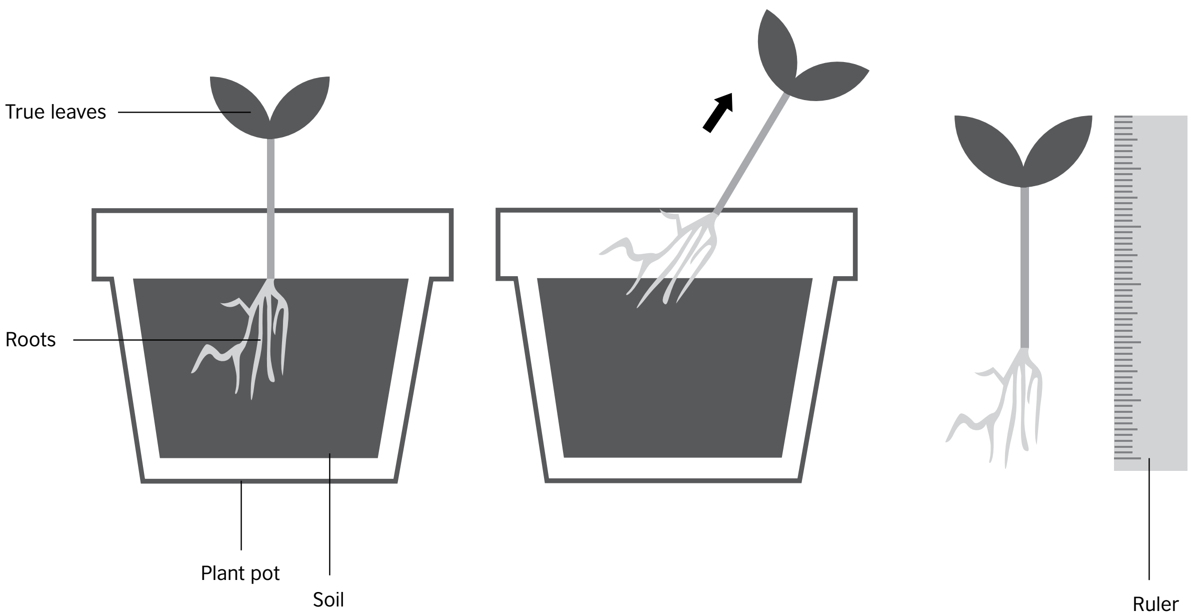
Sow the seeds and grow the plants

Plant the soaked seeds. Don't forget to label your plant pots.



Gather the results

Take the seedlings out of the soil. Record and compare the lengths of their roots.



Appendix B: Floating gardens Activity Sheet 2

Some countries, such as Bangladesh, have a lot of rain at certain times of the year and this causes flooding. More rain is falling now than ever before due to climate change and this has led to an increase in flooding. If land used to grow crops gets flooded on a regular basis, this then contributes to food shortages.

You are going to design a floating garden that can float on water and grow crops on top of it.

Equipment:

You will need construction and modelling equipment, such as:

- plastic drinks bottles
- small food trays
- straws
- string
- card
- yoghurt cartons
- plant material (e.g. vines)
- soil
- lollipop sticks or similar wooden sticks
- scissors, tape and glue.

Instructions:

Design and build a small floating garden. It must float on water in a sink or washing up bowl and be capable of growing seeds on top. Gardens should ideally have a way of being recycled once they are no longer useful.

You will need to think about the following in your design:

- Are the materials readily available?
- How might you dispose of the raft when it can no longer be used? Can it be recycled or used for compost?
- What size should it be and how well does it float?

Extension: Try growing plants on top of your floating garden.

Share your results

Take a picture of your floating gardens and share your results with schools in other countries. Compare your designs and see which was most effective. Why might this have been?

Find out more

Further activities and teacher resources

- Practical Action: http://practicalaction.org/stem
- The Crunch: https://thecrunch.wellcome.ac.uk/
- Edible playgrounds are springing up across the UK to address areas of concern around children's health. Find out more at: http://www.edibleplaygrounds.org and https://www.theguardian.com/teacher-network/2016/apr/05/inside-the-schools-with-edible-playgrounds

The Rocket Science experiment

- https://schoolgardening.rhs.org.uk/Competitions/Rocket-Science-Experiment-Overview
- http://www.stem.org.uk/elibrary/collection/4353/rocket-science
- http://www.bbc.co.uk/news/science-environment-36038508

Further reading

- Royal Society, Genetically modified (GM) plants: questions and answers: https://royalsociety.org/topics-policy/projects/gm-plants/
- Royal Society, Agriculture and food: https://royalsociety.org/topics-policy agriculture-and-food/
- Royal Society, People and the planet report: https://royalsociety.org/topics-policyprojects/people-planet/report/
- The Guardian, UN urges global move to meat and dairy-free diet: http://www.theguardian.com/environment/2010/jun/02/un-report-meat-free-diet
- World data on food: http://www.worldometers.info/
- UN Sustainable Development Goals: https://sustainabledevelopment.un.org/?menu=1300