COMMONWEALTH CLASS

Rising Sea Levels

How can we stay safe as sea levels rise?

In collaboration with

BRITISH COUNCIL

THE ROYAL SOCIETY

The Commonwealth

Introduction

Commonwealth Values: Protecting the environment; Sustainable development; Recognition of the needs of small and vulnerable states

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

Core skills: Critical thinking and problem solving; Digital literacy; Student leadership; Communication and collaboration; Citizenship

Gradual increases in the Earth's temperature have led to mountain glaciers melting and to losses of ice from parts of the Greenland and Arctic ice sheets, all of which contribute to rising sea levels.

As the level of the sea rises, this will ultimately lead to flooding of low-lying coastal areas. Extreme weather events (such as droughts or extreme rainfall) are a further consequence of our changing climate.

One of the UN's Sustainable Development Goals is to take urgent action to combat climate change and its impacts, as well as to make cities and human settlements more inclusive, safe, resilient and sustainable.

Contents

OVERVIEW

Why is it important?

A rise in sea levels can have a negative impact on coastal areas, typically disturbing the local environment through flooding. Populations living along coastlines and closer to the sea will also be more susceptible to extreme weather, like hurricanes, as sea water is pushed on shore.

In poorer areas of the world where there may be less funding available to help people relocate, flooding can lead to greater injury and loss of life. In some Commonwealth countries, such as Kiribati and other low-lying Pacific islands, entire communities may be at risk.

Rising sea levels do not just have an impact on humans, but can also speed up coastal erosion, causing destruction to wildlife habitats. The salinity (the amount of salt content in the water) of coastal areas may also change, potentially changing the type of water from fresh to salty or brackish (a mixture of the two).

This may affect the crops that can be grown in an area and reduce the quantity of available drinking water.

Scientific background to the problem

Since 1900, the Earth's average surface air temperature has increased by about 0.8°C (1.4°F). Most of this increase has taken place since the mid-1970s.

A number of other observations suggest that the planet is getting warmer. For example, scientific evidence points to reductions in Arctic sea ice volumes and rising ocean temperatures. Moreover, many indications from the natural world suggest that global warming is taking place, such as locational shifts of temperature-sensitive species of fish, mammals and insects towards the North and South Poles.

Long-term measurements of tide gauges and recent satellite data also show that global sea levels are rising. Best estimates suggest that over the last 20 years, global sea levels have risen by an average of 3.2 mm per year (0.12 inches per year), and we know that, since 1901, overall sea levels have risen by about 20 cm (8 inches).

There are a number of reasons why a warming climate can cause a rise in sea levels. In order of significance and impact, they are:

- the expansion of water volume as oceans warm
- the melting of mountain glaciers in most regions of the world
- losses from parts of the Greenland and Arctic land-based ice sheets.

When land ice melts it causes sea levels to rise. Melting sea ice, however, does not. Water is unusual in that its volume as a solid is greater than as a liquid. When ice is in water it floats because it is less dense. The volume of water displaced by the ice below the surface is equivalent to the volume of water that makes up the ice. Therefore, when sea ice melts, it takes up the same amount of space in the sea that the ice originally did.

Another adverse effect of climate change is that it can cause an increase in river flooding and rises in ground water level due to changing patterns of rainfall, which can also worsen the effects of coastal flooding (as it may cause the area to flood more quickly).

All major climate changes, including natural ones, are disruptive. In the past, changes to the climate have led to the extinction of many species, population migrations, and pronounced changes to the surface of the land and circulation of ocean currents.

The speed of the current climate change is faster than most of the past events, making it more difficult for human societies and the natural world to adapt. Indeed, if carbon dioxide and other greenhouse gases continue to increase on their current trajectories, it is predicted that sea levels could rise by a further 0.5 to 1m (1.5 to 3 feet) by 2100. That doesn't mean, however, that sea levels won't continue to rise after 2100. They will carry on rising in following centuries as the sea continues to warm and glaciers to retreat.

Science is a continual process of observation, understanding, modelling, testing and prediction. The prediction of a long-term trend in global warming from increasing greenhouse gases is robust and has been confirmed by a growing body of evidence. Nevertheless, as we are still learning about our oceans and seas, it remains an area of active research.

Possible solutions

There are currently two groups of solutions in this area. The first group addresses the underlying problems of climate change, while the other focuses on how we can adapt to them and make settlements more resilient to the consequences of extreme weather, such as flooding.

Many solutions focus on reducing carbon dioxide emissions. The December 2015 Paris Agreement sets out plans for countries to work together on such solutions. Proposed actions include using renewable energy and other low-carbon initiatives, as well as increasing the energy efficiency of homes and businesses, for example, by using energy efficient lights or heating via solar panels instead of wood burning stoves.

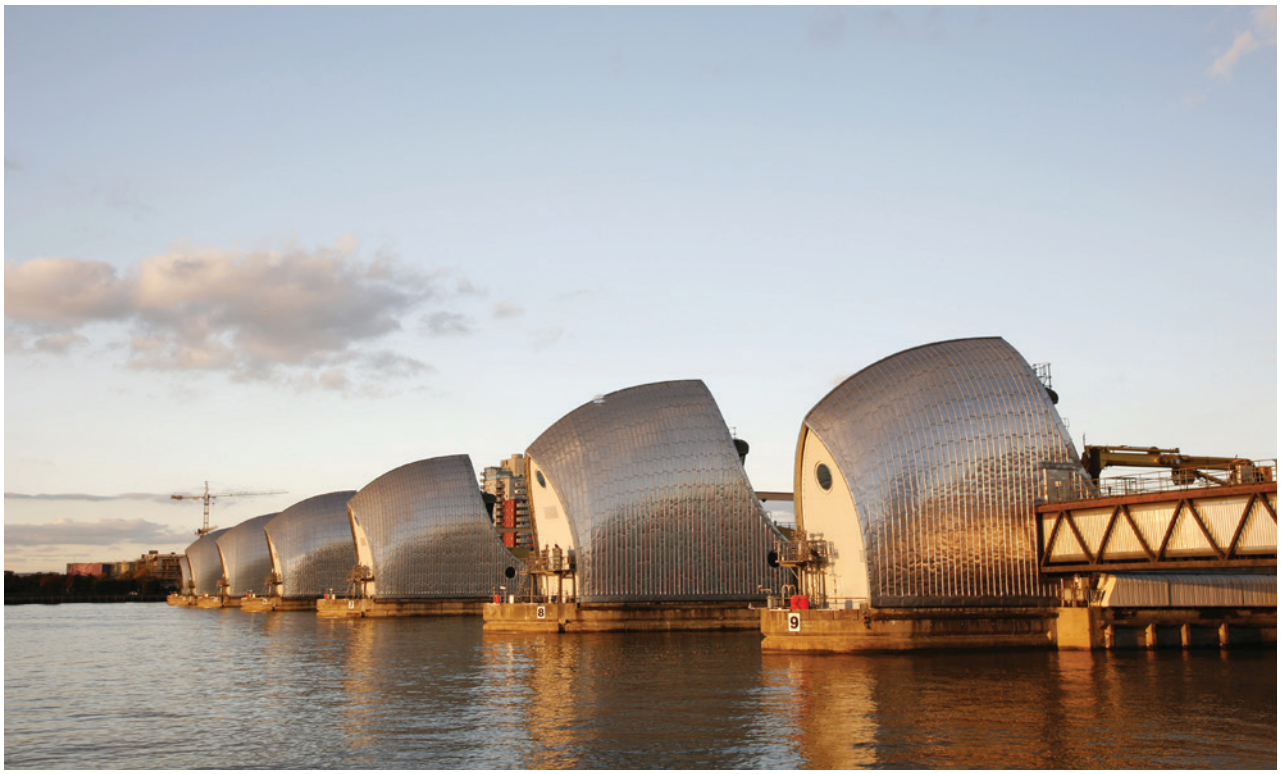
Measures can also be put in place to protect people from the direct impacts of flooding. These include engineered defences, ecosystem management and hybrid solutions.

Engineered defences tend to be more effective when used as immediate protection. For instance, dams and drainage systems can reduce the effects of river flooding by changing the flow of water, while coastal barrages and dykes can act as barriers to coastal flooding. However, these kinds of defences are more costly than ecosystem solutions and can negatively impact on local wildlife.

Ecosystem solutions, on the other hand, such as planting mangroves and maintaining reefs, often have a wide range of additional benefits that engineered defences do not. For instance, they may support local wildlife. Moreover, using natural ecosystems, such as salt marshes or wetlands, can reduce flooding by reducing the energy of waves or by slowing and absorbing the flow of water.

An example of a hybrid solution is what is known as beach and dune nourishment. This technique involves artificially adding sediment (usually sand) to beaches, which can reduce coastal erosion by providing an onshore buffer against extreme high water.

As each of these measures comes with different benefits and drawbacks, combining them could be the way forward. To study the different types of defence systems in more detail, take a look at this interactive chart of defensive options from The Royal Society.



Thames Barrier © Bikeworldtravel, used under license from Shutterstock.com

ACTIVITY 1: HOW MUCH FLOODING OCCURS NEAR YOU?

Overview

This activity asks students to research and investigate how much flooding occurs in their local area and determine whether this is likely to change or increase in the future. Students could research the issues online as well as ask questions. They could also share their findings with schools in other countries.

Activity

Different parts of the world have very different risks of flooding. The level of risk can depend on a number of factors, including the country's typical climate, proximity to rivers or the sea, and the altitude of the land. Even dry countries can be at risk of flooding as a sudden rainstorm can lead to flash flooding if the soil is too dry for the water to drain away.

Ask your students to investigate the risks of flooding occurring near them and then compare this to their country as a whole.

Some questions to investigate and record might include:

- Where is your nearest river, lake or sea?
- Is your area at risk of flooding due to either river flooding, ground water rise or coastal flooding?
- How might an increase in sea level affect flooding in your area?
- What height is your nearest town or village above sea level?
- How much of your country is more than 0.5m above sea level? (This is the minimum estimated rise by 2100 on our current greenhouse gas emissions trajectory.)
- How much precipitation (rain and snow) do you get a year? Is this spread evenly throughout the year or are there times when you get a lot more than at other times?

Extension exercises

1. Arrange a field trip to a nearby water source and measure the height of the water in various weather conditions or at different times of year.
2. If you are in an area where flooding is more common, such as the flood plain of a river, you may also be able to show your class some local flood defences and share the flood plan. You could ask your students to imagine what would happen to your local area and country as a whole if the sea level rose by 0.5m (or more) and draw a map of the areas that might be most at risk.

Share your results

Share and discuss your results with other countries via the teacher forum on Schools Online or through your links with partner schools. You might like to consider what differences there are between your area and other countries and why that might be.

ACTIVITY 2: WHAT HAPPENS WHEN WATER TEMPERATURE RISES?

Overview

In this activity, students will investigate how water expands as it heats up. This has been adapted from a number of resources by the Royal Society of Chemistry.

Learning objectives

Students will be able to understand and determine how much water expands as its temperature increases.

Activity

Global temperatures are on the rise and, because our seas and oceans absorb heat from the higher air temperatures, their own temperatures also increase. As the temperature of an ocean or the sea rises, water gradually expands and a change in volume occurs that is proportional to the change in the water's temperature.

In this activity, your students will be asked to heat up water in a bottle and observe the level rise as the temperature increases. Instructions and a diagram of the experiment can be found in Appendix A – you may want to print and hand this out to your class.

Some points to consider when doing this experiment:

1. You may want to organise your class into small, mixed ability groups.
2. We recommend that you use glass bottles rather than plastic in this experiment, as glass does not expand much with heat. If a plastic bottle is used, there may be an initial drop in the level of the liquid as the plastic bottle expands. However, the level should increase after that.
3. In the water bath for heating, remember to use warm water that is a suitable temperature for students to be handling.
4. Students could observe the result and take photos as a record.
5. Students can also investigate their result more accurately by measuring the exact change in volume with a ruler and comparing the relationship to water temperature.

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

- How will you keep all factors, apart from the temperature, the same?
- How could you measure the changes better?
- What would happen with smaller or greater temperature changes?

Extension exercises

1. Discuss what variables your students could change in this experiment if they wanted to investigate other things. They might, for example, alter the volume of water and how much longer it takes to heat and therefore expand.
2. Ask students to repeat the activity using different liquids or salty water and see if there is any difference.

Students from Rurubao School in Kiribati carrying out this experiment © Royal Society

ACTIVITY 3: DEFEND YOUR TOWN FROM THE SEA

Overview

In this activity, students will design defences that could be constructed around a town or village to protect it against flooding.

Learning objective

There are many settlements around the world that have been built next to the sea in order to take advantage of the benefits of a warmer climate and lower altitude, as well as to provide easy access to fishing and marine transport. However, as sea levels rise, these communities become more vulnerable. For example, when storms occur they are at greater risk of flooding.

In this challenge, students will work in small groups to design, build and test a flood defence to protect a seaside community. Instructions can be found in Appendix B – you may want to print this sheet and hand it out to your students.

You should encourage students to carry out research online first to find out about different types of flood defences before building their own. As a starting point, why not take a look at the 'Find out more' section of this resource?

Activity

Students should focus on engineering based solutions, although they may want to investigate how plants could be used in front of their defence to mimic coastal vegetation. Hybrid systems, such as adding some sediment to their design, could also be included.

The most common engineering solutions to reduce the effects of flooding are coastal barrages and dykes. Coastal barrages are large dam-like structures that absorb the energy of the incoming water, while dykes are embankments made of various materials to prevent the water getting through.

Students should consider the following questions during the activity:

- How readily available are the materials they are planning to use?
- How effective are these materials at keeping out water? They could test for absorbency, strength and water-resistance.
- How might their defences affect the environment?
- Are their defences the right size?
- How well would they stand up to repeat flooding?

To test your students' defences, they could use a hosepipe or another device to direct running water towards their constructions and observe how well they stand up.

Extension exercise

1. Impose a cost on each of the building materials available and set a budget students must stay within. The focus of this activity is to challenge students to produce a system which works but is also cost effective.
2. Set various environmental challenges, such as outlining the width of a beach in the community, or the angle of the ground.
3. Have each group create a 3D model of the coastal location and proposed flood defences.
4. Get students to devise a marketing campaign for their flood defences. Students should consider how they will inform local residents about their new flood defence and how they think it will help protect the community.

Share your results

Share and discuss your results with other countries via the teacher forum on Schools Online or through your links with partner schools. Compare your designs and see which was more effective. Why might this have been?

CROSS-CURRICULAR ACTIVITIES

Be prepared

Sudden flooding can happen in almost any area. Being prepared can help reduce stress in case of a flooding emergency and avoid loss of life. Many areas in different countries have their own plans detailing what to do when floods occur and have regular drills to help them practice their responses.

In the UK, the Environment Agency offers a free flood warning service and gives advice about what to do in a flood emergency. This includes general advice such as:

- move family, pets and valuables to a safe place
- turn off gas, electricity and water supplies if safe to do so
- put flood protection equipment in place
- stay in a safe place with a means of escape
- be ready in case you need to evacuate.

They also suggest that families put together an emergency flood kit of essential items. This might include:

- important documents, such as passports and insurance certificates
- a torch
- a mobile phone to call for help
- waterproof clothing
- a first aid kit
- blankets
- bottled water and non-perishable items of food in case you cannot be rescued for several hours.

In India, floods from monsoon rains often affect village schools near the Brahmaputra River in Assam. Following a particularly devastating flood in 2004, the community planted trees to protect buildings and created raised platforms to store vital possessions. In school, students now practice what to do in a flood emergency including learning first aid.

They are also taught how to make rafts from banana plants, bamboo and tarpaulin, and life jackets from bottles and jerry cans. The village elders have also been showing students how to spot warning signs that a flood is coming by looking at cloud patterns and watching out for unusual behaviour in animals and birds.

Why not ask your students to find out whether your local area has an emergency flood plan in place? Encourage them to create leaflets or posters advising others in their community what to do if a flood should happen in order to stay safe.

CROSS-CURRICULAR ACTIVITIES

Flood fact files

Why are some places more likely to flood than others? Discuss this with your class and consider how human actions might contribute to more frequent or severe flooding:

1. Divide your class into groups and ask each group to carry out research into a particular country or area that has been severely affected by floods in recent years. Suggested reading can be found in the 'Find out more' section of this resource.
2. Mark the locations chosen on maps and, if possible, view images of the regions on Google Earth.
3. Ask each group to find out about the causes of the floods in this location and the effect it has had on people's lives and the environment. Have any precautions been taken to prevent this from happening again?

You could encourage each group to create a fact file with maps and images detailing the location, date, causes, effects and responses and then get them to report their findings back to the rest of the class.

Underwater meetings

The Maldives is at serious risk of being submerged by the sea as a result of rising sea levels. Houses are being destroyed, land lost, fresh water polluted, and tourism and fishing industries are also being affected.

In 2009, the President put on scuba diving equipment and held a cabinet meeting underwater to highlight the threat of climate change to low-lying nations!

Ask your students whether they think this was an effective way to raise awareness of the issue. Can they think of any other creative ways and campaign ideas that could draw attention to the global problems caused by rising sea levels around the world?

If you are working with a partner school you could:

- Share the results of your research and experiments by reading each other's flood fact files
- Exchange your flood prevention posters, leaflets and ideas to raise awareness of the effects of rising sea levels.

APPENDICES

Appendix A: What happens when water temperature rises? Activity sheet 1

Global temperature increases are causing sea levels to rise. A large part of this increase is due to how water expands as the temperature rises. In this activity, you will investigate how much water expands as it warms up.

Equipment:

- bottle (ideally glass)
- water (warm and cold)
- straw
- sticky tack (e.g. Blu-Tack or plasticine)
- food colouring (to make it easier to see the water in the bottle)
- container larger than the bottle (e.g. an ice cream tub)
- marker pen
- thermometer (optional)
- ruler.

Instructions:

1. Fill the bottle with cold water and add food colouring to make it easier to see the water.
2. Put the straw in the bottle and secure it in place with the sticky tack or plasticine. Ensure that a significant amount of the straw is sticking out of the top and that the sticky tack has made the opening of the bottle air tight.
3. Place the bottle inside the larger container.
4. Mark the current position of the water on the straw using the marker pen.
5. Add the warm water to the larger container.
6. Observe the level of water in the straw over five minutes and watch what happens.

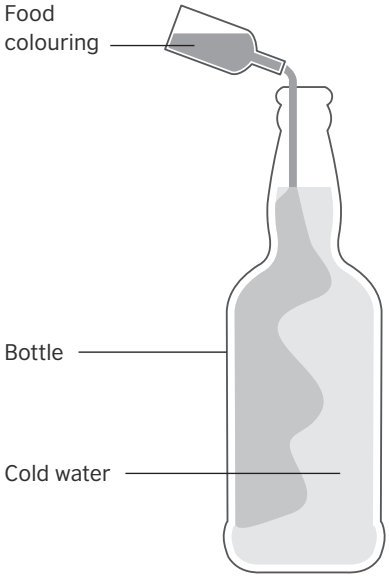
Extension exercise:

1. Make a mark along your straw at every half cm.
2. Measure the temperature of the water inside the bottle by putting a thermometer in next to the straw.
3. Measure the water level in the straw and the temperature of the water every 10 seconds.
4. Plot a graph of your results.
5. If you have worked out the relationship, you can use this to make your own thermometer!

Share your results

Share and discuss your results with other countries via the teacher forum on Schools Online or through your links with partner schools. You can take a photo to show how the level of water changes over time or, if it is available to you, use time lapse software to create a short video to share with your partner school.

Step 1



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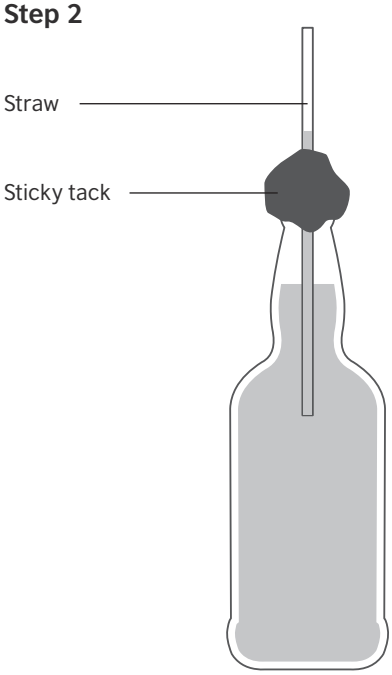

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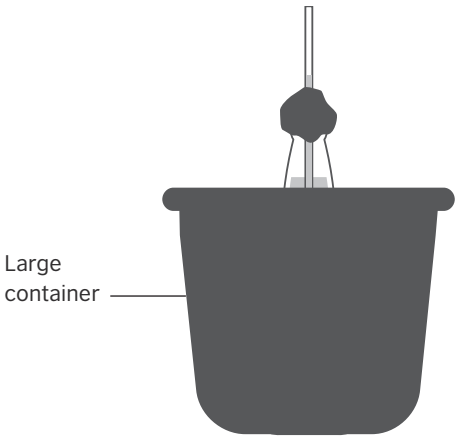

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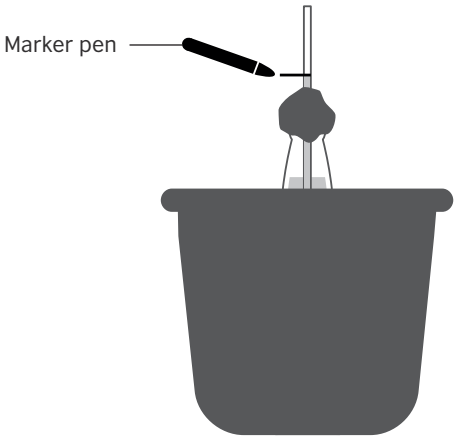

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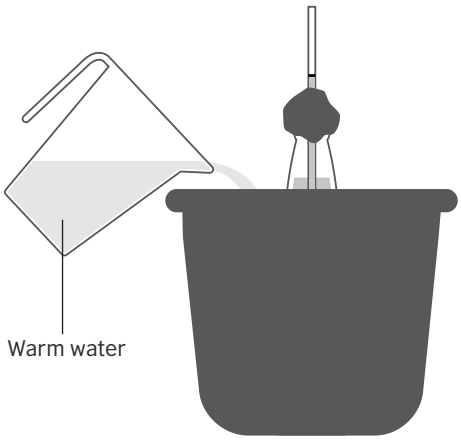

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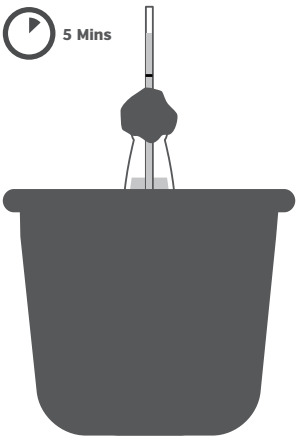

Appendix B: Defend your town from the sea Activity sheet 2

You are going to design, build and test a flood defence to protect a seaside community. You will need to do some research to get ideas about the different types of flood defences that are available.

Equipment:

The following construction and modelling equipment may be useful to use:

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

Instructions:

Based on your research into different types of flood defence structures, design and build your own flood defence. You may want to think about the following questions during your planning:

- How readily available are the materials that you are planning to use?
- How effective are these materials going to be at keeping out water? You may need to test for absorbency, strength and water-resistance.
- How might your defences affect the local environment?
- Are your defences the right size?
- Would your defences stand up to repeat flooding?

Extension exercise:

Using the hosepipe or another source of running water, see how many times your design stands up to flooding before finally letting water in.

Find out more

Further activities and teacher resources

- Royal Society, An introduction to climate change in 60 seconds: www.youtube.com/watch?v=n4e5UPu1co0
- Royal Society, Chart of defensive options: www.royalsociety.org/topics-policy/projects/resilience-extreme-weather/option-plots/
- Practical Action, Beat the Flood challenge: www.practicalaction.org/beattheflood
- Engage, Sinking Island activity: www.engagingscience.eu/en/2014/07/30/sinking-island/

Further reading

- Royal Society, Climate change: evidence and causes: www.royalsociety.org/topics-policy/projects/climate-evidence-causes/
- Royal Society, Resilience to extreme weather: www.royalsociety.org/topics-policy/projects/resilience-extreme-weather/
- Royal Society, Resilience city: www.youtube.com/watch?v=ew-kscKEWIY
- UN Sustainable Development Goals: https://sustainabledevelopment.un.org/
- Geographical Association, Flooding case studies: www.geography.org.uk/resources/flooding/
- BBC, Maldives cabinet makes a splash: http://news.bbc.co.uk/1/hi/8311838.stm
- BBC, iWonder, Why are UK floods on the rise?: www.bbc.co.uk/guides/zcdqxsg