Cambridge Assessment International Education

Scheme of Work

Cambridge International AS Level Environmental Management 8291

For examination from 2022

Cambridge Pathway

Version 2

Contents

Introduction

This scheme of work has been designed to support you in your teaching and lesson planning. Making full use of this scheme of work will help you to improve both your teaching and your learners' potential. It is important to have a scheme of work in place in order for you to guarantee that the syllabus is covered fully. You can choose what approach to take and you know the nature of your institution and the levels of ability of your learners. What follows is just one possible approach you could take and you should always check the syllabus for the content of your course.

Suggestions for independent study **(I)** and formative assessment **(F)** are also included. Opportunities for differentiation are indicated as **Extension activities**; there is the potential for differentiation by resource, grouping, expected level of outcome, and degree of support by teacher, throughout the scheme of work. Timings for activities and feedback are left to the judgement of the teacher, according to the level of the learners and size of the class. Length of time allocated to a task is another possible area for differentiation.

Key concepts

The key concepts are highlighted as a separate item in the new syllabus. Reference to the key concepts is made throughout the scheme of work using the key shown below:

Key Concept 1 (KC1) – Sustainability

The use and management of resources to meet the needs of the present global population without compromising the ability of future generations to meet their own needs is a goal underlying all environmental management strategies.

Key Concept 2 (KC2) – Interactions

The interactions within and between the living and physical environments shape all environments on Earth. Environmental management strategies aim to protect and maintain this balance.

Key Concept 3 (KC3) – Pressure on the environment

Human activities create challenges and put pressure on the local and global environment. Diverse influences may be environmental, economic, social, political or historical and need to be managed to protect the environment.

Key Concept 4 (KC4) – Global dimensions

Actions taken at a local level may have local, regional and global environmental impacts which must be considered. Consequences may be positive or negative, may not take effect immediately, and may not be easily detected.

Key Concept 5 (KC5) – Research methodology

Scientific investigations and research are fundamental to understanding an environment and developing environmental management strategies. Using the appropriate methodology to answer a specific question means the results are more likely to be reliable.

Guided learning hours

Guided learning hours give an indication of the amount of contact time teachers need to have with learners to deliver a particular course. Our syllabuses are designed around 180 hours for Cambridge International AS Level. The number of hours may vary depending on local practice and your learners' previous experience of the subject. The table below gives some guidance about how many hours are recommended for each topic.

Topic	Suggested teaching time (hours / % of the course)	Suggested teaching order
1. Introduction to environmental management	It is recommended that this unit should take about 25 hours/ 14% of the course.	1.1, 1.2, 1.3, 1.4, 1.5, 1.6
2. Environmental research and data collection	It is recommended that this unit should take about 30 hours/ 17% of the course.	2.1, 2.2, 2.3, 2.4, 2.5
3. Managing human population	It is recommended that this unit should take about 20 hours/ 11% of the course.	3.1, 3.2, 3.3
4. Managing ecosystems and biodiversity	It is recommended that this unit should take about 25 hours/ 14% of the course.	4.1, 4.2, 4.3
5. Managing resources	It is recommended that this unit should take about 25 hours/ 14% of the course.	5.1, 5.2, 5.3
6. Managing water supplies	It is recommended that this unit should take about 10 hours/ 5% of the course.	6.1
7. Managing the atmosphere	It is recommended that this unit should take about 20 hours/ 11% of the course.	7.1, 7.2, 7.3, 7.4
8. Managing climate change	It is recommended that this unit should take about 25 hours/ 14% of the course.	8.1, 8.2, 8.3

School Support Hub

School Support Hub is a secure online resource bank and community forum for Cambridge teachers, where you can download specimen and past question papers, mark schemes and other teaching and learning resources. We also offer online and face-to-face training; details of forthcoming training opportunities are posted online. This scheme of work is available as PDF and an editable version in Microsoft Word format; both are available on the School Support Hub. If you are unable to use Microsoft Word you can download Open Office free of charge from www.openoffice.org

Websites

This scheme of work includes website links providing direct access to internet resources. Cambridge Assessment International Education is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

The website pages referenced in this scheme of work were selected when the scheme of work was produced. Other aspects of the sites were not checked and only the particular resources are recommended.

How to get the most out of this scheme of work – integrating syllabus content, skills and teaching strategies

We have written this scheme of work for the Cambridge International AS Level Marine Science 8291 syllabus and it provides some ideas and suggestions of how to cover the content of the syllabus. We have designed the following features to help guide you through your course.

Learning objectives help your learners by making clear the knowledge they are trying to build. Pass these on to your learners by expressing them as 'We are learning to / about…'.

Suggested teaching activities give you lots of ideas about how you can present learners with new information without teacher talk or videos. Try more active methods which get your learners motivated and practising new skills.

Extension activities provide your more able learners with further challenge beyond the basic content of the course. Innovation and independent learning are the basis of these activities.

Independent study (I) gives your learners the opportunity to develop their own ideas and understanding with direct input from you.

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
		https://pbiol.rsb.org.uk/environment/distribution-of-organisms/observing-patterns-in-the-distribution-of-a-simple plant. *Pleurococcus* is a widespread alga whose distribution depends on exposure to light, wind and water. If th is not native to your home country, other species of plant can be investigated using a similar method and using mini-quadrat. **(I)** **Extension activity**: Give more-confident learners some autonomy during practical activities: provide them with list of equipment, from which they choose the most relevant items, or encourage them to consider what range/intervals to use. This can develop higher-order thinking skills in decision-making.
2.5 The use of technology in data collection and analysis **KC5**	2.5.1 State that there are methods of data collection that include the use of technology 2.5.2 Describe what	Plan a class debate. The 'motion' must be a controversial statement, rather than a question, to prompt deeper thought among learners. For example, ask learners to evaluate a statement such as 'The monitoring of human behaviour is crucial for the management of the environment'. Provide a range of sources of information on the of geospatial systems, satellite sensors, radio tracking, computer modelling and crowd sourcing. It may be usef to include an initial 'think, pair, share' opportunity to help learners form an opinion before the debate begins. **(I)** After introducing learners to the benefits and limitations of 'big data' (which should include the amount and type of , the speed at which new data is generated, the trustworthiness of the data, and ways the data can be a competitive learning game called 'bingo.' Divide the class into two groups and identify a volunteer in to act as the teacher. Inform learners that there will be two games of 'bingo' on either side of the class. , there is a competition to identify who can cross out their words the soonest. But also, there is a between the two groups – how many bingo 'rounds' can happen within the time permitted? Provide r with a grid of nine squares. Then provide 10–20 key terms on the board, which focus on 'big data'. lect nine words at random to fill in the grid. The volunteers then f the 20 key terms – in random order – and the first learner to und. **(F)**
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

Formative assessment (F) is ongoing assessment which informs you about the progress of your learners. Don't forget to leave time to review what your learners have learnt: you could try question and answer, tests, quizzes, 'mind maps', or 'concept maps'. These kinds of activities can be found in the

Past papers, specimen papers and **mark schemes** are available for you to download at: www.cambridgeinternational.org/support

Using these resources with your learners allows you to check their progress and give them confidence and understanding.

1. Introduction to environmental management

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
1.1 Continents and oceans **KC4**	identify and name the world's continents and major oceans	Use an interactive globe website that does not label the oceans or continents, such as: http://earth.nullschool.net Host a discussion to find out learners' existing knowledge. Learners identify each continent (Africa, Antarctica, Asia, Europe, North America, South America and Oceania) and ocean (Atlantic Ocean, Pacific Ocean, Indian Ocean, Arctic Ocean and Southern Ocean). Less confident learners or smaller groups could look at an actual globe to identify these. Compare the continents to the oceans – identify that oceans are all connected to each other (forming a World Ocean) but the continents are not all connected to each other. Compare the approximate coverage of the Earth's surface – oceans make up more than 70% of the surface compared to land, which is less than 30%. **(F)** **Extension activity:** set learners a research task to find out facts and figures related to the oceans. Some useful links that have good sources of images and further information are: www.nationalgeographic.com/environment/oceans/ www.seaaroundus.org/ **(I)**
1.2 Country classification by income level **KC3, KC4**	describe the income groups the World Bank uses to classify countries	To prepare for this lesson, ask learners to carry out research to investigate the key terms that they will encounter in this lesson. This will strengthen discussion at the beginning of the lesson. **(F)** Learners discuss the types of economic activity in countries. Collate ideas together as a class and use this to introduce the concept of gross national income (formerly gross national product). For more information, see: http://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries **Extension activity:** learners prepare a factsheet on LICs, MICs and HICs. The audience for this work is next year's class, and the purpose of the factsheet is to give them an overview of the key differences between these countries. **(I)**
1.3 Sustainability **KC1**	define the term sustainability as the ability to meet the needs of the present without compromising the ability of future	Learners individually try to define 'sustainability' and to give examples of resources that could be used sustainably. They note down their own ideas then share their ideas in pairs or small groups before discussing as a whole class to identify a common understanding of the term and address any misconceptions. Discuss resources and identify examples of good practice in sustainable management, and poor practice, identifying problems this is causing or is likely to cause. Summarise why it is important to try and use all resources sustainably.

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	generations to meet their own needs understand the need for the sustainable management of resources	Learners write a short online newspaper column on the effects of not living sustainably. Their piece should be informative and contain a range of weblinks for interested readers. **(I)** **Extension activity:** learners research sustainable agriculture. The USDA's website gives an effective overview of the subject, providing some history on agricultural practices and a range of links to other resources including economic and social impacts: www.nal.usda.gov/main/ (search for 'sustainable agriculture')
1.4 The water cycle **KC2**	describe the water cycle interpret and draw diagrams representing the water cycle	Demonstrate changes in state for water by melting ice and boiling water. After boiling some water show that evaporation still occurs below the boiling point by observing steam rising from hot water. Hold a glass beaker (or similar) that has been in a fridge over the hot water and show condensation of steam on the cold surface. Discuss evaporation at cooler temperatures and the role of winds evaporating puddles at cool temperatures to emphasise that evaporation takes place even at cool temperatures. Learners relate these changes in state (solid, liquid and gas/vapour) to water on Earth and identify where these changes occur with water on Earth. Learners create their own water cycle using these ideas, then compare their cycles and add additional stages as necessary. Learners then create their own posters to illustrate the processes in the water cycle, labelling each process clearly. **(F)** To illustrate the water cycle, show learners an animation. This must cover all aspects, including condensation, precipitation, interception, infiltration, surface run-off, through-flow, ground water flow, transpiration, and evaporation. Search for 'water cycle animation' to give several good examples, such as: http://pmm.nasa.gov/education/videos/water-cycle-animation The water cycle is quite simple, so the main aim is to get learners familiar with it by practice. After you have shown learners an animation, give out blank water cycle diagrams and ask learners to label them based on what they have just seen. This type of exercise can be easily differentiated, for example, supply the relevant words to learners who need support with this topic and not to others. **(I)** **Extension activity:** learners could carry out the activity in the following link at home to reinforce their learning: http://thewaterproject.org/resources/lesson-plans/create-a-mini-water-cycle
1.5 The structure and composition of the atmosphere **KC2**	state the major components of the Earth's atmosphere describe the structure of the Earth's atmosphere	To introduce the atmosphere, show learners a clip of Felix Baumgartner's parachute jump from the stratosphere (search on the internet for 'Felix Baumgartner stratosphere jump' and select videos). Outline how the structure of the Earth's atmosphere is divided into four primary layers: troposphere, stratosphere, mesosphere, and thermosphere.

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	as divided into four primary layers state that the ozone layer is located within the stratosphere describe the ozone layer and outline its role in absorbing ultraviolet radiation outline the natural greenhouse effect that maintains the Earth's ambient temperature	Learners prepare a poster to show the changing temperatures with altitude and the names of each layer, including the position of the ozone layer. **(I)** Learners each draw a pie chart to represent the names and proportions of gases in the atmosphere – this will highlight any misconceptions about the composition of the atmosphere. Question learners about why they have included particular gases or estimated the composition they have drawn, to understand why any misconceptions have arisen. Make sure that the gases nitrogen, oxygen, carbon dioxide, argon, and water vapour are included in the discussion. **(F)** Show learners a graph of changing atmospheric temperature with altitude, such as: http://climate.ncsu.edu/edu/Structure Identify the trends of decreasing and increasing temperatures and how these are linked to changes in the layers of the atmosphere. Make sure the troposphere, stratosphere, mesosphere and thermosphere are included in the discussion. Show a graph of ozone concentration in the atmosphere, such as: http://ozonewatch.gsfc.nasa.gov/facts/SH.html. Point out that although the concentration of ozone peaks in the stratosphere it is still a very low concentration compared to other gases (approx. 8 parts per million) but that this acts as an important 'filter' in absorbing ultraviolet (UV) radiation, similar to the way a thin layer of sun-cream on the skin acts as an important barrier against UV for the skin. Explain that UV radiation (shortwave radiation) passes through the Earth's atmosphere and is absorbed by the Earth's surface. Ask learners what happens to the temperature in a car or a greenhouse on a sunny day – most should recognise that the temperature will increase, and in summer this can result in significantly higher temperatures. Draw links between this analogy and why this happens, and compare to the Earth's atmosphere. Ensure that you refer to shortwave radiation, longwave radiation, absorption, reflection and re-emission in your description. **Extension activity:** as a useful review activity, ask learners to summarise the following information in one or two paragraphs: http://edu.rsc.org/resources/the-greenhouse-effect-and-global-warming/767.article
1.6 Ecosystems **KC2, KC3, KC4**	define the terms biome, ecosystem, population, community, habitat and niche	Introduce ecosystems with a simple game such as: http://illinois.pbslearningmedia.org/ (search for 'feed the dingo'). Learners (or the whole group, led by you) create a community of organisms. Use the game and the introduction of different species to explain the terms and discuss components of an ecosystem. Abiotic factors (temperature, humidity, water, oxygen, salinity, light, pH) are present before any organisms are added, biotic factors (producers, consumers (primary, secondary and tertiary) and decomposers)

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	state the biotic and abiotic components of an ecosystem describe how biotic factors affect the number and the diversity of organisms found within an ecosystem outline examples of biotic interactions define photosynthesis as the process by which plants synthesise glucose using carbon dioxide, water and energy from sunlight state the word and chemical equations for photosynthesis state that chlorophyll captures light energy for photosynthesis explain that the availability of water, concentration of carbon dioxide and the availability of light are limiting factors in the rate of photosynthesis	become important as new species are added. Discuss the impact of adding different species over each 'day' and explain in terms of biotic interactions. Discuss differences between the terms 'biome', 'ecosystem' and 'habitat', particularly in terms of the biotic and abiotic factors and the cycling of minerals and energy. To thoroughly consolidate key terms, provide each learner with a piece of paper divided in half. On one half, there is a key term, and on the other, there is a definition. However, the definition is not for that key term. Examples of terms to include are *biome, ecosystem, population, community, habitat* and *niche*, and so on. Learners move around the room to find the learner who has the paper with the definition of their key word, and also another who has a key word for their definition. Ultimately, learners will arrange themselves in a long line so that the key terms and definitions are aligned next to each other. **(I)** Learners, or small groups of learners, each choose a different habitat and produce a poster to illustrate their different ecosystems. In their work, they must describe both the biotic and abiotic factors of the chosen ecosystem and how the interactions affect the diversity of organisms present. **(I)** Introduce the topic of photosynthesis by using a video clip such as: www.nasa.gov/content/goddard/seeing-photosynthesis-from-space-nasa-scientists-use-satellites-to-measure-plant-health/ Use this to prompt a discussion about the role of photosynthesis. Write down both word and symbol equations – include 'chlorophyll' on the arrow and discuss the role of chlorophyll in *converting* light energy into chemical energy used to produce the glucose. **Resource Plus** Carry out the *Investigating photosynthesis* experiment available for Cambridge IGCSE Biology 0610, referring to the Teaching Pack for lesson plans and resources. This is a simple experiment of an aquatic plant carrying out photosynthesis with an electric lamp, to show bubbles of oxygen being produced. Show learners some unusual food chains, for example, those involving dinosaurs or organisms that inhabit Antarctica or a deep ocean trench. Ask learners to infer the feeding relationships (energy flow) between different organisms in the picture and add annotations. You should write down the most common words on the board in the form of a 'word board.' These will include the terms *producer*, *consumer*, *herbivore*, *carnivore* and *decomposer*. Some learners may have used the term 'niche.' Leave these words on the board for the whole lesson. Can learners use all of these words in their annotations? Walk around the room and listen to learners as they talk and reinforce the idea that, whatever the food chain, the Sun is the principal source of energy input to most biological systems. **(F)** Learners work in small groups to consider the flow of energy through food chains and webs in a local ecosystem by planning a visual display to illustrate all key terms listed in the syllabus. After this preparation time, give learners just 2 minutes to draw their poster. This is an exciting activity in which all learners should have decided

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	explain how photosynthesis on land and in the oceans is a vital part of the carbon cycle and has an important effect on carbon dioxide concentrations in the atmosphere by forming carbon stores define the terms producer, primary consumer, secondary consumer, tertiary consumer and decomposer define trophic levels as feeding levels within food chains identify organisms at different feeding levels in a food chain or food web state that energy is transferred between organisms in a food chain, starting with a producer explain how energy is lost in food chains	which part of the poster they are responsible for producing during this frantic period. When this time is up, learners mount their work on the wall and you score them out of 10, providing formative assessment to inform learners of how they could improve. **(I)** Learners work with a partner on a computer or tablet to show a food web, ideally with animations. To help them with this task, provide success criteria very clearly at the start, including labelling each organism to show which trophic level it is at, or whether it is a producer or a primary, secondary or tertiary consumer. Discuss how organisms release the energy they obtain from their nutrition through the process of respiration. Write the word and symbol equations and discuss how this is the reverse of photosynthesis. Explain that this process is aerobic respiration and that other types of anaerobic respiration also occur (not requiring oxygen) which is beyond this syllabus. Discuss the roles of photosynthesis and respiration and that changes in the rate of either can affect the amount of carbon dioxide in the atmosphere. Follow on with discussions about deforestation and other environmental changes including the impact of burning fossil fuels (the chemical reaction for combustion is very similar to that for respiration) – discuss how fossil fuels formed over millions of years from the remains of living organisms, and how this creates carbon stores which humans are now releasing. Use the links available at: www.carbonbrief.org/ [includes a link to an interesting article arguing against a claim that the use of fossil fuels is decreasing] Host a class discussion. Describe the role of producers in keeping the amount of carbon dioxide in the atmosphere in balance. Revisit the first learning objective for this topic relating to Earth's surface being 70% water and only 30% land to emphasise the importance of producers in the oceans as well as those on land. Challenge learners to write a brief summary of this class discussion. Host a role play that requires learners to act as carbon atoms in a demonstration of the carbon cycle. Choose and label 4–5 areas in the room to represent the difference places that a carbon atom can be at any one time – e.g. fossil fuel deposit, the air, a plant, a fungus, and an animal. Instruct learners to move between the different groups until the atoms are circulating between the different places. Ask the 'carbon atom' what it thinks it is doing or what is happening to it; highlight any instances of incorrect movements (e.g. from the animal to a plant, at least directly). Ask learners to critique this exercise, to identify aspects of the role play that did not represent the actual cycle. Can they suggest improvements? **(I)** In a technique called 'jigsaw grouping,' learners in small groups research one particular part of the carbon cycle to become 'experts'. Learners then break up into rearranged groups to 'teach' how this occurs to their peers. This means that each learner is responsible for another's learning and provides them with alternative views and strategies. Finally, encourage learners to consider how all of their 'parts' can be arranged into one story – the cycle. Emphasise the long-term nature of some of these changes (especially fossil fuel formation).

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	construct simple food chains and food webs define aerobic respiration as the chemical reactions in cells that break down glucose molecules and release energy, carbon dioxide and water state the word and chemical equation for aerobic respiration describe the carbon cycle interpret and draw diagrams representing the carbon cycle	Show learners animations of the carbon cycle, to allow them to compare their work: www.sumanasinc.com/webcontent/animations/content/globalcarboncycle.html **(I)** Learners read the following interesting text on the carbon cycle to extend and support their understanding: https://earthobservatory.nasa.gov/features/CarbonCycle **(I)** Prepare three or four past paper questions, ideally of multiple-choice or short-answer questions, which learners complete and pass to you as they leave the room. This 'exit card' technique enables you to judge whether you need to reinforce the content of this lesson in the next lesson. **(F)** **Extension activity:** challenge learners to write a number of examination-style questions for this topic, complete with mark schemes. You could suggest to them that the very best questions will be used in a subsequent lesson as a formative assessment.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

2. Environmental research and data collection

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
2.1 The scientific method **KC5**	describe how the scientific method involves the interplay between observations and the formation, testing and evaluation of hypotheses formulate hypotheses based on observations or experimental data design investigations in which variables are controlled and quantitative results are collected explain the terms dependent and independent variable and identify each type in a given experiment interpret data to determine whether they support or refute the hypothesis being tested explain how limitations in the measurement of data	Before the lesson, give learners a series of questions on the scientific method for them to research using textbooks and the internet. The intention of these questions is to trigger interest and enrich the dialogue at the start of this lesson. An example could be, 'What is the difference between a hypothesis, an observation and data?' Alternatively, construct a short multiple-choice quiz for which learners 'vote' for their choice of answer by holding up their hand when you call out 'A,' 'B,' 'C' or 'D.' You could use this activity to formatively assess learners before they begin. **(F)** Display a list of key terms related to the scientific method that learners must know in the form of a 'word board'. As you call out a word, ask for a show of hands to see who has heard of it, then ask learners to keep their hand raised if they would like to link at least two of the words together. **(F)** Provide a range of opportunities for learners to carry out investigative work. Alternatively, remind learners of the photosynthesis investigation that they carried out. Discuss how, in this example, the distance of the lamp was the independent variable (the factor that is changed), and the number of bubbles produced by the aquatic plant per minute was the dependent variable (the factor that is measured). Introduce the idea of a hypothesis – an idea that can be tested by investigation and observation, followed by the need to control (sometimes called standardised) factors that are not the subject of a hypothesis. Challenge learners to identify these components in other investigations that you or they think of. **(F)** Many learners benefit from a visual way of describing differences. Learners work in groups to prepare Venn diagrams or tables on posters that visually compare the features of the scientific method, e.g. independent versus dependent variable, hypothesis versus prediction, and observation versus conclusion. These can be prepared on a large piece of paper or card with a range of materials. Then hold a 'marketplace' activity in which one member of each group stands by their poster and offers an explanation to other groups as they move around the room. **(I)** Provide a sheet of 10–15 key terms that learners will meet in this topic. Learners cut them out and arrange them into as many groups of 2–3 as they can, with all words in each group similar in some way. Examples could be 'dependent, variable, measure' (low demand) or 'control, constant, valid' (high demand). Move around the room as learners make their choices to ask why they have made these decisions. **(I)** Under a strict time limit such as 10–15 minutes, learners work in small groups to prepare a piece of work on this topic. This could include, for example, a poster or factsheet to show how limitations in the measurement of data lead to uncertainty in the results, or how a hypothesis that is consistently supported by investigation and observation can become a theory. Note that climate change is a particularly useful context for this exercise, because there are lots of datasets available and opportunities to consider the integrity of data and the influence of groups and organisations. Next, allow leaners to walk around the class and speak with at least three other

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	lead to uncertainty in the results demonstrate an understanding that a hypothesis that is consistently supported by investigation and observation can become a theory	learners, to compare and refine their work. Learners must classify their own errors, to identify their own strengths and weaknesses. This will allow learners to build confidence by interacting with others to see that 'everybody makes mistakes' and develop a growth mindset. **(I)** Provide learners with five examples (that you could write) of learners' responses to an extended-answer question on the scientific method. In small groups, learners choose whether some are better examples than others. They rank the work in terms of quality and then report back to the class. It will be helpful for you to decide beforehand what the model of progression for the work should look like. **(F)** **Extension activity:** more confident learners could host a part of a lesson within this topic. Give learner(s) a copy of the materials you would otherwise present, and, with guidance, help them to deliver the lesson part. This could, for example, be a case study of an environmental management investigation of their choosing. The investigation should include a research aim, methodology, how the data would be collected and how this data could be processed.
2.2 Environmental research in the context of climate change **KC2, KC5**	define the terms reliable and bias and explain their significance to environmental investigations using examples related to climate change, outline how historical data have developed using examples related to climate change, outline how bias has led to the misuse of scientific data using examples related to climate change, outline how unreliable data has led to false reporting	Guide learners, through a class discussion, to understand that historical data have developed. This should include reference to the development of scientific theory, which they studied previously, and advances in technology. In the discussion, help learners to understand that reasons include a limited amount of data, a lack of public and media knowledge, and an uncertainty in climate models. Challenge learners to write down a series of five concluding statements to summarise this discussion. Use a system of 'jigsaw' grouping to focus on independent work and examination technique. Set up a task in which small groups of learners become experts on one past paper question, focusing on one concept listed in the syllabus related to the delivery and communication of scientific data focused on climate change. Concepts include the terms reliable and bias, unreliable data, and false reporting of scientific conclusions. They then deliver their findings to others in small groups. Learners then break up into rearranged groups to 'teach' how to answer it to their peers. This means that each learner is responsible for another's learning, and provides them with alternative views and strategies to answer past paper questions. Circulate during the activity to highlight good ideas to encourage and motivate learners. **(I)** Present a series of questions on the board. Give learners 5 minutes to write down all the key terms they feel are relevant in their answers. Then model how to incorporate relevant key words into clear, exam-style answers. **(F)** Learners brainstorm and list what they know about this subtopic, having studied it. After a few minutes, pairs join into groups of four and then groups of eight to discuss this further and come up with an agreed list of points. One or two learners from each group then write the group's ideas on the class board to form a 'mind map.' **(F)** **Extension activity:** put learners into pairs: one learner who has found this topic difficult with another who has progressed without significant difficulty. They can discuss and investigate the topic further together. The learner who has a stronger understanding of the topic will be able to consolidate their understanding by describing and

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	of scientific conclusions	explaining to their peer. This will, in turn, support the other learner to build their skills and knowledge in the topic through the discussion. This exercise can increase the confidence of both learners. **(I)**
2.3 Collection of environmental data **KC2, KC5**	state that sampling strategies are used to collect representative data explain how random sampling and systematic sampling strategies aim to ensure samples are well distributed with a low risk of bias describe and explain factors influencing the suitability of random sampling or systematic sampling strategies for different studies evaluate the choice of random and systematic sampling strategies in familiar and unfamiliar contexts	Model the process of random sampling by holding up one page from a large newspaper that contains words of different-sized fonts, images and blank areas. Explain that this simulates a field or area of forest, which has no more than 26 species living there, each species represented by a letter of the alphabet. Make the analogy clear by showing a series of images of a region of coastline, grassland or forest from their local area, or satellite images from Google Maps. Learners discuss a method to determine how many different species and how many individuals of each species there are. Discuss a suitable strategy, highlighting the importance of having to sample; taking a number of samples (the sample may be unrepresentative, e.g. a photograph represents a bare rock, so no individuals would be found); choosing the correct size/area of each sample; random sampling (biased sampling – any measurements can only apply to the sample, not to the whole area). Hold a debate to consider which type of sampling, random or systematic, is most appropriate for a specific survey. Help learners understand that the basis of this choice of sampling depends on a number of factors, including size, ease of access, and knowledge of the environment. Others include precision, bias and efficiency of strategies. Ask learners to prepare both sides of an argument for a debate (without knowing which side they will need to be speaking for). This will encourage them to think about both sides in detail as well as any counter-arguments for any assertions made. **(I)** Challenge learners to design a crossword (either with a pencil and paper or on the computer). The various terms associated with sampling strategies, including transect, random, bias, and so on, should be present, and they must write clues for another learner to find them. **(I)** Techniques such as matching words can be useful in this topic. Provide learners with a series of terms in boxes (such as quadrat) that must be matched with their descriptions. This activity could be made more active by providing learners with pictures instead of the terms, and challenging them to find a peer with the matching term or description. **(I)**
2.4 Data collection techniques and data analysis **KC2, KC5**	describe techniques used to collect sample data describe benefits and limitations of each sampling technique listed	Learners work in pairs to list what they know about the techniques commonly used to collect sample data in studies of environmental management. Then ask the pairs to join together into fours and then eights to discuss this further and come up with an agreed list of points. Ask one or two learners from each group to write the points on the class board as a ‘mind map.’ Use this activity to assess learners’ prior knowledge. **(F)** Provide a circus of displays that show the equipment required for the techniques commonly used to collect sample data in studies of environmental management. You could arrange learners in groups of 2–3 for these activities. Depending on the number of learners in the class, it is possible to arrange the equipment at different desks, at which learners spend 10–15 minutes. These should include quadrats (open frame, grid and point), pitfall traps,

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	select and use a suitable sampling technique to collect environmental data use data to: (a) calculate estimated population size using the Lincoln index (b) calculate estimated biodiversity using the Simpson's index of diversity (c) estimate percentage cover and frequency using quadrat data d) estimate abundance using quadrat data	sweep nets, beating trays, kick sampling, light traps, capture-mark-recapture, water turbidity, and descriptions of questionnaires and interviews that yield qualitative data. Host a class discussion to compare learners' observations and conclusions. **(I)** If possible, take learners outside to use quadrats, transects, pooters and pitfall traps, placed both randomly and systematically. Such field outings may be difficult, time-consuming and expensive so it is important to plan them carefully so that learners benefit from them as much as possible. It is very important to know how to study the distribution and abundance of organisms in a habitat. A thorough understanding of the techniques, how and when to apply them, and what the results mean is best obtained from practical experience. **(I)** Model the use of the Lincoln index using a container of beans or beads. Remove a small handful to be marked for the first sample, add them back to the container, shake them up, remove a second sample for the 'recapture' (closed eyes) and record results, obtaining the estimate using the formula. Challenge learners to write a simple method to describe this exercise, or provide a series of cards with the steps listed, which learners should shuffle into a random order then arrange in the correct sequence. There are significant opportunities for practical work during the study of this topic. For example, learners could use quadrats to investigate species abundance or distribution in a grassy area (e.g. a playing field, a lawn or a meadow), a rocky shore, or a sand dune. However, if these are not available, learners investigate different types of moss or lichen on a rock or on a tree trunk, using miniature quadrats. They record results as species frequency, species density, percentage cover or use an abundance scale (e.g. ACFOR). Random sampling can be used, or a systematic sampling method with quadrats to sample organisms along a transect line, perhaps by collecting data to calculate Simpson's index of diversity. Learners follow the instructions available at: https://pbiol.rsb.org.uk/environment/distribution-of-organisms/observing-patterns-in-the-distribution-of-a-simple-plant. *Pleurococcus* is a widespread alga whose distribution depends on exposure to light, wind and water. If this is not native to your home country, other species of plant can be investigated using a similar method and using a mini-quadrat. **(I)** **Extension activity:** give more-confident learners some autonomy during practical activities: provide them with a list of equipment, from which they choose the most relevant items, or encourage them to consider what range/intervals to use. This can develop higher-order thinking skills in decision-making.
2.5 The use of technology in data collection and analysis **KC5**	state that there are methods of data collection that include the use of technology	Plan a class debate. The 'motion' must be a controversial statement, rather than a question, to prompt deeper thought among learners. For example, ask learners to evaluate a statement such as 'The monitoring of human behaviour is crucial for the management of the environment'. Provide a range of sources of information on the use of geospatial systems, satellite sensors, radio tracking, computer modelling and crowd sourcing. It may be useful to include an initial 'think, pair, share' opportunity to help learners form an opinion before the debate begins. **(I)** After introducing learners to the benefits and limitations of 'big data' (which should include the amount and type of data stored, the speed at which new data is generated, the trustworthiness of the data, and ways the data can be

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	describe what is meant by the term 'big data' outline the benefits and limitations of the analysis of big data	used), host a competitive learning game called 'bingo.' Divide the class into two groups and identify a volunteer in each group to act as the teacher. Inform learners that there will be two games of 'bingo' on either side of the class. Within each, there is a competition to identify who can cross out their words the soonest. But also, there is a competition between the two groups – how many bingo 'rounds' can happen within the time permitted? Provide each learner with a grid of nine squares. Then provide 10–20 key terms on the board, which focus on 'big data'. Learners select nine words at random to fill in the grid. The volunteers then describe a definition or idea that links with each of the 20 key terms – in random order – and the first learner to tick off their nine words and call 'bingo' wins that round. **(F)**
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

3. Managing human population

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
3.1 Human population dynamics and structure **KC1, KC3, KC4**	calculate population density from given data describe and explain factors influencing population density and distribution describe populations in terms of their size and the composition of different age groups explain how changes in birth rates, death rates and migration rates may affect population size and composition define and calculate dependency ratio suggest reasons for differences between the population structures of HICs and LICs	Learners engage in a think-pair-share activity to consider the factors influencing population density and distribution. In the discussion that follows, ensure that learners have a good understanding of the key terms that relate to this topic. Show learners a range of graphs showing a number of population growth scenarios. Examples include the growth of a population of yeast over several days (sigmoid-shaped curve) and changes in the human population in the last 6400 years (exponential growth). Help learners understand that the growth of the human population is increasing the demand for global resources, and ask learners to suggest projections for future population growth. An estimate of the increase in the human population size in 'real time' is at: www.worldometers.info/world-population/ Take learners outside and draw a large graph, perhaps in chalk on the playground or open area. Mark the axes 'number of humans' and 'time.' Walk along the 'number of humans' axis and ask learners questions as you go, emphasising that changes to the size, composition and distribution of populations have fundamental impacts on natural resources. When you reach the end of the graph, ask learners to suggest how the population density will change in the future. Take a photograph of this image and, back in the classroom, question learners to find out what they know about the concepts introduced. Introduce, define and calculate the dependency ratio for different points on the graph. **(I)** Review with learners the factors that influence population density and distribution including environmental, economic, social, political and historical factors. Ask learners to carry out research on how these would be different for countries with differing economies. Provide a list of key terms on the board that they must include in their work, such as birth rates, death rates and migration rates. Useful websites: www.prb.org/ [Population Reference Bureau] www.unfpa.org/ [United Nations Population Fund] **(F)** Create a pack of cards. Each card has a key term from this subtopic written on it. Every learner picks out a card. For their card, each learner needs to produce a definition that is as simple as possible. When the definitions are complete, you could compile it into a class glossary for this subtopic. **(I)**
3.2 Impacts of human population change	describe the impacts of ageing populations on countries	Prepare a short, written passage that summarises the impacts of ageing populations on countries. Include between five and ten spelling mistakes and conceptual errors. Learners spot and circle as many mistakes as possible, and offer corrections. An example would be reference to the higher tax revenues and lower pension spending, or reduced retirement age. **(F)**

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
KC1, KC3, KC4		Challenge learners to prepare a glossary of key terms for this subtopic. Set each learner the task of defining 2–3 words each and linking them very clearly with diagrams. **(F)**
3.3 Managing human population change **KC1, KC3, KC4**	describe and evaluate strategies for managing a changing population	Learners pose questions using 'question shells' on this topic. For example, write 'How is _____ responsible for _____?' on the board, and challenge learners to write questions for each other. This helps learners to commit to their choices. Examples could include 'How is improved education and opportunities for women responsible for managing a changing population?' and 'How is improved health care responsible for effects on human population density?' **(F)** **Extension activity:** challenge learners to prepare a report on the local, national and global policies related to managing a changing population. These should include pronatalist and antinatalist polices, United Nations (UN) Agenda 21, and The Club of Rome.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

4. Managing ecosystems and biodiversity

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
4.1 Ecosystems **KC2**	describe the world's major terrestrial biomes in terms of their climate, soil type and vegetation outline the characteristics of primary and secondary succession from pioneer species through intermediate stages to a climax community define the terms gross primary productivity and net primary productivity define ecosystem productivity as the rate of production of biomass for an ecosystem discuss the efficiency of energy transfer between trophic levels interpret and draw ecological pyramids based on numbers, biomass and energy	Divide the class into four groups of learners. Each group should investigate one of the four biomes: desert, forest, grassland and tundra. In a technique called 'jigsaw grouping,' learners use internet research and published resources to become 'experts' on one particular biome. Challenge learners to include content that emphasises the energy transfers that sustain the biodiversity of the world's ecosystems and how we can best manage these ecosystems to conserve that biodiversity. They then deliver their findings to others in small mixed groups. To conclude this exercise, provide an opportunity for learners to record what they have learned on small 'flashcards'. This will help them synthesise new information into brief summaries. **(I)** Learners prepare a table or Venn diagram to compare the different types of succession. Help them by providing points of comparison, e.g. relative timescale, starting point, presence or absence of soil, and presence or absence of pioneer species. It is important to emphasise to learners that the final status of ecosystems affected by both types of succession is a climax community. **(I)** Challenge learners to write the shortest paragraph possible using the following key terms: ecosystem productivity, gross primary productivity, net primary productivity, energy and biomass. This is a good way for learners to focus on developing their higher-order thinking skills to make sense of the meaning of these terms. To scaffold this activity for some learners, provide the first and final sentences, or reduce the number of key terms that they are expected to use. **(F)** Prepare a crossword containing clues for words related to the content of the lesson. Learners undertake the activity in pairs and with a competition format, with the pair that finishes the crossword first as the winning team. **(I)** Learners work in groups of three to discuss a controversial statement, e.g. 'All food chains have three organisms', 'The proportion of energy loss is always the same between different trophic levels', and 'Pyramids of numbers are always pyramid-shaped'. **(F)** Learners work in groups of three to produce a series of cards that have a number of key terms from this sub-unit written on one side, and then some key facts on the reverse of each card that relate to the key term. Learners then separate the pile of cards into two equal halves. Two learners of each group lay down a card at random. The third member of the group is the adjudicator. The aim of this game is for the competing learners to 'steal' as many cards from their partner in a given time. In order to do so, each learner must try to convince the adjudicator that their key term is more important to an understanding of ecosystems than their partner's. If both learners lay down the same key term, they must reshuffle and try again. **(I)** **Extension activity:** learners research the importance of understanding the losses between trophic levels, and their implications for human populations. For example, some farmers keep their animals in pens to restrict the loss

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	explain the shapes of ecological pyramids	of energy from the animals, and it is more energy efficient for humans to eat crop plants than to eat livestock that have been fed on crop plants.
4.2 Managing the conservation of biodiversity **KC1, KC2, KC3**	define the terms native species and invasive species explain the impacts of invasive species on biodiversity describe and explain the benefits of conserving biodiversity describe and evaluate legislation and protocols as methods of conserving biodiversity describe and explain the role of the Evolutionarily Distinct and Globally Endangered species (EDGE) programme in the conservation of biodiversity describe and evaluate captive breeding and release as a method of conserving biodiversity describe and evaluate habitat conservation and	Provide a sheet of 10–15 key terms that you predict learners will have heard of before beginning this topic, such as *biodiversity*, *pollution*, *extinction* and so on. Learners cut them out and arrange them into as many groups of 2–3 as they can, with all words in each group similar in some way. Examples could be 'habitat,' 'marine' and 'freshwater' (low demand), or 'extinction,' 'deforestation' and 'biodiversity' (high demand). **(F)** Learners carry out research and produce an infographic to explain legislation and protocols as methods of conserving biodiversity and protection of species. These should include regulation of sustainable harvesting, international trade in endangered species (CITES), International Whaling Commission (IWC), European Union Common Fisheries Policy (EU CFP), International Tropical Timber Organisation (ITTO), and International Union for Conservation of Nature (IUCN) Red List. Note that detailed knowledge of international agreements is not required. **(I)** Learners write a definition of the term 'endangered', researching a named example and include the species name and the reasons for it being endangered. You may extend this activity by considering listed species using websites for the International Union for the Conservation of Nature (IUCN), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Evolutionarily Distinct and Globally Endangered species (EDGE) programme: www.iucnredlist.org www.cites.org/ https://www.edgeofexistence.org/ If possible, host a visit to a national park, nature reserve, zoo or botanic garden to enable learners to see the work that is being done locally. Each learner prepares a one-page summary that lists key features of the species and why it is endangered. Provide a 'scaffold', containing subtitles and missing words, to maintain consistency. Bind learners' work into a booklet so that the whole class has a copy for future reference. Introduce a number of methods by which conservationists have attempted to undertake rewilding and management and conservation of habitats. You could select relevant photographs to create an exercise in which learners identify the cause of habitat loss, and its recovery depicted in the photographs. Examples include nature reserves, protected areas, conservation zones and national parks. Useful websites include: www.unep-wcmc.org/ https://earthwatch.org.uk/ **(F)** Learners create a very short, highly-visual advertisement video that focuses on the harmful effects of one of the human impacts listed in the syllabus. To set the scene for this activity, arrange learners into small groups and discuss how informative videos can be effective as an appeal. Guide learners to understand that they grab the

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	creation as methods of conserving biodiversity	audience's attention, they are very visual, and how they present very clear statements. Give them time to produce a very short (1–2 minute) video that could appeal to others, about a topic that focuses on habitat destruction. **Extension activity:** learners write a letter to a government to explain the benefits of conserving biodiversity. Include a checklist to help learners, which should include how biodiverse regions may provide potential medicines, sources of food, wood, fibres, oils and fuels, the concept of maintaining diversity in genes, importance of ecological services, and also the impact on culture and recreation if biodiversity does not exist. **(I)**
4.3 Impacts of human activity on ecosystems **KC1, KC2, KC3**	describe and explain the impacts of human activity on tropical rainforests describe and evaluate strategies for managing the impacts of human activity on tropical rainforests describe and explain the impacts of human activity on Antarctica describe and evaluate strategies for managing the impacts of human activity on Antarctica	Introduce this topic in the context of the increasing awareness of extreme weather patterns and human impact on ecosystems all over the world. Examples of websites that provide context and useful exercises to illustrate its importance: www.oxfam.org/en/5-natural-disasters-beg-climate-action www.nationalgeographic.org/activity/natural-disasters-and-climate-change/ www.nationalgeographic.com/news/2016/08/human-footprint-map-ecological-impact/ Describe and explain the impacts of human activity on tropical rainforests, including fragmentation, fuel wood and timber collection, agricultural expansion, mineral extraction, hydroelectric and reservoir projects, climate change, and exploitation of individual species. Project a world map onto the board. Identify regions that contain tropical rainforests and identify those that are under greatest threat. Identify where strategies for managing the impacts of human activity on tropical rainforests have been initiated, including legislation and international agreement, sustainable harvesting, debt for nature swaps, and creation of protected areas. **(F)** Use local examples to illustrate the causes and effects of habitat destruction. Try to take learners to visit places where habitat has clearly been lost, and encourage them to think about how this affects wildlife. You may be able to arrange a visit from an expert who can talk about the particular problems of habitat loss in the local area, and what is being done to try to mitigate these problems. Otherwise, there are many excellent videos on the internet. If possible, help learners to carry out a first-hand investigation into the effects of pollution by sampling local streams or rivers to find the diversity of invertebrates in an attempt to estimate biological oxygen demand and the level of pollution. Instructions can be found at https://pbiol.rsb.org.uk/environment/environmental-indicators/monitoring-water-pollution-with-invertebrate-indicator-species. **(I)** Pairs of learners write a 60-second speech to convince the world of the importance of managing the impacts of human activity on Antarctica. You may wish to pose a motion, such as 'Despite Antarctica having large reserves of oil, the environmental impact of extracting it would be far too great for the resource to be exploited'. Tell learners that they should include in their speech reference to at least two species, and reasons that relate to ethics, ecology, aesthetics, social and commercial. Arrange chairs in the classroom so that they are in two long lines facing each other. Pairs of learners should sit down facing each other. Learners take it in turns to give their speech to each other. The other member of the pair should then explain what was the most convincing part of their

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
		speech, and why, and one piece of advice to help develop their speech further. Learners then move down a pair of seats to face another pair, and give their speech a second time, with some changes in response to the feedback they were given. **(I)** **Extension activity**: Challenge learners to carry out research to investigate how biotechnology and genetic modification have or may in the future help species conservation and sustainable use of resources.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

5. Managing resources

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
5.1 Food security **KC1, KC3, KC4**	define food security as when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life describe and explain causes of food insecurity and threats to food security outline the impacts of food insecurity describe and evaluate strategies for managing food security	For their own daily intake, learners consider and calculate their number of 'food miles', a measurement of how far food has travelled before it reaches them, using: www.foodmiles.com/ Using their own food miles as a basis, learners make an illustrated factsheet about food supply. This could either be one page in detail, or an outline plan for the whole factsheet. The target audience of this factsheet is next year's Cambridge IGCSE learners: they must therefore aim to keep it simple and informative, perhaps emphasising some of the misconceptions and mistakes that they have made while studying this topic. **(I)** Structure a discussion/debate for learners to describe and explain the various causes of food insecurity and threats to food security. These should include population growth, unsustainable production, increase in homogeneity in global food supply, price setting, land degradation, agricultural disease, diverting crops for biofuels, climate change, water shortages, poverty. You could ask another member of staff to visit the class to hear learners' ideas and offer feedback. **(I)** Learners undertake research and prepare, in groups of 2–3, a short 'TED Talk' on the subject: 'How can we manage food security and why is this important?' During the project, provide roles to learners to ensure that all members of the group are engaged. Roles could include the decision maker, the scribe and the internet researcher. This can also be used to differentiate learning: provide a more challenging role for more confident learners. Make sure that you provide adequate support during the activity, including listing a number of key terms and concepts on the board. These should include: subsistence agriculture, increase food production by intensification and extensification, improved agricultural techniques and efficiency, aquaculture and hydroponics, use of selective breeding and genetically modified (GM) crops to developing pest-resistant crops, and crops with a higher yield. **(I)** **Extension activity:** refer learners to the UN Food and Agricultural Organisation: www.fao.org/home/en/. Challenge them to produce a summary, using this source, which summarises the causes and impacts of food and energy insecurity. **(I)**
5.2 Energy resources **KC1, KC3, KC4**	classify energy resources as renewable or non-renewable define energy security as the reliable availability of energy sources at an	Provide learners with data for world energy production from an up-to-date source and demonstrate how fossil fuels remain the dominant sources of energy, in order of importance oil, coal and natural gas. Ask learners to develop a spider diagram of the ways in which energy is used, with links back to the form in which energy is supplied and, eventually, from which sources it is derived. This will be useful to help them understand that electricity is generated from an energy source, for example. Fossil fuel resources are declining, which affects their overall world price, but the demand for commodities such as oil fluctuates quite widely. Help learners to research the oil price over a number of years and try to explain why the graph is not a linear increase.

<table>
<tr><th>Syllabus ref. and Key Concepts (KC)</th><th>Learning objectives</th><th>Suggested teaching activities</th></tr>
<tr><td></td><td>affordable price with a consideration of the environmental impacts

describe and explain the causes of energy insecurity

outline the impacts of energy insecurity

describe and evaluate strategies for managing energy security</td><td>Learners form two groups. In each group, learners engage in research to become ‘experts’ on either renewable or non-renewable energy resources. It may even be possible for them to explore sources of energy that are being used locally (this will mean that learners should become more aware of local issues and opportunities). Learners then join with a member from the other group and exchange their findings. This means that each learner is responsible for another’s learning, and provides them with alternative views and strategies. Provide help to learners so that those studying renewable resources include biofuels (biomass including wood, bioethanol and biogas), geothermal energy, hydroelectric dams, tidal energy, wave energy, solar energy and wind energy, while those studying non-renewable resources include fossil fuels (oil, natural gas, coal) and nuclear energy using uranium as a fuel. (I)

Useful websites to help learners with their research include:
https://biogas.ifas.ufl.edu/, https://www.therenewableenergycentre.co.uk/
https://passivehouse-international.org/

Learners write a short essay on the topic of energy insecurity. They are expected to refer to relevant examples and/or case studies, using any relevant quantitative or qualitative information to support their answers. Help them understand that they are also expected to present reasoned explanations, make reasoned judgements and reach conclusions. Provide them with key terms and tell them that three distinct parts are required –the causes of energy insecurity, the impacts of energy insecurity, and the management of energy insecurity. Examples are provided in the table below. (F)
<table>
<tr><th>Causes – key terms</th><th>Impacts – key terms</th><th>Management – key terms</th></tr>
<tr><td>fossil fuels, inequality, population growth, differing energy needs, climate change, supply disruption, natural disasters, piracy, terrorism.</td><td>disrupted electricity supply, increasing prices, increasing costs, job losses, economic recession, poverty, standards of living, imported sources of energy, civil disruption, conflict</td><td>energy efficiency, investment, carbon neutral fuels, alternative energy technologies, local energy projects, rationing</td></tr>
</table>
</td></tr>
<tr><td>5.3 Waste management
KC1, KC3, KC4</td><td>describe methods of waste disposal and treatment

explain the impacts of waste disposal methods

describe and evaluate strategies to reduce the impacts of waste disposal</td><td>Provide learners with marker pens and ask them to come to the class board to write down as many words that they can think of that relate to ‘waste.’ Learners then return to their seats and work in pairs to construct a number of sentences that include at least three of the terms. Pairs of learners then join to form groups of four, then eight, to share their work. Then ask a number of groups to share their agreed sentences with the class. You can use this activity to assess learners’ prior knowledge of the topic. (F)

Organise learners in small groups to draw up lists of advantages and disadvantages of different types of waste management for a particular country; then as a group to make an overall assessment and decide whether the advantages outweigh the disadvantages, or not. If any groups finish this work before others, challenge them to compare and contrast the impacts of future energy insecurity on a HIC and a LIC. (I)</td></tr>
</table>

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
		Learners prepare a PowerPoint presentation that considers the methods of waste disposal and treatment. These should include landfill sites, incineration, storage, disposal at sea, recycling and exporting waste. They must include in their work the impact of these various waste disposal methods, and also how these impacts can be reduced. **(I)** **Extension activity:** learners prepare, and administer, a survey related to this topic. Provide some autonomy: learners may wish to carry out an investigation into classmates' opinions on waste management, or determine who produces the most waste in a single day.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

6. Managing water supplies

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
6.1 Global water distribution **KC1, KC3, KC4**	describe the distribution of the Earth's water define the term water security as the ability to access sufficient quantities of clean water to maintain adequate standards of food and manufacturing of goods, adequate sanitation and sustainable health care explain the causes of water insecurity explain the impacts of water insecurity describe and evaluate strategies for managing water security	Introduce this topic by describing a case study to illustrate the environmental management challenge of water distribution. The region could be a rural area or rural areas where lack of water access is a major issue. Ask learners to engage in a 'think, pair, share' activity to consider the impacts that the lack of water security has had on a region. Examples should include crop failure, livestock death, food shortages, and illness. Learners access the worldometer water usage meter at: www.worldometers.info/water/ Give learners water usage statistics for the world (8% domestic, 22% industrial and 70% agriculture) or, alternatively, they could research the figures themselves before the lesson. Ask learners to calculate how much water has been used by the three sectors in the time that has elapsed since you ran the starter activity. They could continue and work out the rate of consumption worldwide and for each sector. How does their own water consumption, and that of their family, contribute to these figures? Learners construct a digital infographic to describe the distribution of the Earth's water, including salt water in oceans, surface fresh water (ice sheets, glaciers, lakes, rivers, swamps, marshes, permafrost) sub-surface fresh water (soil moisture, ground water, permafrost) and atmospheric water. You could list these regions on the board and/or ask learners to illustrate in their infographic where most water is stored. **(I)** Learners draw a spider diagram summarising the reasons why access to safe water is worse in rural areas. Encourage them to then add points to their diagram that evaluate the strategies in place to improve the water security of those regions. **(F)** Learners work in small groups to produce a visual display to show the various causes of water insecurity. You could provide specific roles to each learner in the group, perhaps divided in terms of content that they should research (which include concepts such as international competition, climate change, and pollution events), or divided in terms of the skills that they should develop (e.g. team leader, fact-checker, an individual responsible for comparing their work with that of others, etc.). Set this up as a competition for a small prize or points. Each pollutant must be properly referenced, with URL or book/journal details. **(I)** **Extension activity:** help learners plan and write an essay on the ways in which the impacts of water insecurity can be minimised. Provide an essay framework in the form of a table that helps them understand that different paragraphs should consider different strategies, and the importance of an introduction and concluding sections. There is a wide range of possible strategies, which you could list on the board for learners to choose from. For example: • sustainable water extraction and improved supply • reduction in water usage • education on sustainable water use • poverty reduction • international agreement and water-related aid

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
		• rationing. Recommend a range of websites for learners to refer to, to include illustrative examples. Suggestions are: www.water-pollution.org.uk/ www.unwater.org/
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

7. Managing the atmosphere

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
7.1 Acid deposition **KC3, KC4**	define acid deposition as a mix of air pollutants that deposit from the atmosphere as acidic wet deposition (with a pH <5.6) or acidic dry deposition describe the two types of acid deposition outline the formation of acid deposition outline the impacts of acid deposition on: • aquatic environments • vegetation and crops • stone and brick buildings	Ask learners what they understand by 'the atmosphere'. Write their ideas on the board. Show learners an image of atmospheric pollution over an urban area and develop an understanding that humans have a significant impact on its content. Ask them what they think the image shows. Explain that the pollution is concentrated in the lowest layer of the atmosphere – the troposphere – but that there are three other distinctive layers. A useful website which shows air pollution live: http://waqi.info/ The main aim of this session is to help learners understand the phenomenon of acid deposition. Divide learners into pairs. Ask them to draft a summary diagram of the formation of the two types of acid deposition (wet and dry; each learner could outline one type). Next, join pairs of learners together and give them an opportunity to find out from each other where their accounts differ, and what similarities there are. The groups of four learners then undertake a collective task with their work, such as comparing the two types of acid deposition using a Venn diagram or similar. Then hold a 'marketplace activity' in which one member of each group stands by their poster and offers an explanation to other groups as they circulate around the room. **(I)** Learners produce a storyboard to show how acid deposition forms. You could provide an empty 'comic strip' grid with a number of boxes separated by arrows. Learners' work should include how the combustion of fossil fuels that contain sulfur compounds results in the formation of sulfuric acid, and how nitrogen from the atmosphere reacts with oxygen in the high temperatures of vehicle engines to form nitrogen oxides and nitric acid. **(I)** Learners prepare a PowerPoint or Prezi, which they could present in a subsequent lesson, that illustrates how acid deposition can result in: • effects on fish gills and fish populations • defoliation and reduced crop yield • enhanced chemical weathering **(I)** **Extension activity:** give more-confident learners a degree of autonomy during these activities: provide them with as little information as possible about acid deposition; instead, give them a number of websites and other resources to use in their research.
7.2 Photochemical smog **KC3, KC4**	define photochemical smog as a mixture of air pollutants and particulates, including ground level ozone, that is	Learners produce a health leaflet or visual infographic (with commentary) that focuses on the topic of photochemical smog and its health risks. This should include eye and respiratory irritation, decreased crop yields, and deterioration of plastics and rubber. **(I)** Show learners an image of a person wearing a face mask to avoid inhaling pollutants. Challenge learners to describe the image and answer the question 'Why wear a face mask?'. Ask learners if they think the air quality where they live is good or bad, and to explain their answer. Ask if learners have experienced eye irritations or

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	formed when oxides of nitrogen and volatile organic compounds (VOCs) react in the presence of sunlight describe the impacts of photochemical smog	shortness of breath and when. Show images of smog in densely-populated regions of China or India, or even the London smog of 1952. Highlight and develop a discussion that focuses on the impacts of a severe smog on people and the environment. A number of key terms are introduced in this topic. Taboo is a useful technique here: learners work in pairs to describe key words to each other, but without using other (listed) key words. For example, it is challenging for learners to describe smog without using the key terms: pollution, particles, and sunlight. Putting the key terms on the board as they are met reinforces their importance and helps learners become familiar with them. **(F)** **Extension activity:** provide learners with statistics on air pollution for rich and poor countries. Challenge learners to display them in divided bar or pie graphs, and to suggest reasons for differences. Host a class discussion to summarise.
7.3 Managing air pollution **KC3, KC4**	describe strategies for managing air pollution	Divide the class into pairs of learners. To each pair, hand out a set of cards with various air pollution management strategies written on them. Learners sort the cards and decide if they fit into individual, government or international strategies. You could extend this activity to include causes and impacts. Learners prepare an advertising campaign aimed to increase measures to manage air pollution in their home country. Before they start, host a discussion in which a number of themes should emerge. These may include the reduced use of fossil fuels, reducing emissions of sulfur dioxide (by flue gas desulfurisation and fuel desulfurisation), oxides of nitrogen (by catalytic converters), particulates using electrostatic precipitators, and volatile organic compounds (VOCs), and a range of other strategies. **(I)**
7.4 Ozone depletion **KC3, KC4**	outline how ozone depletion occurs state that ozone concentration is measured using the Dobson Unit define the term ozone hole as an area where the average concentration of ozone is below 100 Dobson Units	Ask learners to carry out research before the lesson to investigate why ozone depletion has been greatest over Antarctica: temperature, polar vortex, polar stratospheric clouds (PSCs). This will strengthen discussion at the beginning of the lesson. **(F)** Provide a series of cut-out statements that describe how ozone depletion occurs. Learners work in pairs to arrange the statements in the correct order. **(F)** Help learners to produce a presentation, or even role play, which describes the process of ozone depletion. Learners should include reference to how chlorofluorocarbons (CFCs) from aerosols and refrigerants move into the stratosphere and break down in the presence of ultraviolet light to release a chlorine atom. Then, rapid reactions between chlorine atoms and ozone breaks down ozone (O_3) to oxygen (O_2), causing ozone depletion. Useful resources include: www.epa.gov/ozone-layer-protection/ozone-layer-science **(I)** Challenge learners to write a report to explain to a younger learner why the main hypothesis of ozone depletion was initially not accepted. This should include the fact that some of the auxiliary hypotheses were not backed up

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
	explain why ozone depletion has been greatest over Antarctica describe the impacts of ozone depletion due to the increased amounts of ultraviolet radiation evaluate the international agreements used to reduce and phase out the use of ozone depleting substances outline the impacts associated with the use of some alternatives to ozone depleting substances outline the importance of experimental evidence to support a hypothesis, using the ozone destruction hypothesis suggested by Rowland-Molina as an example	by experimental evidence, but how the hypothesis led to further research and data collection by other scientists, which confirmed that CFCs are ozone depleting. **(I)** Ask learners to do some individual research into the various international agreements used to reduce and phase out the use of ozone depleting substances, and the impacts associated with the use of some alternatives to ozone depleting substances. This could be completed as homework, then in class the learners use the information they have discovered to discuss the topics. Useful resources include: https://www.eea.europa.eu/themes/climate/ozone-depleting-substances-and-climate-change Show learners four or five exemplar answers to a past paper question that considers ozone depletion. Learners rank the answers in order of quality and then explain the order they select. The intention is to help learners understand mark schemes and success criteria. This could take the form of a 'circus' of examination questions, which learners move around to answer in small groups. Include in this circus a range of questions that cover skills including: • structured short-answer questions • extended response • data manipulation and calculation • identification of features and patterns • graph, table and diagram drawing, labelling and interpretation. **(I)** Provide learners with a number of resources and internet links and challenge them to carry out research into the impacts of ozone depletion on human health, crop yields, biodiversity and degradation of materials used in clothing and construction.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

8. Managing climate change

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
8.1 Climate change **KC1, KC3, KC4**	define greenhouse gases as gases in the atmosphere that absorb infrared radiation and identify some common greenhouse gases state the major sources of greenhouse gas emissions from human activities explain how increased concentrations of greenhouse gases in the atmosphere cause the enhanced greenhouse effect leading to global warming outline the difficulties of monitoring and predicting climate change	Host a 'flipped classroom' activity. Learners carry out research into the identities and sources of greenhouse gases: combustion of fossil fuels (carbon dioxide and water vapour), rice fields and livestock (methane), landfill sites (methane). Water vapour remains relatively constant; however, its concentration in the atmosphere is likely to increase if temperatures rise, due to increased evaporation. **(I)** The difficulties of monitoring and predicting climate change lead to significant challenges in the management of climate change. Help learners develop their evaluative skills by discussing the difficulties in monitoring/predicting climate change. Put learners into small groups and ask each group to carry out research into one idea. They should use the internet and other sources to explore the following: • limited historical data used to reconstruct past climate conditions • future climate predictions are made using computer climate models which use different variables • climate feedback mechanisms are not fully understood • time delay between cause and effect • uncertainty over the use of some data in drawing conclusions has resulted in differences in scientific and political opinion. Useful source for research:https://climate.nasa.gov/ Next, each member of the original groups joins other groups so that each new group contains different representatives. Provide 3–4 minutes, before ringing a bell or using a digital timer, for learners to describe their findings to each other. **(I)** Provide pairs of learners with a series of graphs that relate to climate change, for example, showing how increased concentrations of greenhouse gases in the atmosphere cause the enhanced greenhouse effect leading to global warming. Ensure that only one member of each pair of learners is able to see this image – provide it to the pairs of learners folded in half. Ask them to decide who will be the describer (the one who can look at the image) and who will be the interpreter (the one who will convert the description into an image). Give the describers 2–3 minutes to describe the image, instructing them that they cannot use hand signals or help the interpreter in any other way. The interpreter attempts to reproduce the image from the verbal description. As learners work, walk around the room and judge their progress, and then reveal the image to them on the board (or allow the describer to show the original image to the interpreter). **(I)** **Extension activity**: Learners choose 3–4 images from a website, e.g.: www.nationalgeographic.com/environment/ Do not provide them with any criteria for choosing their images. Then challenge them to try to relate each image to the lesson in some way. This provides an opportunity for learners to be creative and make an argument.

Syllabus ref. and Key Concepts (KC)	Learning objectives	Suggested teaching activities
8.2 The impacts of climate change **KC1, KC3, KC4**	state the impacts of climate change on the environment describe the impacts of climate change on human populations	Learners compile a 'diamond nine' activity. Hand out a 'diamond nine' template to pairs of learners (a diamond outline divided into five layers, with a very important impact at the top, two impacts of intermediate importance on the next level, three slightly less important impacts, two impacts of lower importance and finally one impact of the least importance). To each pair of learners, give nine photographs or images of selected impacts of climate change on human populations, such as: increased frequency and severity of extreme weather events leading to flooding and loss of land, drought and wild fires; damage to property and loss of life during extreme weather events; forced migration; impacts on crop yields and increased pest outbreaks; impacts on food, energy and water security; and so on. The learners then decide which impacts they feel are most, to least, important into an order on the diamond nine template. **(I)** **Extension activity:** pairs of learners evaluate the impacts climate change may have on a named country or location. They may need to undertake internet research if the country/location is unfamiliar to them.
8.3 Managing climate change **KC1, KC3, KC4**	describe strategies for managing climate change through the reduction of greenhouse gas emissions outline geo-engineering strategies to counteract climate change evaluate strategies for maintaining climate change	Learners produce an infographic that answers the question 'What is geo-engineering?' Write a list of concepts and key words that they must include in their poster, such as solar radiation management (SRM), e.g. albedo enhancement, space reflectors, stratospheric aerosols. **(I)** Learners work in pairs to construct a poster that considers how climate change could be managed. The emphasis should be on keeping the poster as small as possible to encourage learners to consider the content more carefully. In their work, they must include the proposed strategies to manage climate change, which include: • reduction of global and individual carbon footprint (fewer children per woman, eating a plant-based diet, adopt an energy-efficient lifestyle) • switching to low-carbon fuels • reducing the use of fossil fuels • using alternative forms of energy • transport policies • use of carbon capture and storage • reducing deforestation, increasing reforestation and afforestation • energy efficient buildings and infrastructure • adaptation to climate change • national and international agreements such as Kyoto Protocol 1992, Paris Agreement 2016 (detailed knowledge of international agreements is not required). Learners write a letter to a government or national organisation to suggest which strategies would be most cost-effective and straightforward to implement for that country, and why.
Past and specimen papers		
Past/specimen papers and mark schemes are available to download at www.cambridgeinternational.org/support **(F)**		

Cambridge Assessment International Education
The Triangle Building, Shaftesbury Road, Cambridge, CB2 8EA, United Kingdom
t: +44 1223 553554
e: info@cambridgeinternational.org www.cambridgeinternational.org