ENVIRONMENTAL MANAGEMENT

Paper 8291/11

Principles of Environmental Management

Key messages

In ***Section A***, candidates should note the number of marks available for each part question and write answers accordingly. This will give them an indication of the amount of content and detail expected.

In ***Section B***, candidates should indicate clearly which question they are answering, i.e. **Question 5** or **Question 6**.

It is important that instructions are followed carefully. Candidates should make sure that they understand the difference in meaning of the command words such as state, suggest, predict, justify, describe, explain, compare and evaluate.

Candidates should avoid repeating the question in their answers to make best use of examination time.

General comments

There was generally a good response to all questions across the paper. Most candidates found **Question 2** (climate change) and **Question 3** (food insecurity) more demanding than the other questions in ***Section A***. Topics which proved more challenging were improvements to methods for estimating population size, how stratospheric aerosols reduce climate change, evaluation of use of stratospheric aerosols for counteracting climate change, homogeneity of global food supplies, herbicides, and evaluation of selective breeding as a strategy for managing food security.

Many answers showed a good understanding of terms and attention to detail with effective use of exemplar material.

The strongest answers included effective use of appropriate examples to illustrate key points, along with supporting details using appropriate terminology.

Comments on specific questions

Section A

Question 1

This question covered the topics of food chains and measuring population size in the context of Antarctic krill including the distribution of Antarctic krill, constructing a pyramid of biomass, gross primary productivity, the impacts of harvesting Antarctic krill on global food security, and hydroacoustic surveys as a method to measure the population of Antarctic krill.

(a) This question was generally answered well with most candidates able to gain full credit for describing the distribution of Antarctic krill in Antarctica. The most common correct responses referred to high density of Antarctic krill in Weddell Sea and low density of Antarctic krill in Davis Sea.

(b) (i) Most candidates were able to construct and correctly label a pyramid of biomass for a food chain involving Antarctic krill.

(ii) This question was more challenging and generally less well answered. Few candidates fully understood the term 'gross primary production' and most were unable to explain why humans consuming icefish is not an efficient use of the gross primary production. Although some candidates had labelled the pyramid of biomass drawn in **Question 1(b)(i)** correctly with the energy losses for each trophic level, this knowledge was not used to answer **Question 1(b)(ii)**. The most common correct response referred to energy being lost at each trophic level. Very few candidates were able to explain how energy is lost from the food chain and did not show understanding that it is more efficient to feed at a lower trophic level.

(iii) Candidates found this question challenging with very few accessing the credit available. In general, candidates did not understand the question and responses were made in the context of krill being consumed by humans rather than as a feed in the aquaculture industry. Some candidates were able to access some of the credit for reference to overharvesting and decrease in squid population as negative impacts. A very few candidates suggested correct positive impacts.

(c) Very few candidates were able to make the connection between the method of hydroacoustic surveys to estimate the population of Antarctic krill and random or systematic sampling. A successful response should have included reference to using a map with a grid and using a random number generator to select coordinates (for random sampling) or a survey along a latitude or longitude line at fixed intervals (for systematic sampling).

Question 2

This question covered the topic of climate change in the context of trends in mean sea surface temperatures including the impact on the change in location of the American lobster, impacts of climate change on the marine environment, and the strategy of solar radiation management (SRM) using stratospheric aerosols to counteract climate change.

(a) This question was generally answered well with the majority of candidates gaining some of the credit available. Stronger responses described trends in the mean sea surface temperature in terms of the 100-year average, i.e. above or below the 100-year average. Weaker responses simply referred to actual sea surface temperatures without reference to the 100-year average.

(b) (i) There were some good responses to this question where candidates referred to change in location of the American lobster in terms of changing sea temperatures. The most successful responses included reference to the relation between increase in sea temperatures and the movement of the lobsters North; seas are cooler the further North you go and the idea that migrating North will put the lobsters at their preferred temperature. Less successful responses made vague references to lack of prey or food as a reason for the change in location of the lobster, which was not creditable, as the question asked for the use of data from **Fig. 2.1** which showed mean sea surface temperatures from 1880 to 2020.

(ii) Common correct responses included melting of sea ice, increase in sea levels and coral bleaching or damage to coral reefs. More successful responses referred to changes in ocean currents or wind circulation due to increased storm frequency, ocean acidification and invasive species. Many candidates needed to read the question more carefully as they wrote about the effects of climate change on other animals, rather than the effects of climate change on the marine environment.

(c) (i) The use of stratospheric aerosols as a strategy for counteracting climate change was poorly understood. Very few candidates were able to access credit and misunderstood the question so did not outline how stratospheric aerosols were used. Common misconceptions were that the stratospheric aerosols were energy sources as an alternative to fossil fuels, and that the aerosols were linked to CFCs and damage to the ozone layer.

(ii) The majority of candidates found this question very challenging; a few were able to access credit for reference to the idea that the use of stratospheric aerosols for counteracting climate change is untested or may have adverse effects, or that not all countries can afford it. Where candidates had misunderstood **Question 2(c)(i)**, they were generally unable to gain any credit in **Question 2(c)(ii)**. A successful response should refer to both benefits such as that it is simple, relatively inexpensive and mimics a natural process, and limitations such as unknown effects on weather, and that it does not solve the underlying issue of greenhouse gases and is only a short-term solution.

Question 3

This question covered the topic of food insecurity in the context of homogeneity of global food supplies, causes of food insecurity, GM crops having resistance to herbicides and selective breeding as a strategy for managing food security.

(a) (i) Candidates found this question difficult as homogeneity of global food supplies was poorly understood. Many respondents referred to people not having access to food and defined food insecurity as part of their response, which was not creditworthy. Few candidates understood that homogeneity leads to increased susceptibility to crop disease, to natural disasters and to climate change, and were unable to give examples in support of their answers.

(ii) Many candidates recognised at least two causes of food insecurity, other than homogeneity of global food supplies, and the most common correct responses included poverty, natural disasters such as flooding, drought or water insecurity and climate change. A significant number of candidates merely defined food insecurity rather than describe causes.

(b) (i) This question proved challenging as it was clear that the term herbicide was poorly understood. Most candidates confused herbicides with pesticides or insecticides and referred to protecting crops from pests, insects or diseases, or with fertilisers and nutritional content of the crops. A few candidates were able to refer to the crop being protected from herbicides sprayed on them, weeds being killed reducing competition between crops and weeds and therefore increasing crop yield.

(ii) Very few candidates were able to calculate the mean annual change in the percentage of planted land of GM corn between 2000 and 2012 to provide the correct answer to two significant figures. Few candidates demonstrated that they were able to correctly read off data from **Fig. 3.1**. Credit was allocated for correct working out even if the final answer was incorrect.

(iii) Candidates appeared to be unfamiliar with selective breeding as a strategy for managing food security and misunderstood that the question was asking them to evaluate the strategy and that they should suggest both benefits and limitations. Many candidates thought that selective breeding was simply about choosing the types of crops to grow or animals to breed in response to demand and the efficiency of food production. The most successful responses included reference to the benefit of choosing desired genetic traits such as cows that produce large quantities of milk or crops that are resistant to disease, and the limitation of selective breeding taking a long time. To improve their response to this type of question, candidates need to understand the process of selective breeding and be able to describe a range of both benefits and limitations.

Question 4

This question covered the topic of population pyramids, birth rate and dependency ratio including the impacts that an aging population can have on a country.

(a) Candidates found this question more challenging with many giving responses on the shape of the population pyramid or references to causes rather than comparing population structure of males and females. Candidates who answered this question well gave detailed comparative responses rather than just quoting data unqualified.

(b) (i) Some candidates were able to correctly identify the evidence in **Fig. 4.1** which showed the decrease in population in Uruguay over the 30-year period as a narrower base than the middle of the pyramid.

(ii) Most candidates were able to access credit for their knowledge of the causes of a decrease in birth rate and this question was generally answered well. The most common correct responses included improved availability of contraception, improved education, and opportunities for women such as careers or jobs, and anti-natalist policies.

(c) (i) Dependency ratios were not well understood with the majority of candidates unable to access the credit available. Some candidates thought that the dependency ratio was a measure of population size and therefore suggested that Uruguay had a lower population than Senegal, rather than the ratio of the dependent population compared to the economically active population. A significant number of candidates appeared to be unaware of the syllabus definition of young dependents as those in the age range of 0 – 14 years and elderly dependents as 65+. These responses were

limited in the credit they could achieve for identifying that Uruguay has a lower dependency ratio than Senegal.

(ii) This question was generally answered well with most candidates able to describe one or two impacts that an aging population can have on a country. The most common correct responses included less people in the workplace, a lower birth rate and more spending or pressure on healthcare.

Section B

Significantly more candidates chose to answer **Question 5** rather than **Question 6**. Most candidates clearly indicated which question they were answering.

The questions in ***Section B*** assessed two skill areas: AO2 (Information Handling and Analysis) for which there is a total of 8 marks and AO3 (Investigation Skills and Making Judgements) for which there is a total of 12 marks. The two marks are combined to give a total mark out of the 20 marks available.

In general, the majority of candidates were awarded Level 2 for both AO2 and AO3 with a total mark between 8/20 and 12/20. A small number of candidates were unable to achieve more than Level 1 for AO2 as they did not provide any examples to support their answer, and Level 1 for AO3 as their response was largely descriptive and they did not make any judgements. There were a few candidates who did not answer either question in ***Section B***.

Question 5

A few candidates had a good command of technical terminology to describe improved agricultural techniques such as intercropping, biological control, agroforestry, drought and salt tolerant crops and were able to state a correct definition of food security.

Higher-level responses made good use of specific case study examples, e.g. aeroponic tower gardens in urban farming or improving African rice by breeding with Asian rice, to support their answers. Others discussed a wide range of improved agricultural techniques. In addition, other factors that may impede global food security by 2040, and that may need addressing alongside agricultural techniques, e.g. climate change, natural disasters, wars or conflicts, population change and fresh water management were considered.

Some candidates were aware of improved agricultural techniques such as hydroponics, vertical farming, selective breeding and GM crops, and use of pesticides, and needed to develop their answers to avoid limiting the level of credit awarded. Weaker responses simply suggested that improved agricultural techniques, without named examples or descriptions of the techniques, would ensure food security in terms of increased food production. Very few candidates used specific case study examples in their response.

Most candidates only described one side of the argument, with the majority concluding that improved agricultural techniques will ensure global food security by 2040, thus limiting the response to Level 2 for A03. A minority of responses gave good evaluations and judgements for and against to achieve Level 3 or 4 for A03.

Question 6

Many candidates who opted for this question had good knowledge of captive breeding and release as a method of conserving biodiversity and had a good understanding of the importance of biodiversity. Some respondents were able to use specific case study examples of both successful and unsuccessful captive breeding programmes, e.g. Giant Panda, wolves in Yellowstone Park, the Peregrine Falcon and the White Rhino. Most candidates achieved Level 2 for A02.

Stronger responses showed good knowledge of both the benefits and the limitations of captive breeding and release programmes and were able to consider other conservation techniques that may be more effective such as habitat conservation and habitat creation.

Few candidates were able to achieve more than Level 2 for A03 as evaluations tended to be one-sided, stating captive breeding and release was either successful or not successful as a method to conserve biodiversity. Overall, candidates were able to discuss the benefits of captive breeding and release much more effectively than the limitations of the method.

ENVIRONMENTAL MANAGEMENT

Paper 8291/12

Principles of Environmental Management

Key messages

Descriptions of the distribution of three forest systems in Canada were generally not strong; in weaker responses, candidates discussed the distribution in relation to each forest area rather than in relation to the geography of Canada or compass points on the map.

Knowledge of what 'big data' constituted and limitations of its analysis was poorly understood.

The role of the EDGE programme in the conservation of biodiversity was also poorly understood.

Good knowledge was generally evidenced in terms of being able to compare different population pyramids, although the description of comparing females and males in the pyramid was less secure.

General comments

Evaluating strategies for reducing food insecurity and water insecurity in unfamiliar contexts is an area of the syllabus in which candidates would benefit from more practice.

Good responses did not merely repeat information in the question but added explanations to this where needed.

Section B essays were variable overall, and where candidates provided examples, evidence or case studies to support their answer, they were able to gain higher marks for the question.

Comments on specific questions

Section A

Question 1

(a) (i) The question required candidates to describe the distribution of three forest ecosystems. Strong responses included a description of the dense forest running from north-west to south-east (or east to west). Credit was also given if candidates cited this for limited forest and low vegetation or the latter being further north. Limited forest was correctly identified as being in the south of Canada or along the North American border. Where candidates had quantified an equal amount of dense forest to limited forest with low vegetation, then credit was given. Weaker responses referred to areas being near the coast or described why the forest or vegetation was there, e.g. more rain, which was not required for this question.

(ii) This was generally well answered. Candidates gave reasons of urbanisation for forest and grass ecosystem as well as being colder in the north so less vegetation would be present, and some responses suggested ground conditions such as permafrost or soil type affected distribution. Credit was not given for suggestions of being nearer the north pole as these were not qualified.

(b) (i) The majority of candidates demonstrated an understanding of the definition of sustainability. Some responses correctly linked resources being available in the future and needed to include reference to the present for full credit.

(ii) Candidates were asked for sustainable strategies for harvesting forest in Canada, and in many cases, reference to protected areas, felling by quota and forest regeneration through afforestation/replanting was correctly identified. Weaker responses gave such ideas as population control and education, which often were not qualified or directly linked to sustainable harvesting.

(c) (i) Candidates were required to define 'big data' and strong responses cited complex or large amounts of data, using technology or reference to data being collected rapidly. Weaker and incorrect responses discussed the lidar technology or referred to the large area where the data was being collected from and therefore were not qualified or developed further.

(ii) Limitations of 'big data' often correctly cited inaccuracy possibilities as well as time constraints in the analysis of data, the latter also requiring technology and expertise which is costly.

Question 2

(a) (i) Candidates were required to suggest why the Hispaniolan solenodon was designated an EDGE species. Many candidates demonstrated good use of the information provided in the question to suggest it was due to unusual features/characteristics (including quoting these features from the question) or that it had no similar species like it, i.e. evolutionarily distinct. Credit was also given to it only being located on one island as well as it being threatened or endangered**.** References to it being preyed upon or general hunting of them were not credited although often seen in responses.

(ii) Responses were generally limited in their understanding of the role of the EDGE programme. Stronger candidates recognised raising awareness of endangered species as well as providing support for conservation projects. Weaker responses tended to include EDGE conducting capture and release projects or purchasing land to conserve species rather than them supporting projects.

(b) Most candidates were able to provide factors for the decrease in population of the Hispaniolan solenodon, which included a lack of prey, invasive species or competition, as well as climate change or loss of habitat.

(c) The question required listing five strategies to conserve the Hispaniolan solenodon. Strong responses included banning hunting, captive breeding programmes, and legislation to protect the habitat or species. As the animal is only endemic to one island, credit was not awarded for creating another habitat elsewhere and common references to improving their location were not sufficiently qualified to be awarded credit.

Question 3

(a) (i) The question required candidates to define food insecurity, and while there were correct responses, many candidates defined food security and so were only able to gain partial credit where they referred to nutritious and safe food. Candidates should also recognise that food insecurity is a lack of access to these at all times.

(ii) Candidates were required to explain how agricultural diseases in crops can reduce food security. Most were able to describe the reduction in yield and a potential escalation in the cost of food. Stronger responses considered the impact on feeding crops to farm animals and the likely consequences.

(b) The majority of candidates were able to evaluate hydroponics as a strategy for reducing food insecurity. The idea of using less water in the system, as well as reduced pest and disease aspects were commonly provided, whilst issues surrounding installation cost or infrastructure and the system not being appropriate for staple crops were often cited. Some candidates needed to provide qualification in their response: providing a statement that a system is expensive is limited when it is not explained fully, for example by considering expense in relation to another irrigation method.

Question 4

(a) Candidates were required to compare the population of males to females with the use of a population pyramid. Commonly candidates noted the difference of higher male population up until the age of 40 – 45 and then a switch to a higher female proportion above the age of 60 – 65. Common errors with this question often surrounded candidates responding generally by stating the

working age having a higher proportion of either females or males; the working age is often a subjective term and so stronger responses included data from the question to support their statements.

(b) (i) Candidates were required to identify the evidence on **Fig. 4.1** that birth rate has decreased in the last 40 years in Japan. Correct responses acknowledged the population pyramid as having a narrower base.

(ii) Most candidates provided a strong response surrounding reasons for the reduced birth rate in Japan, and the question was answered well. Common reasons included availability of contraception, anti-natalist policies and family planning.

(c) The majority of candidates responded strongly to suggesting reasons for the difference in population structure between Japan and Haiti. Responses included Japan being a HIC and having better health and social care, which was often further developed by stating longer life expectancy. Haiti was correctly identified as a LIC with higher birth rate; this was often linked to the culture in Haiti of having larger families. In addition, poorer healthcare, sanitation and poorer diet were often correctly cited.

Question 5

(a) The question required candidates to state three categories of water other than ocean water. Responses were mixed overall - credit was given to surface water, sub-surface water and atmospheric water. Where candidates gave an example of a lake or permafrost, this was also credited.

(b) (i) The calculation of the percentage of global water used in agriculture was answered poorly overall. A significant number of candidates needed to express their answer to two significant figures as stated in the question.

(ii) A well-answered question overall, demonstrating good understanding of strategies a farmer could use to reduce water usage. Credit was awarded for naming a method followed by development and description of that method, for example drip irrigation followed by more accurate placement of water near the crop. No credit was given for water storage, which was at times evidenced, as the question invited candidates to discuss reducing usage. Other responses included recycling water, with many candidates discussing the recycling of grey water for further credit.

Section B

Question 6

The question required candidates to discuss to what extent reducing water usage would provide water security for all countries by 2040.

The question requirements meant candidates needed to evidence an understanding of water security, threats to water security, and ways to reduce water usage. As well as this, a judgement (AO3) was required using information surrounding all these areas.

Strong responses defined what water security was, as well as highlighting the various uses of water, i.e. the demand for water such as domestic demands and demand from the manufacturing industry. Where candidates provided a secure response, this was often illustrated with a relevant case study such as the relatively recent droughts experienced in Cape Town. Distinctions were made between potable water and water used to irrigate or wash items through recycling or collecting water in tanks. In addition, legislation and the need to restrict water usage by taking shorter showers were also creditworthy points. In the case of the Cape Town reference, assessment was evident in some responses where candidates stated that ‘day zero’ was not reached through the communities adhering to these policies.

Climate change was often cited as a threat to water security, and there were some very strong responses that discussed improved irrigation techniques by farmers such as drip irrigation or using drought resistant crops as a strategy to achieve water security.

More limited responses lacked the use of examples, both of named countries as well as named methods of reducing water use. These responses were therefore general and although they demonstrated awareness of

the question, the illustration and development were not sufficient to ensure the response was secure and able to access higher levels of credit.

Question 7

This question required candidates to evaluate habitat conservation and habitat creation as methods of conserving biodiversity. It invited responses that illustrated relevant examples and reasons for how both strategies could achieve this.

The question required demonstrating a knowledge of the importance of biodiversity together with showing an understanding of habitat conservation and creation including rewilding, extracted reserves, protection of habitats, nature reserves, protected areas, conservation zones and national parks.

The key to the question was illustration through relevant examples and an appraisal of how successful these conservation projects have been.

Again, as in **Question 6**, candidates who provided relevant examples were generally awarded higher levels of credit. Good responses evidenced projects such as the Gonarezhou game reserve (later becoming Gonarezhou National Park). Issues of economic recession within the country and a lack of funding accessed AO3. In addition, this particular example illustrated hunting concessions in force and a judgment as to the management of animal numbers. Other responses included the management of endangered species and how anti-poaching strategies were implemented.

In addition to providing a relevant case study as an example, the stronger responses included examples of other conservation projects that perhaps were not deemed to be as successful. Habitat creation examples included zoos and aquariums, again with examples.

As in **Question 6**, candidates who discussed habitat conservation or creation without specific examples were not able to access higher levels of credit due to their responses being insecure and less factual.

ENVIRONMENTAL MANAGEMENT

Paper 8291/13

Principles of Environmental Management

There were too few candidates for a meaningful report to be produced.

ENVIRONMENTAL MANAGEMENT

Paper 8291/21
Management in Context

Key messages

Candidates should note the number of marks available for each question and write answers accordingly. This will give them an indication of the amount of content and detail expected.

It is important that instructions are followed carefully. Candidates should make sure that they understand the difference in meaning of the command words such as state, suggest, predict, justify, describe, explain, compare and evaluate.

Candidates should avoid repeating the question in their answers to make best use of examination time.

Candidates should show all working out in calculation questions as credit may be available for the correct calculation method even if the final answer is incorrect.

General comments

There was generally a good response to all questions across the paper.

Topics which proved more challenging were comparing systematic sampling strategies, the process of leaching, the link between plant-based diets and climate change, the role of international agreements in controlling air pollution, the quadrat method to estimate population and the importance of conserving biodiversity.

Many answers showed a good understanding of terms and attention to detail with effective use of exemplar material.

The strongest answers included effective use of appropriate examples to illustrate key points, along with supporting details using the correct terminology.

Comments on specific questions

Question 1

This question covered the topics of the World Bank classification of income groups, the impact of China's one-child policy per family and dependency ratio.

(a) The majority of candidates were able to correctly identify the overall trend between 1987 – 2015 that HICs increased and LICs decreased shown in **Fig. 1.1**. A significant number of candidates included reference to MICs which was not relevant to the question and therefore could not be credited. Candidates who answered this question well gave detailed comparative responses on HICs and LICs rather than just quoting data unqualified.

(b) (i) This question was answered well with candidates able to use a wide range of data from **Table 1.1** to suggest why Chad has an HDI score of 0.328 and gain full credit.

(ii) This question was also answered well with most candidates able to suggest a valid reason why some people think the HDI score is better than the World Bank classification.

(c) This question was generally well answered. Most candidates were able to access some credit by suggesting that the impact of the one-child policy, in China, was less use of natural resources or that natural resources were conserved for future generations. Some candidates needed to go on to identify the natural resources which were used less, e.g. fossil fuels, food, land and water.

(d) The majority of candidates were able to correctly calculate the dependency ratio using the equation provided.

(e) Candidates found this question, which asked for the impacts that the one-child policy in China would have on China's economy by 2050, more challenging. The most common impacts suggested were a decrease in the economy overall and a smaller workforce. Candidates who answered this question well were able to identify other economic constraints such as lower tax revenues, greater spending on pensions or greater spending on health care. Some candidates suggested non-economic impacts such as a lower birth rate or decreasing population which was either given in the stem of the question or not relevant to the question being asked.

Question 2

This question covered the topics of a method to investigate the concentration of nitrate ions in a lake, data analysis of nitrate ion concentration in drinking-water wells in Minnesota, US and water insecurity.

(a) (i) Most candidates were able to correctly state that the independent variable in the investigation was air temperature. Where candidates did not understand the term 'independent variable' there were a variety of answers with the most common being reference to the lake water or water samples.

(ii) Most candidates were able to correctly state one control variable with the most common response being volume or amount of water collected.

(iii) Most candidates were able to access some credit for reference to identifying errors or comparison of results. Very few candidates referred to the idea of finding an average or mean. Many answers referred to 'making the results more accurate' which, unless qualified, was not creditworthy.

(b) (i) Most candidates were able to correctly calculate the mean concentration of nitrate ions. Some candidates were able to access limited credit for the correct, unrounded answer.

(ii) Candidates were generally able to correctly calculate the air temperature range where they understood that the answer was the difference between maximum air temperature and minimum air temperature. The most common incorrect responses were either 26 °C or 14 °C but it was unclear how these answers were derived as no working was shown.

(iii) The majority of candidates were able to correctly interpret data from **Table 2.1** to conclude that the candidate's hypothesis was incorrect.

(iv) Candidates found this question very challenging as systematic sampling was poorly understood. Very few candidates accessed the credit available and there was a significant number of candidates who did not attempt to answer this question. Candidates needed to describe systematic sampling, e.g. every nth distance across the lake was selected.

(v) Most candidates were able to suggest that it was not possible to conclude from the results in **Table 2.1** that lake water is suitable to provide drinking water as there were only five samples collected, or that the lake water may contain other pollutants as only nitrate ion concentration was measured.

(c) (i) This question was poorly answered with the majority of candidates describing the distribution of wells rather than the distribution of nitrate ion concentration in drinking-water wells which limited the credit that could be awarded.

(ii) Very few candidates knew that the process by which nitrate ions enter groundwater from soil was leaching. Some candidates referred to 'run-off' and a significant number of candidates did not attempt to answer this question.

(d) Most candidates were able to give one of the two supply methods for drinking water other than artesian wells from a wide range of possible answers. The most common incorrect answers were rivers and lakes.

(e) (i) This question was more challenging as candidates did not show understanding of water insecurity and the link with poverty, i.e. being unable to work or get an income. Stronger responses made the link between spending hours collecting water or drinking contaminated water and becoming ill, both of which would lead to people being unable to work or earn money.

(ii) This question was not well answered with a significant number of candidates giving answers about making water clean rather than food production. Successful responses referred to an unreliable water supply as water is needed for plant growth, leading to less feed grown for livestock, so overall less crop, meat and dairy production.

Question 3

This question covered the topics of layers of the atmosphere, surface albedo, the role of space reflectors and a plant-based diet in counteracting or reducing climate change, gases in the Earth's unpolluted atmosphere, and the role of international agreements in the control of air pollution.

(a) (i) Candidates were generally able to correctly name the layer of the atmosphere directly above the stratosphere as the mesosphere.

(ii) This question was less well answered as many candidates did not understand the term 'surface albedo' and referred to the process of snow melting rather than snow and ice reflecting incoming solar radiation.

(iii) This question was more challenging and generally less well answered. The most common response for full credit included IR radiation trapped by greenhouse gases. Many candidates did not show understanding of the difference between the greenhouse effect or global warming and the hole in the ozone layer. A common misconception was that the ozone layer prevented IR radiation leaving the Earth's atmosphere.

(iv) Candidates found this question challenging and very few referred back to the diagram in **Fig. 3.1** which would have prompted them in their answer. The most successful responses were able to refer to the incoming solar radiation being reflected back before it reached the Earth's surface. Candidates showed little understanding of solar radiation management (SRM) methods and how they work. Weaker responses had vague references to reducing global warming or climate change rather than how space reflectors counteract climate change.

(b) This question was poorly answered with very few candidates gaining credit. The majority of candidates did not recognise that cattle or livestock produce methane and incorrectly focused their answer on energy and products from meat factories. A successful response should refer to cattle producing methane, a greenhouse gas, and that livestock rearing requires more energy than growing crops.

(c) Most candidates were able to correctly state the three major gases in the Earth's unpolluted atmosphere as nitrogen, oxygen and carbon dioxide. Some candidates incorrectly referred to carbon monoxide or simply just 'carbon' instead of carbon dioxide or methane.

(d) This question was not well answered and the role of international agreements was poorly understood. Many candidates needed to identify the benefits of countries working together and the fact that the atmosphere has no boundaries, so were limited in the credit they could access.

Question 4

This question covered the topics of energy security, impacts of energy insecurity, the benefits of an energy efficient house on the environment and the source of energy for plants.

(a) (i) The definition of energy security was generally well known, and most candidates were able to give an acceptable definition to attain minimal credit. Common more successful responses gained further credit as they recognised that people have reliable availability of energy at an affordable

price. The most successful responses for full credit also included reference to consideration of environmental impacts.

(ii) This question was generally answered well. The most common correct responses were disrupted supply or power cuts, poverty and economy decreases. Some candidates misunderstood the question and stated causes of energy insecurity rather than impacts of energy insecurity. Common incorrect answers included vague references to climate change and global warming.

(b) (i) This question was more challenging and poorly answered with most candidates accessing only limited credit. Most responses focused on the solar panels and wind turbine shown in **Fig. 4.1** and therefore referred to reduction in use of fossil fuels, increased use of renewable energy sources and reduction in climate change. Very few candidates noticed the rain water collection which provides water for irrigation or recycles water, or the composting which reduces waste and can provide nutrients for soil. Some responses included reference to the insulated walls and windows which reduce heat transfer and linked this to keeping the house cool in hot weather reducing the need for air conditioners.

(ii) Some candidates were able to suggest one benefit of having a roof planted with grass with the most common responses either insulation or photosynthesis.

(iii) Most candidates were able to correctly state that the source of energy for plants was the Sun.

Question 5

This question covered the topic of an investigation of the population of beetles in five different locations in Italy including population estimation, quadrat technique, the ACFOR scale, habitat loss, biodiversity and food chains.

(a) Most candidates were able to plot the data in **Table 5.1** as a bar chart to access some of the credit available. Graph drawing skills were generally good although bars touching and not of equal width were common errors.

(b) (i) Most candidates were able to correctly estimate the total number of beetles in the quadrat in **Fig. 5.1**.

(ii) This question was challenging and poorly answered. Understanding and explanation of representation and scaling up is an area for improvement for candidates.

(iii) Some candidates were able to suggest different counting as a reason why using two different people to count the number of beetles in a quadrat can lead to inconsistent results. A very few candidates suggested either the ability to ‘see’ beetles or misclassification, e.g. between woodlouse and beetle as alternate responses.

(iv) Some candidates were able to correctly suggest a technique for surveying beetle populations other than quadrats, with the most common suggestions of either pitfall trap or sweep net. The most common incorrect responses were kick sampling and capture-mark-recapture.

(c) Most candidates were able to access credit for reference to foxes constantly moving around as a reason why the quadrat method is not suitable to estimate the population of foxes. Some candidates gained full credit as they went on to suggest that foxes are too large.

(d) This question was poorly answered and it was evident that candidates did not have a good understanding of the ACFOR scale. Few candidates accessed full credit and the majority gained no credit. There were a significant number of candidates who did not attempt to answer this question. Respondents who answered well made reference to the ACFOR scale being subjective, qualitative method rather than quantitative, and that some species of plants can be confused with others.

(e) Most candidates were able to correctly identify that there was a higher percentage of population loss for beetle species A when 25% of their local habitat is lost. More successful responses also included correct comparative quoted data.

(f) Candidates found this question more challenging, the most common correct answer was the prevention of extinction, and a few candidates referred to genetic diversity or pollination. Understanding of the benefits of conserving biodiversity is an area for improvement for candidates.

(g) (i) Most candidates were able to state that the aphid is a primary consumer because it eats the producer or is in the second trophic level. Some candidates referred to the aphid eating grass which was insufficient to gain credit.

(ii) This question was answered well with most candidates able to suggest that the beetle populations decreased as there was less food to gain full credit.

(h) Most candidates were able to correctly calculate the efficiency of the energy transfer from aphid to beetle using the equation provided. The most common incorrect answer was 11.1% in which candidates divided 50 by 450 instead of 50 divided by 500 in the initial stages of the calculation.

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Key messages

Candidates should note the number of marks available for each question and write answers accordingly. This will give them an indication of the amount of content and detail expected.

It is important that instructions are followed carefully. Candidates should make sure that they understand the difference in meaning of question command words such as state, suggest, predict, justify, describe, explain, compare, outline and evaluate.

Candidates should avoid repeating the question in their answers to make best use of examination time.

Candidates should show all working out in calculation questions as credit may be available for the correct calculation method even if the final answer is incorrect.

Candidates should always use the answer line(s) provided for their responses and if at all possible they must avoid using white space on the examination paper to continue their answers. If extra space is required, then continuation sheets should always be used. Candidates using continuation sheets should be mindful to label their responses accurately according to the question part. This is particularly important when there are several parts to one question.

General comments

Topics which proved the most challenging were the proposed methods of reflecting incoming solar radiation by stratospheric aerosol injection, and by surface albedo enhancement through growing crops with shiny leaves. It was evident that understanding of solar radiation management and surface albedo enhancement methods were areas requiring improvement for most candidates.

Despite these challenges, there were good responses to most of the other questions across the paper. Many answers showed a good understanding of syllabus terms and topics. Where asked for, candidates generally made effective use of the information given in tables, charts and figures.

The most successful answers included effective use of appropriate examples to illustrate key points, along with supporting details using appropriate terminology.

Comments on specific questions

Question 1

This question examined knowledge of geo-engineering strategies to counteract climate change, such as stratospheric aerosol injection and growing crops with shiny leaves. This led on to predicted impacts of these strategies including flooding and drought and their links with water insecurity and food insecurity.

(a) (i) Nearly all candidates found this the most challenging question across the paper. Most answers incorrectly suggested either that the aerosols worked to deplete stratospheric ozone, or that they chemically 'fixed' ozone depletion. There was a general misconception that the aerosols sprayed were chlorofluorocarbons (CFCs) rather than sulfate aerosols.

(ii) The strongest answers correctly indicated that shiny leaves enhance surface albedo, thereby reflecting incoming solar radiation away from Earth's surface and reducing global temperatures.

Weaker responses incorrectly suggested that shiny leaves 'attract' more sunlight and therefore more photosynthesis would take place, reducing atmospheric carbon dioxide.

(b) (i) Candidates found this question demanding and needed to identify specifics to access credit. The model answer would have included mention of changed atmospheric circulation, adverse effects on rainfall, temperature changes and crucially more extreme weather, such as hurricanes and heatwaves.

(ii) Many candidates were able to use the information in **Table 1.1** to reach an adequate balanced evaluation of the geo-engineering strategies including positive and negative results.

(iii) Most candidates did not access credit here. It was evident that candidates struggled to understand the topic of geo-engineering strategies to counteract climate change. The model answer would have mentioned small-scale (or laboratory) testing, field testing or repeating the computer models with different parameters.

(c) The majority of candidates scored well. The strongest answers showed a neat graph with vertical bars drawn with a ruler, of equal width and not touching, both axes labelled correctly with a *y*-axis scale of 10 (million) people per 5 small squares and all five countries correctly plotted.

Candidates should remember to include zero on the *y*-axis. Bars not drawn with a ruler meant a loss of credit where the plot was not clear and a further reduction where it was not clear the bar widths were equal.

Responses where countries were labelled by their initials only lost partial credit for plotting due to the ambiguity between the position of India and Indonesia.

(d) Most candidates scored highly and showed a strong understanding of the link between flooding and water insecurity. The most successful answers provided named examples of pollutants as well as knowledge of the issues of both inland and coastal flooding.

(e) The question asked for an explanation of why drought leads to food shortages and malnutrition. A few candidates scored maximum credit and many understood that plants/crops need water for growth, with a very few linking this to the process of photosynthesis. Most answers correctly identified reduced crop yield and needed to go on to link this to famine or develop it further by identifying food insecurity as an outcome.

(f) The majority of responses scored well for identifying and summarising the global distribution of under five-year-old children who are underweight. The strongest answers used given geographical features such as the Tropic of Cancer, the Tropic of Capricorn and the Equator, as well as quoted data. Many identified all five possible marking points.

Question 2

This question examined data handling, interpretation and investigation skills on the topic of sulfate ion concentration in a lake in response to rainy (wet) and dry days. The question also asked for knowledge of the formation of acid deposition as well as interpretation of the trends of sulfur dioxide emissions over 150 years for four regions.

(a) (i) Nearly half of the responses identified the concentration of sulfate ions as the correct answer. Other responses incorrectly stated the amount of lake water, the weather and the number of samples.

(ii) Just over half of the responses named a control variable such as volume of lake water, time or depth of collection or sample location. Many incorrectly suggested that temperature was a control variable.

(iii) The majority of answers scored credit for correctly identifying a range of control variables other than that already stated in **Question 2(a)(ii)**. A few scored full credit. Most candidates needed to carefully read the question and take note of the qualifying word 'other' to avoid repeating their answer to **Question 2(a)(ii)**.

(b) (i) Most candidates were able to calculate the correctly rounded answer for the mean concentration of sulfate ions.

(ii) Most candidates correctly calculated the range for the concentration of sulfate ions.

(iii) The majority of candidates had carefully read the question and gave answers that provided both requirements for credit. A few responses were not awarded credit where they had correctly specified that wet days had the highest concentration but had not indicated that the student's hypothesis was correct.

(iv) Most answers correctly stated that either more samples could be taken or more samples on dry days specifically. Very few answers suggested to record the volume of rain or to repeat and find the average.

(c) (i) A quarter of responses correctly stated pH 5.6.

(ii) Most candidates found this question challenging. The strongest answers correctly stated that sulfur dioxide is emitted into the atmosphere upon combustion of fossil fuels which contain sulfur impurities. Candidates should avoid vague terms such as sulfur dioxide 'mixes' with water vapour. Some described the effects of acid deposition, which was not required.

(iii) This question was generally well answered with many candidates scoring credit by identifying a reduction in crop yield or describing damage to leaves such as browning. Some of the stronger answers also described weakened crops or reduced growth for full credit. Many answers indicated soil damage, which was not given credit as this would be an indirect impact. Candidates should avoid vague answers such as 'crops die' without giving specifics.

(iv) Most candidates answered well on this question, being able to compare two or more regions in terms of their trends, or were able to quote correct comparative data for any given year. The majority identified that North America and Europe were the biggest emitters of sulfur dioxide until the 1990s and had both been decreasing in emissions since 1972–1975, and that East Asia was now increasing in emissions. Many answers correctly specified that the Middle East has remained the lowest emitter since 1850. Candidates who did not score any credit here needed to remember to read the question carefully, which asked for comparisons between regions rather than individual descriptions of the trends for each region.

(v) A third of candidates correctly suggested that sulfur dioxide emissions are global and that because there are no borders in the atmosphere, emissions travel between countries and therefore international agreements are needed. Other responses mistakenly stated that action was needed at a regional, continental or countrywide level, none of which would be enough to reduce sulfur dioxide emissions.

Question 3

This question tested knowledge of the environmental issues surrounding paddy fields for growing rice and methods of surveying for insect pests and pest control. It also examined competency in data handling and analysis using results from an experiment to determine the highest yielding variety of rice. Candidates were then asked to calculate Simpson's Index of diversity using the given formula and results from an insect pest survey.

(a) (i) There were some good answers with the best responses developing the provided information to score maximum credit. The strongest answers determined that paddy fields have a high carbon footprint and that carbon dioxide and methane are both greenhouse gases that contribute to climate change and global warming. Some responses also identified high water usage as an environmental issue. Very few candidates developed an argument for rice as a staple food. Responses that only restated the given information without development or were vague answers, were not credited. Specifically, poor responses described neither carbon dioxide nor methane as greenhouse gases. Candidates should avoid vague terms such as 'causes pollution' or 'harms the environment'.

(ii) Less than half of candidates suggested a creditworthy answer. Most correct answers specified a high yield or that there was no need to irrigate. A few answers correctly suggested tradition or nutrients in the water as a benefit. No answers suggested terracing or poor soil quality.

(b) (i) Nearly half of the cohort suggested one correct answer, with a third gaining full credit. Most candidates needed to read the question more carefully before answering as the majority of responses gave information about the rice grown or farming methods rather than aspects of the fields, such as soil type or area.

(ii) The majority of responses correctly identified field **C** as having the lowest yield and therefore this field may contain an insect pest.

(iii) Candidates found this question demanding, it was evident that candidates had little knowledge of a sweep net or how it is used to survey for insects. Many answers incorrectly implied a large flat net with small holes is placed over the whole field and dragged along or left for a period of time to catch insects. Others understood that a sweep net is hand-held and swept along the crops but very few adequately described a side-to-side motion or how to empty the net for counting. The question asked for a survey of insect pests, whereas many responses described capturing insects to kill them. Candidates should avoid suggesting the insects are destroyed during surveys. Very few responses correctly described either random or systematic sampling and few detailed counting the insects to complete the survey.

(iv) The majority of responses correctly described at least one limitation of using a sweep net with some insects being missed or escaping as the most popular answer. The strongest answers also described its limitations as being easily damaged or that it is time consuming. Nearly half of all responses accessed full credit.

(v) In general, this question was well attempted with most candidates able to give at least one or two advantages of using a chemical insecticide. The most popular responses for advantages were that chemical insect control is effective and quick. Few answers described that biological control can become invasive or that it reintroduces a predator. Some indicated that it prevents a decrease in crop yield but none outlined that it reduces the chance of food insecurity. Disadvantages were less well outlined with many incorrectly indicating damage to the crop or soil and making vague references to health issues for humans. Some of the stronger answers correctly outlined that non-target species were harmed and gave examples of pollinators. Some described insecticide running off into water bodies or entering the food chain and a few mentioned insects becoming resistant. Candidates should be careful not to confuse insecticide with herbicide and to be sure they know the difference.

(vi) This question split responses into those scoring full credit for each correct step of the calculation, and those scoring a little for the first step or first two steps. The vast majority were able to calculate the first step. For the second step, many rounded too far, rounded incorrectly or did not give the answer for aphid in standard form, despite their calculations for the other insects being correct. Candidates should be careful when transferring what is displayed on their calculator to the answer line and know the difference between decimal (normal or expanded form) and standard form.

Question 4

This question examined competency in the use of given information on electric cars versus petrol and diesel cars, as well as knowledge of the advantages and disadvantages of electric cars. It also tested knowledge of the causes of energy insecurity and its economic impacts.

(a) There were some good answers with most responses giving at least one or more advantages using the given information. The most common answers for advantages used one or more pieces of information from **Fig. 4.1** and the information given above it. Disadvantages were less well outlined with most answers being too vague or underdeveloped for credit. The most common answers for disadvantages were issues with short battery life or poor charging point infrastructure. Candidates should avoid vague statements such as ‘electric cars are more expensive’ without qualification such as that they are expensive to buy or have a high initial cost. Stronger respondents used the given information as well as their knowledge. For example, good answers for advantages stated that electric cars emit no carbon dioxide, that this is a greenhouse gas and therefore electric cars have less impact on climate change than petrol or diesel cars which do emit carbon dioxide. Further, good outlines for disadvantages developed the given information that electricity for charging comes from burning fossil fuels and that this also releases carbon dioxide.

(b) (i) A third of responses accessed credit for explaining that open questions require the processing of answers that is time consuming or difficult. Most responses were not specific enough and none explained that a large amount of information is obtained. Candidates should avoid writing in shaded boxes such as in **Fig. 4.2** which, in this case, is an example questionnaire.

(ii) The vast majority of candidates were able to correctly complete **Fig. 4.3** with the tally of 23.

(c) (i) Most candidates were able to read **Fig. 4.4** correctly and state that there are 62 000 electric cars in Norway.

(ii) Most candidates were able to read **Fig. 4.5** correctly and state that of all car types in Norway, 42% are electric cars.

(iii) Few responses suggested that percentage data gives a more accurate representation of the use of electric cars within a country or that it shows the differences or allows comparison between countries. Candidates should be aware that percentage data is always out of a total number, which in this case is the total number of all types of cars (e.g. petrol, diesel, electric). Most answers were too vague to access credit.

(d) (i) Most candidates were able to state at least one correct cause of energy insecurity. Nearly half of all responses gained full credit. Many candidates misunderstood the question being asked and stated one or more impacts of energy insecurity, which was not asked for here.

(ii) This question was slightly less well answered than **Question 4(d)(i)**, with the majority of responses giving non-economic impacts. Many answers also stated the causes of energy insecurity, which was not asked for here. Candidates should take great care to read each question carefully throughout the paper, particularly where question parts are closely linked such as **Question 4(d)(i)** and **Question 4(d)(ii)**.

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There were too few candidates for a meaningful report to be produced.