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**. Although it was usually possible to work out which question was being answered, it is good practice to clearly indicate which question is being answered.
In addition, candidates should be encouraged to avoid writing a lengthy but general introduction with background information and focus on specific strategies related to the question being asked with explanation of the benefits and limitations of each of their ideas. Candidates should also draw their ideas together in the conclusion rather than writing a general conclusion which simply restates ideas already written about.

It is important that instructions are followed carefully. Candidates must 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 avoid wasting exam time.

General comments

There was generally a good response to all questions across the paper. Most candidates found **Question 1** (Earth's atmosphere and the natural greenhouse effect) and **Question 3** (impacts of mineral extraction) more demanding than the other questions in ***Section A***.

Topics which proved more challenging were the natural greenhouse effect, gross and net primary productivity, evaluating the strategy of reducing the use of rechargeable batteries, and long-term energy security.

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

The most effective 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 the structure of the Earth's atmosphere, the natural greenhouse effect and how it maintains the temperature of the Earth's atmosphere, links between eating a plant-based diet and reducing the enhanced greenhouse effect, and human activities that lead to the enhanced greenhouse effect.

(a) (i) The structure of the atmosphere was generally well known and most candidates were able to identify **D** as the thermosphere and **A** as the troposphere.

(ii) Most candidates were able to interpret Fig. 1.1 to give creditworthy descriptions of how the temperature shown in layers **A** and **B** changed with altitude. However, some candidates did not access the two marks available as they did not make it clear which layer they were referring to or described the difference in temperatures between layers **A** and **B** rather than the change of temperature within each layer. The most successful responses simply stated that in layer **A**, temperatures decrease with altitude and in layer **B**, temperatures increase with altitude.

(iii) Candidates found this question asking for an explanation of the change in temperature between 20 km and 50 km in layer **B** (the stratosphere) challenging. The majority of candidates were able to access one mark for mentioning ozone and few candidates went beyond stating that layer **B** contains the ozone layer. Candidates that did refer to UV radiation often gave incorrect explanations such as 'ozone blocks UV radiation' rather than demonstrating an understanding that ozone absorbs UV radiation. Very few candidates understood that the absorbed energy then heats the atmosphere. Some candidates digressed into a discussion of human health issues related to ozone depletion which is not relevant to the question being asked. Successful responses, to access the three marks available, referred to ozone present in layer **B** absorbing UV radiation which in turn warms or heats the atmosphere.

(b) (i) Most candidates found this question about how the natural greenhouse effect maintains the temperature of the Earth's atmosphere difficult. Very few candidates discussed ultraviolet radiation and infrared radiation, and those who did, often did not have them in the correct context or sequence. Candidates would benefit from being given clear definitions and the correct sequence of the processes involved i.e. short wave radiation (UV) is absorbed by the Earth's surface and converted to long wave radiation (IR). The infrared radiation is then re-emitted into the atmosphere where it is absorbed by greenhouse gases. The absorbed infrared radiation warms the atmosphere.

Imprecise terminology such as 'heat' being trapped or greenhouse gases 'heat up the atmosphere' was not credited. Weaker responses focused on greenhouse gases being trapped in the atmosphere rather than infrared radiation being absorbed by the greenhouse gases in the atmosphere. A common misconception was that solar radiation is reflected from the Earth's surface rather than incoming ultraviolet radiation being absorbed and then re-emitted as infrared radiation.

(ii) Few candidates were able to access more than one mark for suggesting how a plant-based diet can reduce the enhanced greenhouse effect. Most candidates correctly suggested that cattle or livestock release methane, or that less cattle would result in less methane released into the atmosphere. More successful responses referred to the high energy costs of meat processing and refrigeration, or that meat processing factories produce greenhouse gas emissions. In general, weaker responses were not specific enough to attain marks. Few candidates were able to suggest that rearing cattle results in deforestation and that trees absorb carbon dioxide or act as a carbon sink. Many candidates simply stated a plant-based diet has a lower carbon footprint than eating meat but did not give any valid suggestions as to why. A common misconception was that plants would not need cooking, or they could be grown locally.

(iii) This question was generally answered well with most candidates able to attain some credit for stating two other ways human activities contribute to the enhanced greenhouse effect. However, some responses were not precise enough to access the two marks available i.e. reference was made to use of fossil fuels, vehicles or factory emissions without using precise terminology e.g. combustion or burning of fossil fuels. Similarly, reference was made to aerosols without naming CFCs. In addition, some candidates repeated the same point e.g. stating combustion of fossil fuels and then stating vehicle use as the second example, seemingly not understanding that using a vehicle involves burning fossil fuels in the engine.

Question 2

This question covered the topics of primary succession, gross and net primary productivity, and included the plotting of a bar chart of the net primary productivity of five ecosystems from data given.

(a) (i) Candidates were generally able to recognise correct evidence for primary succession of an ecosystem from Fig. 2.1. Common correct responses included that the rock is bare or new, plants are small or pioneer species, or that there is a lack of soil. Less successful responses tended to repeat the information given in the stem of the question and stated that 'plants are growing on the

rock'. Some candidates stated solid rock or that the lava cooled to form rock but gave no indication that this had happened recently so could not be awarded the mark.

(ii) There were some excellent responses to this question asking for an explanation of how the ecosystem will change over time. Most candidates were able to access at least three out of the six marks available. The most successful responses included effective use of technical terminology such as pioneer species, biodiversity and climax community with ecological succession described in the correct sequence. However, some candidates mistakenly referred to organisms rather than animals colonising the ecosystem whereas other candidates misinterpreted the question, describing the negative consequences of human intervention such as habitat destruction and climate change instead of describing the development of soil and an increasingly complex ecosystem. Some candidates also digressed into the consequences of a further volcanic eruption which was not creditworthy.

(b) (i) In general, most candidates were able to plot the bar chart correctly and access at least three out of the four marks available. Common errors included: omission of units for net primary productivity on the y-axis, choosing non-linear or difficult scales e.g. 10 small grid squares = 72 (so that the 'forest ecosystem' bar of 360 filled the grid space, making it difficult to plot some of the other bars accurately) and plotting a histogram with bars touching (bar charts with separated bars are used for discrete data such as that provided in Table 2.1, whereas histograms are used for continuous data). Although not penalised, a considerable number of candidates did not put a 0 at the bottom of the y-axis scale. Candidates should be encouraged to include 0 on scales where appropriate, and some candidates could have improved the accuracy of their plot by using a sharp HB pencil and a ruler for plotting the bars.

(ii) Most candidates found this question challenging. The candidates who carefully studied the information in Fig. 2.1 and Table 2.1 were able to come to the conclusion that the net primary productivity of the lava field ecosystem would be similar to that of the desert scrubland, as Fig. 2.1 showed a large area of rock with sparse, small plants. However, most candidates were unable to provide a prediction of the net primary productivity within the acceptable range.

There were a significant number of candidates who did not seem to understand the question who, incorrectly added up all the net productivities of the different ecosystems to give a total of 702 or calculated the mean to give a value of 140.4. Very few candidates were able to make the link between the lack of vegetation and low levels of photosynthesis or low nutrient content in the ecosystem.

(iii) Candidates found this question difficult. Many candidates did not understand the difference between gross primary productivity and net primary productivity of an ecosystem. Some candidates attempted to put their response, incorrectly, in an economics context of GDP and NDP so did not access any marks. Some candidates incorrectly, gave the equation of NPP = GPP – respiration the wrong way round. More successful candidates correctly referred to GPP as the total carbon captured by photosynthesis and that plant respiration or energy losses should be subtracted to give NPP, for three marks. Very few candidates were able to access all four marks available.

Question 3

This question covered the topics of impacts of small-scale mineral extraction on an ecosystem, comparison of mining and recycling cobalt, and evaluating the strategy of reducing the use of rechargeable batteries.

(a) This question was generally answered well with the loss of habitat, soil erosion or degradation, contamination of water and loss of biodiversity as the most common impacts of small-scale mineral extraction on an ecosystem. Well-prepared candidates were able to access the five marks available.

Some candidates, however, did not take careful note of the question which asked for impacts of small-scale mineral extraction on the ecosystem and focused their response, incorrectly, on the impacts on humans such as crop yields, jobs and the economic benefits of selling the extracted minerals. Discussion of climate change and air pollution did not gain credit as these are unlikely to result from a small-scale mineral extraction operation, as in Fig. 3.1, with little machinery in evidence.

(b) (i) Most candidates attained at least one mark out of the two available for suggesting two reasons why cobalt is mined rather than recycled. The higher costs of recycling compared to mining and the difficulties of recycling compared to mining were most often cited. The most successful responses were those where candidates understood that they needed to give their answer in comparable terms such as 'mining of cobalt is cheaper or easier than recycling'.

(ii) Strategies for waste disposal such as landfill, disposal at sea, exporting and composting were well known but some candidates were not able to access the three marks available because they suggested incineration or recycling which was given in the stem of the question which asked for one other strategy. Those candidates who chose landfill were the most likely to attain full marks, with the impacts of toxic leachate and smell as the most common cited impacts. Candidates who chose exporting waste or disposal at sea, struggled to articulate creditworthy impacts.

(iii) Candidates found this question, where they were required to evaluate the strategy of reducing the use of rechargeable batteries, challenging. Very few candidates were able to access all three marks available. A common misconception was that reducing the use of rechargeable batteries would lead to less waste production when, in fact, the opposite is likely to be true as more single-use batteries would be used, increasing the amount of waste.

The most common correct benefit cited for reducing the use of rechargeable batteries was the reduction in demand for cobalt so less would need to be mined. Some candidates did recognise a limitation of the strategy was that it could lead to greater use of single-use batteries and therefore increase in waste, while other candidates acknowledged that lots of electronic devices including electric cars, are dependent on the use of rechargeable batteries.

Question 4

This question covered the topic of energy security and included sustainability (definition), causes of energy insecurity, long-term energy security and strategies to improve energy sustainability.

(a) (i) The concept of sustainability was well understood, and most candidates were able to give a definition of sustainability to attain at least one mark out of the two available. Some candidates were swayed by Fig. 4.1 which was energy oriented, but these candidates could still access the two marks available for a correct definition given in an energy sustainability context. Candidates who phrased their response in terms of meeting the needs of the present without compromising the needs of future generations tended to be the most successful. Less successful responses gave a definition of renewability rather than sustainability.

(ii) This question was generally answered well with many candidates able to describe long-term energy security for one or two marks. Where candidates had clearly learnt the definition of long-term energy security, they were able to access all three marks with ease. Less successful candidates merely repeated the question using alternative wording such as having energy for a long time or being energy secure in the long run. A few candidates misread the question and described energy insecurity rather than energy security, while other candidates repeated a definition of sustainability in an energy context.

(iii) The causes of energy security were well known, and most candidates were able to access at least two marks out of the five marks available. The most successful responses provided an explanation of the chosen causes e.g. severe weather events such as hurricanes bringing down power lines, rather than simply stating 'natural disasters destroy energy sources'. Less successful responses often focused too much on one or two factors and gave long-winded explanations which repeated the same marking point over again, while others gave a list without explanations limiting the response to a maximum of two marks.

(b) This question was well answered. Most candidates demonstrated good data handling skills and were able to use the data provided in Table 4.1 to give creditworthy suggestions as to how Finland could improve their overall rank position for energy sustainability. Most candidates, in their responses, focused on how Finland could improve equal access to energy and reduce environmental impact. Suggestions of general strategies for improving environmental impact such as introducing more recycling, was not given credit as these strategies are not specifically linked to energy sustainability.

Section B

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

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

This was by far the most popular question choice. Many candidates were able to demonstrate their knowledge and understanding of the issues and problems of managing water security. Successful responses often started with a definition of water security and recognition that the agriculture sector is the largest user of water in many countries.

Candidates with a good understanding of the subject matter, gave balanced accounts of strategies to reduce water use in agriculture such as drip and high-tech irrigation systems, drought resistant selective breeding and GM crops, aquaponics and hydroponics, and regenerative agriculture techniques, alongside other strategies to reduce water use such as reducing domestic water wastage through education, rainwater harvesting, use of grey water and desalination. A few candidates referred to international agreements to limit climate change, a cause of recent droughts in many countries.

Higher-level responses made good use of specific case study examples including some that were local to them. Candidates discussed named African countries suffering from drought, the Middle East, Singapore, Denmark, India and Central American countries, along with the Aral Sea in Central Asia. These candidates also recognised the difficulties faced by LICs trying to implement expensive water conservation strategies and often achieved Level 3 for AO2.

Less successful responses went off topic and described energy security or management of growing population as ways of achieving water security, perhaps prompted by the content of **Question 6**. Some candidates made the assumption that reducing water in agriculture would simply involve no water use in agriculture leading to collapsing crop yields and food insecurity. Not all candidates realised that practices such as aquaponics and hydroponics are types of agriculture, so their conclusion did not match their evidence. Conclusions were generally a repeated list of the points already discussed.

Most candidates only described one side of the argument with conclusions evenly split between candidates who decided that reducing water used in agriculture is the most effective strategy, and those who decided that there were other more effective strategies. This limited the response to Level 2 for AO3. Only a minority of responses gave balanced evaluations and judgements for both sides of the argument to achieve Level 3 or Level 4 for AO3.

Question 6

Many candidates who opted for this question had sound knowledge and understanding of national strategies for management of human population but were less able at discussing examples of local or global policies. Some responses started with an effective introduction describing the current global human population of over 8 billion and the UN's future prediction of 11 billion by 2100. The phrase 'local, national and global' appeared to have presented some difficulties for some candidates in how to approach the question.

In terms of local population management policies, few candidates went further than mentioning education, family planning programmes and access to contraception.

Knowledge of national policies was better but less successful responses did not go beyond mentioning China's 'one-child' policy (not all were aware that this policy ended in 2015). More successful responses discussed both sides of this policy with comment on the fact that China no longer had a one-child policy (it

has now become a two-child policy) as it had been too successful in reducing population growth and had resulted in an ageing population and a gender imbalance.

Higher-level responses made good use of correct terminology such as pro-natalist and anti-natalist policies and included specific case studies to exemplify both policies.

In general, a wide range of HICs such as France, Japan, Russia, Singapore and South Korea with ageing populations were cited as countries with pro-natalist policies. MICs and LICs such as India, South Sudan, Thailand and Uganda with large and often rapidly growing populations were cited as countries with anti-natalist policies. A few candidates referred to Africa, incorrectly, as a country rather than a continent.

Not all candidates were able to convincingly argue whether the countries they named had been successful or unsuccessful in their approach. Some more successful responses recognised the issues faced by LICs in funding and lack of public support for implementing birth control strategies.

Only the highest-level responses were able to provide examples of global population policies such as UN Agenda 21 or The Club of Rome intellectual think tank's recommendations.

Discussion about migration was confused and many candidates did not realise that this is not really managing population, just moving it from one place to another.

Most candidates achieved Level 2 for AO2 and few candidates achieved more than Level 2 for AO3 as evaluations were mostly one-sided stating either that the strategies were successful or unsuccessful. Very few responses gave balanced evaluations and judgements for both sides of the argument to achieve Level 3 or Level 4 for AO3.

ENVIRONMENTAL MANAGEMENT

Paper 8291/12

Principles of Environmental Management

Key messages

Candidates should note the number of marks available for each part question and write answers accordingly. This will indicate the amount of content and detail expected. Under time constraints, bulleted answers are often the clearest way to show knowledge in the structured questions.

It is important that instructions are followed carefully. Teachers can help by making sure the difference in meaning of question command words is understood. The command words in this paper are: state, define, identify, calculate, suggest, describe, explain, compare, outline, construct and evaluate.

Questions should always be read carefully before responding. If an answer needs to be re-written, a single line through the incorrect passage is appropriate. The re-attempted answer should be clearly written. If there is insufficient remaining answer space, the lined space at the back of the booklet may be used and the response should be clearly labelled with the question number to which it refers.

Candidates should avoid repeating the question to make best use of examination time. The context in which a clear answer is written will be understood by examiners.

Candidates should remember to show all working out in calculation questions as credit may be available for the correct method by an error carried forward.

Vague terms such as: resources, pollution, environmentally-friendly, harms, affects, impacts, etc., should be avoided as much as possible without qualification. For example, resources could be qualified as food, water, energy, etc. Pollution could be qualified as air pollution, noise pollution, visual pollution, land pollution etc.

General comments

For ***Section A***, topics which proved the most challenging were transfer of energy within a food web (**Question 2(a)(ii)**), comparison of wet and dry acid deposition (**Question 3(b)(i)**), the formation of acid deposition (**Question 3(b)(ii)**) and its effects on the environment (**Question 3(c)(i) and 3(c)(ii)**) and topics surrounding the impacts of energy insecurity and climate change as a cause of energy insecurity (**Question 4(b)(ii)** and **4(b)(iii)**). For ***Section B***, most candidates who attempted **Question 6** on waste management had mis-read the question, which negatively impacted their score for AO2 Information handling and analysis.

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

Section A

Question 1

This question examines knowledge of food insecurity and management of food security in the USA. It also tests understanding of data presented in a line graph and reasons for the trend, whereby candidates are expected to draw on knowledge of changes in agricultural practices in the USA. On the whole, candidates found this question easier than other questions across the paper.

(a) Most responses gave the correct definition of food insecurity. The least successful answers were too vague for any marking point. Candidates who had not read the question carefully responded by giving the definition of food security.

(b) (i) The vast majority of candidates were able to access maximum credit for a correct description of the graphic trend, making use of the most obvious features as well as data quotes.

(ii) Many candidates were able to suggest appropriate reasons for the decline in food insecurity between 2015 and 2019. The most successful responses accessed full credit for considering a wide range of strategies including improvements in commercial agricultural techniques and management, improvements in infrastructure and food storage as well as ideas around food rationing and food aid. Others also acknowledged an increase in subsistence agriculture. Some candidates attempted to describe strategies for improving water security, suggesting the question had not been understood.

(c) (i) Most candidates were able to explain that **Question C** was an open-ended question or that **Question A** and **B** gave a yes or no response and were easier to quantify.

(ii) The vast majority of candidates gave an appropriate question, clearly indicating their understanding of the definition of food insecurity. Some accessed no credit for a question that was too close in wording as those already given in Table 1.1. This illustrates the importance of reading the question carefully.

(d) There were many good responses with the most successful considering both the positive as well as the negative impacts on food security. Many were able to correctly identify extensive agriculture of a single crop only (monoculture), which increases vulnerability to pests, disease and climate change as well as land (or soil) degradation. Balanced answers showed an understanding of an increase in food production that can be harvested more quickly than by hand and which, therefore, meets demand. Candidates should avoid phrases or terms which repeat the question for which no credit will be given. In this example ‘a very large field/area’ is cultivated is too vague to credit the idea of increased crop yield.

Question 2

Candidates are examined on the marine environment, specifically the Antarctic marine food web including knowledge of photosynthesis, as well as aspects and methods of whale conservation. Candidates are tested on their knowledge of the energy transfer links between trophic levels within the web, and on the chemical equation for photosynthesis and factors that limit its rate.

(a) (i) The majority gained full credit for correctly constructing the Antarctic marine food web, using the information provided. Credit was commonly lost where the direction of energy transfer was incorrect or no direction was given at all. Correct energy transfer is always indicated by an arrow passing from a lower trophic level to a higher trophic level.

(ii) This question was challenging for most candidates with very few accessing full credit. Common mistakes included describing organisms as ‘containing energy’ or ‘having more energy’ whereas the question seeks understanding of the energy *transfer* between trophic levels. It is scientifically incorrect to describe an organism as ‘containing energy’. The correct terminology to use in study of food webs is that organisms have more (or less) *biomass* than others. Credit would have been given in this context had an indication of the length of the food chain been given. Other common errors were a description of which tropic level organisms occupied, also without indication of the

length of the food chain between organisms. Those who accessed credit, correctly described that energy is lost between trophic levels by (named) metabolic processes.

(b) (i) Many candidates stated the correct balanced chemical equation for photosynthesis. Those who stated the word equation, or gave incomplete chemical formulae, were not credited. Others lost 1 mark for incorrect balancing.

(ii) This question was answered well with most candidates able to state two correct abiotic factors that limit the rate of photosynthesis with light intensity being the most common answer, followed by concentration of carbon dioxide. A few identified water temperature as a limiting factor.

(c) (i) This was poorly answered with most candidates providing an answer too vague for any credit, such as 'to see where they go'. The most successful answers gave specifics for tracking the whales' movements in the ocean such as identification of their migration routes, breeding grounds or feeding depths.

(ii) There were some good responses, with the most common suggestion being the tracking device may fall off or get lost in the ocean, or that it may malfunction. Others correctly suggested the device may be difficult to fit or that it may harm the whale.

(iii) Responses were mixed with some very good responses showing candidates' in-depth knowledge of the work of the International Whaling Commission. Others were not sure of their answers highlighted by use of vague terminology. Very few had knowledge of setting catch limits. One of the top correct answers was raising awareness and education.

Question 3

This question tests candidates' skills in describing the distribution of high acid deposition from a world map, the differences and similarities of wet and dry acid deposition, its formation from human activities and its impacts on the environment. In general, candidates found this question the most challenging across the paper.

(a) The majority of responses were able to access at least two marks, with many gaining full credit for identification of the relevant continents. The best responses used the compass points north and/or south rather than above and below or over and under (the Equator, or the Tropic of Cancer). Candidates should use the correct terminology for describing the distribution of features on a map such as 'north of' or 'south of'. No credit was given for high acid deposition is '*in* the Equator' or '*within* the Tropic of Cancer'.

(b) (i) This question gave mixed responses. Many were able to state at least one example of the correct type of acid deposition. Very few showed knowledge of a mix of air pollutants or that these were of an acidic nature. A large proportion incorrectly described the impact of wet and dry acid deposition on the environment, which was not asked for. A few candidates contradicted themselves by giving an example of wet acid deposition for dry.

(ii) This proved challenging with many candidates giving vague answers about (right or wrong) gases mixing with clouds or water vapour and precipitating as acid rain. Where sulfur dioxide or nitrogen monoxide were named, many gave vague answers on their origin or confused the two. The best responses gave clear and separate accounts on the origin and formation of nitric acid and/or sulfuric acid describing the logical route. Candidates need to better understand the differences between the formation of nitric acid and sulfuric acid in the atmosphere, which involves details of their origins and the chemical reactions which form them.

(c) (i) Responses were mixed with the best answers identifying specific impacts such as defoliation or leaf damage. The poorer answers involved vague descriptions such as 'damaged trees' or 'wilted plants'. The image depicts a forest; therefore, candidates should avoid general terms such as vegetation or plants.

(ii) This question was generally poorly answered with many candidates describing incorrect impacts such as eutrophication of water bodies or vaguely described impacts on soil. Whereas a minority described damage to fish gills or impacts to the marine food chain, very few correctly described negative impacts on crop yield, or crop damage. Some of the better answers correctly described damage to buildings or infrastructure with a component of concrete or limestone. Candidates are

advised to avoid general terms such as 'kills fish' or 'kills animals' without qualification of how this happens.

Question 4

Here, candidates are examined on aspects of energy security and insecurity including impacts of energy insecurity and how climate change can cause energy insecurity. They are also asked to manipulate data presented in a line graph showing year-on-year rise in the cost of natural gas in US dollars.

(a) (i) This question was well answered with most candidates able to identify both the solar panels and the wind turbines. The better answers also noted that these were sources of renewable energy and/or that meant no carbon dioxide emissions. Most struggled to identify a third feature of the homes such as the blinds or shades over the windows for temperature control.

(ii) There were mixed responses with most able to access at least one mark. The most common creditable answers were for limitations with candidates quoting the initial expense of setting up, buying or maintaining either the solar panels or the wind turbines. Also popular were good descriptions of solar and wind energy being weather dependant and therefore not always reliable. The better responses gave at least one credit-worthy benefit and one for limitations. The most common answer for benefits also centered on cost, with many describing low energy bills for users. Others gave answers too vague to gain any credit. Candidates should remember to be specific with their answers and avoid vague terms such as 'environmentally friendly' or 'there is no pollution'. In this case they needed to be more specific and describe *how* this sort of energy benefits the environment, e.g., they do not emit carbon dioxide and therefore play a role in mitigating climate change. Also, when describing pollution candidates should always be aware that 'pollution' unqualified will not gain credit. Instead the *type* of pollution is required. In this case it is *air* pollution.

(b) (i) Many candidates were able to access at least one mark for correctly reading the figures from the graph. Some went on to correctly calculate the percentage increase. Most gave the wrong value due to difficulty in understanding how to perform the calculation. Percentage increase is:

$$\frac{\text{final value (120)} - \text{initial value (15)}}{\text{initial value (15)}} \times 100$$

(ii) This question was generally well answered with the most common answers being job losses and poverty. Other popular answers were conflict and various acceptable ways of describing disrupted supply, such as black-outs. Candidates who accessed no credit or only one mark had invariably confused the *impacts* of energy insecurity with *causes* of energy insecurity, such as population growth or fossil fuel depletion. Candidates are encouraged to take an extra moment to re-read the question before responding.

(iii) Candidates found this challenging, with many providing answers too vague to access credit. Many had described the causes of climate change, which was not asked for. Others gained at least one mark for explaining how severe weather, such as flooding, can damage power lines or infrastructure. Other popular answers were explanations of how drought limits the supply of hydroelectric power, or how severe storms limits solar power. Very few were able to score full marks.

Section B

Slightly more than half of the candidates chose to answer **Question 5** (Protected areas in tropical rainforests) than **Question 6** (Strategies to reduce the impacts of waste disposal).

The questions in Section B assess 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. Some were able to achieve Level 3 for AO3, and a few top-scorers attained Level 4, for excellent development of both sides of the argument, supported by good examples. A small number of candidates were unable to achieve more than Level 1 for AO2 as they provided no examples to support their

answer, and Level 1 for AO3 as their response was largely descriptive and they did not make any judgements.

Question 5

Many candidates were able to achieve at least Level 2 for AO2 with some good descriptions of impacts of humans on tropical rainforests with the more common answer being deforestation for urbanisation. Another popular description centered around exploitation of native flora or fauna. Many were able to exemplify their answer by naming at least one tropical rainforest area with the most common being The Amazon Rainforest. Others expertly described National Parks in the rainforests of Borneo and the Congo. A common mistake was to include examples of protected areas in biomes other than tropical rainforests, for example Yellowstone National Park. Some of these candidates spent time explaining the successes of captive breeding programmes of animals not native to tropical rainforests. Candidates are encouraged to make a plan before writing and to focus fully on the key areas and topic.

Many answers were able to describe one other strategy with the top answer being international agreements and/or local legislation but few were able to clearly describe the benefits and limitations of these. A minority were also able to name an aspect of sustainable harvesting and provide benefit and limitations. Very few also went on to name Debt for Nature Swaps. A few candidates were able to achieve more than Level 2 for AO3 as evaluations tended to be one-sided, stating simply that they agreed or disagreed with the statement. Candidates are reminded to support such statements with reasoning.

Very few answers accessed the top level scores; those who were able to, named at least one other strategy for managing the impacts of humans on tropical rainforests (apart from protected areas), and gave a balanced argument with a consistent conclusion providing justifiable benefits and limitations of each.

Question 6

The most common mistake was candidates had mis-read the question and provided discussion on the benefits and limitations of the *methods* of waste disposal, rather than *strategies* for reducing the impacts of these methods. This negatively impacted their score in the AO2 area with the vast majority accessing no higher than Level 2 for this reason. Very few of these candidates were able to access higher than Level 2 in the AO3 area since there are very few credible benefits to any of the waste disposal methods except perhaps for the Reduce, Reuse and Recycle method and, weakly, the Incineration method providing a local energy source if used correctly without release of greenhouse gases. Some tried to argue that disposal at sea had benefits. Candidates are encouraged to take a moment longer to re-read the question and make a plan before attempting the answer. A plan will ultimately save time if a mistake is realised some time into writing the essay.

Despite these challenges there were some good examples of local waste disposal methods, some of which candidates had visited during their course and were able to describe the methods used. In addition, a few candidates were able to expertly describe the benefits and limitations of a range of credit-worthy strategies giving a balanced evaluation and consistent conclusion.

Examiners were delighted to read some answers with an impressive range of relevant strategies and well-balanced discussions on the benefits and limitations of each followed by consistent, balanced conclusions.

ENVIRONMENTAL MANAGEMENT

Paper 8291/13

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Key messages

Candidates should note the number of marks available for each part question and write answers accordingly. This will indicate the amount of content and detail expected. Under time constraints, bulleted answers are often the clearest way to show knowledge in the structured questions.

It is important that instructions are followed carefully. Teachers can help by making sure the difference in meaning of question command words is understood. The command words in this paper are: state, define, identify, calculate, suggest, describe, explain, compare, outline, construct and evaluate.

Questions should always be read carefully before responding. If an answer needs to be re-written, a single line through the incorrect passage is appropriate. The re-attempted answer should be clearly written. If there is insufficient remaining answer space, the lined space at the back of the booklet may be used and the response should be clearly labelled with the question number to which it refers.

Candidates should avoid repeating the question to make best use of examination time. The context in which a clear answer is written will be understood by examiners.

Candidates should remember to show all working out in calculation questions as credit may be available for the correct method by an error carried forward.

Vague terms such as: resources, pollution, environmentally-friendly, harms, affects, impacts, etc., should be avoided as much as possible without qualification. For example, resources could be qualified as food, water, energy, etc. Pollution could be qualified as air pollution, noise pollution, visual pollution, land pollution etc.

General comments

For ***Section A***, topics which proved the most challenging were transfer of energy within a food web (**Question 2(a)(ii)**), comparison of wet and dry acid deposition (**Question 3(b)(i)**), the formation of acid deposition (**Question 3(b)(ii)**) and its effects on the environment (**Question 3(c)(i) and 3(c)(ii)**) and topics surrounding the impacts of energy insecurity and climate change as a cause of energy insecurity (**Question 4(b)(ii)** and **4(b)(iii)**). For ***Section B***, most candidates who attempted **Question 6** on waste management had mis-read the question, which negatively impacted their score for AO2 Information handling and analysis.

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

Section A

Question 1

This question examines knowledge of food insecurity and management of food security in the USA. It also tests understanding of data presented in a line graph and reasons for the trend, whereby candidates are expected to draw on knowledge of changes in agricultural practices in the USA. On the whole, candidates found this question easier than other questions across the paper.

(a) Most responses gave the correct definition of food insecurity. The least successful answers were too vague for any marking point. Candidates who had not read the question carefully responded by giving the definition of food security.

(b) (i) The vast majority of candidates were able to access maximum credit for a correct description of the graphic trend, making use of the most obvious features as well as data quotes.

(ii) Many candidates were able to suggest appropriate reasons for the decline in food insecurity between 2015 and 2019. The most successful responses accessed full credit for considering a wide range of strategies including improvements in commercial agricultural techniques and management, improvements in infrastructure and food storage as well as ideas around food rationing and food aid. Others also acknowledged an increase in subsistence agriculture. Some candidates attempted to describe strategies for improving water security, suggesting the question had not been understood.

(c) (i) Most candidates were able to explain that **Question C** was an open-ended question or that **Question A** and **B** gave a yes or no response and were easier to quantify.

(ii) The vast majority of candidates gave an appropriate question, clearly indicating their understanding of the definition of food insecurity. Some accessed no credit for a question that was too close in wording as those already given in Table 1.1. This illustrates the importance of reading the question carefully.

(d) There were many good responses with the most successful considering both the positive as well as the negative impacts on food security. Many were able to correctly identify extensive agriculture of a single crop only (monoculture), which increases vulnerability to pests, disease and climate change as well as land (or soil) degradation. Balanced answers showed an understanding of an increase in food production that can be harvested more quickly than by hand and which, therefore, meets demand. Candidates should avoid phrases or terms which repeat the question for which no credit will be given. In this example ‘a very large field/area’ is cultivated is too vague to credit the idea of increased crop yield.

Question 2

Candidates are examined on the marine environment, specifically the Antarctic marine food web including knowledge of photosynthesis, as well as aspects and methods of whale conservation. Candidates are tested on their knowledge of the energy transfer links between trophic levels within the web, and on the chemical equation for photosynthesis and factors that limit its rate.

(a) (i) The majority gained full credit for correctly constructing the Antarctic marine food web, using the information provided. Credit was commonly lost where the direction of energy transfer was incorrect or no direction was given at all. Correct energy transfer is always indicated by an arrow passing from a lower trophic level to a higher trophic level.

(ii) This question was challenging for most candidates with very few accessing full credit. Common mistakes included describing organisms as ‘containing energy’ or ‘having more energy’ whereas the question seeks understanding of the energy *transfer* between trophic levels. It is scientifically incorrect to describe an organism as ‘containing energy’. The correct terminology to use in study of food webs is that organisms have more (or less) *biomass* than others. Credit would have been given in this context had an indication of the length of the food chain been given. Other common errors were a description of which tropic level organisms occupied, also without indication of the

length of the food chain between organisms. Those who accessed credit, correctly described that energy is lost between trophic levels by (named) metabolic processes.

(b) (i) Many candidates stated the correct balanced chemical equation for photosynthesis. Those who stated the word equation, or gave incomplete chemical formulae, were not credited. Others lost 1 mark for incorrect balancing.

(ii) This question was answered well with most candidates able to state two correct abiotic factors that limit the rate of photosynthesis with light intensity being the most common answer, followed by concentration of carbon dioxide. A few identified water temperature as a limiting factor.

(c) (i) This was poorly answered with most candidates providing an answer too vague for any credit, such as 'to see where they go'. The most successful answers gave specifics for tracking the whales' movements in the ocean such as identification of their migration routes, breeding grounds or feeding depths.

(ii) There were some good responses, with the most common suggestion being the tracking device may fall off or get lost in the ocean, or that it may malfunction. Others correctly suggested the device may be difficult to fit or that it may harm the whale.

(iii) Responses were mixed with some very good responses showing candidates' in-depth knowledge of the work of the International Whaling Commission. Others were not sure of their answers highlighted by use of vague terminology. Very few had knowledge of setting catch limits. One of the top correct answers was raising awareness and education.

Question 3

This question tests candidates' skills in describing the distribution of high acid deposition from a world map, the differences and similarities of wet and dry acid deposition, its formation from human activities and its impacts on the environment. In general, candidates found this question the most challenging across the paper.

(a) The majority of responses were able to access at least two marks, with many gaining full credit for identification of the relevant continents. The best responses used the compass points north and/or south rather than above and below or over and under (the Equator, or the Tropic of Cancer). Candidates should use the correct terminology for describing the distribution of features on a map such as 'north of' or 'south of'. No credit was given for high acid deposition is '*in* the Equator' or '*within* the Tropic of Cancer'.

(b) (i) This question gave mixed responses. Many were able to state at least one example of the correct type of acid deposition. Very few showed knowledge of a mix of air pollutants or that these were of an acidic nature. A large proportion incorrectly described the impact of wet and dry acid deposition on the environment, which was not asked for. A few candidates contradicted themselves by giving an example of wet acid deposition for dry.

(ii) This proved challenging with many candidates giving vague answers about (right or wrong) gases mixing with clouds or water vapour and precipitating as acid rain. Where sulfur dioxide or nitrogen monoxide were named, many gave vague answers on their origin or confused the two. The best responses gave clear and separate accounts on the origin and formation of nitric acid and/or sulfuric acid describing the logical route. Candidates need to better understand the differences between the formation of nitric acid and sulfuric acid in the atmosphere, which involves details of their origins and the chemical reactions which form them.

(c) (i) Responses were mixed with the best answers identifying specific impacts such as defoliation or leaf damage. The poorer answers involved vague descriptions such as 'damaged trees' or 'wilted plants'. The image depicts a forest; therefore, candidates should avoid general terms such as vegetation or plants.

(ii) This question was generally poorly answered with many candidates describing incorrect impacts such as eutrophication of water bodies or vaguely described impacts on soil. Whereas a minority described damage to fish gills or impacts to the marine food chain, very few correctly described negative impacts on crop yield, or crop damage. Some of the better answers correctly described damage to buildings or infrastructure with a component of concrete or limestone. Candidates are

advised to avoid general terms such as 'kills fish' or 'kills animals' without qualification of how this happens.

Question 4

Here, candidates are examined on aspects of energy security and insecurity including impacts of energy insecurity and how climate change can cause energy insecurity. They are also asked to manipulate data presented in a line graph showing year-on-year rise in the cost of natural gas in US dollars.

(a) (i) This question was well answered with most candidates able to identify both the solar panels and the wind turbines. The better answers also noted that these were sources of renewable energy and/or that meant no carbon dioxide emissions. Most struggled to identify a third feature of the homes such as the blinds or shades over the windows for temperature control.

(ii) There were mixed responses with most able to access at least one mark. The most common creditable answers were for limitations with candidates quoting the initial expense of setting up, buying or maintaining either the solar panels or the wind turbines. Also popular were good descriptions of solar and wind energy being weather dependant and therefore not always reliable. The better responses gave at least one credit-worthy benefit and one for limitations. The most common answer for benefits also centered on cost, with many describing low energy bills for users. Others gave answers too vague to gain any credit. Candidates should remember to be specific with their answers and avoid vague terms such as 'environmentally friendly' or 'there is no pollution'. In this case they needed to be more specific and describe *how* this sort of energy benefits the environment, e.g., they do not emit carbon dioxide and therefore play a role in mitigating climate change. Also, when describing pollution candidates should always be aware that 'pollution' unqualified will not gain credit. Instead the *type* of pollution is required. In this case it is *air* pollution.

(b) (i) Many candidates were able to access at least one mark for correctly reading the figures from the graph. Some went on to correctly calculate the percentage increase. Most gave the wrong value due to difficulty in understanding how to perform the calculation. Percentage increase is:

$$\frac{\text{final value (120)} - \text{initial value (15)}}{\text{initial value (15)}} \times 100$$

(ii) This question was generally well answered with the most common answers being job losses and poverty. Other popular answers were conflict and various acceptable ways of describing disrupted supply, such as black-outs. Candidates who accessed no credit or only one mark had invariably confused the *impacts* of energy insecurity with *causes* of energy insecurity, such as population growth or fossil fuel depletion. Candidates are encouraged to take an extra moment to re-read the question before responding.

(iii) Candidates found this challenging, with many providing answers too vague to access credit. Many had described the causes of climate change, which was not asked for. Others gained at least one mark for explaining how severe weather, such as flooding, can damage power lines or infrastructure. Other popular answers were explanations of how drought limits the supply of hydroelectric power, or how severe storms limits solar power. Very few were able to score full marks.

Section B

Slightly more than half of the candidates chose to answer **Question 5** (Protected areas in tropical rainforests) than **Question 6** (Strategies to reduce the impacts of waste disposal).

The questions in Section B assess 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. Some were able to achieve Level 3 for AO3, and a few top-scorers attained Level 4, for excellent development of both sides of the argument, supported by good examples. A small number of candidates were unable to achieve more than Level 1 for AO2 as they provided no examples to support their

answer, and Level 1 for AO3 as their response was largely descriptive and they did not make any judgements.

Question 5

Many candidates were able to achieve at least Level 2 for AO2 with some good descriptions of impacts of humans on tropical rainforests with the more common answer being deforestation for urbanisation. Another popular description centered around exploitation of native flora or fauna. Many were able to exemplify their answer by naming at least one tropical rainforest area with the most common being The Amazon Rainforest. Others expertly described National Parks in the rainforests of Borneo and the Congo. A common mistake was to include examples of protected areas in biomes other than tropical rainforests, for example Yellowstone National Park. Some of these candidates spent time explaining the successes of captive breeding programmes of animals not native to tropical rainforests. Candidates are encouraged to make a plan before writing and to focus fully on the key areas and topic.

Many answers were able to describe one other strategy with the top answer being international agreements and/or local legislation but few were able to clearly describe the benefits and limitations of these. A minority were also able to name an aspect of sustainable harvesting and provide benefit and limitations. Very few also went on to name Debt for Nature Swaps. A few candidates were able to achieve more than Level 2 for AO3 as evaluations tended to be one-sided, stating simply that they agreed or disagreed with the statement. Candidates are reminded to support such statements with reasoning.

Very few answers accessed the top level scores; those who were able to, named at least one other strategy for managing the impacts of humans on tropical rainforests (apart from protected areas), and gave a balanced argument with a consistent conclusion providing justifiable benefits and limitations of each.

Question 6

The most common mistake was candidates had mis-read the question and provided discussion on the benefits and limitations of the *methods* of waste disposal, rather than *strategies* for reducing the impacts of these methods. This negatively impacted their score in the AO2 area with the vast majority accessing no higher than Level 2 for this reason. Very few of these candidates were able to access higher than Level 2 in the AO3 area since there are very few credible benefits to any of the waste disposal methods except perhaps for the Reduce, Reuse and Recycle method and, weakly, the Incineration method providing a local energy source if used correctly without release of greenhouse gases. Some tried to argue that disposal at sea had benefits. Candidates are encouraged to take a moment longer to re-read the question and make a plan before attempting the answer. A plan will ultimately save time if a mistake is realised some time into writing the essay.

Despite these challenges there were some good examples of local waste disposal methods, some of which candidates had visited during their course and were able to describe the methods used. In addition, a few candidates were able to expertly describe the benefits and limitations of a range of credit-worthy strategies giving a balanced evaluation and consistent conclusion.

Examiners were delighted to read some answers with an impressive range of relevant strategies and well-balanced discussions on the benefits and limitations of each followed by consistent, balanced conclusions.

ENVIRONMENTAL MANAGEMENT

Paper 8291/21
Management in Context

Key messages

- There was a widespread misunderstanding of the cause of ozone depletion. Many candidates associated ozone depletion with chemicals that cause acid rain or greenhouse gases.
- Acid rain was not a well-known area of the syllabus.
- There was confusion over the terms respiration and photosynthesis.
- The syllabus term 'fragmentation' was not well known.
- Candidates need more practice in describing sampling techniques in a logical way.
- Graph drawing was poorly done by many candidates.
- Candidates should check they have attempted every question and have not overlooked the completion of a diagram, for example, in Fig. 1.1 **Question 1(c)**.
- Candidates should always show their working in calculations.
- Candidates should read the question carefully before responding to avoid any misunderstanding of what is required.

General comments

The bar in the bar chart (Fig. 4.1) was poorly completed, without use of a ruler and often drawn in pen so errors could not easily be corrected. The plot was often wrong and the bar width did not match the other bars on the chart. The line graph, **Question 1(f)**, was also frequently drawn in pen which made correcting errors very difficult for candidates. The scale was often non-linear, axes markers were not used, a ruler was not used to draw a straight line between each point and a bar chart was sometimes given instead of a line graph.

Identifying benefits and limitations of environmental management strategies in unfamiliar contexts is an area of the syllabus that candidates need more practice in.

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

It is not necessary to repeat the question in an answer. Bullet points are often the clearest way to respond and ensures that candidates give sufficient answers to match the mark allocation. For example, [3] indicates that three separate ideas should be given.

Comments on specific questions

Question 1

(a) Some candidates described the pie charts in Fig. 1.1 rather than suggesting reasons for the differences in water usage.

(b) Most responses contained a clear explanation of why contaminated drinking water leads to poverty. Some candidates were not guided by the mark allocation of [3] and only stated two separate points.

(c) Most completed responses could draw the location and depth of an artesian well. There were a number of candidates who did not respond to this question.

(d) The majority of candidates identified that the strategy could capture rainwater. Some were also able to give further explanation as to why this improves water security. The most common response was to suggest the water could be used for a stated purpose such as watering plants or crops and that this would reduce the use of ground water supplies.

(e) Most candidates gave a source of fresh water other than marshes. A few did not read the question carefully and stated a process or ground water stores.

(f) The line graph was poorly completed by many candidates. Non-linear scales were common and where scales were given, the axes markers were often missing from the axes making it impossible to determine where the candidate intended for the scale to be located. The scale chosen sometimes did not enable the plotted points to cover at least half of the grid. Units were frequently missing from the y-axis label. Bar charts were sometimes drawn instead of a line graph. The line between each plotted point was often not drawn with a ruler so was not straight. Multiple lines were also common. Many candidates drew their graph in pen which made correcting errors impossible. A few plotted large blobs which covered an area too large for any credit. For those that could give a linear scale, the plotting was often correct. The best graphs were drawn with a sharp pencil giving small neatly plotted points and ruled straight lines between points.

Question 2

(a) (i) Many good suggestions for a negative impact of importing timber were seen. 'Cost' was commonly seen but this did not gain credit unless the response indicated what the cost would be associated with.

(ii) The majority of responses suggested that the land would not be able to be used for growing crops or grazing livestock so this would lead to food insecurity. Others gave vague answers about poor soil quality, which were not credited.

(b) Most responses explained that trees take in carbon dioxide. However, there were many confused ideas about what this process was. Many suggested respiration or referred to trees 'breathing' or 'eating'. Candidates are encouraged to further their understanding of the differences between photosynthesis and respiration and to appreciate their role in the carbon cycle.

(c) The term fragmentation was not well known. Candidates struggled to describe evidence for fragmentation shown in Fig. 2.1. Many described the impacts of deforestation or urbanisation, which was not asked for.

(d) (i) The majority were able to describe the distribution as mainly in the north of Scotland. Fewer expanded on this and did not refer to the rest of the map showing scattered populations. Some used 'up', 'down', 'left', 'right' rather than the compass references: north, south, east or west.

(ii) There was a general good understanding of the limitations of a crowd sourced online survey with the most common answer being that the public are not experts on bee species.

(e) Candidates were not familiar with how to estimate population in the context of the broken-belted bumblebee. Candidates are recommended to regard descriptions of fieldwork as a set of instructions that must be logical and coherent enough so that another learner could follow the method provided to obtain an estimate of a population. Candidates were not always clear on how to use a transect line to count the bees and scale this up to the area under investigation.

(f) Some good suggestions of the benefits and limitations of the artificial nests were seen. Candidates would have benefitted from using bullet points as long sections of prose appeared to convince the candidates they had given five separate points. It was not sufficient to regard the reverse argument as a separate point. For example, 'the sun hive can easily get blown away and the wood hive cannot' is one point – not two separate ideas.

(g) Most responses could explain why hornets may endanger the bees. Stating 'they take all the resources' was insufficient as candidates were expected to explain what these resources were. Also insufficient was the idea of the hornets killing the bees without qualification of how this happens.

Question 3

(a) (i) A common error was to describe the trend shown in Fig. 3.1 rather than describing the impacts of the trend. There was also a wide spread major misconception that increased methane will deplete the stratospheric ozone layer. Candidates are encouraged to further their understanding of the role of methane in the atmosphere and the differences between stratospheric ozone and ground-level ozone.

(ii) The sources of methane were not well known. Common errors included 'fossil fuels', 'CFCs' and 'burning'. 'Factories' and 'car emissions' were also not acceptable.

(b) (i) Most responses recognised there had been a decrease in emissions. Better performing candidates went on to use the key in Fig. 3.2 and 3.3 to state that in 2020 there were no areas greater than 18 000 tonnes. The best responses accessed maximum credit for recognition of an increase in emissions on the west coast.

(ii) The formation of acid deposition from sulfur dioxide was not well known. The best responses were able to describe a reaction with water rather than sulfur dioxide being 'trapped' in water or 'getting into clouds.' Very few were able to name sulfuric acid as a product and some contradicted their answers by describing the formation of nitric acid.

(iii) Many candidates were able to state 'rain' for a type of wet deposition but few could name a type of dry deposition. Commonly, candidates gave the process such as 'combustion of fossil fuels', which was not asked for. Many provided more than one answer for each which sometimes meant they contradicted themselves.

(iv) Strategies to reduce the impact of acid deposition were not well described. Many candidates gave vague answers about reducing combustion of fossil fuels without qualification. Some better answers referred to increasing the use of renewable resources and replacing combustion engine vehicles with electric vehicles. Very few candidates knew desulfurisation or the use of catalytic convertors. Confused answers referred to carbon dioxide emissions and carbon capture, which is not relevant for acid deposition.

(c) (i) Most responses suggested the nutrients needed to be evenly distributed throughout the soil. Weaker answers repeated the question with 'to thoroughly mix the soil' – repetition of question content is unlikely to gain credit.

(ii) Very few candidates realised that the pH 6.0 water was to act as a control as it was the only sample that had the pH of non-acid deposition. It was common to see this incorrectly referred to as 'neutral pH' or a 'basic pH'.

(iii) The pH value was usually identified. Common errors included the plant type or soil.

(iv) Some candidates suggested having 10 plants would enable anomalous results or outliers to be identified. A common incorrect response was to suggest 'to improve accuracy'.

(v) Most responses did not gain credit. The most common mistake was to suggest that water adds mass to the leaves. Candidates who performed well were able to suggest that the mass of water would vary between each leaf.

(vi) The majority gave good conclusions. Occasionally, pH and acidity were confused. For example, 'a low pH value is low acid and this gives the lowest mean mass'. Some candidates incorrectly thought that the pH was drying the leaf and removing the water.

(vii) Most were able to correctly calculate the range and give their answer to two decimal places. A common mistake was to calculate the mean value of the four values provided.

(viii) Relevant conclusions were commonly seen, with occasional confusion over pH and acidity. Weaker responses were too vague, such as 'acid harms leaves'.

Question 4

(a) (i) Candidates struggled to work out the scale on the bar chart and many incorrect plots were seen. The bar width often did not match the existing bars. Pen was often used and this prevented candidates from correcting mistakes. Another common mistake was in not using a ruler to draw the bar.

(ii) Many candidates were not able to extract a correct reading from the bar chart to use in their calculations. Very few candidates showed their working out. Candidates may gain credit for their working even if the final answer is incorrect.

(iii) The percentage was usually correctly determined.

(iv) In general, this was well answered with the most popular response being the availability of jobs. Weaker responses did not give economic factors. A common mistake was to describe strategies for managing human population.

(b) (i) Very few candidates showed their working out. This meant a large number were unable to gain credit as no credit could be awarded for an error carried forward. Many were able to calculate the correct percentage however.

(ii) Good responses explained that people aged 15 might not be working because they are students and those over 64 might have chosen to continue working. They also suggested that some people retire early so stop working before 64. Few suggested non-working parents would be included in the age range. Candidates who suggested people between the ages of 15 and 64 were not working without qualification of why, did not gain credit.

(iii) A common error was to describe the trend or a reason for the trend in Fig. 4.2 rather than the impacts of increasing life expectancy. Candidates are reminded to read the question carefully before responding. Stronger answers were able to suggest credit-worthy impacts with the most common answer being an ageing population resulting in pressure on healthcare.

(c) This was well answered by many. However, a few did not focus on local strategies as stated in the question.

ENVIRONMENTAL MANAGEMENT

Paper 8291/22
Management in Context

Key messages

- Good responses added further development and explanations to points where needed rather than simply repeating information given in the question.
- Candidates, for the most part, demonstrated reasonably good application of knowledge to unfamiliar contexts.
- Many candidates did not demonstrate secure knowledge of solar radiation management in reducing the impact of climate change.
- Dependency ratios and factors affecting the dependency ratio are not fully understood by candidates.
- A description of carbon capture and storage is a concept candidates demonstrated very limited knowledge of.
- The syllabus term rewilding was not well known.

General comments

The drawing of graphs was an area requiring improvement for some respondents. Candidates should make use of a ruler to connect data points rather than draw freehand. Candidates need to use an appropriate scale that occupies over half of the grid provided. Non-linear scales resulted in inaccurate data points in some responses.

Where candidates were required to complete a bar chart from given data, this should have been completed in pencil, which would allow errors to be erased and hence maintain clarity with data points. A ruler is recommended when completing bar charts such as that in **Question 1(d)(i)**; candidates generally used the correct shading when drawing the bar.

Candidates need more practice in their understanding and application of research methodology to unfamiliar contexts.

Comments on specific questions

Question 1

(a) (i) Candidates generally found it challenging to describe the distribution of fertility rate given a global map; common errors included reference to above, on or near the equator or tropics which was not specific enough to provide a clear description; strong responses used north or south or demonstrated a clear knowledge of continents or individual countries. Quoted data given from the global map provided further credit in responses.

(ii) Some responses were able to explain why fertility rate reduced the impact of climate change, and stronger candidates were able to select a factor and link it to a reduction in global warming.

(iii) The majority of responses provided a range of factors that affect fertility rate such as improved education and careers for women as well as access to contraception. Credit was also given to cultural reasons such as early marriage.

(b) Many candidates were not able to suggest a valid reason as to why the dependency ratio for Bangladesh had decreased; responses often included migration. Candidates needed to recognise that the question surrounded the working population providing for dependents. Immigration of working age people into the country was credited.

(c) Most candidates were able to explain the impacts of climate change on roads, which commonly included rising sea levels and flooding.

(d) (i) The majority of candidates were able to take data and apply it to the bar chart correctly. A common error was a lack of appropriate use of the key for planned CCS facilities to illustrate their application of data.

(ii) A significant proportion of candidates struggled to provide the specific years with the most operational CCS facilities.

(iii) Candidates demonstrated a limited ability to interpret the graph to determine the required numerical value of 6.

(iv) There were many good suggestions as to why the number of planned CCS facilities in 2010 was fewer than in 2021.

(e) Generally, this question evidenced limited knowledge of how carbon capture and storage can reduce carbon concentration in the atmosphere. A few candidates were able to describe compression, piped transportation and storage underground.

(f) The concept of Solar radiation management was not widely understood by candidates, misconceptions often included solar panels, whilst stronger candidates referred to the use of stratospheric aerosols and cloud brightening, as well as the use of space reflectors.

Question 2

(a) (i) Whilst many candidates were able to provide data justifications surrounding tree ring width, many were not able to provide a conclusion as to whether the scientists hypothesis was correct, i.e. that overall there were more years where tree ring width was greater than the average tree ring width.

(ii) The majority of candidates provided methods for reconstructing past climate conditions which often included ice cores and historical data using geomorphic data.

(b) (i) A common response included the mass of plant stem increasing with both ozone concentrations. Stronger responses included data comparisons.

(ii) There were strong responses that included the species of plant, soil pH, amount of water etc. In order to repeat the investigation, variables needed to be kept the same for the model to be fair. Further development in knowledge of methodology is needed for candidates to make progress with this type of question.

(c) (i) Some candidates were able to state the layer of the atmosphere which contains ground level ozone.

(ii) A significant number of candidates were able to describe the formation of photochemical smog; the most common omission was the significance of sunlight.

(iii) Generally the impacts of photochemical smog on human health were recognised**.**

(d) (i) The majority of candidates were able to plot a graph accurately. Areas of development should be centred around labelling axes with the correct units and using a ruler to draw straight lines and connect plotted points. Candidates should use pencil to draw graphs instead of pens to enable easier correction of mistakes.

(ii) Candidates were generally able to calculate the range of ground level ozone in the 24-hour period, to achieve the answer of 0.82.

(iii) A very few candidates were able to provide a justification as to whether the conclusion was sensible, underlining the importance of developing a thorough knowledge of methodology. A small minority were able to identify the importance of repetition or obtaining more data points.

Question 3

(a) (i) Some candidates were able to suggest why the scientist needed to investigate more than one bee-eater population; a significant number were not able to make any creditable suggestion.

(ii) Most candidates were able to circle and identify an anomalous data point.

(iii) There was some variability in responses to writing a conclusion surrounding the number of bee-eaters and populations using sound recordings; whilst some candidates accurately interpreted the correlation in the graph, others were not able to interpret the results correctly.

(iv) Many candidates recognised that this would be a time-consuming method, there would be interference from other noises with bird song, and the difficulty of accurately recognising the bee-eater song.

(v) Most candidates recognised the benefit of using sound recordings to investigate populations, such as less/no harm to birds or having a record of bird songs to re-listen to.

(b) (i) Candidates were generally able to substitute and use the given formula to calculate population size to obtain the answer of 474.

(ii) Few candidates were able to suggest the impact of an increase in population of bee-eaters to the number of marked individuals recaptured in a second sample.

(c) (i) The concept of rewilding to increase biodiversity was not fully understood by candidates. Whilst many cited the introduction of species by various means, few were able to develop their response further to include the idea of nature maintaining itself or reducing human aspects of management.

(ii) Responses generally recognised lack of predators, more food, a ban on hunting etc. as reasons for an increase in bee-eater populations.

Question 4

(a) (i) Most candidates were able to define water insecurity as an inability to access sufficient quantities of clean water. A significant number needed to develop their definition to include aspects such as maintaining adequate standards of food, sanitation etc. to gain further credit.

(ii) The impacts of water insecurity were better understood by candidates with the majority mentioning at least two impacts correctly.

(b) (i) A significant proportion of candidates were able to correctly calculate the percentage of fresh water derived from sea water through reverse osmosis as 40%.

(ii) Most students correctly calculated the volume of sea water needed to produce a given volume of fresh water as 500 000 000 dm^3.

(c) (i) Candidates were generally able to interpret a diagram of reverse osmosis and suggest why it is an expensive process.

(ii) Most responses gave an indication of the impact of wastewater from a desalination factory as having a negative impact on marine organisms, however a significant proportion suggested the wastewater caused a change in the pH of the water, which was incorrect.

(d) The large majority of candidates correctly identified cost as being an issue as to why desalination does not occur in more countries, as well as countries being landlocked.

(e) Candidates generally were able to provide suggestions surrounding the difficulty of moving people from high water usage areas to areas of low usage.

(f) The majority of candidates recognised the strategy to maintain water security from the image as a dam/reservoir.

(g) Candidates were mostly able to provide other sources of surface water, a common source being rivers or lakes.

ENVIRONMENTAL MANAGEMENT

Paper 8291/23
Management in Context

Key messages

- Good responses added further development and explanations to points where needed rather than simply repeating information given in the question.
- Candidates, for the most part, demonstrated reasonably good application of knowledge to unfamiliar contexts.
- Many candidates did not demonstrate secure knowledge of solar radiation management in reducing the impact of climate change.
- Dependency ratios and factors affecting the dependency ratio are not fully understood by candidates.
- A description of carbon capture and storage is a concept candidates demonstrated very limited knowledge of.
- The syllabus term rewilding was not well known.

General comments

The drawing of graphs was an area requiring improvement for some respondents. Candidates should make use of a ruler to connect data points rather than draw freehand. Candidates need to use an appropriate scale that occupies over half of the grid provided. Non-linear scales resulted in inaccurate data points in some responses.

Where candidates were required to complete a bar chart from given data, this should have been completed in pencil, which would allow errors to be erased and hence maintain clarity with data points. A ruler is recommended when completing bar charts such as that in **Question 1(d)(i)**; candidates generally used the correct shading when drawing the bar.

Candidates need more practice in their understanding and application of research methodology to unfamiliar contexts.

Comments on specific questions

Question 1

(a) (i) Candidates generally found it challenging to describe the distribution of fertility rate given a global map; common errors included reference to above, on or near the equator or tropics which was not specific enough to provide a clear description; strong responses used north or south or demonstrated a clear knowledge of continents or individual countries. Quoted data given from the global map provided further credit in responses.

(ii) Some responses were able to explain why fertility rate reduced the impact of climate change, and stronger candidates were able to select a factor and link it to a reduction in global warming.

(iii) The majority of responses provided a range of factors that affect fertility rate such as improved education and careers for women as well as access to contraception. Credit was also given to cultural reasons such as early marriage.

(b) Many candidates were not able to suggest a valid reason as to why the dependency ratio for Bangladesh had decreased; responses often included migration. Candidates needed to recognise that the question surrounded the working population providing for dependents. Immigration of working age people into the country was credited.

(c) Most candidates were able to explain the impacts of climate change on roads, which commonly included rising sea levels and flooding.

(d) (i) The majority of candidates were able to take data and apply it to the bar chart correctly. A common error was a lack of appropriate use of the key for planned CCS facilities to illustrate their application of data.

(ii) A significant proportion of candidates struggled to provide the specific years with the most operational CCS facilities.

(iii) Candidates demonstrated a limited ability to interpret the graph to determine the required numerical value of 6.

(iv) There were many good suggestions as to why the number of planned CCS facilities in 2010 was fewer than in 2021.

(e) Generally, this question evidenced limited knowledge of how carbon capture and storage can reduce carbon concentration in the atmosphere. A few candidates were able to describe compression, piped transportation and storage underground.

(f) The concept of Solar radiation management was not widely understood by candidates, misconceptions often included solar panels, whilst stronger candidates referred to the use of stratospheric aerosols and cloud brightening, as well as the use of space reflectors.

Question 2

(a) (i) Whilst many candidates were able to provide data justifications surrounding tree ring width, many were not able to provide a conclusion as to whether the scientists hypothesis was correct, i.e. that overall there were more years where tree ring width was greater than the average tree ring width.

(ii) The majority of candidates provided methods for reconstructing past climate conditions which often included ice cores and historical data using geomorphic data.

(b) (i) A common response included the mass of plant stem increasing with both ozone concentrations. Stronger responses included data comparisons.

(ii) There were strong responses that included the species of plant, soil pH, amount of water etc. In order to repeat the investigation, variables needed to be kept the same for the model to be fair. Further development in knowledge of methodology is needed for candidates to make progress with this type of question.

(c) (i) Some candidates were able to state the layer of the atmosphere which contains ground level ozone.

(ii) A significant number of candidates were able to describe the formation of photochemical smog; the most common omission was the significance of sunlight.

(iii) Generally the impacts of photochemical smog on human health were recognised**.**

(d) (i) The majority of candidates were able to plot a graph accurately. Areas of development should be centred around labelling axes with the correct units and using a ruler to draw straight lines and connect plotted points. Candidates should use pencil to draw graphs instead of pens to enable easier correction of mistakes.

(ii) Candidates were generally able to calculate the range of ground level ozone in the 24-hour period, to achieve the answer of 0.82.

(iii) A very few candidates were able to provide a justification as to whether the conclusion was sensible, underlining the importance of developing a thorough knowledge of methodology. A small minority were able to identify the importance of repetition or obtaining more data points.

Question 3

(a) (i) Some candidates were able to suggest why the scientist needed to investigate more than one bee-eater population; a significant number were not able to make any creditable suggestion.

(ii) Most candidates were able to circle and identify an anomalous data point.

(iii) There was some variability in responses to writing a conclusion surrounding the number of bee-eaters and populations using sound recordings; whilst some candidates accurately interpreted the correlation in the graph, others were not able to interpret the results correctly.

(iv) Many candidates recognised that this would be a time-consuming method, there would be interference from other noises with bird song, and the difficulty of accurately recognising the bee-eater song.

(v) Most candidates recognised the benefit of using sound recordings to investigate populations, such as less/no harm to birds or having a record of bird songs to re-listen to.

(b) (i) Candidates were generally able to substitute and use the given formula to calculate population size to obtain the answer of 474.

(ii) Few candidates were able to suggest the impact of an increase in population of bee-eaters to the number of marked individuals recaptured in a second sample.

(c) (i) The concept of rewilding to increase biodiversity was not fully understood by candidates. Whilst many cited the introduction of species by various means, few were able to develop their response further to include the idea of nature maintaining itself or reducing human aspects of management.

(ii) Responses generally recognised lack of predators, more food, a ban on hunting etc. as reasons for an increase in bee-eater populations.

Question 4

(a) (i) Most candidates were able to define water insecurity as an inability to access sufficient quantities of clean water. A significant number needed to develop their definition to include aspects such as maintaining adequate standards of food, sanitation etc. to gain further credit.

(ii) The impacts of water insecurity were better understood by candidates with the majority mentioning at least two impacts correctly.

(b) (i) A significant proportion of candidates were able to correctly calculate the percentage of fresh water derived from sea water through reverse osmosis as 40%.

(ii) Most students correctly calculated the volume of sea water needed to produce a given volume of fresh water as 500 000 000 dm^3.

(c) (i) Candidates were generally able to interpret a diagram of reverse osmosis and suggest why it is an expensive process.

(ii) Most responses gave an indication of the impact of wastewater from a desalination factory as having a negative impact on marine organisms, however a significant proportion suggested the wastewater caused a change in the pH of the water, which was incorrect.

(d) The large majority of candidates correctly identified cost as being an issue as to why desalination does not occur in more countries, as well as countries being landlocked.

(e) Candidates generally were able to provide suggestions surrounding the difficulty of moving people from high water usage areas to areas of low usage.

(f) The majority of candidates recognised the strategy to maintain water security from the image as a dam/reservoir.

(g) Candidates were mostly able to provide other sources of surface water, a common source being rivers or lakes.