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**.

In addition, candidates should 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 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 should make sure that they understand the difference in meaning of the command words such as state, suggest, predict, justify, describe, explain, compare and evaluate.

To make best use of examination time, candidates should avoid repeating the question in their answers as no credit is available for this.

General comments

There was generally a good response to all questions across the paper. Most candidates found **Question 3** (population density, population change and ageing populations) and **Question 4** (types of biofuel, biofuels as an energy resource, biofuels and biodiversity, and biofuels and food security) more demanding than the other questions in ***Section A***.

Topics which proved more challenging were factors that explain differences in population density, types of biofuels, benefits of using biofuels as an energy resource, how biofuels reduce biodiversity, and how biofuels decrease food security.

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

The most effective answers included the 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This question covered the topics of evaporation, interception and the water cycle, comparison of fresh water withdrawn from water sources by industry and countries of different income groups, distribution of permafrost, and the role of methane in increasing global temperatures.

(a) This question was successfully accessed by most candidates and the process of evaporation was well understood. Most candidates effectively included the key terms 'gas', 'gaseous state' or 'water vapour' to gain the credit available.

(b) (i) Most candidates attained some credit for describing how interception affects the water cycle. Weaker candidates did not include technical terms such as 'infiltration', 'surface run-off' or 'groundwater stores' which led to unclear responses. A common misconception was that interception leads to less water in the water cycle overall.

(ii) Most candidates attained credit by correctly identifying two processes that add water to ground water stores. A good proportion of candidates were able to correctly identify all three processes of infiltration, precipitation and surface run-off for full credit. Transpiration was the most common process to be incorrectly identified.

(c) (i) This question was generally well answered and most candidates were able to describe the correct relationship between income group and the percentage of fresh water withdrawn by industry for the countries listed in **Table 1.2**. Some candidates would have benefited from a greater understanding of the term 'relationship' as less successful responses simply stated that HICs withdraw the most fresh water or LICs withdraw the least fresh water, which did not describe a relationship.

(ii) Candidates were generally able to give a prediction for the percentage of fresh water withdrawn from water sources by industry in Mongolia, a MIC, and then explain their prediction using data from **Table 1.2**. Some candidates gave a percentage range for their prediction rather than a single value which did not attain credit for the prediction. Furthermore, a significant number of candidates incorrectly stated the range for the MICs in **Table 1.2** as 20 – 30 per cent rather than 22 – 30 per cent, meaning that some did not access the credit for the explanation. A few candidates misread the question and referred to Mongolia as a LIC.

(d) (i) The majority of candidates were able to identify the continent labelled **X** as North America. The most common incorrect responses were Europe and United States of America (which is a country not a continent).

(ii) Candidates often misunderstood that this question required a description of the distribution of permafrost shown in **Fig. 1.2** and not an explanation of the distribution of permafrost, which limited the credit achieved. The most common correct marking point was that (continuous) permafrost is mostly located around or close to the North Pole. Some candidates did not appreciate that the areas of continuous permafrost in northern North America and Asia are on land and incorrectly stated that continuous permafrost is located north of the continents. Other candidates stated incorrectly that the land areas of North America and Asia only have discontinuous permafrost. Many candidates identified that Asia has permafrost and needed to make the correct comparison that Asia has the most or more permafrost than the other land areas. References to the Equator were not accepted as it is not shown in **Fig. 1.2**.

(iii) Most candidates were able to use **Fig. 1.2** and the key provided in **Fig. 1.3** to draw a prediction of the distribution of permafrost in the Arctic in 2035 to access credit. Successful responses showed that the overall area of permafrost had decreased and the area of continuous permafrost had decreased. A significant number of candidates did not attempt this question.

(iv) This question was more challenging and generally less well answered. Successful responses, for full credit, referred to methane as a greenhouse gas which traps infrared or longwave radiation and leads to the enhanced greenhouse effect. The most common correct response was that methane is a greenhouse gas. Imprecise terminology such as 'heat' being trapped or greenhouse gases 'heat up the atmosphere' was not credited. A common misconception was that UV radiation is trapped rather than incoming ultraviolet radiation being absorbed by the Earth's surface and then re-emitted as infrared radiation which is absorbed by methane. Some candidates misread the question and explained how trapped methane is released form permafrost.

Question 2

This question covered the topics of using quadrats in a random sampling strategy to estimate the populations of plant species in a grassland biome, limitations of using a quadrat as a sampling technique, calculating the Simpson's index of diversity, and comparison of grassland and tundra biomes.

(a) (i)(ii) Due to an issue with **Questions 2(a)(i)** and **2(a)(ii)**, full marks have been awarded to all candidates and the questions removed from the published version of the paper.
The syllabus states in the Topic 2 Environmental research and data collection section that the Assessment Objective 3 skills of planning investigations and identifying the limitations and benefits of the methods used are limited to paper 2.

(b) (i) Most candidates were able to correctly complete **Table 2.1** and calculate $\Sigma(n/N)^2$ as 0.29 (or answer between 0.28 and 0.30) for full credit. If the final answer given was incorrect, candidates could still access credit for correct working, for example, if they had correctly calculated N as 840, demonstrated one correct calculation of n/N and demonstrated one correct calculation of $(n/N)^2$. Some candidates did not convert fractions to decimals in the columns for (n/N), and $(n/N)^2$ did not attain credit unless $\Sigma(n/N)^2$ was given as 0.29 (or between 0.28 and 0.30).

(ii) Candidates generally found this question more challenging. Most who correctly calculated $\Sigma(n/N)^2$ for **Question 2b(i)**, were able to follow through and use the formula provided to correctly calculate Simpson's index of diversity, D, as 0.71 (or answer between 0.70 and 0.72). Some candidates did not realise that the calculation was simply to subtract their final answer for **Question 2b(i)** from 1. A significant number of candidates did not attempt this question.

(iii) The majority of candidates were able to use the data in **Table 2.2** to compare the biodiversity of the grassland and tundra biomes and correctly conclude that the grassland biome is more biodiverse than the tundra biome. Higher level responses made reference to the data in **Table 2.2** that the Simpson's index of diversity for the grassland is closer to 1 than that for the tundra biome which indicates that it has a higher biodiversity. Weaker responses often did not refer to the data in **Table 2.2** and responses gave vague references to the grassland biome having more animals or that the tundra biome is very harsh.

(iv) This question, in general, was not well answered with most candidates accessing limited credit. Candidates were asked to complete **Table 2.3** to describe the climate and vegetation in the tundra biome and soil type in the grassland biome. Most answers correctly described the grassland soil type as deeper and with more nutrients than the tundra soil type. Higher level responses referred to the soil being red in colour due to the high iron content and having moderate fertility. Although the majority of candidates knew that the tundra climate has low temperatures or is cold, few included reference to the climate being dry so could not access the credit available for climate. Very few candidates gained the credit for climate in the tundra biome. Most were able to correctly describe the vegetation for the tundra biome as low-lying mosses, lichens, grasses or shrubs. Some answers referred to trees being present in the tundra biome, which is a contradiction to low-lying plants and, therefore, did not attain credit for vegetation. A significant number of candidates thought that the climate of the tundra was hot and referred to cacti as the likely vegetation, which suggested they had confused the tundra with hot desert environments.

Question 3

This question covered the topics of population density, population change, relationship between annual population change and median age, factors that affect population change and ageing populations.

(a) (i) The majority of candidates were able to use the data in **Table 3.1** to correctly calculate the population density of Shanghai in 2022 as 4498 people km^{-2}. Common errors included not converting 'millions of people' to number of people, or rounding errors where candidates gave an answer of 4497 or 4500.

(ii) Candidates found this question on factors that explain the difference in population density between Beijing and Tianjin more challenging with very few accessing full credit. It was clear that the concept of population density was not well understood. As the question asked for factors that explain, listing factors such as economic opportunities or access to food or water was insufficient. Candidates also needed to make a comparison between the two cities, i.e. Beijing has more or Tianjin has less. Answers needed to refer to factors that would make a difference to population density in urban areas rather than population density in general. Most candidates were able to access some credit, and the most common correct response was that Beijing has more geographical opportunities such as more land area. Some candidates misread the question and compared Beijing or Tianjin to Shanghai which did not answer the question. Some candidates also

thought that Tianjin was in a different country to Beijing and more rural than Beijing rather than them being two cities in China.

(b) (i) This question was answered well and the majority of candidates were able to correctly read from the graph in **Fig. 3.1**, the median age for China as 38 years and the annual percentage population change for Australia as 0.5 per cent. Some candidates could have improved their answers by ruling horizontally or vertically to ensure that they read the values from the graph accurately. A small number of candidates contradicted themselves as they stated the annual percentage population change for Australia was 0.5/50 per cent.

(ii) The majority of candidates were able to correctly interpret data from **Fig. 3.1** to describe the relationship between the annual percentage population change and the median age for the countries shown in **Fig. 3.1**. Some candidates attempted to explain why different countries had different percentage population changes or different median ages, and some candidates simply defined the two terms, which did not answer the question.

(c) Factors that affect population change were generally well known and most candidates were able to access full credit for this question. The most common correct responses included birth rate, death rate, migration and contraception. As this question required candidates to state three factors, the most successful responses consisted of concise lists of factors rather than explanations of push-pull factors without linking them to migration or discussion of education for women, both of which did not answer the question.

(d) While many candidates clearly understood the impacts of ageing populations, some candidates did not give precise enough answers to attain credit. The most successful responses included impacts such as less people in the workforce, increased pension spending, increased demand or stress on health care and pressure to increase retirement age. Some candidates referred to an increase in taxes or a higher dependency ratio, which did not gain credit as these are not necessarily an impact of an ageing population.

Question 4

This question covered the topics of types of biofuel, biofuels as an energy resource, how growing biofuel crops reduces biodiversity and how biofuels decrease food security.

(a) (i) This question was poorly answered with few candidates able to correctly name any types of biofuel other than the biofuel crop shown in **Fig. 4.1**. The most successful responses named biogas and bioethanol (ethanol was not credited as it can have a chemical rather than a biological source). Some candidates knew that wood or wood derivatives can be considered as a biofuel and biodiesel was also accepted. Common incorrect responses included naming two types of fossil fuels, two renewable energy sources or two specific examples of biofuel crops such as cane and corn.

(ii) Most candidates were able to access credit here, with the most successful responses recognising that biofuels are renewable energy sources as crops can be replanted or regrown and are not finite for full credit. Some candidates used imprecise terminology such as recycled, reused or restored, and a significant number of candidates confused the term renewable with sustainability.

(iii) Although candidates often recognised other benefits of using biofuel as an energy resource, few responses were precise enough to attain credit. Therefore, this question on the whole was poorly answered. The most successful answers referred to biofuels as sustainable, reducing reliance on fossil fuels, or a cheaper source of energy. Reference to cost needed to include a comparative statement as an energy source rather than cheaper to produce. Many candidates gave vague responses such as ‘biofuels are more environmentally friendly’ or incorrect responses such as ‘biofuels produce less greenhouse gas emissions’. Candidates could improve their response, in this regard, by stating that biofuels are carbon neutral, and take in carbon dioxide or reduce atmospheric carbon dioxide when growing.

(iv) Growing biofuel crops and the link with reduced biodiversity was poorly understood and very few candidates accessed full credit. Candidates who had some understanding of how growing biofuel crops reduces biodiversity referred to growing large areas of a single crop or one type of crop species. The most successful responses used the correct technical term monoculture and explained that this is at the expense of native plant species. Very few candidates referred to the issues of reduction in soil fertility or use of large quantities of water.

(v) This question was found to be more challenging. Most candidates were able to access some credit and a few achieved full credit. Stronger responses referred to biofuels reducing the amount of food crops grown, land used for growing biofuel crops cannot then be used for growing food crops and can lead to increased cost of food or price setting. Some candidates explained factors that reduce biodiversity, which would have gained credit for **Question 4a(iv)** but which did not answer this question about food security. Some candidates also referred to food crops as agriculture, not appreciating that biofuel crops are also agriculture, so their responses were unclear.

(b) This question was well answered with most candidates able to correctly identify the 5-year period with the greatest increase in energy production from biofuels using **Table 4.1** as 2005 to 2010. A small number of responses stated the energy production values, rather than the years, which did not answer the question and therefore was not credited.

Section B

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

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. 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

Many candidates were able to demonstrate their knowledge and understanding of nuclear energy, the causes of energy insecurity, the impacts of energy security and describe strategies for improving energy security, evaluating whether nuclear energy is the most effective strategy for managing energy security. Successful responses often started with a definition of energy security and ultimately most concluded that using a mix of energy sources was the best way to manage energy security. Candidates with a good understanding of the subject matter, gave balanced accounts of the advantages and disadvantages of nuclear energy compared to other energy sources such as fossil fuels and renewable energy sources. These candidates also included accurate explanations of how electricity is generated from uranium in a nuclear power station.

Higher-level responses made good use of a range of specific case study examples including HIC countries such as France, Germany, Japan, South Korea, Switzerland and the United States, and LIC countries such as Yemen and Zimbabwe, and highlighted the different issues faced by HICs and LICs in their evaluation. The nuclear accidents of Three Mile Island, Chernobyl and Fukushima were documented while some candidates discussed the recent nationwide power outages faced by Spain and Portugal. These candidates often achieved Level 3 for AO2.

Less successful responses were often limited to discussing the advantages and disadvantages of nuclear energy rather than comparing nuclear energy to other strategies for managing energy security. Other candidates simply listed alternative strategies, barely mentioning nuclear energy, and the responses lacked detailed discussion. Common misconceptions seen included that nuclear energy is renewable and nuclear power stations emit greenhouse gases. 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 nuclear energy is the most effective strategy for managing energy security, 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

For this question on strategies for managing air pollution, candidates needed to demonstrate an understanding of the causes of air pollution, impacts of air pollution, and discuss examples of both successful and less successful strategies to manage air pollution. Well-prepared candidates referred to a wide range of specific, named air pollutants such as carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, particulates and VOCs. Candidates often went on to explain the impacts of these pollutants, causing problems such as climate change, wet and dry acid deposition, photochemical smog, harm to human health, particularly respiratory diseases, damage to vegetation, aquatic ecosystems and stonework. These candidates also displayed a sound knowledge of management strategies such as reduced use of fossil fuels, flue gas desulfurisation, carbon capture and storage, transport policies, catalytic converters, legislation including international treaties, and the polluter pays principle.

Higher-level responses made good use of correct terminology and included a range of specific case studies to exemplify the different approaches taken by HICs, MICs and LICs. The transport policies of cities such as London, Paris, Los Angeles and New York were frequently cited. China and India were regularly referred to as examples of rapidly developing countries attempting to convert to cleaner technologies. The success of international treaties such as Paris Agreement, Kyoto Protocol and COP 26, were also evaluated. These candidates often achieved Level 3 for AO2.

Less successful responses made vague references to gas emissions or toxic fumes without stating any correct named air pollutants. A significant number of candidates dedicated a large proportion of their responses to ozone depletion, the Montreal Protocol and banning of CFCs, landfill waste disposal and recycling, or lengthy discussion of smoking and vaping bans, none of which were directly relevant to managing air pollution. In addition, a number of candidates limited their response to Level 2 or Level 1 for AO2 through discussion of education and individual behavioural changes, or utilised their response to provide their own opinions on why and how air pollution could be reduced with little reference to any quantitative or qualitative data to support their claims. 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 as this indicates the detail expected. Where time is short, bulleted answers are often the clearest way to show knowledge in the structured questions (**Section A**).

Questions should always be read carefully before responding to ensure that the question asked is answered. This helps avoid having to restart an answer and wasting valuable examination time.

The difference in the meaning of command words needs to be better understood, particularly between describe and explain.

Repeating the question in an answer is unnecessary. The context in which a clear answer is written will be understood. If an answer needs to be rewritten, then a single line through the incorrect passage is appropriate.

Candidates should remember to show all working in calculations as credit may be available for the correct method even if the final answer is incorrect.

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

Candidates should avoid using terms that have a specific meaning in science unless they are used in an appropriate context, e.g. accurate, reliable, valid.

Candidates must avoid using the white space on the examination paper to continue their answers. Similarly, long answers squeezed into short answer spaces in small hand-writing, is often difficult to read. If extra space is required, then an additional answer booklet should always be used. In these cases, care should be taken to label responses accurately, particularly where there are several question parts.

General comments

For ***Section A***, topics which proved the most challenging were understanding and identifying features of subsistence agriculture from a photograph, **Question 1(a)(i)**, the concept of biodiversity, **Question 2(a)(iii)** and soil salinisation, **Question 4(a)(i)**.

For ***Section B***, many candidates who attempted **Question 6** on sustainable water extraction and improved water supply, had not understood the question requirements. This 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 clear 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 examined knowledge of both subsistence and sustainable agriculture as well as an understanding of food security. It also tested facts about the carbon cycle including the role of methane in the enhanced greenhouse effect.

Overall, candidates found this question the most difficult across the paper.

(a) (i) This question was challenging for many, who were unable to identify three features of subsistence agriculture from the figure. A common mistake was to describe features of rice farming shown in the image. Others defined subsistence agriculture, which was not asked for. The more successful answers identified small-scale farming, by a sole farmer using hand tools and a water buffalo for ploughing.

(ii) Responses were mixed, with the more successful candidates able to describe at least one way of improving food security. Top answers included diversification of crops, using fertilisers and using pest control or pest-resistant crops. Others gave answers too vague for credit or methods to improve irrigation, which is not appropriate for rice farming.

(b) (i) Some were able to correctly state the balanced chemical equation for respiration to access full credit. Other responses gave a correct but unbalanced equation. Also seen was an incorrect equation or the word equation for photosynthesis, which was not asked for.

(ii) Full credit was given to some for correctly explaining that the greenhouse gas methane absorbs infrared (longwave) radiation in the atmosphere, preventing energy from escaping into space, thereby causing atmospheric warming. Others confused infrared with ultraviolet (shortwave) radiation. A common misconception was that methane destroys the ozone layer. Candidates need to understand the different roles atmospheric gases play in regulation of our atmosphere, the natural balance of these gases and how human activity upsets this natural balance.

(iii) The carbon cycle was generally well understood with the most common answer being respiration or that rice plants are consumed. Others correctly stated that they form organic waste or can be combusted.

(c) Candidates generally found this question challenging. Some responses appreciated that water buffalo provide manure as a natural fertiliser or that they replace tractors which limits the use of fossil fuels. Others demonstrated a poor understanding of sustainability in agriculture by providing vague answers. Some incorrectly attempted to describe the role of the buffalo. Many candidates did not access credit because an explanation of a correct description was missing.

Question 2

Mathematical skills were examined in this question, where candidates were asked to calculate the Lincoln Index using tabulated data from a study of a shrew population. Also tested was the concept of biodiversity and benefits of conserving biodiversity. The benefits and limitations of the capture-mark-recapture method for estimating the population of shrews were asked for. Skills in describing the changes in the Living Planet Index over 50 years from a line graph were also examined.

(a) (i) The vast majority were able to correctly calculate *N* as 510, given the tabulated information.

(ii) There were some good answers with the most common being that only some of the population can be captured.

(iii) This question proved challenging for the majority. The difference between population and biodiversity was poorly understood. Candidates needed to understand that biodiversity is a measure of the variety of different species or organisms, rather than the size of the population of one species.

(b) Due to an issue with **Question 2(b)**, full marks have been awarded to all candidates and the question removed from the published version of the paper.
The syllabus states in the Topic 2 Environmental research and data collection section that the Assessment Objective 3 skills of planning investigations and identifying the limitations and benefits of the methods used are limited to paper 2.

(c) (i) This question was well answered with many able to access credit by describing the trend of at least one region accurately. The strongest answers also offered a data quote and provided comparative information, such as North America having the smallest decrease or having a small increase after 2010. Candidates could make better use of examination time by describing the most obvious trends rather than minor details.

(ii) The benefits of preserving biodiversity were clearly understood by many. Other responses were mixed and some answers were too vague for credit. The best answers stated provision of ecological services such as air purification and food. The top answer stated the potential for medicinal plants. Candidates could improve by better understanding the requirements of the command word 'state', which does not ask for long descriptions.

Question 3

The theme for this question was energy and energy sources. Candidates were given information about seed husks, instead of wood, to generate biomass energy – in this case to heat kilns for making clay bricks. They were asked to suggest benefits of using seed husks for biomass energy and to describe the impacts making clay bricks using kilns has on the ecosystem. A chart was provided showing the change in energy production between 2020 and 2021 for various energy resources in Brazil, which candidates needed to refer to, to answer a variety of questions. The definition of energy security was required, as were strategies for how Brazil could improve its energy security.

(a) There were some good answers, most commonly that seed husks are renewable or sustainable. Other common valid answers were that there is no need for waste disposal, or that it is cheap. Many repeated the benefits of deforestation, which was not asked for. Candidates should always read the question carefully before answering.

(b) This question prompted some good answers with many able to access some credit. Those who had carefully read the question were often able to score all or almost all of the credit available. Others focused on the impacts of deforestation or extracting clay for bricks, which was not asked for. Those who focused on localised impacts of using kilns understood the impact on air quality, such as the release of carbon dioxide and other gases that can form smog. Some other good answers included descriptions of habitat destruction or described impacts on the food chain. Five clear points needed to be made here in order for candidates to achieve full credit.

(c) (i) The majority were able to correctly suggest oil as non-renewable energy resource **X** from the chart provided.

(ii) Many incorrectly suggested that usage of hydroelectric energy had reduced. The chart shows change in energy production, not usage.

(iii) Answers were mixed. Some were able to identify the non-renewable energy resources from the chart and therefore correctly describe an increase in production between 2020 and 2021. Others gave the opposite answer. Careful study of the provided data, including the axes labels, was required before responding.

(iv) Many responses were able to access credit for the correct definition of energy security. Some gave answers too vague for credit. A common mistake was not clarifying the availability of energy as being either reliable or to all people at all times. Availability of energy does not mean energy security without this qualification.

(v) This question was very well answered with the majority able to suggest two or three creditworthy strategies. The top answer was to invest in renewable energy, with many able to give examples such as solar, wind or hydroelectric energy. Another common suitable answer was to increase energy efficiency and conservation, with some good descriptions of how to do this in the home. Others correctly suggested rationing and energy diversification.

Question 4

Here, candidates were examined on aspects of irrigation in agriculture, in this case for growing wheat. They were shown an image of an irrigation system and asked to suggest benefits and limitations of this system, including the process of soil salinisation as a limitation. Candidates were also invited to plot a line graph to show the yield of wheat against the volume of water for irrigation. They were asked to explain why crop yield is dependent on water.

(a) (i) The process of soil salinisation was not well known. Most candidates were unable to access credit for this question. Candidates may benefit from further engagement through demonstration and practical involvement in the classroom or fieldwork in this subject area.

(ii) There were some good responses with the majority able to suggest at least one valid benefit and one limitation. The top answers were that the system is quicker than manual labour and that it covers a wide area. Many correctly suggested a limitation is the expense of installation or maintenance and the issue of water wastage or water insecurity. Vague answers such as 'it is expensive' without qualification of what is expensive, were not awarded credit.

(b) (i) There were some very good responses with the majority able to provide a neat, correctly plotted line graph with fully labelled axes on an appropriate linear *y*-axis scale. The best answers included a smooth curve between points, or points joined point to point with a ruler. The most common mistake was not labelling the axes fully with units, or at all.

(ii) The most common correct answer was that water is needed for photosynthesis, and a few who went on to explain that this makes water a limiting factor gained full credit. Some other good responses explained that water is needed for nutrient uptake. Many answers were too vague for credit, such as 'water is needed for growth' and required the specific details of how plants or crops grow, i.e., by photosynthesis and nutrient uptake.

Section B

The questions in ***Section B*** assess two skill areas: AO2 (Information Handling and Analysis) for which there is a total of eight marks and AO3 (Investigation Skills and Making Judgements) for which there is a total of twelve marks. The two marks are combined giving a total mark out of the twenty marks available.

Two-thirds of candidates who attempted ***Section B*** answered **Question 5** (The extent to which agricultural diseases are the main threat to global food security); the remaining third answered **Question 6** (An evaluation of the success of sustainable water extraction and improved water supply as strategies for managing water security).

The majority were awarded Level 2 or 3 for AO2 and the lower levels of AO3 with a total mark between 8/20 and 15/20. Here, candidates had some good ideas and needed to develop the argument further for a higher mark. A common mistake was to present only one side of the argument.

A few high achievers attained Level 4 for AO3, for excellent development of both sides of the argument, supported by some good examples. Some candidates were unable to achieve higher than Level 1 for AO2 as no examples were provided to support their answer, or examples were irrelevant. Those awarded Level 1 for AO3 provided a largely descriptive response with minimal judgement.

Candidates are encouraged to make a plan before writing and to focus on the key areas and topic. They should also take careful note of instructions to give reasons and include information from relevant examples to support their answer.

Question 5

For AO2, the majority of candidates were able to achieve at least Level 2 by providing good descriptions of the effects of agricultural diseases on crops or livestock and impacts on humans. The best answers, achieving Level 3, gave examples of many other threats to global food security with descriptions of regions where this has been an issue, or is a current issue. A common answer was a description of one or more ongoing conflicts in 2025. A common mistake was to suggest that pesticides and herbicides cause crop disease.

For AO3, a few achieved top marks within Level 4 or 3 for excellent development of both sides of the argument, making a firm judgement either way on whether agricultural diseases are the main threat to food security or not. A common conclusion was that agricultural diseases are a local or regional issue that can easily be managed by various strategies (e.g., disease-resistant genetically modified crops or vaccination of livestock), whereas the more pressing issue is that of climate change including water shortage affecting global agriculture, with no easy solution. Other excellent responses argued that population growth was the main threat.

Others answers were vague, giving weak judgement or a largely descriptive response. This limited marks to within Level 2 or lower Level 3 for AO3 where only one side of the argument was given, or one side of the argument was stronger than the other. An inconsistent conclusion negatively impacts the candidate's score for AO3. It is important that candidates support their statements with reasoning.

Question 6

A common mistake resulted from candidates misreading the question and providing a description of strategies for managing water security, rather than an evaluation of the success of two of those strategies: sustainable water extraction and improved water supply. This negatively impacted scores for both AO2 and AO3 skill areas with the majority accessing no higher than Level 2 for this reason.

Despite these challenges there were some good descriptions of sustainable water extraction and methods for improved supply. A common answer for improved supply was the use of aquifers, wells (or boreholes) and reservoirs. Some relevant examples included local projects, expertly described by candidates who had visited these projects during their course, as well as well-known schemes such as the Three Gorges Dam in China.

Others had a poor understanding of the topic; some tried to argue that offshore pollution events at sea impacted water security. Candidates are encouraged to carefully reread the question and make a plan before attempting their answer. This will ultimately save time if a mistake is realised some time into writing the essay.

ENVIRONMENTAL MANAGEMENT

Paper 8291/13

Principles of Environmental Management

Key messages

Candidates should note the number of marks available for each part question as this indicates the detail expected. Where time is short, bulleted answers are often the clearest way to show knowledge in the structured questions (**Section A**).

Questions should always be read carefully before responding to ensure that the question asked is answered. This helps avoid having to restart an answer and wasting valuable examination time.

The difference in the meaning of command words needs to be better understood, particularly between describe and explain.

Repeating the question in an answer is unnecessary. The context in which a clear answer is written will be understood. If an answer needs to be rewritten, then a single line through the incorrect passage is appropriate.

Candidates should remember to show all working in calculations as credit may be available for the correct method even if the final answer is incorrect.

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

Candidates should avoid using terms that have a specific meaning in science unless they are used in an appropriate context, e.g. accurate, reliable, valid.

Candidates must avoid using the white space on the examination paper to continue their answers. Similarly, long answers squeezed into short answer spaces in small hand-writing, is often difficult to read. If extra space is required, then an additional answer booklet should always be used. In these cases, care should be taken to label responses accurately, particularly where there are several question parts.

General comments

For ***Section A***, topics which proved the most challenging were understanding and identifying features of subsistence agriculture from a photograph, **Question 1(a)(i)**, the concept of biodiversity, **Question 2(a)(iii)** and soil salinisation, **Question 4(a)(i)**.

For ***Section B***, many candidates who attempted **Question 6** on sustainable water extraction and improved water supply, had not understood the question requirements. This 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 clear 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 examined knowledge of both subsistence and sustainable agriculture as well as an understanding of food security. It also tested facts about the carbon cycle including the role of methane in the enhanced greenhouse effect.

Overall, candidates found this question the most difficult across the paper.

(a) (i) This question was challenging for many, who were unable to identify three features of subsistence agriculture from the figure. A common mistake was to describe features of rice farming shown in the image. Others defined subsistence agriculture, which was not asked for. The more successful answers identified small-scale farming, by a sole farmer using hand tools and a water buffalo for ploughing.

(ii) Responses were mixed, with the more successful candidates able to describe at least one way of improving food security. Top answers included diversification of crops, using fertilisers and using pest control or pest-resistant crops. Others gave answers too vague for credit or methods to improve irrigation, which is not appropriate for rice farming.

(b) (i) Some were able to correctly state the balanced chemical equation for respiration to access full credit. Other responses gave a correct but unbalanced equation. Also seen was an incorrect equation or the word equation for photosynthesis, which was not asked for.

(ii) Full credit was given to some for correctly explaining that the greenhouse gas methane absorbs infrared (longwave) radiation in the atmosphere, preventing energy from escaping into space, thereby causing atmospheric warming. Others confused infrared with ultraviolet (shortwave) radiation. A common misconception was that methane destroys the ozone layer. Candidates need to understand the different roles atmospheric gases play in regulation of our atmosphere, the natural balance of these gases and how human activity upsets this natural balance.

(iii) The carbon cycle was generally well understood with the most common answer being respiration or that rice plants are consumed. Others correctly stated that they form organic waste or can be combusted.

(c) Candidates generally found this question challenging. Some responses appreciated that water buffalo provide manure as a natural fertiliser or that they replace tractors which limits the use of fossil fuels. Others demonstrated a poor understanding of sustainability in agriculture by providing vague answers. Some incorrectly attempted to describe the role of the buffalo. Many candidates did not access credit because an explanation of a correct description was missing.

Question 2

Mathematical skills were examined in this question, where candidates were asked to calculate the Lincoln Index using tabulated data from a study of a shrew population. Also tested was the concept of biodiversity and benefits of conserving biodiversity. The benefits and limitations of the capture-mark-recapture method for estimating the population of shrews were asked for. Skills in describing the changes in the Living Planet Index over 50 years from a line graph were also examined.

(a) (i) The vast majority were able to correctly calculate *N* as 510, given the tabulated information.

(ii) There were some good answers with the most common being that only some of the population can be captured.

(iii) This question proved challenging for the majority. The difference between population and biodiversity was poorly understood. Candidates needed to understand that biodiversity is a measure of the variety of different species or organisms, rather than the size of the population of one species.

(b) Due to an issue with **Question 2(b)**, full marks have been awarded to all candidates and the question removed from the published version of the paper.
The syllabus states in the Topic 2 Environmental research and data collection section that the Assessment Objective 3 skills of planning investigations and identifying the limitations and benefits of the methods used are limited to paper 2.

(c) (i) This question was well answered with many able to access credit by describing the trend of at least one region accurately. The strongest answers also offered a data quote and provided comparative information, such as North America having the smallest decrease or having a small increase after 2010. Candidates could make better use of examination time by describing the most obvious trends rather than minor details.

(ii) The benefits of preserving biodiversity were clearly understood by many. Other responses were mixed and some answers were too vague for credit. The best answers stated provision of ecological services such as air purification and food. The top answer stated the potential for medicinal plants. Candidates could improve by better understanding the requirements of the command word 'state', which does not ask for long descriptions.

Question 3

The theme for this question was energy and energy sources. Candidates were given information about seed husks, instead of wood, to generate biomass energy – in this case to heat kilns for making clay bricks. They were asked to suggest benefits of using seed husks for biomass energy and to describe the impacts making clay bricks using kilns has on the ecosystem. A chart was provided showing the change in energy production between 2020 and 2021 for various energy resources in Brazil, which candidates needed to refer to, to answer a variety of questions. The definition of energy security was required, as were strategies for how Brazil could improve its energy security.

(a) There were some good answers, most commonly that seed husks are renewable or sustainable. Other common valid answers were that there is no need for waste disposal, or that it is cheap. Many repeated the benefits of deforestation, which was not asked for. Candidates should always read the question carefully before answering.

(b) This question prompted some good answers with many able to access some credit. Those who had carefully read the question were often able to score all or almost all of the credit available. Others focused on the impacts of deforestation or extracting clay for bricks, which was not asked for. Those who focused on localised impacts of using kilns understood the impact on air quality, such as the release of carbon dioxide and other gases that can form smog. Some other good answers included descriptions of habitat destruction or described impacts on the food chain. Five clear points needed to be made here in order for candidates to achieve full credit.

(c) (i) The majority were able to correctly suggest oil as non-renewable energy resource **X** from the chart provided.

(ii) Many incorrectly suggested that usage of hydroelectric energy had reduced. The chart shows change in energy production, not usage.

(iii) Answers were mixed. Some were able to identify the non-renewable energy resources from the chart and therefore correctly describe an increase in production between 2020 and 2021. Others gave the opposite answer. Careful study of the provided data, including the axes labels, was required before responding.

(iv) Many responses were able to access credit for the correct definition of energy security. Some gave answers too vague for credit. A common mistake was not clarifying the availability of energy as being either reliable or to all people at all times. Availability of energy does not mean energy security without this qualification.

(v) This question was very well answered with the majority able to suggest two or three creditworthy strategies. The top answer was to invest in renewable energy, with many able to give examples such as solar, wind or hydroelectric energy. Another common suitable answer was to increase energy efficiency and conservation, with some good descriptions of how to do this in the home. Others correctly suggested rationing and energy diversification.

Question 4

Here, candidates were examined on aspects of irrigation in agriculture, in this case for growing wheat. They were shown an image of an irrigation system and asked to suggest benefits and limitations of this system, including the process of soil salinisation as a limitation. Candidates were also invited to plot a line graph to show the yield of wheat against the volume of water for irrigation. They were asked to explain why crop yield is dependent on water.

(a) (i) The process of soil salinisation was not well known. Most candidates were unable to access credit for this question. Candidates may benefit from further engagement through demonstration and practical involvement in the classroom or fieldwork in this subject area.

(ii) There were some good responses with the majority able to suggest at least one valid benefit and one limitation. The top answers were that the system is quicker than manual labour and that it covers a wide area. Many correctly suggested a limitation is the expense of installation or maintenance and the issue of water wastage or water insecurity. Vague answers such as 'it is expensive' without qualification of what is expensive, were not awarded credit.

(b) (i) There were some very good responses with the majority able to provide a neat, correctly plotted line graph with fully labelled axes on an appropriate linear *y*-axis scale. The best answers included a smooth curve between points, or points joined point to point with a ruler. The most common mistake was not labelling the axes fully with units, or at all.

(ii) The most common correct answer was that water is needed for photosynthesis, and a few who went on to explain that this makes water a limiting factor gained full credit. Some other good responses explained that water is needed for nutrient uptake. Many answers were too vague for credit, such as 'water is needed for growth' and required the specific details of how plants or crops grow, i.e., by photosynthesis and nutrient uptake.

Section B

The questions in ***Section B*** assess two skill areas: AO2 (Information Handling and Analysis) for which there is a total of eight marks and AO3 (Investigation Skills and Making Judgements) for which there is a total of twelve marks. The two marks are combined giving a total mark out of the twenty marks available.

Two-thirds of candidates who attempted ***Section B*** answered **Question 5** (The extent to which agricultural diseases are the main threat to global food security); the remaining third answered **Question 6** (An evaluation of the success of sustainable water extraction and improved water supply as strategies for managing water security).

The majority were awarded Level 2 or 3 for AO2 and the lower levels of AO3 with a total mark between 8/20 and 15/20. Here, candidates had some good ideas and needed to develop the argument further for a higher mark. A common mistake was to present only one side of the argument.

A few high achievers attained Level 4 for AO3, for excellent development of both sides of the argument, supported by some good examples. Some candidates were unable to achieve higher than Level 1 for AO2 as no examples were provided to support their answer, or examples were irrelevant. Those awarded Level 1 for AO3 provided a largely descriptive response with minimal judgement.

Candidates are encouraged to make a plan before writing and to focus on the key areas and topic. They should also take careful note of instructions to give reasons and include information from relevant examples to support their answer.

Question 5

For AO2, the majority of candidates were able to achieve at least Level 2 by providing good descriptions of the effects of agricultural diseases on crops or livestock and impacts on humans. The best answers, achieving Level 3, gave examples of many other threats to global food security with descriptions of regions where this has been an issue, or is a current issue. A common answer was a description of one or more ongoing conflicts in 2025. A common mistake was to suggest that pesticides and herbicides cause crop disease.

For AO3, a few achieved top marks within Level 4 or 3 for excellent development of both sides of the argument, making a firm judgement either way on whether agricultural diseases are the main threat to food security or not. A common conclusion was that agricultural diseases are a local or regional issue that can easily be managed by various strategies (e.g., disease-resistant genetically modified crops or vaccination of livestock), whereas the more pressing issue is that of climate change including water shortage affecting global agriculture, with no easy solution. Other excellent responses argued that population growth was the main threat.

Others answers were vague, giving weak judgement or a largely descriptive response. This limited marks to within Level 2 or lower Level 3 for AO3 where only one side of the argument was given, or one side of the argument was stronger than the other. An inconsistent conclusion negatively impacts the candidate's score for AO3. It is important that candidates support their statements with reasoning.

Question 6

A common mistake resulted from candidates misreading the question and providing a description of strategies for managing water security, rather than an evaluation of the success of two of those strategies: sustainable water extraction and improved water supply. This negatively impacted scores for both AO2 and AO3 skill areas with the majority accessing no higher than Level 2 for this reason.

Despite these challenges there were some good descriptions of sustainable water extraction and methods for improved supply. A common answer for improved supply was the use of aquifers, wells (or boreholes) and reservoirs. Some relevant examples included local projects, expertly described by candidates who had visited these projects during their course, as well as well-known schemes such as the Three Gorges Dam in China.

Others had a poor understanding of the topic; some tried to argue that offshore pollution events at sea impacted water security. Candidates are encouraged to carefully reread the question and make a plan before attempting their answer. This will ultimately save time if a mistake is realised some time into writing the essay.

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. How ozone is depleted was also not well known.
- There was confusion over the role of chlorophyll in photosynthesis and many candidates referred to chlorophyll as an organism.
- The syllabus term 'climax community' was not well known.
- Candidates should refer to the compass points north, south, east and west and avoid using up, down, left and right for distribution questions.
- Graph drawing was poorly completed by many candidates.
- Candidates should check they have attempted every question. For example, **Question 2(a)(i)** was often left blank.
- Candidates should always show their working in calculations so that credit can be awarded for the working where appropriate.
- Candidates should read the question carefully before responding to avoid any misunderstanding of what is required. For example, in **Question 3(c)(i)**, the majority of candidates described the data trend rather than explaining the data as required by the question. In **Question 4(b)(vi)**, some candidates misread the question and answered in terms of increased food security rather than insecurity.

General comments

The bar chart in **Question 4(b)(i)** was poorly completed. Many candidates would benefit from practising graph plotting in order to develop their skills in this area.

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

More successful candidates did not simply repeat information provided in the question, they 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 ensure that candidates give sufficient answers to match the mark allocation. For example, where the mark allocation is [3], three separate ideas should be given.

Candidates should use terms that have a specific meaning in science only in an appropriate context, e.g. accurate, reliable, valid. Vague terms such as 'to harm/affect/damage' or 'cause pollution' should always be qualified with what this impact is or what is polluted.

Comments on specific questions

Question 1

(a) Some candidate responses showed a lack of awareness of the term pilot study. Answers often included a list of terms such as 'for accuracy' or 'for precision' – these have specific meanings in a scientific context and candidates are advised to explain their meaning in the context of the question set. For example, 'to see if questions are valid by meeting the intended question objective'.

(b) Weaker responses needed to make it clear which question style they were referring to.

(c) (i) Higher-performing candidates were guided by the mark allocation of and gave two distinct suggestions about the benefit of recorded interviews. Weaker candidates stated 'for accuracy', 'for precision' or 'for validity' without explaining what they meant by these terms in the context of the benefits of recorded interviews.

(ii) Weaker responses repeated the information in the question without adding any additional information.

(d) (i) Most candidates could give one reason for a lack of recycling facilities, usually lack of available land to build the recycling facilities; fewer could give two. Weaker responses focused on why people do not recycle rather than why there might be a lack of recycling facilities.

(ii) Most candidates recognised that a fine or a tax on not recycling was a financial incentive and some gave examples of this, such as refunds on the return of glass bottles. Many responses also focused on the idea of people not wanting to get into trouble if a law on recycling was imposed.

(e) The impacts of landfill as a method of waste disposal were well known. Some vague responses referred to pollution without qualifying what this meant. Examples of stronger answers included 'causes contamination of water', 'pollution of soil' or 'greenhouse gases emitted'.

Question 2

(a) (i) There were a large number of no responses to this calculation, indicating that some candidates overlooked this question. Successful responses gave the answer of 1.70.

(ii) The strongest reasons were detailed and included an example of a specific weather condition and why the Secchi disc was not suitable in that stated condition.

(iii) Weaker answers stated 'for accuracy', or 'for validity' without explaining what was meant by these terms in the context of repeating measurements. Good responses recognised that anomalous results could be identified and excluded and a mean could be found.

(b) (i) Many candidates knew that the Sun is the source of energy for producers such as phytoplankton. Common errors included 'algae', 'plants' and 'chlorophyll'.

(ii) Candidates struggled to articulate their answer in a clear manner. A common misconception was to suggest that chlorophyll is an organism. Many made the link between chlorophyll and photosynthesis; fewer went on to say how this links to primary productivity. Weaker responses stated there was a link but did not say what this was.

(c) Many candidates expressed their conclusion poorly. These candidates needed to read the introduction to the question where Secchi depth was explained more carefully. These answers were often about water depth rather than Secchi depth.

(d) (i) Candidates performed well on this question about the benefits and limitations of crowd sourcing. Occasionally, responses were confused and candidates wrote about limitations in the benefits part of the response area.

(ii) Most candidates understood that ocean temperatures would increase and some then linked this to the conditions becoming unsuitable for phytoplankton. Some answers were vague and commented on climate change in general terms rather than about how this could decrease phytoplankton populations, for example, 'sea levels rise'.

(e) (i) The majority of candidates could interpret the graph and gave the location as 4.

(ii) A slightly more challenging question than **Question 2(e)(i)**; the majority of candidates were able to give the turbidity of location 41 as 29.

(f) Candidates often needed to read the exact instructions given in the question, which were to look at a particular point on the figure and use information from this point. Weaker responses listed all the information from the figure.

Question 3

(a) (i) The layer of the atmosphere which contains the ozone layer was known by most candidates.

(ii) Candidates found this a very challenging question and responses indicated that many were not familiar with how ozone depletion occurs. Confused and inaccurate answers were common. There were many vague responses about aerosols and refrigerators as sources for CFCs where candidates needed to go on to explain how CFCs deplete ozone. Some had the idea that sunlight is involved, but sometimes linked this to the wrong process, e.g. oxygen breaking up ozone. Many candidates incorrectly referred to greenhouse gases depleting the ozone layer. A very few responses referred to polar stratospheric clouds (PSCs) or the polar vortex. This is an area of the syllabus where many candidates would benefit from further study.

(b) (i) Candidates performed well on this question and most were able to evaluate the effectiveness of the international agreements using the figure to support their answer. Weaker responses discussed Montreal without clarifying which agreement, 1987 or 2007, they were referring to.

(ii) Many candidates confused the natural sources of ODS for something that humans could use to replace synthetically produced ODS.

(c) (i) Overall, candidates found this the most challenging question on the paper and it was very poorly answered. The majority of responses described the trend in the data shown rather than explaining it as required by the command word used in the question. Many candidates would benefit from more careful reading to ensure that they answer the question being asked.

(ii) Confusion about ozone depletion, UV, greenhouse gases and climate change was apparent here. Many responses answered in terms of climate change instead of UV-related impacts.

(d) The stronger candidates used bullet points and clearly identified each different issue when referring to a limitation or to a benefit. Many candidates struggled to give a clear response and there were a number of no responses to this question.

Question 4

(a) (i) The strongest responses recognised that the biogas produced was a renewable fuel. Very few answers referred to the heat from the process being fed back into the heater so that no additional energy is required. Weaker responses repeated information directly from the stem of the question.

(ii) Most candidates copied information from the introduction rather than expanding their answer with their own understanding.

(b) (i) The bar chart proved to be an area for improvement for many candidates. The *y*-axis scale was often non-linear, both axes lacked labels, plots were inaccurate, bars were not equally spaced and were touching rather than having equal spaces between them. Many candidates used a pen to complete the bar chart, which caused them problems when they made an error as it was not easy for mistakes to be corrected. Many of the responses included bars that had not been drawn with a ruler.

(ii) Most candidates recognised that sorghum was the required answer.

(iii) Candidates are expected to be familiar with the mathematical requirements of the syllabus, which include calculation of a range. Some candidates were not able to calculate this correctly or gave the numbers at each end of the range rather than the range itself.

(iv) Most candidates recognised that sorghum was the required answer.

(v) Candidates would benefit from learning the stated abiotic and biotic factors of an ecosystem which are listed in the syllabus, as the abiotic components were not universally recalled; climate and soil were two common incorrect answers.

(vi) Many candidates misread the question and answered in terms of increased food security.

(vii) Many candidates repeated information given at the start of the question rather than building on this and applying it. For example, 'increases nutrients in the soil' was given in the information. Stronger responses suggested how this was a benefit: 'increases nutrients in the soil which improves crop growth and therefore crop yield'.

(c) Good descriptions focused on describing what was asked for in the question, the distribution of deforested areas, rather than areas which did not have deforestation. These responses used points of the compass instead of up, down, left and right, in their descriptions.

(d) (i) It was sometimes difficult to distinguish between the two shades of grey, especially when candidates used a pen instead of pencil. The most common error was an incorrect key for small scale agriculture, with vertical lines used instead of horizontal lines. Some candidates chose to use their own key with letters, but this did not match what was presented in the pie chart.

(ii) Some vague answers were seen, such as 'humans' and some candidates gave causes that were already included in the other sectors of the pie chart, such as agriculture. Some also gave examples of agriculture.

(e) (i) Many candidates were unfamiliar with a pioneer species and suggested these were animals or large trees.

(ii) The term climax community was not well known. Candidates would benefit from more study in this area of the syllabus.

ENVIRONMENTAL MANAGEMENT

Paper 8291/22
Management in Context

Key messages

- Candidates must carefully read each question, for example, in **Question 1(a)** where the question asks for a description of one specific category, many candidates described other categories.
- It is important to give the correct unit with calculations and round to the correct number of significant figures where the question specifies this.
- Candidates would benefit from further practice with regard to questionnaires, particularly the benefits and limitations of them. Knowledge and understanding surrounding the benefits of recycling was generally good.

General comments

Overall, there were some very strong responses, particularly in answers to **Question 3(b)(i)**, drawing a bar chart: units were given correctly, axes labelled with an appropriate scale and the plotting of points was done accurately. The descriptions of graphical data and images of unfamiliar concepts would benefit from further practice, especially where a description of distribution in terms of a global geographical image is required. Responses often included terms such as to the right or left or, in response to the equator, above or below the equator which are too general for any credit to be awarded.

Secure knowledge was generally demonstrated surrounding impacts of climate change. Population density calculations and environmental factors particularly need further work and reinforcement.

Comments on specific questions

Question 1

(a) Most candidates were able to compare the percentage of people who thought recycling was extremely important, many highlighting Africa and Oceania as being the highest and lowest percentages in this category. Candidates should note that the question surrounded the extremely important category and therefore credit was not given to the important or not important categories.

(b) (i) This was generally answered to a high standard with candidates stating easy to answer and quantifiable as benefits, whilst citing lack of explanation or lack of detail in terms of limitations.

(ii) This provided a challenge to many candidates who thought a questionnaire to business owners or households was linked to them being the demographic that produces the most waste, which is an assumption; strong responses cited a representative sample or large sample. Credit was not awarded for reliable or precise reasons as potentially these are subjective.

(c) The question required candidates to suggest why people do not recycle; responses were mixed overall, with common answers being lack of facilities or time consuming/inconvenient. Cost was often cited, though not credited.

Other responses included it not being important, but this was not qualified or developed any further for it to be credited.

(d) (i) Responses were generally of a high standard, with common answers surrounding the impacts of plastic in oceans being non-biodegradable, marine organisms choking or consuming plastics as well as reference to reduced biodiversity and bioaccumulation, though there was some misunderstanding of the terms biomagnification and bioaccumulation.

(ii) A few candidates demonstrated excellent specific knowledge of cotton crops in terms of them requiring extensive irrigation in comparison to the use of plastic fibres. Common answers included a reduction in cotton farming and cited opportunities for more food crops being grown. Other responses included the recycling aspect of using plastic fibres together with reducing the amount of plastic in marine water.

(e) The benefits and limitations of incineration of plastic were generally answered well. Common benefits included obtaining energy for electricity as a byproduct, together with less waste going to landfill. Limitations commonly evidenced by candidates surrounded air pollution and toxic compounds with correct examples being given, e.g. carbon dioxide or nitrous oxides.

Question 2

(a) (i) This question proved very challenging for a significant number of candidates who commonly incorrectly suggested to estimate the total population of moths, or to distinguish moth species, rather than focusing on the fact that not all of the public would be able to identify different species of moth.

(ii) Candidates found the reason for recording weather conditions during 'Moth Night' challenging. Strong responses identified the idea of a possible correlation between moth numbers and weather conditions. Incorrect responses often included being able to identify a species preference for weather conditions, although there would be insufficient data to make that connection.

(b) (i) Most candidates were able to interpret the moth trap diagram and explain how it could be used to record data on moth populations; this usually included moths being attracted to the light and falling/flying into the container.

(ii) Very few candidates were able to link the idea of a damp sponge being a source of water for moths to survive/hydrate; many responses incorrectly suggested the damp sponge wetting the moths' wings and preventing them from flying out of the container. A few candidates correctly referred to the sponge reducing the temperature of the box which was credited.

(iii) Collection of non-target species, or predators of the moth being attracted to the light trap were common and correct responses by candidates; reference to harming the moths was also credited as a limitation of this method of recording data on moth populations.

(c) (i) The majority of candidates were able to identify the range from **Fig. 2.3** to give the correct answer of 420. A significant proportion of candidates gave 540 – 120 without calculating the answer and were not credited.

(ii) This question was answered well and candidates were able to correctly interpret the graph and draw correct conclusions, which commonly included fluctuating moth populations or an overall decline in the period. Credit was not awarded for reading a specific moth population at a particular time which was commonly seen in responses.

(d) (i) Candidates demonstrated secure knowledge and interpretation of how pollinators improve food security with most candidates citing an increase in fruit yield and profit. Full credit proved challenging to many candidates who needed to extend their answers to refer to reinvestment into crop systems or the culmination of lower food prices linked to increased yield.

(ii) This question was answered less strongly overall, regarding a description of crops dependent on pollinators. When provided with the Equator, Tropic of Cancer or Capricorn in the diagram, candidates should note descriptions of above or below are not creditable and that reference should be to north or south of these lines. Credit was given to common responses such as 25 – 49% and 10 – 24% being most frequent as well as reference to specific countries.

(e) Candidates were generally able to interpret the food web in **Fig. 2.6** and correctly provide four trophic levels. Incorrect responses often seen were five trophic levels or just reference to primary consumer, producer etc. with no actual use of the food web provided.

(f) Full credit was awarded to candidates who discussed specific numbers at each trophic/food chain level with many candidates giving an example of a single tree supporting many invertebrate populations. Most candidates were unable to demonstrate secure knowledge and many incorrectly discussed biomass.

Question 3

(a) Candidates found the link between climate change and wildfires very challenging. Many responses referred to increasing temperatures/global warming and drought, and a small number included dry vegetation to be awarded full credit.

(b) (i) The majority of candidates were able to draw a bar chart to a high standard, including labelled axes with units and correct plotting of bar heights. A few candidates incorrectly drew a line graph. Candidates must use rulers to draw lines to show precise plotting, bars should not be touching and should be of equal width. A high standard of response was seen overall.

(ii) Most candidates correctly identified that not all the actual wildfires had been recorded.

(c) Generally, most candidates demonstrated secure knowledge of how climate change can cause extreme rainfall. Reference to increased temperatures and increased evaporation was commonly seen and credited, whilst reference to convection or condensation was evidenced much less often.

(d) (i) Many candidates were credited for stating a slight increase between 1900 and 2000. Others misinterpreted the graph, particularly the *y*-axis which indicated global surface temperature change, and incorrectly assumed the global surface temperature was below 0°C for that period.

(ii) Although there were some appropriate responses to reasons why the prediction models were different, such as different data variables and reference to outdated technology, candidates generally stated that the computer models were different and did not state or focus on what data may have been used to make the prediction.

(e) (i) Many candidates correctly identified why climate change is a concern for Antarctica, such as melting of the ice shelf or loss of biodiversity/habitat. A significant number of candidates stated increasing sea levels due to the melting ice shelf which is incorrect.

(ii) Most candidates demonstrated strong knowledge of the specification, and many achieved full credit with a wide range of points evidencing the control of impacts surrounding tourism such as controlled access to protected areas, restriction of tourist numbers and travel permits.

Question 4

(a) (i) The majority of candidates were able to calculate the number of people who lived in cities in 2022. Answers not given to two significant figures were not awarded full credit.

(ii) Secure knowledge was shown by candidates in explaining the impacts of increased urbanisation on water security with many citing increased cost of water, potential increased water contamination and increased pressure on sanitation services. Conversely and not often cited was improved water security in terms of modern water filters and services generally, which was also credited.

(b) (i) Candidates enthusiastically suggested the benefits to the environment of a vertical forest, and most responses discussed the benefits of photosynthesis and reduced impacts of climate change, such as reduced urban temperatures and reduced need for air conditioning. Less knowledge of mitigating pollution such as trapping particulates or mitigating run-off of storm water was seen.

(ii) The calculation of population density was generally not well understood; whilst some candidates were able to calculate the number correctly, not all provided a correct unit for the calculation and hence were only awarded partial credit.

(iii) Some candidates needed to read the question more carefully, as it required economic factors that affect population density, such as availability of jobs, level of salary, cost of healthcare (qualified). Some candidates incorrectly gave environmental factors that affect population density.

(iv) The key aspect with this question was an explanation; candidates often correctly identified environmental factors such as soil type, and needed to qualify them by linking to the volume of food able to be grown in that area. Some gave possible tectonic activity, and could have refered to it limiting settlement to gain the credit.

(c) (i) Candidates struggled to understand the age groups that separate the young and elderly dependents from the actively working population. Overall, responses were very mixed with some candidates only able to recognise the age of one dependent demographic.

(ii) This question was not well answered overall, with many candidates incorrectly referring to high birth rates or high death rates rather than describing how the pyramid of a LIC is different from a HIC. Stronger candidates referred to differences in the shape of the pyramids – e.g. wider base or narrower top or fewer people reaching old age.

ENVIRONMENTAL MANAGEMENT

Paper 8291/23
Management in Context

Key messages

- Candidates must carefully read each question, for example, in **Question 1(a)** where the question asks for a description of one specific category, many candidates described other categories.
- It is important to give the correct unit with calculations and round to the correct number of significant figures where the question specifies this.
- Candidates would benefit from further practice with regard to questionnaires, particularly the benefits and limitations of them. Knowledge and understanding surrounding the benefits of recycling was generally good.

General comments

Overall, there were some very strong responses, particularly in answers to **Question 3(b)(i)**, drawing a bar chart: units were given correctly, axes labelled with an appropriate scale and the plotting of points was done accurately. The descriptions of graphical data and images of unfamiliar concepts would benefit from further practice, especially where a description of distribution in terms of a global geographical image is required. Responses often included terms such as to the right or left or, in response to the equator, above or below the equator which are too general for any credit to be awarded.

Secure knowledge was generally demonstrated surrounding impacts of climate change. Population density calculations and environmental factors particularly need further work and reinforcement.

Comments on specific questions

Question 1

(a) Most candidates were able to compare the percentage of people who thought recycling was extremely important, many highlighting Africa and Oceania as being the highest and lowest percentages in this category. Candidates should note that the question surrounded the extremely important category and therefore credit was not given to the important or not important categories.

(b) (i) This was generally answered to a high standard with candidates stating easy to answer and quantifiable as benefits, whilst citing lack of explanation or lack of detail in terms of limitations.

(ii) This provided a challenge to many candidates who thought a questionnaire to business owners or households was linked to them being the demographic that produces the most waste, which is an assumption; strong responses cited a representative sample or large sample. Credit was not awarded for reliable or precise reasons as potentially these are subjective.

(c) The question required candidates to suggest why people do not recycle; responses were mixed overall, with common answers being lack of facilities or time consuming/inconvenient. Cost was often cited, though not credited.

Other responses included it not being important, but this was not qualified or developed any further for it to be credited.

(d) (i) Responses were generally of a high standard, with common answers surrounding the impacts of plastic in oceans being non-biodegradable, marine organisms choking or consuming plastics as well as reference to reduced biodiversity and bioaccumulation, though there was some misunderstanding of the terms biomagnification and bioaccumulation.

(ii) A few candidates demonstrated excellent specific knowledge of cotton crops in terms of them requiring extensive irrigation in comparison to the use of plastic fibres. Common answers included a reduction in cotton farming and cited opportunities for more food crops being grown. Other responses included the recycling aspect of using plastic fibres together with reducing the amount of plastic in marine water.

(e) The benefits and limitations of incineration of plastic were generally answered well. Common benefits included obtaining energy for electricity as a byproduct, together with less waste going to landfill. Limitations commonly evidenced by candidates surrounded air pollution and toxic compounds with correct examples being given, e.g. carbon dioxide or nitrous oxides.

Question 2

(a) (i) This question proved very challenging for a significant number of candidates who commonly incorrectly suggested to estimate the total population of moths, or to distinguish moth species, rather than focusing on the fact that not all of the public would be able to identify different species of moth.

(ii) Candidates found the reason for recording weather conditions during 'Moth Night' challenging. Strong responses identified the idea of a possible correlation between moth numbers and weather conditions. Incorrect responses often included being able to identify a species preference for weather conditions, although there would be insufficient data to make that connection.

(b) (i) Most candidates were able to interpret the moth trap diagram and explain how it could be used to record data on moth populations; this usually included moths being attracted to the light and falling/flying into the container.

(ii) Very few candidates were able to link the idea of a damp sponge being a source of water for moths to survive/hydrate; many responses incorrectly suggested the damp sponge wetting the moths' wings and preventing them from flying out of the container. A few candidates correctly referred to the sponge reducing the temperature of the box which was credited.

(iii) Collection of non-target species, or predators of the moth being attracted to the light trap were common and correct responses by candidates; reference to harming the moths was also credited as a limitation of this method of recording data on moth populations.

(c) (i) The majority of candidates were able to identify the range from **Fig. 2.3** to give the correct answer of 420. A significant proportion of candidates gave 540 – 120 without calculating the answer and were not credited.

(ii) This question was answered well and candidates were able to correctly interpret the graph and draw correct conclusions, which commonly included fluctuating moth populations or an overall decline in the period. Credit was not awarded for reading a specific moth population at a particular time which was commonly seen in responses.

(d) (i) Candidates demonstrated secure knowledge and interpretation of how pollinators improve food security with most candidates citing an increase in fruit yield and profit. Full credit proved challenging to many candidates who needed to extend their answers to refer to reinvestment into crop systems or the culmination of lower food prices linked to increased yield.

(ii) This question was answered less strongly overall, regarding a description of crops dependent on pollinators. When provided with the Equator, Tropic of Cancer or Capricorn in the diagram, candidates should note descriptions of above or below are not creditable and that reference should be to north or south of these lines. Credit was given to common responses such as 25 – 49% and 10 – 24% being most frequent as well as reference to specific countries.

(e) Candidates were generally able to interpret the food web in **Fig. 2.6** and correctly provide four trophic levels. Incorrect responses often seen were five trophic levels or just reference to primary consumer, producer etc. with no actual use of the food web provided.

(f) Full credit was awarded to candidates who discussed specific numbers at each trophic/food chain level with many candidates giving an example of a single tree supporting many invertebrate populations. Most candidates were unable to demonstrate secure knowledge and many incorrectly discussed biomass.

Question 3

(a) Candidates found the link between climate change and wildfires very challenging. Many responses referred to increasing temperatures/global warming and drought, and a small number included dry vegetation to be awarded full credit.

(b) (i) The majority of candidates were able to draw a bar chart to a high standard, including labelled axes with units and correct plotting of bar heights. A few candidates incorrectly drew a line graph. Candidates must use rulers to draw lines to show precise plotting, bars should not be touching and should be of equal width. A high standard of response was seen overall.

(ii) Most candidates correctly identified that not all the actual wildfires had been recorded.

(c) Generally, most candidates demonstrated secure knowledge of how climate change can cause extreme rainfall. Reference to increased temperatures and increased evaporation was commonly seen and credited, whilst reference to convection or condensation was evidenced much less often.

(d) (i) Many candidates were credited for stating a slight increase between 1900 and 2000. Others misinterpreted the graph, particularly the *y*-axis which indicated global surface temperature change, and incorrectly assumed the global surface temperature was below 0°C for that period.

(ii) Although there were some appropriate responses to reasons why the prediction models were different, such as different data variables and reference to outdated technology, candidates generally stated that the computer models were different and did not state or focus on what data may have been used to make the prediction.

(e) (i) Many candidates correctly identified why climate change is a concern for Antarctica, such as melting of the ice shelf or loss of biodiversity/habitat. A significant number of candidates stated increasing sea levels due to the melting ice shelf which is incorrect.

(ii) Most candidates demonstrated strong knowledge of the specification, and many achieved full credit with a wide range of points evidencing the control of impacts surrounding tourism such as controlled access to protected areas, restriction of tourist numbers and travel permits.

Question 4

(a) (i) The majority of candidates were able to calculate the number of people who lived in cities in 2022. Answers not given to two significant figures were not awarded full credit.

(ii) Secure knowledge was shown by candidates in explaining the impacts of increased urbanisation on water security with many citing increased cost of water, potential increased water contamination and increased pressure on sanitation services. Conversely and not often cited was improved water security in terms of modern water filters and services generally, which was also credited.

(b) (i) Candidates enthusiastically suggested the benefits to the environment of a vertical forest, and most responses discussed the benefits of photosynthesis and reduced impacts of climate change, such as reduced urban temperatures and reduced need for air conditioning. Less knowledge of mitigating pollution such as trapping particulates or mitigating run-off of storm water was seen.

(ii) The calculation of population density was generally not well understood; whilst some candidates were able to calculate the number correctly, not all provided a correct unit for the calculation and hence were only awarded partial credit.

(iii) Some candidates needed to read the question more carefully, as it required economic factors that affect population density, such as availability of jobs, level of salary, cost of healthcare (qualified). Some candidates incorrectly gave environmental factors that affect population density.

(iv) The key aspect with this question was an explanation; candidates often correctly identified environmental factors such as soil type, and needed to qualify them by linking to the volume of food able to be grown in that area. Some gave possible tectonic activity, and could have refered to it limiting settlement to gain the credit.

(c) (i) Candidates struggled to understand the age groups that separate the young and elderly dependents from the actively working population. Overall, responses were very mixed with some candidates only able to recognise the age of one dependent demographic.

(ii) This question was not well answered overall, with many candidates incorrectly referring to high birth rates or high death rates rather than describing how the pyramid of a LIC is different from a HIC. Stronger candidates referred to differences in the shape of the pyramids – e.g. wider base or narrower top or fewer people reaching old age.