

ENVIRONMENTAL MANAGEMENT

Paper 8291/11
Principles of Environmental Management

Key messages

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

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

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

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

General comments

There was generally a good response to all questions across the paper. Most candidates found **Question 2** (conservation strategies) and **Question 3** (population) more demanding than the other questions in **Section A**.

Topics which proved more challenging were the equation for analysing data on change in volume of water removed from ground water or surface sources per person, evaluation of use of coral nursery lines as a conservation strategy, dependency ratio and aeroponics.

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

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 covered the topics of the water cycle including transpiration, water insecurity (causes and management of global water security) and comparison of data (volume of water removed from ground water or surface sources per person for two countries in 1970 and 2015).

(a) (i) The water cycle was generally well understood and most candidates were able to identify **E** as precipitation and **D** as infiltration. **A** (condensation) and **B** (evaporation) were the most common incorrect answers given for precipitation. **C** (groundwater flow) was the most common incorrect answer given for infiltration.

(ii) Few candidates fully understood the role of transpiration in the water cycle, although stronger candidates were able to describe the diffusion of water vapour through the stomata of leaves and the origin of the water vapour as water that had travelled through trees or plants. Most candidates were able to access credit by stating that transpiration returned water to the atmosphere or air. Imprecise terminology such as 'into the sky' or 'clouds' was not credited. Weaker responses focused on evaporation of water from the surface of leaves rather than release of water through the stomata.

(b) This question was generally well answered with most candidates gaining credit. The most common correct responses referred to climate change, drought, inadequate sanitation, lack of water treatment facilities and water-borne diseases. High-level answers also suggested problems such as saltwater intrusion into aquifers or dams affecting the water security of countries downstream. Overuse of water was ignored as this is mismanagement of water which was given in the question. Unqualified statements such as sanitation, irrigation or poverty were not credited as it was unclear how these would cause water insecurity, e.g. poor sanitation would cause water insecurity whereas good sanitation would reduce water insecurity.

(c) Candidates found this question more challenging with very few accessing all of the credit available. Most candidates were able gain some credit for the benefit of the IHP promoting education and raising awareness of water security issues. The most successful responses referred to the benefits of coordination such as cooperation between countries or recognised the limitations that not all countries would agree to or could afford to participate. Some also recognised that the strategies would not be applicable to all countries.

(d) (i) The formula for calculating percentage change was not well known with a minority of candidates able to correctly complete the calculation and provide the answer. Some candidates gave their answer as a negative value, i.e. as a percentage decrease rather than a percentage increase, while others needed to take note of the instruction to give their answer to one decimal place.

(ii) Candidates found this question difficult. Many did not appreciate that the data provided was the volume of water removed per person or that this volume had decreased. Many candidates did not realise the question was about water conservation and answered as if the question was about a decrease in the total volume of fresh water removed or available. Incorrect responses ranged from suggesting the population of Denmark had either increased or decreased, the country had suffered a drought or a flood, that the freshwater sources had become polluted or contaminated, or that Denmark is a LIC.

Question 2

This question covered the topic of conservation in the context of staghorn coral including the role of the IUCN Red List, how climate change affects the population of staghorn coral, and strategies to conserve staghorn coral including the use of nursery lines.

(a) Most candidates were familiar with the role of the IUCN Red List. The most common correct responses included the role of tracking, classifying and identifying species at risk of extinction; providing education and raising awareness of endangered species; and implementing protection plans. Some candidates thought that the IUCN had the authority to legislate and pass laws, which is not the case as their role in policy making is of an advisory nature. Weaker answers merely repeated the information given in the question.

(b) There were some very good responses to this question on the effects of climate change on staghorn corals which scored full credit. These candidates had a good command of the subject matter and understood the issues caused by rising ocean temperatures and ocean acidification. There was good use of technical terminology, including reference to coral bleaching being caused by corals expelling symbiotic algae. Some candidates were able to correctly name zooxanthellae algae. Less successful responses referred to changes in temperature or acidity but did not specify what they were, while others suggested that climate change causes both colder and hotter conditions. Some candidates were confused about pH, suggesting increasing pH made water acidic, while others discussed water pollution or ozone depletion which were not relevant to this question about climate change.

(c) (i) The use of coral nursery lines as a strategy for conserving staghorn corals was poorly understood. Many candidates repeated the information given in the question and responses were largely descriptive with little correct evaluation given. Very few candidates accessed all the credit available for this question; most candidates who gained credit gave only the idea of an overall increase in the coral population.

(ii) This question was generally well answered, and most candidates gained some credit for suggesting other strategies that could be used to conserve staghorn corals. Common correct responses included restrictions on human activity in the vicinity of the staghorn corals, reducing pollution in oceans and setting up marine parks or reserves. Few candidates understood that the key to conserving staghorn corals would be to reduce climate change, and only the most successful responses described specific strategies to do this. Education was often cited and was only creditworthy if given in the context of strategies to save energy and reduce climate change.

Question 3

This question covered the topic of birth and death rates in the context of population change, dependency ratio and strategies for managing population change.

(a) (i) Many candidates interpreted the graph in **Fig. 3.1** correctly and identified Line **A** as representing the death rate for the country. Some candidates were then able to go on to give a correct explanation of why the increase in population shown on the graph resulted from the birth rate (Line **B**) being higher than the death rate (Line **A**). Candidates who focused on lines **A** and **B** after the intersect also gained credit if their explanations were correct.

(ii) Many candidates recognised that, other than birth and death rates, migration would be the cause of population change, and most of these were able to give a creditworthy example of a push or pull factor for migration. A significant number of candidates merely defined migration, emigration or immigration, which gained no further credit. Weaker responses gave examples of factors such as people dying of disease or improved medical care without the realisation that these would affect birth and death rates, already given in the question.

(b) Dependency ratios were not well understood with the majority of candidates unable to access the credit available, largely as a result of stating impacts of falling dependency. Some candidates thought the dependency ratio was a measure of how much a country is dependent on international aid, rather than the ratio of the dependent population compared to the economically active population. Others did not make use of **Table 3.1** which showed that the dependency ratio decreased from 1990 to 2020, so in 2020 there were less dependents and a higher percentage of people in the 15 – 64 year old category. A significant number of candidates did not refer to the syllabus definition of young dependents as those in the age range of 0 – 14 years and elderly dependents as 65+. Consequently, responses such as raising the retirement age or an increase in child labour could not be credited as these do not affect the number of people aged 15 – 64.

(c) Most candidates attained some credit for this question about the benefits and limitations of improved availability of contraception as a strategy for managing population change, and a few achieved full credit. Stating the number of pregnancies would be reduced was not enough as candidates needed to appreciate that it would be the number of unwanted pregnancies that would be reduced. Responses that suggested contraception is not 100 per cent effective as a limitation were not creditworthy as even at 80 – 90 per cent effectiveness, this would still result in the reduction of a lot of unwanted pregnancies.

Question 4

This question covered the topic of food security (definition), causes of food insecurity, the use of aeroponics as a strategy for reducing food insecurity, use of pesticides to increase food security, and advantages of perennial crops compared to annual crops.

(a) (i) The definition of food insecurity was well known, and most candidates were able to give an acceptable definition to attain some credit. Common successful responses recognised that people do not have access to enough food, and many went on to gain further credit for describing lack of sufficient nutrition. Those who gave their definition in terms of food security, rather than insecurity, were unable to score full credit.

(ii) Most candidates were able to access credit for their knowledge of the causes of food insecurity and this question was generally answered well. The most common correct responses included population growth, climate change leading to lack of rain or drought and crop failure, land degradation, natural disasters, war and poverty. Some answers that lacked a description and consisted of a list, were restricted in the credit they could achieve.

(b) Many candidates were able to use the information provided in the question to apply their own knowledge to suggest several plausible benefits or limitations of the use of aeroponics to grow crops. Candidates were generally unfamiliar with the technique and very few gained all of the credit available. Weaker responses repeated the information provided in the question. Common misconceptions included that aeroponics would use more water, no fertilisers would be required, crops would lack nutrients, and some candidates thought that the crops would be more susceptible to pests and diseases, rather than less, as their roots are exposed. There were also contradictory ideas about the plants lacking nutrition and that there would be problems as the plants were grown horizontally and lower plants would not get sunlight. The most common correct responses for benefits were reduction in space needed, no requirement for soil, and less water required, and that for limitations was the cost of installation.

(c) Very few candidates were able to access all of the credit available for this question about pesticides. More successful responses correctly named a pest such as an insect or fungus and stated that crop yield would be improved. A minority of candidates also mentioned the idea of storage of crops. However, many candidates just repeated the information given in the question and stated that pesticides killed 'pests' or used non-technical terms such as 'bugs' or 'critters'. Some candidates referred to more food rather than higher crop yields which, again, repeated the information in the question. A common misconception was confusion of pesticides with fertilisers, with some candidates suggesting that pesticides would allow crops to grow bigger or faster or would provide nutrients to the soil.

(d) Candidates found this question challenging and very few candidates were able to use the information provided to correctly suggest two advantages of perennial crops compared to annual crops. Successful responses recognised that perennial crops would require less input from farmers in terms of planting and that seeds would not have to be purchased each year thus reducing costs. Weaker responses simply repeated the question, stating that perennial crops live for more than two years or produce a crop each year. The strongest responses suggested benefits in terms of reduced soil erosion or possible retention of biodiversity.

Section B

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

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

In general, the majority of candidates were awarded Level 2 for both AO2 and AO3. 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

Existing strategies for waste disposal such as landfill, disposal at sea, incineration and recycling were well known; not all candidates used technical terminology and some just referred to piles of waste or lots of waste, thus limiting the level awarded.

Some candidates had a good command of technical terminology to describe the impacts of current waste disposal strategies such as soil and groundwater pollution, bioaccumulation and biomagnification, problems of non-biodegradable waste including plastics, and the release of greenhouse gases.

A minority of candidates knew that incineration was the most likely method used to generate electricity from waste, and that it requires combustion in an adapted thermal power station. Consequently, few realised that using waste to generate electricity could have the same impacts as burning fossil fuels in terms of

greenhouse gas emissions, release of particulates and toxic chemicals, e.g. dioxins, causing air pollution. Few candidates recognised that there would still be the problem of ash disposal.

Many candidates stated that there would be no greenhouse gas emissions and suggested that waste was a renewable resource, thereby solving global warming; this often limited AO2 to Level 2 as they did not consider the negative aspects of using waste to generate electricity.

Higher-level responses made good use of specific case study examples, e.g. Singapore's waste management system, to support their answers. Others suggested that a disadvantage of using waste to generate electricity would result in people becoming complacent and more waste being produced which would detract from the use of more effective methods of waste management such as recycling and reusing.

Most candidates only described one side of the argument with the majority concluding that using waste to generate electricity is an effective strategy, thus limiting the response to Level 2 for AO3. A minority of responses gave good evaluations and judgements, for and against, to achieve Level 3 or 4 for AO3.

Question 6

Many candidates who opted for this question had good knowledge of the direct impacts of human activity on Antarctica such as tourism and scientific research, waste disposal, disturbance of protected species, and the possibility of future mining and oil extraction. Fewer candidates described the indirect impacts of climate change and ozone depletion.

It was clear that some candidates were confused between the Antarctic and the Arctic, with some mistakenly referring to polar bears or the Willow Project, which is a proposed oil drilling venture in Alaska that has been approved by the US Government. Others were unable to give specific examples of the impact of human activities.

In common with **Question 2(b)**, there was confusion between global warming and ozone depletion. A common misconception was that greenhouse gases destroy ozone in the atmosphere leading to global warming. In addition, some candidates thought that the problem of greenhouse gas emissions was due to human activity on the Antarctic continent, rather than global emissions.

Stronger responses showed good knowledge of the strategies for managing the direct impacts of human activity on Antarctica including the Antarctic Treaty, regulations on scientific research, tourism and fisheries, waste management, and prohibited mineral extraction. The most successful responses also included correct explanations of the causes of global warming and ozone depletion and evaluated the relative success of international agreements such as the Kyoto Protocol, Paris Agreement and the Montreal Protocol.

Most candidates achieved Level 2 for AO2. Few candidates were able to achieve more than Level 2 for AO3 as evaluations were often one-sided, stating that the strategies were either successful or not successful.

ENVIRONMENTAL MANAGEMENT

Paper 8291/12
Principles of Environmental Management

Key messages

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

General comments

There was generally a good response to all questions across the paper. Most candidates found **Question 3** (PBDEs and waste management) and **Question 4** (big data and dredge mining of zircon) more demanding than the other questions in **Section A**.

Topics which proved more challenging were the evaluation of disposal at sea as a waste management strategy for PBDEs, the definition of and limitations of 'big data', and the impacts (both positive and negative) of dredge mining zircon.

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

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 covered the topics of sustainable resources (definition), changes in world population including predicted change until 2100, strategies to limit increase in human population and population pyramids.

- (a) The definition of the term sustainable resource was generally well known, and most candidates attained credit. Common successful responses recognised that a resource that meets the needs of people now and will also meet the needs of future generations is considered sustainable.
- (b) (i) Most candidates interpreted the graph in **Fig. 1.1** correctly and were able to describe the change in world population both between 1800 and 2022, and how it is predicted to change up to 2100 to achieve full credit.

(ii) This question was well answered with most candidates gaining the majority of the credit available. The most common responses referred to access to contraception, and education both on use of contraception and providing opportunities to women to work. Many candidates were also able to refer to anti-natalist policies.

(c) (i) Candidates were generally able to compare the pyramids and most were able to describe the pyramid for Kenya having a wide base compared to the narrow base for Italy. Some responses compared the overall shape and referred to the 'barrel shape' for the Italy population pyramid compared to the triangular shape for that of Kenya. A very few candidates referred to even proportions of males and females in both pyramids, and used comparative data to access all of the credit available. A significant number of responses referred to data from **Fig. 1.2** and **Fig. 1.3** but it was descriptive rather than comparative and therefore did not gain credit. Some candidates gave details of the causes of the differences rather than compare the shape of the pyramids which was not required for this question.

(ii) Most candidates attained some credit for this question, and a few achieved full credit. Common suggestions for the differences in the population pyramids of Italy and Kenya were economic status, i.e. Italy is a HIC whereas Kenya is a LIC, and the differences in healthcare between the two countries. Many candidates discussed ideas surrounding contraception which were not relevant to this question. The most successful responses also referred to differences in migration between the two countries and discussed ideas such as sanitation and food or water security.

Question 2

This question covered the topics of causes of energy insecurity, the benefits of building hydroelectric dams other than reducing energy insecurity, renewable resources, conservation in the context of the Chinese paddlefish including the role of the IUCN Red List, and reasons for opposition to building of hydroelectric dams.

(a) (i) Most candidates were able to access credit for their knowledge of the causes of energy insecurity and this question was generally well answered. The most common correct responses included population growth, depletion of fossil fuels, war or conflict disrupting supplies, and reference to people in LICs not being able to afford energy costs. Strong answers also suggested the idea of inequality in global energy resources and the high cost of investment in renewable energy resources.

(ii) Many candidates recognised, other than reducing energy insecurity, at least two reasons why it was important for the Three Gorges dam to be built. The most common reasons given were that hydroelectric dams do not produce greenhouse gases or contribute to global warming and they create job opportunities. Weaker responses often referred to providing cheap energy without the realisation that this would reduce energy insecurity, already given in the question.

(iii) Almost all candidates correctly stated one other renewable energy resource, other than hydroelectric power. The most common response was solar energy.

(b) (i) Most candidates attained some credit for this question about strategies that can increase the population of critically endangered fish with a few achieving full credit. Simply stating captive breeding as a strategy was not enough and needed reference to 'release' as the question was about the population in the wild. Protected areas and education were the most common correct responses.

(ii) Most candidates were familiar with the role of the IUCN Red List. The most common correct responses included the role of tracking, classifying and identifying species at risk of extinction; providing education and raising awareness of endangered species; and implementing protection plans. Some candidates thought that the IUCN had the authority to legislate and pass laws, which is not the case as their role in policy making is of an advisory nature. Weaker answers were not credited as they repeated the information given in the question.

(c) This question was generally well answered, and most candidates achieved some of the credit available for suggesting reasons, other than its effect on endangered species, for people being opposed to the Three Gorges dam. Common correct responses included displacement of people and loss of homes, high cost of construction when that money could be used for things such as better healthcare, and loss of land for food production or farming.

Question 3

This question covered the topics of PBDEs as a pollutant, how PBDEs can be found in humans, disposal at sea as a waste management strategy for PBDEs and strategies for limiting the impacts of PBDEs.

(a) Some candidates were able to access full credit for this question about PBDEs and how they can be found in humans as they had clearly understood the concept of bioaccumulation and biomagnification. Weaker responses briefly discussed this and generally achieved credit for suggesting that the PBDEs were 'eaten' by fish and then humans caught and consumed the fish. Some candidates also included the idea of inhalation of the PBDEs in their response.

(b) (i) The use of disposal at sea as a waste management strategy for PBDEs was poorly understood and consequently, candidates were not able to evaluate this strategy. Many answers discussed the impacts on marine life of pollution by PBDEs which was not relevant to the question. Very few candidates appreciated that dispersion in the ocean would reduce the concentration of PBDEs to much lower levels which reduces the risks. Similarly, very few candidates understood that the PBDEs would need to be removed from the fabrics and that disposal at sea requires plastic or metal containers.

(ii) This question was generally answered well, and most candidates gained some credit for suggesting at least one strategy for limiting the impacts of PBDEs. Common correct responses included banning the use of PBDEs, development of alternative flame retardants and recycling of materials containing PBDEs. Few candidates considered treating waste water containing PBDEs or monitoring levels in different foods.

(c) Almost all candidates gained the credit available for giving the reason for their agreement or disagreement with the conclusion from the data in **Table 3.1** that 'salmon have the lowest mean concentration of PBDEs'. Most candidates stated that they did not agree with the conclusion, citing their reason as the sample size of salmon was too small. A few candidates agreed with the conclusion because, as seen in the table, salmon does have the lowest mean concentration.

Question 4

This question covered the topics of 'big data' including a definition and its limitations, the impacts (both positive and negative) of dredge mining zircon, and the sustainable management of zircon extraction from freshwater lakes.

(a) (i) Candidates found this question challenging. Most understood that 'big data' was a large amount of data and some stated that it used technology. A small number of candidates were able to describe 'big data' as being collected rapidly or understood that computer analysis was required. Consequently, the majority of candidates were unable to access full credit.

(ii) Candidates also found this question more challenging. The most common limitation of using 'big data' to find mineral deposits suggested was unreliability of the data. Candidates did not show understanding that potential mineral sites still have to be surveyed manually or that, as minerals are underground, surveying is complex.

(b) (i) This question was generally well answered with most candidates gaining some credit. The most common suggested positive impacts were providing jobs and raising the GDP of the country. The most common suggested negative impacts were damage to the lake bed habitat and disruption of the food chain. High-level answers also suggested that water can be polluted, so is no longer drinkable and cannot be used for irrigation, which in turn leads to water and food insecurity.

(ii) Candidates found this question difficult. Many responses did not show understanding of the term 'sustainably' and so did not suggest the idea of leaving reserves for future generations. A common misconception was that by leaving zircon deposits for a few years after they had been extracted, they would be able to replenish in some way. Successful responses recognised that processing materials more efficiently and controlled extraction by local communities would be a more sustainable approach. The most common suggestion was the idea of quotas for extraction.

Section B

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

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

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

The majority of candidates were able to outline the processes of deforestation, reforestation and afforestation with some excellent case study detail of local or national bans on deforestation, reforestation or tree planting projects and projects to establish new forests. Some stronger candidates had a good command of technical terminology to describe these processes with reference to photosynthesis, carbon capture by trees and the release of stored carbon when large areas are deforested. In addition, some candidates recognised that more carbon emissions are released when trees give out stored carbon when they rot or burn on the forest floor.

Some candidates also made clear links to climate change and demonstrated a good understanding of how these strategies limit climate change.

Most candidates achieved Level 2 for AO2. Those who included detailed consideration of case studies achieved Level 3 for AO2.

Most candidates only described one side of the argument, with the majority concluding that reducing deforestation, reforestation and afforestation are effective strategies for reducing the impact of climate change, thus limiting the response to Level 2 for AO3. A minority of responses gave good evaluations and judgements, for and against, to achieve Level 3 or 4 for AO3.

Question 6

Many candidates who opted for this question had good knowledge of the different strategies that can be used to manage water security and this was demonstrated by a wide use of case study detail such as wetland or mangrove restoration projects, reduction in water pollution and introduction of agricultural techniques including planting water-efficient crop varieties and improved irrigation techniques. Some candidates also included a definition of water security in terms of sufficient quantities of clean water to maintain adequate standards of food, manufacturing of goods, adequate sanitation and sustainable health care. Most candidates achieved Level 2 for AO2, candidates who included case study detail in their responses generally achieved Level 3 for AO2.

Generally, candidates demonstrated better evaluation for this question than for **Question 5**, particularly in the discussion of both the successful and less successful strategies to manage water security. However, responses could be improved through evaluation of these strategies on individual, local, national and global levels.

Only some candidates were able to achieve more than Level 2 for AO3 as evaluations were often one-sided, stating that the strategies were either successful or not successful.

ENVIRONMENTAL MANAGEMENT

Paper 8291/13
Principles of Environmental Management

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Section A

Question 1

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- (b) (i) Most candidates interpreted the graph in **Fig. 1.1** correctly and were able to describe the change in world population both between 1800 and 2022, and how it is predicted to change up to 2100 to achieve full credit.

(ii) This question was well answered with most candidates gaining the majority of the credit available. The most common responses referred to access to contraception, and education both on use of contraception and providing opportunities to women to work. Many candidates were also able to refer to anti-natalist policies.

(c) (i) Candidates were generally able to compare the pyramids and most were able to describe the pyramid for Kenya having a wide base compared to the narrow base for Italy. Some responses compared the overall shape and referred to the 'barrel shape' for the Italy population pyramid compared to the triangular shape for that of Kenya. A very few candidates referred to even proportions of males and females in both pyramids, and used comparative data to access all of the credit available. A significant number of responses referred to data from **Fig. 1.2** and **Fig. 1.3** but it was descriptive rather than comparative and therefore did not gain credit. Some candidates gave details of the causes of the differences rather than compare the shape of the pyramids which was not required for this question.

(ii) Most candidates attained some credit for this question, and a few achieved full credit. Common suggestions for the differences in the population pyramids of Italy and Kenya were economic status, i.e. Italy is a HIC whereas Kenya is a LIC, and the differences in healthcare between the two countries. Many candidates discussed ideas surrounding contraception which were not relevant to this question. The most successful responses also referred to differences in migration between the two countries and discussed ideas such as sanitation and food or water security.

Question 2

This question covered the topics of causes of energy insecurity, the benefits of building hydroelectric dams other than reducing energy insecurity, renewable resources, conservation in the context of the Chinese paddlefish including the role of the IUCN Red List, and reasons for opposition to building of hydroelectric dams.

(a) (i) Most candidates were able to access credit for their knowledge of the causes of energy insecurity and this question was generally well answered. The most common correct responses included population growth, depletion of fossil fuels, war or conflict disrupting supplies, and reference to people in LICs not being able to afford energy costs. Strong answers also suggested the idea of inequality in global energy resources and the high cost of investment in renewable energy resources.

(ii) Many candidates recognised, other than reducing energy insecurity, at least two reasons why it was important for the Three Gorges dam to be built. The most common reasons given were that hydroelectric dams do not produce greenhouse gases or contribute to global warming and they create job opportunities. Weaker responses often referred to providing cheap energy without the realisation that this would reduce energy insecurity, already given in the question.

(iii) Almost all candidates correctly stated one other renewable energy resource, other than hydroelectric power. The most common response was solar energy.

(b) (i) Most candidates attained some credit for this question about strategies that can increase the population of critically endangered fish with a few achieving full credit. Simply stating captive breeding as a strategy was not enough and needed reference to 'release' as the question was about the population in the wild. Protected areas and education were the most common correct responses.

(ii) Most candidates were familiar with the role of the IUCN Red List. The most common correct responses included the role of tracking, classifying and identifying species at risk of extinction; providing education and raising awareness of endangered species; and implementing protection plans. Some candidates thought that the IUCN had the authority to legislate and pass laws, which is not the case as their role in policy making is of an advisory nature. Weaker answers were not credited as they repeated the information given in the question.

(c) This question was generally well answered, and most candidates achieved some of the credit available for suggesting reasons, other than its effect on endangered species, for people being opposed to the Three Gorges dam. Common correct responses included displacement of people and loss of homes, high cost of construction when that money could be used for things such as better healthcare, and loss of land for food production or farming.

Question 3

This question covered the topics of PBDEs as a pollutant, how PBDEs can be found in humans, disposal at sea as a waste management strategy for PBDEs and strategies for limiting the impacts of PBDEs.

(a) Some candidates were able to access full credit for this question about PBDEs and how they can be found in humans as they had clearly understood the concept of bioaccumulation and biomagnification. Weaker responses briefly discussed this and generally achieved credit for suggesting that the PBDEs were 'eaten' by fish and then humans caught and consumed the fish. Some candidates also included the idea of inhalation of the PBDEs in their response.

(b) (i) The use of disposal at sea as a waste management strategy for PBDEs was poorly understood and consequently, candidates were not able to evaluate this strategy. Many answers discussed the impacts on marine life of pollution by PBDEs which was not relevant to the question. Very few candidates appreciated that dispersion in the ocean would reduce the concentration of PBDEs to much lower levels which reduces the risks. Similarly, very few candidates understood that the PBDEs would need to be removed from the fabrics and that disposal at sea requires plastic or metal containers.

(ii) This question was generally answered well, and most candidates gained some credit for suggesting at least one strategy for limiting the impacts of PBDEs. Common correct responses included banning the use of PBDEs, development of alternative flame retardants and recycling of materials containing PBDEs. Few candidates considered treating waste water containing PBDEs or monitoring levels in different foods.

(c) Almost all candidates gained the credit available for giving the reason for their agreement or disagreement with the conclusion from the data in **Table 3.1** that 'salmon have the lowest mean concentration of PBDEs'. Most candidates stated that they did not agree with the conclusion, citing their reason as the sample size of salmon was too small. A few candidates agreed with the conclusion because, as seen in the table, salmon does have the lowest mean concentration.

Question 4

This question covered the topics of 'big data' including a definition and its limitations, the impacts (both positive and negative) of dredge mining zircon, and the sustainable management of zircon extraction from freshwater lakes.

(a) (i) Candidates found this question challenging. Most understood that 'big data' was a large amount of data and some stated that it used technology. A small number of candidates were able to describe 'big data' as being collected rapidly or understood that computer analysis was required. Consequently, the majority of candidates were unable to access full credit.

(ii) Candidates also found this question more challenging. The most common limitation of using 'big data' to find mineral deposits suggested was unreliability of the data. Candidates did not show understanding that potential mineral sites still have to be surveyed manually or that, as minerals are underground, surveying is complex.

(b) (i) This question was generally well answered with most candidates gaining some credit. The most common suggested positive impacts were providing jobs and raising the GDP of the country. The most common suggested negative impacts were damage to the lake bed habitat and disruption of the food chain. High-level answers also suggested that water can be polluted, so is no longer drinkable and cannot be used for irrigation, which in turn leads to water and food insecurity.

(ii) Candidates found this question difficult. Many responses did not show understanding of the term 'sustainably' and so did not suggest the idea of leaving reserves for future generations. A common misconception was that by leaving zircon deposits for a few years after they had been extracted, they would be able to replenish in some way. Successful responses recognised that processing materials more efficiently and controlled extraction by local communities would be a more sustainable approach. The most common suggestion was the idea of quotas for extraction.

Section B

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

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

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

The majority of candidates were able to outline the processes of deforestation, reforestation and afforestation with some excellent case study detail of local or national bans on deforestation, reforestation or tree planting projects and projects to establish new forests. Some stronger candidates had a good command of technical terminology to describe these processes with reference to photosynthesis, carbon capture by trees and the release of stored carbon when large areas are deforested. In addition, some candidates recognised that more carbon emissions are released when trees give out stored carbon when they rot or burn on the forest floor.

Some candidates also made clear links to climate change and demonstrated a good understanding of how these strategies limit climate change.

Most candidates achieved Level 2 for AO2. Those who included detailed consideration of case studies achieved Level 3 for AO2.

Most candidates only described one side of the argument, with the majority concluding that reducing deforestation, reforestation and afforestation are effective strategies for reducing the impact of climate change, thus limiting the response to Level 2 for AO3. A minority of responses gave good evaluations and judgements, for and against, to achieve Level 3 or 4 for AO3.

Question 6

Many candidates who opted for this question had good knowledge of the different strategies that can be used to manage water security and this was demonstrated by a wide use of case study detail such as wetland or mangrove restoration projects, reduction in water pollution and introduction of agricultural techniques including planting water-efficient crop varieties and improved irrigation techniques. Some candidates also included a definition of water security in terms of sufficient quantities of clean water to maintain adequate standards of food, manufacturing of goods, adequate sanitation and sustainable health care. Most candidates achieved Level 2 for AO2, candidates who included case study detail in their responses generally achieved Level 3 for AO2.

Generally, candidates demonstrated better evaluation for this question than for **Question 5**, particularly in the discussion of both the successful and less successful strategies to manage water security. However, responses could be improved through evaluation of these strategies on individual, local, national and global levels.

Only some candidates were able to achieve more than Level 2 for AO3 as evaluations were often one-sided, stating that the strategies were either successful or not successful.

ENVIRONMENTAL MANAGEMENT

Paper 8291/21
Management in Context

Key messages

When adding bars to a bar chart, a ruler and pencil should be used so that errors can be easily corrected. Bar widths should be equal.

It is important that candidates learn the definitions given to them in the syllabus, such as that of acid rain. The causes and how to reduce the impact of acid rain were also not well known.

Respiration was poorly understood.

There was a general misconception that greenhouse gases are responsible for ozone depletion.

General comments

Identifying benefits and limitations of environmental management strategies in unfamiliar contexts was an area of the syllabus that candidates needed to further develop skills in, as shown in **Question 4(b)**.

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

It is not necessary to repeat the question in an answer, such as in **Question 4(d)**, 'The processes in the water cycle that explain how the solar still can produce drinking water are...'. This practice uses valuable time during the examination and takes up answer space. In this example it was sufficient to answer in bullet points:

- the Sun heats the salt water
- the water evaporates
- this water condenses.

Bullet points are often the clearest way to respond and ensure that candidates give sufficient answers to match the mark allocation.

Comments on specific questions

Question 1

(a) Coal was the most common response. Gas was insufficient and needed to be qualified by stating 'natural' gas. Some candidates suggested oil, which had already been given in the question.

(b) (i) Many candidates realised that recycling was a way of reducing water wastage and some went on to suggest that this reduced the risk of water insecurity. Weaker responses described recycling which was not the focus of the question.

(ii) Many responses suggested that water pollution would be a concern and developed this answer by stating that toxic contents could reduce biodiversity. The phrases 'affects biodiversity' or 'impacts biodiversity' were frequently seen; candidates needed to explain how biodiversity is affected to gain credit. Some responses referred to contamination of soil; weaker answers stated 'pollution' or 'damages the ground' – these were too vague for credit.

(c) The abundance of rivers was noticed by many and stronger responses went on to suggest that this could lead to water pollution. The impact of road transport was commonly seen in terms of leading to increased carbon dioxide emissions. A number of responses identified that crossing international borders could be problematic.

(d) (i) This was well answered by many candidates who gave comparative answers for conventional oil sources and oil sands. Most correctly focused on the trends; oil sands starting lower than conventional sources, the production being the same in 2011 and both peaking in 2019. Good answers gave one comparative data quote, such as: 'oil sands started at 1 million and conventional oil sources at 1.5 million'. Weak responses gave a list of individual data values that were not comparative and described the individual graph plots rather than comparing the two.

(ii) A few candidates struggled with rounding to one decimal place and gave the answer 3.3 instead of the correct answer of 3.4. Some stated the inverse for the percentage calculation. Others were unable to determine the percentage.

(iii) The majority of candidates knew that fossil fuels are non-renewable. A few related this to an increase in price as supply decreases.

(e) (i) A significant number of candidates incorrectly suggested that greenhouse gases caused ozone depletion and focused their answer on UV light, the ozone 'hole' and skin cancer.

(ii) Most responses suggested that when many countries and decision makers work together, this is more likely to be a successful strategy for controlling greenhouse gases. A large number of candidates went on to repeat the wording of the question and needed to develop their ideas further to gain full credit.

(iii) Many candidates stated that emission rate had decreased due to the reduced use of fossil fuels by improved technology such as renewable power. Some suggested there could have been a reduction in extraction from oil sands. Weaker answers suggested that conventional sources had overtaken oil sands, despite the contrary being shown in **Fig. 1.3**.

(f) This was well answered with an increase in jobs, lower oil prices and an economic benefit to Canada or the USA being the most commonly seen answers.

Question 2

(a) (i) A very small minority of candidates were able to define acid deposition.

(ii) The formation of acid rain from sulfur compounds was not well described and this question was often left blank. Many confused responses were seen with a significant number of candidates suggesting that acid rain can only occur from 'evaporation of acid lakes'.

(iii) Most answers referred to a reduction in fossil fuel usage. It was rare to see any other correct response.

(b) (i) Most candidates were able to determine the range of 1.6; some quoted the maximum and minimum values and needed to calculate the range.

(ii) This was well answered and most recognised that the data was anomalous.

(iii) Many good conclusions were seen. Weaker responses repeated the data without drawing overall conclusions from the data.

(iv) This was well answered and most appreciated that the purpose was to remove contaminants from the bottle. Weaker answers suggested that it was to take an average but as the question stated the water was emptied each time, this was incorrect.

(v) Time and water temperature were the most common correct answers. Weaker responses stated pH and sulfate concentration that were already recorded by the investigation.

(vi) The majority recognised that the sampling sites were close together; few could suggest a second improvement such as taking more than three samples or at different depths.

(c) (i) Almost all candidates correctly identified the producer.

(ii) A large number correctly stated the second trophic level. Some chose to name this as the primary consumer. A few negated their answers by stating second trophic level and then an incorrect name, such as producer or secondary consumer.

(iii) Most stated that energy was lost as heat and that only 10% of energy is passed between levels. Occasionally, this was incorrectly stated as 90%. Some good answers gave the biological process by which the energy was lost, with respiration, digestion and movement being the most commonly seen answers.

Question 3

(a) (i) There were a large number of blank responses here. Where completed, the 100 000 plot was usually correct whereas the 28 000 plot was frequently incorrect. Bars were not always drawn with a ruler and, when presented in pen, this made correction difficult. Bars were often not the same width and wavy lines were very common.

(ii) This was occasionally left blank and often incorrect.

(iii) Most responses stated three correct reasons for forest loss. There were many candidates who unnecessarily repeated the question in their answers, stating 'The reasons for the loss of Brazil's Atlantic forest are...' This should be avoided.

(b) This question was poorly understood. There was confusion with the term 'swap' with some candidates interpreting this as 'swamp'. Responses often incorrectly referred to Brazil being given \$21 million rather than the debt being cancelled. Some believed that the USA bought the forest and had become its owners.

(c) (i) Many good responses were seen and the lack of representation and potential bias was identified by many.

(ii) The benefit of yes/no questionnaires was well known.

Question 4

(a) (i) Most candidates were able to gain some credit here. A few needed to draw a conclusion or provide an explanation for the numbers they presented. The strongest responses were logical, showed full working and gave a conclusion.

(ii) The idea that the quantity of water needed would be too heavy was well understood. Fewer responses went on to give a second correct suggestion.

(iii) There were many confused answers to explain respiration. Photosynthesis and breathing were frequently described. Reactants and products were confused. Production of 'sugar' rather than the specific term 'glucose' was also seen.

(b) Candidates found this question particularly challenging. Some repeated information given in the question and needed to add any further detail, for example: 'needs high temperature' required an explanation that not everyone has access to the electricity to achieve this. Very few benefits were identified. Stating that it 'provided access to safe drinking water' also repeated the question. A few explained that the process eliminates wastage of water.

(c) Some responses were confused and suggested that precipitation occurred within the solar still; others needed to identify water cycle processes for further credit.

(d) This was well answered with many candidates realising that lack of water reduces crop yield, causes crops and livestock to die, and therefore leads to food shortages.

ENVIRONMENTAL MANAGEMENT

Paper 8291/22
Management in Context

Key messages

The bar chart provided a range of strong responses, where bar widths were the same and were correctly plotted; weaker responses showed unequal bar widths, poor scaling such that only half the graph paper was used, and lack of use of a ruler.

Many candidates did not fully understand climate change, especially when discussing how the albedo effect of plants may mitigate climate change.

Sampling methods for ponds and the use and application of a quadrat proved to be an area requiring improvement for candidates.

There was a general misconception that greenhouse gases are responsible for ozone depletion.

General comments

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

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

Comments on specific questions

Question 1

(a) Many candidates provided the word equation for photosynthesis, carbon dioxide plus water produces glucose and oxygen. Symbol equations were not credited, and weaker candidates often omitted water and wrote sunlight in place of this, which was incorrect.

(b) Many candidates realised that the developed chemical provided more food for the population and often linked this with surplus food or improved distribution of food. In addition, many cited increased affordability of food given the increased yield. Weaker responses described the chemical providing more nutrients rather than more food being produced.

(c) This question required a calculation of the percentage increase in maize yield. Strong responses were able to clearly provide a formula and demonstrate substitution to achieve the correct answer. Weaker candidates were often credited for subtracting the 1961 yield from the 2018 yield, i.e. $5.92 - 1.94 = 3.98$. Calculating the percentage increase from then on proved challenging for many.

(d) (i) This was well answered by many candidates who gave cost of refrigeration being a barrier to low-income economies. Limited access to energy or energy insecurity was also given as a correct response, as well as lack of infrastructure. Weaker responses gave cost of refrigerators as well as cost of energy, where credit for cost/affordability could only be awarded once.

(ii) Strategies for reducing the use of fossil fuels in the transport of food were generally well understood. The idea of using renewable energy such as biofuels or stating use of electric vehicles was often cited and stronger candidates related the use of solar panels on vehicles as an example. Weaker candidates included geothermal or hydroelectric power for transport, which was incorrect unless they made the link to the use of renewable fuels for providing energy for electric vehicles.

(e) (i) The idea of a higher yield was often given as a correct benefit to the use of 'Roundup Ready' soya. Many candidates wrongly suggested that the GM crop was resistant to insects instead of describing it as being easier to manage due to its herbicide resistance.

Common limitations included the risk to human health in addition to increased cost of seed and potential issues of creating superweeds.

(ii) Some candidates gained credit by explaining the reflection of solar radiation and hence a cooling effect brought about by the leaves of the plants. Many other responses suggested that the albedo effect of leaves reduced carbon dioxide levels or wrongly linked the phenomenon to photosynthesis being able to counteract climate change.

Question 2

(a) (i) The majority of candidates were able to calculate the range for the number of adult frogs from frog D.

(ii) This question required candidates to draw a bar chart. The most common errors were that bars were not drawn with a ruler and were presented in pen so when a candidate made an error, correction was difficult. Bars were often not the same width and in many cases the bars were incorrectly touching each other. Use of an adequate scale was an issue with a significant number of candidates.

(iii) Most answers correctly stated an anomaly or an outlier.

(iv) The majority of candidates recognised that the more artificial light per day the fewer the number of adult frogs. Several candidates referred to more light producing fewer numbers of adult frogs and omitted to state artificial light, and so confused with natural light which was one of the treatments.

(v) Many candidates correctly stated that each female may lay different numbers of eggs or that the original number of eggs was not known. Weaker responses referred to adult female frogs as having disease which impacted on the eggs. Precision and reliability were not credited.

(b) This was poorly answered with many candidates not demonstrating knowledge of the use of an open quadrat for sampling. Many described dividing the pond up into grids and using drones or images to assess the number of frogs. Stronger responses provided the idea of random or systematic sampling along the 20 m tape, counting frogs in the quadrat, repeating and taking an average.

(c) (i) Most candidates referred to the sampling points being too close together and at the edge of the pond.

(ii) A significant majority correctly calculated and gave their answer to the nearest whole number. The most common error was not rounding to a whole number.

(d) A significant number of candidates did not show understanding of the term invasive species and suggested that frogs could travel/migrate large distances to new habitats.

(e) Most candidates provided an abiotic component; the incorrect answer 'soil' was often included and was not credited as it is a medium that is composed of abiotic and biotic factors.

(f) (i) Many candidates recognised snake as the tertiary consumer.

(ii) A common misconception from candidates was that the producers would be most affected by biomagnification.

(iii) Most candidates correctly stated a decrease in grasshopper population due to an increase in consumption by the increased population of frogs.

Question 3

(a) Many candidates gave the west coast of Mexico and Chile as well as the west coast of South America. Others described the population of Indian or Atlantic turtles instead of the Eastern Pacific species.

(b) The question required a comparison of two populations of leatherback turtles in terms of past, present and future; many candidates only compared the populations generally and needed to use data from the bar chart for further credit.

(c) (i) Stronger responses linked increased greenhouse gases and global warming to higher sand temperatures as a result of climate change. Other answers were confused and linked lack of water or drought as the cause of high sand temperatures.

(ii) Many candidates stated a decrease in population due to a higher ratio of females to males leading to the development of fewer males available for mating. Some candidates gave a higher number of females as the impact and also damage to eggs by high temperatures during incubation.

(iii) Stronger responses gave extreme weather and/or a rise in sea levels and then linked this to destruction of habitat or beaches where turtles laid their eggs. Weaker candidates suggested high temperature that had already been given in the question.

(iv) Common responses included increase in mesh/net size as well as legislation and prevention of fishing in waters occupied by turtles.

(d) The question required candidates to discuss the benefits and limitations of captive breeding and release of turtles. Responses regarding lack of predation with benefits were common, and a few candidates provided other reasons such as control of diseases and opportunity for research. Limitations were more strongly addressed and included issues surrounding a change of turtle behaviour adversely affecting the turtles and their return to a natural environment. Cost was also recognised as a common issue in captive breeding programs.

Question 4

(a) (i) A few stronger candidates discussed CFCs not being broken down in the troposphere and rising to the stratosphere and CFCs being broken down in the presence of UV light; quite a few candidates wrongly suggested carbon dioxide as being a factor in ozone depletion.

(ii) A significant proportion of candidates were able to state that average ozone concentrations were less than 100 Dobson units.

(b) (i) Some candidates recognised a higher effect on global warming compared to carbon dioxide for alternative chemicals and some discussed oxides of nitrogen producing acid rain and subsequent damage to buildings. Overall, this question was poorly answered with some candidates discussing smog and many just lifting data from the question and repeating it.

(ii) This question was generally well answered, most candidates referring to issues of cost and the lack of alternatives. A few mentioned lack of research to fully justify a ban.

Question 5

(a) (i) A well-answered question overall, demonstrating good understanding; most candidates recognised increased particulate matter was due to increased population, industry or vehicle use.

(ii) Most candidates recognised different economic levels as being one of the main reasons for fewer monitoring stations in Africa compared to Europe.

(b) The benefits to the method of air pollution monitoring described were generally weak in responses, with the main one being that it provides an instant data source and promotion of greater pollution awareness. Limitations were generally stronger, including loss of equipment, ethical concerns of electronic devices on birds and no control of sampling flight/data area.

(c) (i) A significant proportion of candidates were able to define photochemical smog and provide examples.

(ii) The most common correct answers included decreased crop/plant yield and deterioration of rubber. Some candidates needed to read the question more carefully as they gave health related issues surrounding photochemical smog that were not required.

(iii) Most candidates were able to gain some credit here. Responses included use of electric vehicles, renewable energy or legislation, for example, increasing vehicle tax (polluter pays principle).

ENVIRONMENTAL MANAGEMENT

Paper 8291/23
Management in Context

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