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Markscheme

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Environmental systems and societies

Standard level

Paper 2

19 pages

Subject details: Environmental systems and societies SLP2 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions in Section A **[40]** and **ONE** question in Section B **[20]**.
- The maximum total = **[60]**.

1. Environmental systems and societies uses marking points and markbands to determine the achievement of candidates

When using marking points (<u>All of this paper except</u> Section B, part (c) questions):

i. A markscheme often has more marking points than the total allows. This is intentional
ii. Each marking point has a separate line and the end is shown by means of a semi-colon (;)
iii. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **<u>precise point</u>** where it becomes clear that the candidate deserves the mark. **<u>One tick to be shown for each mark awarded</u>**
iv. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

When using markbands (<u>Only</u> for Section B, part (c) questions):

i. Read the response and determine which band the response fits into
ii. Then re-read the response to determine where the response fits within the band
iii. Annotate the response to indicate your reasoning behind the awarding of the mark
Do not use ticks at this point
iv. Decide on a mark for the response
v. At the end of the response place the required number of ticks to enable RM Assessor to input the correct number of marks for the response.

2. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

3. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

4. Words that are <u>underlined</u> are essential for the mark.

5. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect).

6. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

7. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

8. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

Section A

1. (a) Identify the plant-based food that produces the highest greenhouse gas emissions. **[1]**

Rice;

(b) State **two** greenhouse gases emitted from food production systems shown in **Figure 1**. **[1]**

Carbon dioxide / CO_2 / Nitrous oxide / N_2O / Methane / CH_4 / Water vapour / H_2O;

Two answers required for the 1 mark.

Note to examiner: *Do not accept nitrogen oxides/NOx or carbon monoxide/CO.*

(c) (i) Using the information in **Figure 1**, state whether greenhouse gas emissions are higher from plant-based foods or animal-based foods. **[1]**

Greenhouse emissions from plant foods are less than the animal foods / GHG emissions from animal foods are higher than the plant foods;

Note to examiner: *Accept only "animal-based food".*

(ii) Describe **two** reasons for the answer stated in (c)(i). **[2]**

a. Animals such as cows/sheep/pigs release methane (through enteric fermentation/rumination/digestion);
b. Plant-based foods act as a carbon sink which reduces the amount of GHG emissions;
c. Producing animal-based foods often requires more land (and additional fertiliser) (to grow animal feed/for grazing) causing deforestation/loss of carbon sinks releasing stored/increasing amount of CO_2 /N_2O into the atmosphere;
d. The production, processing, and transportation of animal-based foods can be more energy-intensive/higher fossil use, thus release more GHGs;
e. Animals produce manure and the decomposition releases GHGs/methane/carbon dioxide;

Note to examiner: *Do not accept that there is a higher demand for beef/animal products. Do not accept that respiration from animals releases* CO_2.

(d) Evaluate **one** strategy to mitigate the greenhouse gas emissions associated with beef production. **[3]**

Strategy 1: Alter the cattle feed

Advantages (2 max):
a. Changes in feed can lead to reductions in (methane) emissions per unit of beef produced;
b. May have other positive heath impacts for cattle to improve digestion and increase growth/other minerals;

Disadvantages (2 max):
c. Require investment in research /infrastructure to ensure widespread adoption among beef producers;
d. New altered food may negatively affect animal health and reduce productivity~~;~~
e. High implementation cost to change feed;
f. Does not affect other sources of GHG emission such as deforestation to produce land/manure decomposition;

Strategy 2: Taxes/quotas/legislation/awareness campaign to change to plant-based diet to reduce demand for beef production

Advantages (2 max) :
g. Any reduction in demand for beef will reduce GHG emissions from cattle/beef production;
h. Revenue from taxes could be used to fund research into reducing GHG emissions;

Disadvantages (2 max):
i. (Cultural) resistance from public towards shift in diet away from beef products;
j. Loss of income for beef farmers/producers could discourage a drop in production;
k. Government incentives may not be significant enough to encourage farmers to reduce beef production;

Strategy 3: Reducing the reliance on fossil fuels during different <u>named</u> stages in beef production for feed production/ housing/transport/machinery/refrigeration

Advantages (2 max):
l. Reducing fossil fuel use will reduce carbon emissions;
o. Could lower long-term energy bills/increase energy security for farmer once installed;

Disadvantages (2 max):
q. It will be difficult to completely switch from non-renewable to renewable due to initial cost associated with set up;
r. Change of energy source to renewable may be controlled by government policies and not open to the farmer/producer;
s. The climate/ local geography/ prevailing technology may not favour the use of a certain renewable sources of energy;
t. It does not address methane emissions from digestion/fermentation which make up a large proportion of beef's overall climate impact;

Note to examiner: *No marking point for strategy alone. 2 max for either advantages or disadvantages. 1 mark available for balanced concluding statement with evidence.*

Strategy must be linked to mitigating emissions during beef production (such as methane capture for biogas/diversifying to polyculture/irrigation systems to reduce evaporation) but evaluation can be more open.
Do not accept "more expensive" as a disadvantage without viable reason.

2. (a) Calculate the percentage projected increase in waste generation in south Asia between 2016 and 2050, shown in **Figure 2**. **[1]**

$\frac{661 - 334}{334} \times 100 = 97.99 / 98\ (\%)$;

***Note to examiner**: unit is not required for the mark. Answer must be rounded correctly. Do not accept 97.*

(b) Outline **two** reasons for the trend in sub-Saharan Africa over the given period, shown in **Figure 2**. **[2]**

a. As countries develop economically, citizens tend to consume more goods and services, leading to more waste being generated (from packaging materials to discarded products/food/increasing tourism);
b. An increasing population leads to more waste production (as more people generate waste in their daily lives);
c. The growth of industries can lead to more industrial waste (this includes everything from by-products of manufacturing processes to the packaging of products);
d. Technological advancements result in more gadgets/appliances, leading to increased electronic waste.
e. Increase in imported materials/charitable donations (clothes) that increase the amount of waste for the region;
f. Increased urbanisation is generating more waste from construction/infrastructure;
g. Lack of education/awareness/legislation encouraging reduction of waste;

***Note to examiner**: Do not accept, accepting waste from other countries or any practices to do with waste management e.g. recycling.*

(c) (i) State **two** non-biodegradable materials present in solid domestic waste. **[1]**

Plastic / PET bottles / polystyrene / glass / metal / aluminium / steel / electronic waste / electronics / batteries / synthetic textiles / nylon / polyester/ construction debris;

***Note to examiner:** Accept named material or broader category. Do not accept food/garden waste/paper.*
Two correct materials are required for one mark.

(ii) Describe **two** negative impacts of non-biodegradable waste on ecosystems. **[2]**

a. Plastic ingestion reduces appetite / cause death due to starvation of species;
b. Plastic can get tangled around limbs/wings/necks causing death of species;
c. (microplastic/chemical) ingestion can cause bioaccumulation/ biomagnification/behavioural changes/reduced reproduction rates/death in organisms reducing species populations;
d. Heavy metals/chemicals released from waste contaminate water bodies/groundwater /soil (and become toxic/harmful to organisms);
e. Broken glass may cause physical injuries to organisms;
f. Covering of soil/habitat by waste can restrict plant growth/reduce photosynthesis/reduce primary productivity;
g. ... any decrease in one species population due to stated impact could limit food source for other species in higher trophic levels/decreases biodiversity;

Note to examiner: *accept other valid responses that link directly to ecosystems. Do not accept GHGs as an example. Do not accept biodiversity decrease on its own. Do not accept only "waste is toxic to species" without reason.*

(d) (i) Outline **one** preventative strategy **and one** restorative strategy to reduce the global trend in the production of solid domestic waste, as shown in **Figure 2**. **[2]**

Preventative strategy [1 max]*:*

a. Use awareness/education campaigns to reduce the consumption of resources that generate waste;
b. Implementing laws to set limits on waste generation by companies through taxes / incentives for waste reduction at the source/ban single use plastic;
c. Economic incentives for consumers to produce less waste such as pay-to-throw schemes/money back on items reused;
d. Encouraging the design and manufacture of products that are durable/ repairable/reusable/biodegradable packaging;

Restorative strategy [1 max.]*:*

e. Removing/collecting/extracting wastes from ecosystems / example-removing plastic garbage from marine ecosystem;
f. Recycling program or management/reusing/composting/material recovery facilities to reduce SDW from landfill/gyres/accumulated waste;
g. Restoring/sealing landfill sites to reduce leachate;
h. Incineration of waste to reduce volume in landfill (and release energy from waste);

Note to examiner: *Allow any other reasonable points. Allow points which are reducing the impact of SDW not just production. Do not just accept 'recycling' without a link to a strategy or effect.*

(ii) Justify why preventative strategies are more effective than restorative strategies for ecosystem sustainability. **[2]**

a. Preventative strategies reduce the amount/type of wastes released into the environment/ ecosystems thereby they minimize/reduce the impacts of those wastes on species / ecosystems;
b. Preventative strategies protect biodiversity/maintain biocapacity which is essential for resilient and sustainable ecosystems whereas restoration may not recover lost species/be able to restore habitats;
c. Preventative strategies avoid reaching tipping points/stops damage before it occurs (whereas restoration takes place after the damage) which supports long term sustainability;
d. Preventative approaches reduce long-term resource use/use fewer energy resources making them more sustainable than repeated restorative efforts;

Note to examiner: *Accept reverse arguments.*
Only award one MP if both sides of the argument are presented together.
Do not accept reference to preventative strategies being more cost-effective.

3. (a) (i) Identify the trophic level of the red fox in **Figure 3**. **[1]**

Secondary consumer / trophic level 3;

(ii) With reference to **Figure 3**, explain the impacts of increased red fox numbers on other organisms. **[2]**

a. Decrease in the numbers/population size of snowshoe hare/ woodland jumping mouse due to increased predation;
b. Decreasing numbers of snowshoe hare/woodland jumping mouse will lead to increase in the numbers/population size/biomass of maple;
c. Increase in moose/beaver/fairy moth population due to increase in maple;
d. Decrease in food choices/increased competition for Northern saw-whet owl/Algonquin wolf as fewer prey species/herbivores;
e. Decrease in population of Grey Jay due to decrease in the food choices/prey species (snowshoe hare/woodland jumping mouse) for Northern saw-whet owl;
f. Increase in Algonquin wolf population due to increased availability of prey species for Algonquin wolf;

Note to examiner: *Accept any other valid impacts taken from food web.*
Do not accept decrease/increase only without a reason to explain the change.

(b) List the data required to convert the food web into a pyramid of energy. **[2]**

a. Identify the trophic levels of the species;
b. Energy content in biomass/amount of energy flowing in between each trophic level;
c. Apply the 90/10 rule to energy flow/second law of thermodynamics;
d. Size of study area included;
e. Time period during which the study is conducted/study should be for 1 year;

Note to examiner: *need to state any two out of the three options for 2 marks.*
Must state more than "energy" for MP b.

(c) (i) State the term for total gain in biomass by an organism. **[1]**

Gross (primary/secondary) productivity / GP / GPP / GSP;

Note to examiner: *Do not accept net productivity*

(ii) Using named examples from **Figure 3**, explain the energy transfer between producer and primary consumer. **[2]**

Example: Maple and moose/ black bear/ grey jay/ beaver/ snowshoe hare/ woodland jumping mouse/ fairy moth.

a. Producers make light energy available as chemical energy (through photosynthesis) for primary consumers;
b. Not all the amount of energy gained by producers is transferred to the primary consumers as some amount (90 %) energy is lost /only 10 % is transferred to the primary consumers/due to second law of thermodynamics;
c. Energy is lost via respiration/heat loss/movement/excretion/reproduction;
d. Not all parts of producers are eaten by primary consumers/ hence energy contained in those not eaten parts is wasted/ not transferred;

Note to examiner: *Max of 1 if no examples are used.*
No mark for examples used.
Do not accept "energy is lost" only.

(d) State **three** structural features that can be used to construct dichotomous keys for the animals in **Figure 3**. **[2]**

Presence/absence or colour of fur / Presence/absence of horns / Presence/absence of mammary glands / Size and shape of tail / Presence/absence of wings/feathers / Beak size/colour / Presence/absence of hoof / Type and size of teeth / Position of eyes on head;

Accept any sensible answer relating to visible features seen on organisms in Figure 3.

Note to examiner: *No mark for stating only one correct response.*
Do not accept only "size" or behavioural characteristics.
Must be a discrete characterisation shown in Figure 3.
0 marks for only one correct answer.
1 mark for stating two correct responses.
2 marks for stating three correct responses.

4. (a) With reference to **Figure 4**, identify **one** biotic **and one** abiotic factor that were monitored. **[1]**

Biotic: Invertebrate diversity / (Understorey) plant cover

Abiotic: soil water content;

***Note to examiner**: Must state one biotic factor and one abiotic factor for one mark.*
Only accept the first answer for each.
Only accept abiotic and biotic factors shown on Figure 4.

(b) (i) Describe a method to estimate the soil invertebrate diversity in the two forest systems shown in **Figure 4**. **[4]**

a. Soil invertebrates can be collected using attractant traps or pitfall traps/soil samples collected and separated;
b. Sampling set in randomly chosen sites/transect/quadrat/grid sampling in each of these forests;
c. Multiple samples taken from each site;
d. Record number of individuals of each species identified/or labelled as different;
e. Calculate the diversity (D) using a relevant formula/Simpson's Diversity Index (in each sampling site);
f. Repeating the samples so average may be calculated for each site;

(ii) Outline **one** factor that could decrease the accuracy of the method described in (b)(i). **[1]**

a. Sampling sites not being selected at random may increase bias;
b. Location of sampling sites/size of sampling sites / number of sampling sites may not be appropriate for collection of relevant data;
c. Incorrect identification of species (that look similar or have juvenile stages);
d. Carrying out the method in the two forests on two different days / two different times such as day and night / seasonal changes may affect the accuracy;
e. Fast moving / smaller / deep burrowing species are more difficult to count / easy to miss;

***Note to examiner:** The factor described must be relevant to the method in 4(b)(i) to gain a mark.*

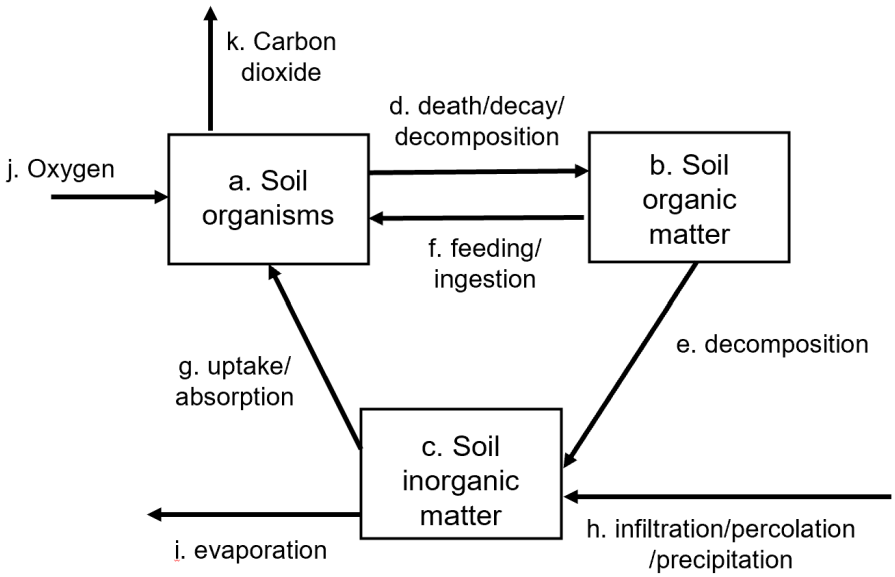
(iii) Outline how data on soil invertebrate diversity shown in **Figure 4** could be used by ecologists. **[1]**

a. Helps to assess the health/quality of ecosystems impacted by introduction of pine species/monoculture/removal of native forest on soil invertebrate diversity;
b. Assess the ecological impact of pine plantations vs native forests in terms of soil quality/erosion potential/health;
c. Soil invertebrate diversity estimates could be useful for conservation efforts/future planning/restoration efforts/future research;

(c) Using the data in **Figure 4**, suggest why the soil invertebrate diversity is higher in native forest sites than in pine plantations. **[2]**

a. Increased (understory) plant cover in the native forest sites could support a high soil invertebrate diversity through providing more habitats / niches/ nesting / breeding grounds / food/shade etc.
b. Native forest site has increased plant cover so lower risk of soil erosion which would reduce diversity;
c. Increased soil water content in the native forest sites could support a high soil invertebrate diversity as water is crucial for biological activity / nutrient cycling / supporting plant growth/productivity/suitable for a wider range of species;
d. Native forest site is older/stable climax community has higher resilience/more complex food webs so has higher diversity;

(d) Construct a system diagram for the soil system in **Figure 4**, including two storages and two flows. **[3]**



Note to examiner: *1 mark for stating one correct storage **and** one correct flow **OR** two correct storages **OR** two correct flows;*
*2 marks for stating two correct storages **and** one flow **OR** one correct storage **and** minimum two flows;*
*3 marks for stating minimum two correct storages **and** minimum two correct flows;*
Do not include above ground stores or flows e.g. photosynthesis, transpiration.
For soil organisms accept named relevant organism e.g. fungus, bacteria, worm or plant roots.
For soil organic matter accept hummus.
For inorganic matter accept nutrients/minerals <u>and</u> water.
Accept flow if relevant input or output of soil system.
Flows should be arrows, accept circles for storages.

Section B

5. (a) State **two** sources of particulate matter (PM) **and two** negative impacts they could cause in urban areas. **[4]**

Sources of PM (max 2)
vehicle exhaust / industrial emissions / construction activities / burning fossil fuels / forest fires / volcanic ash / waste incineration;

Effects of PM (max 2)
reduced visibility / formation of smog / dirtying of buildings / respiratory problems in humans / premature death in vulnerable people;

Note to examiner: *Only credit first two responses.*

(b) Explain how acid deposition may impact the biotic components of a forest–river ecosystem. **[7]**

a. Foliage damage from direct contact with acid rain leading to less growth/reduced productivity in plants;
b. Reduction in soil pH could cause reduction in plants, leading to a reduction in herbivore populations/species diversity;
c. Reduction in plants could increase the risk of soil erosion as reduced protection from rain causing reduction in soil invertebrates;
d. Release of toxic metal ions/aluminium ions into soil affecting the growth of plants/ effect on species in soil;
e. Acid deposition can cause leaching of nutrients (named e.g. nitrates, magnesium, calcium) from soil leading to reduced plant growth/productivity/health;
f. Reduced pH in soil can negatively affect decomposers so reduce the decomposition rates and nutrient cycles;
g. Reduction in pH of freshwater ecosystems can increase toxicity risk from ions/aluminium ions on species;
h. Damage to fish gills reducing gas exchange;
i. Reduction in pH leading to damage to invertebrates with exoskeleton or shells;
j. Species sensitive to pH changes are more at risk of negative impacts (water or land) so can reduce in population;
k. Increase in species who can tolerate lower pH levels in soil/water;

(c) To what extent is an anthropocentric approach, as opposed to a technocentric approach, the most effective strategy for managing urban air pollution? **[9]**

The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria in each of the markbands (although ESS terminology has been conflated with "understanding concepts"). This guide simply provides some possible inclusions and should not be seen as requisite or comprehensive. It outlines the kind of elements to look for when deciding on the appropriate markband and the specific mark within that band.

Answers may include:

- **Understanding concepts and terminology** anthropocentrism; ecocentrism; technocentrism; urban air pollution; particulate matter (PM); natural and anthropogenic sources of pollution; primary and secondary pollutants; point of release; pollution management strategies;
- **Breadth in addressing and linking** environmental value systems with the different management strategies used to reduce pollution release and effects in urban systems.
  Anthropogenic suggestions could be to include legislation, low emission zones, green zones in urban areas, international agreements, vehicle bans.
  Technocentric suggestions could include use of catalytic converters, converting to renewable energy sources electric vehicles or hydrogen fuel cells, carbon capture systems, scrubbers.
- **Examples** of management strategies used and how they relate to an environmental value system.
  Examples could include London ULEZ, Beijing odd/even registration plate restriction, EU laws on catalytic converters in vehicles, Example of green urban planning e.g. Singapore.
- **Balanced analysis** addressing the effectiveness of different approaches to managing urban air pollution and relating back to the EVS
  Anthropogenic effectiveness; Laws and standards encourage compliance by whole population, laws can be adapted as needed, behaviour change to reduce air pollution. However, can be hard to enforce, laws can be unpopular or have negative economic effect.
  Technocentric effectiveness: Directly reduces/eliminates pollutant at source, new innovations can be introduce faster than laws can be changed. However, technology may be too expensive or not popular to adopt, electric cars still rely on energy source, does not address consumption leading to pollution.
- **A conclusion that is consistent with and supported by analysis and examples given,** e.g. "While a technocentric approach is invaluable in terms of reducing emissions or managing emissions, the anthropocentric approach of setting laws can enforce the use of the technologies which will have a bigger impact long term."

Please see markbands on page 19.

6. (a) Identify **four** possible impacts of urban sprawl on the surrounding terrestrial ecosystems. **[4]**

a. Reduce soil fertility / destroy soil structure / change nutrient cycling patterns due to urban run off/concreting surfaces;
b. Habitat fragmentation/degradation/reducing habitat diversity from construction of roads/expanding residential areas/materials used for construction...;
c. ...Leading to loss of species/reduction in species diversity (due to loss of habitat/habitat degradation from construction);
d. Increase edge effect on species from habitat fragmentation / road construction / land reclamation / noise pollution;
e. Disrupt wildlife corridors / change dispersal patterns / hindering animal migration due to road construction/fencing;
f. Reduce resources (nesting, food, etc.) (leading to population reduction) from loss of green space/concreting surfaces;
g. Reduced genetic diversity / reduced reproductive potential of species populations / leading to extinction vortex due to habitat fragmentation from roads;
h. Change to foraging/hunting/mating behavioral patterns from light/noise pollution/fencing/land reclamation;
i. Harm the health/reduction in number of sensitive species due to air/water pollution;
j. Water pollution due to construction reduces amount/quality of water available ;
k. Urban heat island effect due to more concrete/glass constructions;
l. Via gardening/opening roads/causing edge effect may introduce invasive species outcompeting native ones / create ideal urban environment for pests / urban exploiters/adapters;

Allow [1max] for positive impacts (last MP).
No credit for socio-economic impacts.

Note to examiner: *Credit should be gained for a theoretical statement or example linking any urban sprawl element (Construction of roads / covering soil by impermeable structures (e.g. concrete/tarmac) / land reclamation for expanding residential/commercial areas / increased air/light/noise pollution / fencing / loss of green areas) to a relevant impact, as exemplified in MPs (more combinations with urban sprawl elements possible). Link could be implicit depending on context.*

No credit for listing impacts without linking to an urban sprawl element, e.g. "urban sprawl would lead to reduction of genetic, species and habitat diversity" is TV and should not gain any mark.

(b) Using named examples for both, explain how the reintroduction of apex predators and keystone species can impact biodiversity. **[7]**

*Definition **[1max]**:*
a. APs are found at the top of a food chain/ have no natural predators (at least in the specific community);

Reintroducing an apex predator can increase biodiversity...
b. ...as they consume herbivores/reduce herbivore populations limiting overgrazing/may increase plant species/diversity;
c. ...and allowing vegetation recovery/increase plant growth/diversity / increase in shelters/habitats/niches attracting a higher variety of other species;
d. Presence of AP causes herbivores to hide/move away from open areas allowing plant species to recover (increasing biodiversity);
e. APs reduce populations of species at lower trophic levels in the food web, decreasing competition that allow other species to increase in population / may prevent one species from becoming dominant.

Reintroducing an apex predator can reduce biodiversity (leading to extinction of already present species) ...
f. ...by causing imbalance in established predator-prey oscillations/relationships...;
g. (In small/isolated/island/degraded habitats) AP can cause population declines preying on/consuming native species;
h. ...or overexploit resources for competitive predators (increase competition for food/habitat);

[4max] points for Apex predator impect on biodiversity.

Keystone species: relevant examples would include (apex and non-apex) predators (e.g. purple see star, orca), ecosystem engineers (e.g. beaver, elephant) or mutualists (e.g. honeybee, mycorrhizal fungi).

*Definition **[1max]**:*
i. KSs have a disproportionately significant impact on community structure/sustainability of ecosystems / their removal may lead to ecosystem/food web collapse;

Reintroducing Keystone species may increase biodiversity...
j. ...by preventing the dominance of a single species monopolizing an ecosystem;
k. ...by maintaining structural integrity of their ecosystem/food web community/ support ecosystem interactions (e.g. sea otters in kelp forests)...;
l. ...or by alleviating competition (e.g. non-apex starfish keeping mussels in check);
m. ...or by creating habitat (e.g. African elephants expanding savanna = habitat diversity/beavers and ponds)...;
n. ...allowing colonization by more species /acting as catalyzers of succession (e.g. nitrogen fixing plants or free-living bacteria);
o. ...or by restoring ecosystems (e.g. willow recovery by introducing beavers in Scotland);
p. ...or contributing to soil/humus formation (e.g. earthworms, termites);
q. ...or adding to soil fertility (e.g. soil mixing by pocket gophers / prairie dog adding dung);

Reintroduced Keystone species may decrease biodiversity...
r. ... if it functions as invasive (non-apex predator) species, e.g. outcompeting rare native species (as in the case of sea otters locally extirpating abalones)...;

s. ...or it explodes in population lacking natural control mechanisms (like introducing water buffalo in Ermakov island of Danube river);
t. ... if it leads to unintended consequences causing population crash/extinction (e.g. introducing dingoes in fenced conservation areas in Australia may have led to reduction of bettongs instead of helping them recover as expected);

[4max] *points for Keystone impact on biodiversity.*

Note to examiner: *Allow* ***[6max]*** *if no named example given (no need for two named examples, as many APs may also be considered KSs, like Yellowstone wolf). For the same reason avoid crediting the same impacts twice, once linked to an AP, and again to a KSs. Obviously, allow MPs linked to different named species.*
Apex/top predators: (accept any carnivore/omnivore, as they may function as apex predators in degraded food webs where highest trophic level is missing, but do not accept herbivores, which, however, could be example of keystone species).

(c) "The world is reaching the tipping point beyond which climate change may become irreversible." Kofi Annan, former Secretary-General of the United Nations (UN). Discuss the validity of this statement. **[9]**

The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria in each of the markbands (although ESS terminology has been conflated with "understanding concepts"). This guide simply provides some possible inclusions and should not be seen as requisite or comprehensive. It outlines the kind of elements to look for when deciding on the appropriate markband and the specific mark within that band.

Answers may include:

- **Understanding concepts and terminology** tipping points, positive feedback, mitigation strategies, adaptation strategies, stable equilibrium, negative feedback loops, climate change, greenhouse gases, resilience, planetary boundary model.
- **Breadth in addressing and linking** positive feedback loops associated with climate change heading towards tipping points as well as discussing mitigation strategies or negative feedback loops that can reduce/reverse effects of climate change. Breadth to show multiple feedback loops from a range of biomes/latitudes/causes.
- **Examples** could include melting of Arctic ice and reducing albedo or increasing sea-levels, loss of Amazon rainforest from deforestation, melting permafrost, reduction in sea ice as well as strategies to reduce climate change such as the Paris Agreement, increase renewable energy or carbon capture. Reforestation, methane reduction, carbon taxing and emissions schemes, removing fossil fuel subsidies.
- **Balanced analysis** to discuss the ability of climate strategies to mitigate processes heading towards a tipping point.
  Supporting the statement: scientific consensus on positive loops in action/evidenced, emissions trajectories, Greenland ice melt as example of tipping point, exceeding the planetary boundary model limit for climate change.
  Against the statement: Negative feedback loops in nature also exist, technological interventions to reduce impact, International collaboration has improved, models might overestimate risk.
- **A conclusion that is consistent with and supported by analysis and examples given,** such as "while the statement highlights the real threat of reaching tipping points, its validity depends on the extent and effectiveness of global mitigation efforts. Without immediate action, the world risks reaching irreversible tipping points, but with coordinated efforts (with examples), it may still be possible to prevent the worst outcomes"

Please see markbands on page 19.

Section B, part (c) markbands

Marks	Level descriptor
0	The response does not reach a standard described by the descriptors below and is not relevant to the question.
1–3	The response contains: • minimal evidence of knowledge and understanding of ESS issues or concepts • fragmented knowledge statements poorly linked to the context of the question • some appropriate use of ESS terminology • no examples where required, or examples with insufficient explanation/relevance • superficial analysis that amounts to no more than a list of facts/ideas • judgments/conclusions that are vague or not supported by evidence/argument.
4–6	The response contains: • some evidence of sound knowledge and understanding of ESS issues and concepts • knowledge statements effectively linked to the context of the question • largely appropriate use of ESS terminology • some use of relevant examples where required, but with limited explanation • clear analysis that shows a degree of balance • some clear judgments/conclusions, supported by limited evidence/arguments.
7–9	The response contains: • substantial evidence of sound knowledge and understanding of ESS issues and concepts • a wide breadth of knowledge statements effectively linked with each other, and to the context of the question • consistently appropriate and precise use of ESS terminology • effective use of pertinent, well-explained examples, where required, showing some originality • thorough, well-balanced, insightful analysis • explicit judgments/conclusions that are well-supported by evidence/arguments and that include some critical reflection.