Diploma Programme
Programme du diplôme
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Markscheme

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Environmental systems and societies

Standard level

Paper 2

18 pages

Subject details: Environmental systems and societies SLP2 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions in Section A **[25]** and **TWO** questions in Section B **[40]**.
- The maximum total = **[65]**.

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) With reference to **Figure 1**, identify the recycling rate in England in 2018. **[1]**

44%;

Note: *Accept 43%–45%*

(b) Outline **one** reason for the shape of the recycling rate curve from 2013 to 2018. **[1 max]**

Curve has flattened between 2013–18 due to:
only certain types of waste are recyclable;
limited market for recyclable materials/goods (*OWTTE*);
difficult to change human behaviour completely;
recycling facilities/ability may have reached full capacity (*OWTTE*);

Note: *Accept other valid reasons for* ***the plateau*** *– do not credit responses that explain why it has increased.*

(c) Estimate the reduction in solid domestic waste (in million tonnes) going to landfill from 2001 to 2018. **[1]**

(22 – 4 =)
~18 (million tonnes);

Note: *Accept 16–19 (million tonnes); do not accept percentage (eg 18%)*

(d) Describe **three** reasons why the proportion of solid domestic waste being recycled/composted and incinerated has changed. **[3 max]**

public awareness campaigns/government legislation/education promoting recycling/incineration;
meeting international agreements/quotas/obligations;
lack of space / suitable sites for landfill;
to reduce environmental impacts of landfill (*eg* leachates/landfill gas/habitat destruction/ pests/vermin);
developing technology/facilities for recycling/for energy production;
increasing need for renewable/cleaner energy sources;
financial reward/incentive for energy production;

Note: *Avoid double marking (sim) where responses give similar reasons for* both *recycling/composting* and *incineration (eg more efficient than landfill)*

(e) Outline **one** reason why there has been an overall change in recorded total solid domestic waste between 2001 and 2018. **[1 max]**

There has been an overall decrease in total solid waste due to:
government promotion/incentives for reuse/upcycling;
economic changes leading to reduced consumption;
greater awareness of environmental issues leading to less wasteful consumerism;
changes/errors in methods of data collection;
reduction in amount of packaging;
reduction in production/use of single-use items;

Note*: *Credit any valid reason for a **decrease** in total waste. (Do not credit 'increase in recycling' as recycling is included in SDW in the graphic ...but reuse or upcycling is OK)

2. (a) (i) With reference to **Figure 2**, identify when the diversity of species was lowest in the past 400 million years. **[1]**

around 250 million years ago/Ma/Mya;

***Note:** Accept 240–255 Mya.*
Do not credit if units (million years/Mya) are not given.

(ii) Describe what may have caused the deviation from the trend line at point X in **Figure 2**. **[2]**

mass extinction/extinction event / mass extinction of dinosaurs (65 Mya);
due to meteor/asteroid impact / volcanic activity / climatic change / ice age;

(b) (i) Identify the relationship between the number of continents and the diversity of species during the past 250 million years. **[1]**

the greater the number of continents, the greater the diversity / positive correlation (OWTTE);

(ii) Describe **two** reasons why there is a relationship between the number of continents and the diversity of species. **[2 max]**

separation of continents isolates populations leading to (allopatric) speciation;
continents are moved into different climatic regions causing evolution of different species;
continental movement creates new habitats, *eg* mountain ranges/islands;

(c) Outline the role of natural selection in increasing the diversity of species. **[2 max]**

natural selection (resulting from changing environment) acts on existing genetic variation (that has arisen through mutations over the eons);
natural selection increases the survival of fittest genetic variations/traits;
these traits are heritable/passed onto offspring / selected individuals will have higher reproduction potential / so species will adapt to different environments;
the proportion of these traits may increase in some populations/in subsequent generations;
which can lead to speciation/increasing species diversity if there is reproductive isolation;

3. (a) (i) Identify **one** primary pollutant from the pollutants shown in **Figure 3**. **[1]**

NO/NO_2/hydrocarbons;

(ii) Outline why the pollutant named in Question 3 (a)(i) is referred to as a primary pollutant. **[1]**

impacts environment directly on emission / undergoes no chemical change before impacting environment / is active on emission;

Note: *Even if response to 3(a)(i) is wrong full credit (ECF) can be given for appropriate definition of primary pollutant.*

(b) Outline **one** reason why there is an increase in nitrogen oxides and hydrocarbons early in the day. **[1]**

increase in fossil fuel combustion/increased traffic/transport/industry/power plants;

(c) Explain the changes in ozone concentration over the period shown in **Figure 3**. **[3 max]**

ozone is (a secondary pollutant) produced from nitrogen oxides/NOx reacting with oxygen;
it increases as more NOx accumulates in atmosphere due to human activity/fossil fuel use;
sunlight/heat catalyses this reaction so it increases towards midday;
later, ozone decreases due to dispersal by wind/less fossil fuel use/light becoming less intense;

Note: *Do not credit any further detail of chemical process of ozone formation.*
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(d) State **one** environmental impact of the accumulation of ozone shown in **Figure 3**. **[1 max]**

damages plants (crops and forests) / reduces photosynthesis/plant growth;
increase susceptibility to diseases/other pollutants;
habitat deterioration;
change in water and nutrient cycles;
loss of biodiversity;
impacts human health *eg* eye irritation/respiratory illness;
damages fabrics and rubber materials;
contributes to global warming/climate change / adverse weather;

Note: *Do not credit responses that address ozone depletion.*

(e) Outline **two** local conditions that may increase the severity of photochemical smog. **[2 max]**

low-lying topography/valley/mountains/high-rise buildings;
low windspeed/air movement;
thermal inversion / hot humid days;
high population density/heavy use of fossil fuels;
cities closer to equator get more intense sunlight;

(f) Outline the role of catalytic converters in reducing photochemical smog. **[1]**

conversion/reduction of nitrogen oxides/carbon monoxide/hydrocarbons from cars;

Section B

Part (c) questions in Section B are all to be assessed using the markbands on page 18 with the guidance given below for each question.

4. (a) Outline how species diversity and population size influence the resilience of an ecosystem. **[4 max]**

greater species diversity/greater population size usually lead to greater resilience;
with more species, it is more likely others can take over the role/niche of any lost/declining species;
more food chains/energy/biogeochemical pathways in an ecosystem provides redundancy therefore greater stability;
a variety of species is more likely to include those resistant to environmental change;
larger populations provide greater storages that can last over periods of lower productivity; larger populations generally carry greater genetic diversity;
larger populations of invasive species may lead to reduced diversity/resilience;
lower populations are more prone to extinction after a disturbance (*eg* habitat fragmentation) / or due to stochastic fluctuations;
an ecosystem may be more resilient if there are many small populations of different species than one large population of a single dominating species;
large populations of foundation/keystone species may be crucial for resilience of certain ecosystems (*eg* corals, kelp, beavers, elephants, pines, hemlock);

Note: *Award credit to any valid arguments providing they directly relate species diversity or population size to resilience.*
*Award **[3]** max for responses addressing only diversity or only population size.*

(b) Describe the similarities and differences in using a biotic index and a diversity index to assess ecosystems. **[7 max]**

Similarities:
both may involve species identification;
both may involve quantitative sampling/estimating the abundance of living organisms;
both require multiple samples for effective comparisons/reliability;
both indices involve evaluating the range/variety of different species;
both involve calculating a single figure (index) from a collection of data;

Differences:
only biotic indices (not diversity indices) give different values to sensitive and tolerant species;
biotic indices are specifically used for evaluating impact of pollution whereas diversity indices just measure variety and evenness of species/general condition/maturity of an ecosystem;
diversity indices are appropriate for most ecosystems whereas biotic indices are usually for aquatic systems;
biotic indices usually focus on animal species/macroinvertebrates alone whereas diversity indices can be used for plant or animal communities;
diversity indices usually address all species present in system whereas biotic index focuses on a particular selection;

Note: *Award **[4]** max if only similarities or only differences are given.*
Only credit differences where both sides of the contrast are given or clearly implicit. No credit for naming indices eg Simpson's, Trent etc.

(c) With reference to named examples, discuss the significance of diversity in the sustainability of food production systems. **[9 max]**

*The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria given 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** of genetic/species/habitat diversity; cultural / political diversity; sustainability; ecological footprint; yield per unit area; aquatic and terrestrial food production; commercial vs. subsistence; multinational vs. local production; monoculture v polyculture; organic farming; GMOs; selective breeding; impact of escapees on wild populations; integrated agriculture; habitat loss/degradation; air/water/soil pollution; threats to biodiversity/pollinators; pesticide/fertilizer/antibiotic use; biological pest control; food choice; buffer zones; mineral cycles; crop rotation, *etc*;
- **breadth in addressing and linking** technological and management strategies of terrestrial and aquatic food production systems with genetic/species/habitat diversity and significance of this in terms of sustainability and ecological footprint in the context of a range of geographical locations, social settings, levels of economic development, traditional values, international relations, legislations, personal attitudes and EVSs, *etc*;
- **examples** of named food production systems and strategies involved in monoculture, polyculture and integrated agriculture, wild fisheries, aquaculture *etc*;
- **balanced analysis** evaluating the extent to which diversity is significant in determining the sustainability of food production systems along with relevant limitations and counterarguments, *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "because diversity is such a significant factor in maintaining stability of systems, it is inevitably of great significance in maintaining both a sustainable production system and the wider environment in which the production takes place";

Please see markbands on page 18.

5. (a) Outline the role of the atmospheric system in the distribution of biomes. **[4 max]**

atmospheric/tri-cellular circulation (including Hadley, Ferrel & polar cells) creates patterns of climate that determine dominant vegetation types;
low pressure due to intense heating/high insolation at the equator causes / rising moist air in the tropics creates high precipitation giving rise to rainforests;
moving polewards (at high altitude), air cools, becomes denser and sinks forming a high-pressure zone / descending/dry air (20–30° latitude/tropics) creates water-limiting/arid conditions giving rise to deserts;
some of the air continues towards the poles to equalize temperature difference / atmosphere transfers heat from (sub-)tropics to mid-latitudes giving rise to temperate biomes;
descending/dry air (high latitude/polar regions) creates water-limiting conditions in tundra;
water vapour (from mid-latitudes/temperate regions) is transferred to high latitudes giving rise to heavy precipitation/snow in boreal forest;
water vapour is transferred from ocean surfaces overland generating freshwater aquatic systems;
prevailing winds/jet streams (blowing from high to low pressure) bring precipitation to a region, *eg* temperate rainforest in mountainous region/riverine/water-margin systems;
rain shadow effect of high mountains causes dry winds in the leeward side, resulting in arid or semi-arid biomes (*eg* Tibetan Plateau, Mongolian Gobi desert and steppes);
atmosphere may be responsible for shifting biomes due to global warming/climate change;

(b) Explain how human impacts on the atmosphere may influence the productivity of terrestrial biomes. **[7 max]**

release of ozone-depleting substances reduces stratospheric ozone increasing UV on Earth...;
UV can damage plants/photosynthesis reducing primary productivity;
release of NO_x/SO_x from fossil fuels can generate acid precipitation...;
acid rain can damage plants/leaves reducing primary productivity;
acid rain can cause leaching of nutrients from soils reducing plant growth/productivity;
acid rain can release toxic cations/minerals in soil that reduce plant growth/productivity; emission of greenhouse gases can lead to an increase in global temperatures/global warming...;
increased temperatures may lead to higher rates of photosynthesis/increased productivity;
higher temperatures may damage certain plant species reducing productivity;
higher temperatures may cause greater evaporation/water scarcity that reduces plant growth/productivity;
higher temperatures may melt permafrost increasing primary productivity in tundra / ice retreat, *eg* in Greenland, can lead to expansion of tundra ecosystem;
emissions from fossil fuel combustion causing photochemical smog which reduces photosynthesis;
any reduction in primary productivity will lead to reduction in secondary productivity/productivity of consumers;

Note: *Credit may be given for any further potential impacts of* atmospheric *pollution on* productivity *of* terrestrial *biomes.*

(c) To what extent is the need for conservation more significant in tropical biomes? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of biodiversity; conservation strategies; tropical biomes; rainforests; swamps; coral reefs; hotspots; LEDCs & MEDCs; international v national conservation bodies; environmental value systems; productivity; carbon sinks; global warming; unsustainable exploitation; resources of tropical ecosystems; medicines; indigenous cultures; endangered species; Red List, *etc*;
- **breadth in addressing and linking** threats to biodiversity with different societies, ecosystems, conservation strategies; the global dependence upon and significance of tropical biomes compared with others; implications of economic development in tropical regions with challenges of conservation; different EVS perspectives on reasons for conservation, *etc*;
- **examples** of tropical biomes/ecosystems; their local societies; conservation efforts; reasons/needs for conservation, *etc*;
- **balanced analysis** evaluating the extent to which conservation efforts are of particular importance for tropical biomes along with relevant limitations and counterarguments, *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "although the loss of any species may be considered of equal significance from an ecocentric point of view, the high productivity and biodiversity that characterize tropical biomes, along with the limited facility of local societies, which are often less developed, make tropical biomes a priority for international conservation efforts";

Please see markbands on page 18.

6. (a) Outline **four** ways in which urbanization may influence processes in the hydrological cycle. **[4 max]**

urban (paved) surfaces/reduced veg cover will lead to increase in run-off;
…and thus increase stream-flow/flooding;
urban (paved) surfaces/reduced veg cover will reduce infiltration of water into soils;
…and thus reduce inputs to groundwater/aquifers/water table level;
urbanization can increase heat/local temperature leading to greater evaporation/downwind precipitation;
urbanization will reduce vegetation cover and thus reduce evapotranspiration/regional precipitation;
urbanization will increase local water extraction reducing river flows/increasing outputs from groundwater storages/aquifers;
urbanization may lead to increased emission of greenhouse gases/global warming /climate change that may result in multitude of changes in hydrological cycle eg increased melting of glaciers/shifting precipitation patterns/increased evaporation etc;
urbanization may lead to increased emissions of NOx/SOx leading to acid precipitation;

Note: *Ensure that each markpoint includes an explicit link to a direct consequence of urbanization* and *how this influences a process in the hydrological cycle.*
Award ***[1]*** *max for changes associated with global warming.*

(b) Hydropower is a resource that can be exploited from rivers. Explain how the value of this resource to a society may vary over time. **[7 max]**

Positive changes promoting the value of hydropower:
rise in environmental awareness/need for renewable energy may increase value of hydropower;
need for industrial development entails increased demand for energy, thus increasing value of hydropower;
improved/more efficient technology of dam building making the political decision more attractive to voters / increasing the margin of profit / reducing the initial investment for LEDCs / making overall project more sustainable;
technological development of small scale/damless projects may render hydropower more aesthetically appealing / cheaper to implement in LEDCs / more environmental-friendly / more fit to ecocentrists;
hydropower may become favoured due to depletion in local non-renewable sources/need for energy security;

Negative changes reducing value of hydropower:
impacts of hydropower on aquatic systems / local human settlements cause increasing conflict with cultural values/local needs;
other renewable resources may become more favourable through technological development/reduced costs;
decreasing rainfall/increased evaporation due to climate change renders an existing dam less efficient / profitable;
energy security reasons / political change / economic recession dictate shift from hydropower to more dense nuclear power / cheaper coal;
societal values/EVS may stop seeing damming of a river as sustainable and demand shift away from river dams to wind/solar power;
society realizing it was unethical to relocate a local tribe and demanding the restoration of the river;

***Note**: Do not credit general arguments on dynamic nature of natural capital, unless explicitly linked to hydropower or clearly discussed in the context of hydropower.*
Do not credit any argument relating to the high value (monetary, intrinsic, aesthetic, environmental, cultural, economic, ethical, social, spiritual, technological) of hydropower, if not explicitly shown how this value has <u>changed</u> over time. (eg local Native American tribe resents river diversion due to its spiritual value; this is not a valid MP, as no change shown, just a different value system)

(c) To what extent are water scarcity issues better addressed through changing human behaviour than through technological development? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of water accessibility, distribution, security, scarcity; approaches of different EVS to water management; management policies/legislation; irrigation; domestic use; industrial development; international conflict; water conservation strategies; desalination; artificial recharge of aquifers; rainwater harvesting; grey-water recycling, *etc*;
- **breadth in addressing and linking** changes in human behaviour and technological approaches with a range of water conservation strategies in the context of different societies and geographical locations, *etc*;
- **examples** of water scarcity issues and changes in human behaviour and technological solutions that may address these issues, *etc*;
- **balanced analysis** evaluating the extent to which changes in human behaviour address water scarcity more effectively than technological solutions along with limitations and counterarguments, *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "although technological solutions often become necessary when scarcity is particularly severe, changing human behaviours address the root of the problem and have a more widespread affordability";

Please see markbands on page 18.

7. (a) Outline the processes involved in the formation of fertile soils from bare rock. **[4 max]**

(mechanical/chemical) weathering/breaking up of parent rock producing small particles;
deposition of sediment/eroded material (through wind/water) increasing soil depth;
dissolving of particle material to release soluble minerals;
colonization of parental rock/sediments by plants/animals/decomposers/pioneer species;
biological/atmospheric nitrogen fixation adds available nitrogen (nitrates, ammonium) to soil;
activity of mycorrhizal fungi/decomposition of dead organisms/leaf litter to release mineral/nutrients/organic material/humus;
growth of mosses form mats that stabilize soils in sterile/barren ecosystems;
earthworms/burrowing insects spread soil particles/open soil pores;
precipitation adding water to soil;

(b) Explain how negative and positive feedback mechanisms may influence the growth of decomposer populations in the soil. **[7 max]**

negative feedback occurs when the output of a process inhibits or reverses the same process / in such a way as to reduce change/counteract deviation/maintain equilibrium;

positive feedback occurs when the output of a process accelerates that same process (will tend to amplify changes) / deviate away from equilibrium / or drive the system toward a tipping point (adopting a new equilibrium);

Negative feedback (occurring at carrying capacity):
growth of decomposer populations will reduce available organic material;
…thus leading to reduced growth in population;
growth of decomposer population may lead to increase in predators feeding on decomposers;
…thus leading to reduction in population growth;

Positive feedback (occurring during phase of exponential growth):
increase in number of decomposers will increase potential for reproduction;
…thus leading to increased rate of population growth;
increase in decomposers may favourably modify environment (*eg* increase temperature/improve soil);
…thus leading to increased rate of population growth;

Note: *Candidates may answer with the help of a diagram (eg feedback-links diagram) for which credit should be given.*
*Award **[2]** max for each valid feedback loop correctly identified.*
Only give credit if a complete loop is identified i.e. an increase of factor X leading eventually to a decrease or further increase of factor X (or the converse).
Do not credit simple changes in decomposer populations.

(c) To what extent are natural limiting factors more likely than population policies to limit global human population growth in the future? **[9 max]**

The following guide for using the markbands suggests certain features that may be offered in responses. The five headings coincide with the criteria given 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** of limits to growth: water supply, food supply, pollution, environmental degradation; disease; carrying capacity; ecological footprints; demographic transition; population/development policies; crude birth & death rates; natural increase rates; population projections; Malthus/Boserup models, *etc*;
- **breadth in addressing and linking** human population growth with range of anti-natal policies, limiting resources, environmental degradation over time and in different locations/nations, *etc*;
- **examples** of potentially limiting natural resources, population policies and populations, *etc*;
- **balanced analysis** evaluating the extent to which natural limiting factors or population policies are most likely to limit global human population growth along with limitations and counterarguments, *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "although technological developments are currently going a long way to keep pace with resource availability in line with Boserup's approach, there has to be an upper limit and ultimately populations will need to reduce their own rate of increase through management policies such as is already happening in some countries";

Please see markbands on page 18.

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.