Diploma Programme
Programme du diplôme
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Markscheme

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Environmental systems and societies

Standard level

Paper 2

17 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 **Figures 1(a)** and **1(b)**:

(i) State the food that has the highest environmental impact. **[1]**

beef;

(ii) State the food that has the highest recommended consumption. **[1]**

fruit/vegetables;

(b) Describe the relationship between both pyramids in **Figures 1(a)** and **(b)**. **[2 max]**

generally, the foods with the higher level of recommended consumption have a lower environmental impact;
foods at the "top" (pictorially, rather than both apices) of both pyramids tend to be from higher trophic levels/produce a higher ecological footprint (EF) /
foods at "bottom" of both pyramids tend to be from lower trophic levels/primary producers/produce a lower EF;
pyramids appear opposite to one another / have an inverse relationship/negative correlation;

(c) Identify **two** environmental impacts associated with producing the foods near the base of the recommended consumption pyramid (**Figure 1**(a)). **[2 max]**

use of pesticides/herbicides causing soil degradation / superbugs / superweeds;
over use of fertilizers causing soil degradation / eutrophication;
over-cultivation of land causing soil degradation;
intensive irrigation/over use of water leading to water scarcity / salinization;
mono-cropping reducing biodiversity/increasing risk of losses through disease;
use of fossil fuels through mechanization/intense farming/food miles that release GHGs/CO_2;
methane released from rice-farming;

Credit can be given to any valid impact of agricultural food production.
Credit may be given for positive impacts (eg roots prevent soil erosion/crop rotation enriches soils) but not just the absence of negative impacts (eg less methane/less water, etc)

(d) Describe how foods high on the environmental impact pyramid, shown in **Figure 1(b)**, are likely to affect the ecological footprint of global food production. **[2 max]**

Ecological footprint will be greater because…
higher trophic levels/more energy loss…;
…greater land area required (to produce same quantity of food);
more dependence on fossil fuels/mechanisation/food miles (+ release of GHG/CO_2);
release of methane from cattle increases global greenhouse gas concentration;
higher water consumption when farming animals;
overgrazing leading to loss of arable land;

*Award **[1 max]** if* INCREASE *in ecological footprint/land area required is not mentioned.*
Credit may be given for any valid impact on EF due to production of food high on environmental impact (beef/pork/poultry/fish/cheese/olive oil)

(e) Outline **two** reasons why the composition of a typical diet in other regions of the world may differ from the Western European diet shown in **Figure 1(a)**. **[2 max]**

Their choice may be influenced by…
traditional/cultural/religious values of certain foods;
suitability of the prevailing climate/topography/arable land;
availability of water supply;
available technology/expertise for certain cultivation techniques;
wealth / relative cost of production;
some countries/cultures may have different perceptions of what constitutes health/healthy eating;
some cultures may consider environmental impacts/have EVS that influences choice of food production;
some LEDCs may not be able to import foods so rely on more local foods;

This is a general question addressing potential factors affecting food choice; no specific examples of other diets are required for full credit.

2. (a) State the general pattern of change in global water scarcity predicted from 1995 to 2025 as shown in **Figure 2**. **[1 max]**

in many countries water scarcity will increase / higher percentages of water present will be extracted;
changes are usually greater in the mid to lower latitudes/nearer the equator (than the poles);

(b) Identify **two** ways in which climate change may influence the predicted changes shown in **Figure 2**. **[2 max]**

increased global temperatures will change wind/precipitation patterns affecting water supplies;
increased precipitation will increase availability reducing scarcity / decreased precipitation will decrease availability increasing scarcity;
increased temperatures will increase evaporation losses/drought/drying up of water sources (lakes, rivers, reservoirs) reducing availability;
increased temperatures will melt ice storages increasing availability / run off into oceans decreasing availability;
rising sea levels may cause salinisation of freshwater sources;

(c) Identify **two** possible human influences, not related to climate change, that may cause the changes in water scarcity predicted for 2025. **[2 max]**

increased population (demanding more water);
increased/intensive food production/agriculture (demanding more water);
increased standards of living/industrialization (demanding more water);
increased levels of contamination/pollution (through industrial development);
damming of river/water supply upstream reducing available water downstream;
increased surface run off due to urbanisation;

(d) Outline **two** reasons why some countries are unlikely to experience water scarcity. **[2 max]**

favourable climate where precipitation is high/evaporation is low;
countries may have large replenishable storages (*eg* lakes/rivers/ice);
developed countries with technology for effective water harvesting / desalination;
more ecocentric value systems promoting sustainable use of water resources / limited pollution;
no external conflicts over water sources;
low population densities (with lower industrial/agricultural/domestic demands);
low standards of living (with lower industrial/agricultural/domestic demands);

3. (a) State where the ozone hole referred to in **Figure 3** is located. **[1]**

in the (lower) stratosphere / over the poles / above the Antarctic/Arctic / at higher latitudes / Australia/NZ;

(b) Describe the changes in mean ozone hole area between 1979 and 2016. **[2 max]**

rapid increase during the 1980s/up to 1990s/ from 1979–87;
reaches maximum in late 1990s;
relative stable during late1990s;
fluctuating from 2000 onwards;
possibly declining in late 2000s/from 2014;

Be prepared to give a little leeway in precise years for changes in trends, but some reference to their timing is required.

(c) Identify **one** possible reason for the changes shown during the 1980s. **[1 max]**

increasing use of/disposal of refrigerants containing CFCs;
increasing use of CFCs in aerosols;
increasing release of NO_x from fossil fuel combustion;
increasing use of methyl bromides as pesticides;

Responses should identify the ODS and its use for full credit.

(d) Explain how the data in **Figure 3** can be used in judging the success of the Montreal Protocol in addressing ozone depletion. **[4 max]**

Montreal Protocol was introduced in 1987/graph covers period before and after introduction of Montreal Protocol;
it introduced a ban on the use of CFCs / led to use of alternative HCFs/HFs;
rate of ozone destruction/growth of the ozone hole slows down/stops soon after this date;
suggesting it had some success/favourable impact on ozone depletion;
however, there is little evidence of ozone levels being restored to earlier levels / hole disappearing;
possibly some evidence in last few years/2014–2016 on graph of ozone hole reducing/ozone being restored;
the stabilisation/limited decline in ozone hole may suggest black market sale of ODSs (limited success);
continued impact of long-lasting ODSs (CFCs/HCFs) delay final judgement;

Section B

Part (c) questions in Section B are all to be assessed using the markbands on page 17 with the guidance given below for each question.

4. (a) Outline the processes by which a species may evolve a greater tolerance to higher temperatures **[4 max]**

a species will contain a variety of different genotypes/characteristics / mutations will increase the variety of genes/characteristics;
some genes may provide greater tolerance to high temperature than others;
individuals with these genes are more likely to survive if high temperatures are limiting / there will be "survival of the fittest" / tolerant will outcompete intolerant;
these individuals will reproduce offspring with their tolerance/genetic characteristics / their characteristics are heritable/passed on to next generation;
natural selection will eliminate intolerant individuals/increase frequency of tolerant individuals;
over time/generations, tolerance may become a dominant characteristic in population;

If candidates mistakenly address process of speciation then just credit those aspects that are equally valid in microevolution, eg natural selection/survival of fittest/heritability, etc

(b) Explain how the atmosphere plays a role in maintaining life-supporting temperatures over the Earth's surface. **[7 max]**

atmosphere allows solar energy/wide range of wavelengths to reach Earth's surface;
water vapour/humidity/clouds absorb/reflect incoming IR/solar energy exerting a cooling effect;
greenhouse gases such as CO_2/methane/NOx/tropospheric ozone/ CFC/HCFCs/water vapour;
absorb re-radiated heat/outgoing longer wavelength (Earth's) radiation;
this creates greenhouse effect that keeps planet warmer;
most heat is radiated to the equatorial/lower/tropical latitudes;
the tricellular model/convection currents/prevailing winds transfer this heat to higher latitudes;
maintaining a greater dispersal of life-supporting temperatures over planet;
heat at equator causes rapid evaporation;
…this water vapour carries latent heat that can be released on condensation/at higher latitudes;
tropical cyclones transfer large quantities of such heat to higher latitudes;
winds may contribute to oceanic currents transferring heat;

Credit should be awarded only for MPs that address role of atmosphere, not other influences on temperature.
Do not credit response that ozone hole leads to warming ...unless it is qualified by being a relatively insignificant contribution.

(c) In addressing environmental issues, mitigation strategies may be seen as primarily ecocentric and adaptation strategies as primarily technocentric.

To what extent is this view valid in the context of named strategies for addressing the issue of global warming? **[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 mitigation, adaptation, ecocentric/technocentric values, causes and impacts of global warming, strategies for reducing causes/managing impacts, carbon sinks, *etc*;
- **breadth in addressing and linking** wide range of relevant strategies with mitigation or adaptation and with ecocentric values *eg* restraint/low consumption, changed lifestyles, sustainability, low technology, decentralization, and technocentric values *eg* maximizing growth, unlimited exploitation, resolving issues through technology, & scientific expertise, *etc*;
- **examples** of mitigation improving energy efficiency/consumption, alternative energies, reduction of emissions, *eg* catalytic converters, geoengineering, fertilizing oceans, afforestation/forest protection, UN-REDD, carbon capture and storage, nutrifying oceans, *etc* and adaptation flood defence, desalinization, vaccination, crop choice, *etc*;
- **balanced analysis** of the extent to which mitigation strategies are genuinely ecocentric and adaptation strategies are technocentric including counterarguments (may include reference to anthropocentric nature of some strategies) *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "although, in general terms, ecocentric values favour a preventative approach and living within the sustainable limits rather than adapting to human impacts, some mitigation strategies involve a heavy use of large scale technology, acceptable to technocentrics, but to which ecocentrics are generally opposed";

Please see markbands on page 17.

5. (a) Outline the procedures in a laboratory-based method to find the gross productivity for a population of named aquatic animals in terms of biomass per day. **[4 max]**

find the dry weight of food presented to the population at start;
collect and find the dry weight of food remaining after a number of days;
subtract the weight of food remaining from that presented / find dry weight of food eaten;
collect and find the dry weight of feces produced over this period;
subtract weight of feces from food eaten to find food absorbed/gross productivity / food eaten – fecal loss = gross productivity;
divide final weight/gross productivity by number of days of the study;

Do not credit reference to weighing organisms (only relevant in net productivity).

(b) Explain how acid deposition falling on a forest may impact a nearby aquatic ecosystem. **[7 max]**

run-off/groundwater flow may carry acidity directly to water body;
acidity/low pH may directly reduce survival of sensitive species;
reduced productivity of aquatic plants reduces food for higher trophic levels;
acidity in soils will release/leach cations/metal ions from soil particles;
aluminium/metal ions released from soil will enter water body;
aluminium ions may affect gills of fish reducing their survival;
other metal ions (cadmium) may be more toxic/lethal;
acidity reduces solubility of nutrients (*eg* N, P) so less nutrients leach/flow into aquatic system;
loss of trees/terrestrial/riparian vegetation may lead to erosion of soil into water body/reduced shade/increased temperatures;
more soil entering water body will increase turbidity;
high turbidity may lead to reduced photosynthesis/lower productivity;
all these impacts will lead to loss of biodiversity/low productivity;
forest soil may be alkaline reducing acidity of impact on aquatic system;

Only credit impacts on aquatic system, not impacts solely affecting forest.

(c) When harvesting is limited to the sustainable yield, associated processes involved in a food production system may still make the production unsustainable.

In this context, to what extent can aquatic food production systems be truly sustainable? **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of harvesting wild populations, capture fisheries, quotas, maximum sustainable yield, net productivity, fish stocks, overfishing, aquaculture, eutrophication, aquatic pollution, habitat loss, marine protection/exclusion zones, commercial vs. subsistence FPSs, *etc*;
- **breadth in addressing and linking** aquaculture with unsustainable impacts *eg* eutrophication from excess feed/fecal deposits, genetic degradation of wild populations through escapees, pollution with medication, **and** means of reducing impacts *eg* polyculture, biological pest control, *etc* **and** wild fishing with unsustainable impacts *eg* overfishing, capture of other species/immature individuals, lost nets/gear, water pollution due to mechanization, fossil fuel use, *etc* **and** means to reduce impacts *eg* quotas, legislation on mesh size, seasonal limits, exclusion zones, possible miscalculation of MSY, *etc*;
- **examples** of unsustainable impacts from aquaculture *eg* anti-fouling agents; antibiotics; excess feed, medicines, genetic modification, escapees, disease, *etc* **and** fishing *eg* trawling, physical damage to *eg* corals/sedentary species, mesh size, bycatch, lost fishing gear, *etc*;
- **balanced analysis** of degree to which collateral impacts of aquaculture/capture fisheries through mechanization, fossil fuel use, *etc* can be sustainably managed including counterarguments, *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "a great deal can be done through legislation and choice of appropriate strategies to move aquatic food production toward true sustainability but ultimately certain unsustainable impacts are inevitable";

Please see markbands on page 17.

6. (a) With reference to **four** different properties of a soil, outline how each can contribute to high primary productivity. **[4 max]**

particle size affects ability of soil to store/retain water necessary for productivity;
high mineral content provides nutrients for healthy growth/productivity;
high organic content / deep humus provides long term storage of nutrients (released through decomposition);
air spaces provide more O_2 to roots for growth/respiration / allow deeper penetration of roots;
appropriate porosity allows soil to hold enough water for plant growth;
better drainage prevents water-logging that inhibits growth/productivity;
abundant biota help to aerate/break up the soil allowing for better root growth/recycle nutrients;
microorganisms contribute to mineral-cycling promoting growth/productivity;
neutral to slightly acidic pH is the optimal for most plants (6.0–7.5);
low or no slope prevents water erosion / loss of soil;

No credit for ground cover reducing wind erosion / soil conservation/management (not soil properties)

(b) Explain how the level of primary productivity of different biomes influences their resilience. **[7 max]**

resilience is the ability to withstand disturbances / tendency to maintain stability/avoid tipping points;
generally, biomes with higher primary productivity (*eg* rainforests/estuaries/wetlands) are more resilient than those with lower productivity (*eg* tundra/deserts);
more productive biomes can support more species/diversity;
diversity increases resilience because loss of one species is more easily replaced by others;
more productive biomes support more branching food chains / greater complexity of interrelationships;
…that allows for more negative feedback mechanisms/shifting feeding habits maintaining stability/providing more resilience;
more productive biomes produce larger biotic storages;
larger storages are less likely to be eliminated/reduced beyond a tipping point so contribute to greater resilience;
larger storages provide higher maximum sustainable yields so are less prone to overharvesting;
higher productivity entails faster plant growth, thus more effective regeneration after a disturbance;
oceanic biomes have low productivity per unit area but their large size increases their resilience;
coral reefs have high productivity but narrow niche requirements give them low resilience;

Allow credit for valid counterexamples as in last two MPs.

(c) Discuss the role of feedback mechanisms in maintaining the stability and promoting the restoration of plant communities threatened by human impacts. **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of negative and positive feedback, steady state and dynamic equilibria, tipping points, resilience, sustainability, colonization, pioneer communities, succession, biodiversity, variety of nutrient and energy pathways, human threats *eg* climate change, eutrophication, deforestation, land degradation, marine pollution, toxic pollution of lakes;
- **breadth in addressing and linking** negative feedback with stability, steady state, resilience in natural systems mitigating adverse impacts; *and* positive feedback with dynamic equilibria, growth, succession in restoration as well as amplifying/exacerbating human disturbance and destabilization of systems, *etc*;
- **examples** of organisms, feeding and non-feeding relationships, abiotic & biotic interactions generating negative feedback loops in natural systems and positive feedback promoting population growth, succession (*ie* earlier successional stages modifying environment to allow more and more colonization of later stages), and human impacts leading to positive feedback through *eg* agriculture, unsustainable exploitation, overharvesting, eutrophication, global warming, *etc*;
- **balanced analysis** of the extent to which feedback mechanisms maintain stability and promote restoration in face of human impact with counter examples of positive feedback leading to greater destabilization, or to a new equilibrium (past a tipping point), *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "generally, negative feedback is significant in maintaining stability, while positive feedback promotes restoration of plant communities. However, human impacts frequently drive systems beyond their tipping point, and then positive feedback drives the system even further from its naturally stable equilibrium";

Please see markbands on page 17.

7. (a) Identify **four** ways to ensure reliability of the mark–release–recapture method in estimating population size. **[4 max]**

ensure process of capture does not reduce/increase potential for recapture / generate trap-shy/trap-happy individuals;
ensure marking process does not impact individual's survival;
ensure method of marking is durable for period of investigation;
ensure sufficient proportion of population is caught/marked in first capture;
repeat procedure/recapture to increase reliability;
ensure traps are well distributed throughout area of population;
ensure sufficient time between captures to allow mixing of population;
only apply procedure to motile species that do not travel outside study area;

(b) Explain how the interactions between a species and its environment give rise to the S-shape of its population curve. **[7 max]**

the slow initial growth rate is due to low numbers reproducing;
…and/or unfamiliarity with resources / threats of the newly colonized habitat;
growth rates/numbers increase more rapidly due to abundance/accessibility of resources/greater numbers reproducing;
…leading to positive feedback/exponential growth;
growth rate subsequently decrease/numbers increase more slowly due to limiting/density dependent environmental factors/environmental resistance;
…*eg* limited food/greater predation/competition/nesting sites, *etc*;
growth rate eventually becomes zero / population stabilizes / fluctuates around carrying capacity;
due to reaching the carrying capacity of the environment;
…kept stable by density dependent factors / negative feedback / predator–prey cycles;

Note: These marking points may be achieved through an appropriately annotated diagram.

(c) The future growth of human populations is unlikely to be limited by the availability of energy resources. However, they could easily be limited by the impacts of energy production.

Discuss the validity of this statement. **[9 max]**

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Answers may include:

- **understanding concepts and terminology** of human population growth, limiting factors, "limits to growth", renewable/non-renewable energy, sustainable development; natural capital/income, carrying capacity, ecological footprints, energy choice, energy security, impacts of climate change, air, water pollution, soil degradation on food production/water availability/disease, *etc,* predictive models on growth and resource availability;
- **breadth in addressing and linking** longevity/sustainability of a range of energy sources with human population growth and a range of impacts of energy production from extraction to transportation to infrastructure with a range of limits to human population growth, *etc*;
- **examples** of non-renewable energy sources *eg* oil, coal, fracking, natural gas, nuclear, *etc* and renewable sources *eg* hydropower, geothermal, wind, wave, tidal, *etc* and impacts of energy production *eg* climate change/shifting biomes/agricultural conditions/food production/water availability/scarcity/disease and possible limits to growth *eg* pollution, disease, potable water, arable land, food, *etc*;
- **balanced analysis** of likelihood of energy itself becoming a limiting factor to human population growth compared to a variety of limiting factors resulting from energy production, including counter arguments (possible sustainability of energy choices), *etc*;
- **a conclusion that is consistent with, and supported by, analysis and examples given** *eg* "despite the development of sustainable energy that would prevent energy itself becoming a limiting factor, countries still persisting in their dependence on fossil fuels may well impair the availability of food and water and spread of disease, each of which could soon become a limiting factor to the growth of human populations";

Please see markbands on page 17.

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.