8823 – 6303M

Diploma Programme
Programme du diplôme
Programa del Diploma

# Markscheme

## November 2023

## Environmental systems and societies

## Standard level

## Paper 2

21 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) State the trophic level of herring. **[1]**

secondary consumer / third/3rd(trophic level);

(b) State the relationship between POPs concentration and the trophic level**.** **[1]**

POP concentration increases/is higher moving up to higher/at increasing trophic levels / positive/direct correlation / as one increases the other increases;

***Note:*** *Do not credit biomagnification or bioconcentration in response to this question.*

(c) Explain the relationship between POPs concentration and trophic level. **[2]**

a. POPs <u>bioaccumulate/bioconcentrate</u> within organisms/tissues, as they are taken up from surrounding environment/polluted ocean water/food;
b. … because POPs are non-biodegradable/don't break down…;
c. …and result in <u>biomagnification</u>, as they pass from one trophic level to the next (across levels)...;
d. ...due to the decrease of biomass/energy (respiratory losses) up the food chain;

***Note:*** *Do not award marks if similar statements are given in 2(b) and 2(c)*

(d) Calculate, as a percentage, the efficiency of energy transfer between herring and cod. **[1]**

(5/25) x 100 = 20 (%);

(e) Outline **one** strength **and one** weakness of a pyramid of productivity as a model to represent energy in an ecosystem. **[2]**

*Strength:* ***[1 max]***

a. shows the flow/production rate of energy/biomass through a food chain (rather than the standing stock) / never inverted;
b. tracks change over time (rather than "snapshot" in time);
c. more efficient comparison of different ecosystems;
d. visual representation / simplification of complex system/ easy to communicate information to non-specialist;
e. can be used to make predictions;

*Weakness:* ***[1 max]***

f. difficult to place organisms that occupy more than one trophic level;
g. hard to get accurate data because collection is difficult / inevitably some values are approximate;
h. (estimating in field) may involve killing of organisms;
i. oversimplification and loss of detail/complexities of interacting factors

**2.** (a) Identify the region that shows the greatest $NO_x$ emission reductions in February 2020 as shown in **Figure 2(a)**. **[1]**

Asia and Middle East;

(b) Outline **one** reason for the $NO_x$ emission reductions during Covid-19 lockdowns, as shown in **Figure 2(a).** **[1]**

reduced burning/combustion of fossil fuels, a source of $NO_x$ / due to reduced traffic/factory closures;

(c) Explain the relationship between the $NO_x$ emissions shown in **Figure 2(a)** and tropospheric ozone concentrations shown in **Figure 2(b)**. **[2]**

a. the two have a positive correlation/as $NO_x$ decreases so does tropospheric ozone;
b. …because $NO_x$ (is a primary pollutant) that can lead to tropospheric ozone (secondary pollutant);
c. …because $NO_x$ interacts with sunlight/UV (and sometimes VOCs) to produce tropospheric ozone;
d. tropospheric ozone reductions continue to increase in some regions after $NO_x$ reductions level off / possibly because other factors (e.g. weather, other pollutants) influence tropospheric ozone production;

(d) Outline **two** impacts of tropospheric ozone on living systems. **[2]**

a. damages the leaves of plants / the ability of plants to photosynthesize / reduces agricultural/primary productivity;
b. reduced PP/global warming may cause loss of habitats/food for animals;
c. damages lung tissue / causes respiratory diseases / lung inflammation
d. eye irritation;

***Note:*** *Do NOT credit "global/local warming" unless explicitly linked to other impacts in living systems, as in MPb. Do NOT credit impacts that are due to increased UV/solar radiation (e.g. cataracts).*

(e) Tropospheric ozone is a major component of photochemical smog. Outline **two** conditions that contribute to high levels of photochemical smog in an area. **[2]**

a. topographic conditions: next to mountains / in a depression/low-lying area traps pollution;
b. climatic conditions: high pressure systems / weak winds / temperature inversions / high insolation / limited rainfall / high temperature;
c. high population urban density: heavy use of fossil fuels due to high vehicle use/industrial output / evaporation of paint and cleaning (VOC- releasing) products;
d. burning of forests increases the formation of primary pollutants that contribute to smog;

(f) $NO_x$ also contributes to acid deposition. State **one** method that could be used to restore an ecosystem damaged by acid deposition. **[1]**

liming / reforestation / restocking fish / extracting toxic metals from water/soils / adding nutrients/fertilisers to soils / adding wood ash / planting acid resistant plants to bind soil;

**3.** (a) With reference to **Figure 3**, identify the stage that represents the greatest food loss and waste in North America. **[1]**

use / stage 5;

(b) Outline **two** strategies to reduce food waste at the **use** stage (stage 5) in North America**.** **[2]**

a. buy only food that will be consumed;
b. pay attention to expiry dates of purchased food;
c. ensure proper storage conditions (at home) to reduce spoilage / avoid pest infestation;
d. buy/consume "ugly"/misshaped fruits and vegetables;
e. donate unsold/unused food;
f. some food items may be re-cooked / put in freezer (for later consumption);
g. education/ awareness campaign to reduce wasteful attitudes related to food consumption;

***Note**: Accept other valid points relevant to <u>use</u> of food; do NOT credit "composting" or any SDW disposal method*

(c) With reference to a stage in **Figure 3**, describe **one** reason for a difference between food loss and waste in a less economically developed country (LEDC). **[2]**

LEDCs might have <u>more</u> waste in stage 1/2/3/4/5…; **[1max]**
…due to… **[1max]**
a. …more pest infestation due to lack of pesticides (stage 1);
b. …poor storing conditions/ higher ambient temperatures increasing spoilage during handling/transportation (stage 2 or 4);
c. ...less efficient facilities/machinery may lead to increased waste during harvest/handling/packaging (stage 2 or 3);

LEDCs might have <u>less</u> waste in stage 1/2/3/4/5…; **[1max]**
…due to… **[1max]**
d. …subsistence farming reduced productivity (stage 1);
e. …local consumption of grown food reducing need for handling and processing (stages 2 or 3);
f. …buying/eating the cheaper "ugly" food (stages 4 or 5);
g. …consuming less food due to less income (stages 4 or 5);
h. ...consuming lower on food chain/less meat (stages 4 or 5);

***Note:** Accept any point of equal significance*
*Only award credit for reasons that are correctly linked with "less" or "more" waste.*

(d) Discuss the sustainability of **two** solid domestic waste disposal strategies that can be used to manage food waste. **[4]**

a. Composting is turning food waste into natural fertilizer / reduces waste to landfill / emits less methane (aerobic composting)…;
b. …but does not apply to meat/dairy/liquids / may associate with pests/disease;
c. Methane collection from landfills would contribute to sustainable/low-impact energy production / sustainably designed landfills (e.g. liner, collecting & treating leachate) is an efficient method of dealing with huge amounts of waste…;
d. …but landfills are notorious for emitting various pollutants contaminating ground/water/air / prevent any possibility of re-using food waste / require large amount of land;
e. Incineration would efficiently reduce volume of food waste / require less land…;
f. …but would release harmful air pollutants / would require a lot of energy/initial investment;
g. anaerobic digestion/fermentation may turn food waste into biogas/fuel...;
h. ...but requires facilities (digesters)/expertise not available in LEDCs;

*Allow **[1 max]** for a conclusion, like "landfill/incineration overall increase EF / composting overall contributes to lower EF" or comparing the sustainability of the SDWs discussed "compost is a less expensive SDW than incineration / compost is less efficient for management of large quantities of food waste"*

*Award **[2 max]** for each SDW strategy (i.e. one mark for positive, one for negative)*

***Note:** only award mark once for same point for different strategies*
***Note:** recycling is not a valid method*

## Section B

**4.** (a) Outline how the ecological footprint (EF) of a country can be measured. **[4]**

a. EF is the area of land and water required to sustainably provide all resources at the rate at which they are being consumed by a given population;
b. find total amount of waste produced from food production/domestic activities;
c. find the total amount of food consumed;
d. find the total amount of water consumed by the population;
e. find the total amount of energy consumed / carbon (dioxide) emissions;
f. find the mean rate of productivity of local vegetation;
g. find the total availability of local water supply;
h. calculate the area of local vegetation/land required to absorb all waste and produce all food / (annual) total consumption rate plus waste emission rate divided by (annual) land productivity;
i. (If per capita rates are initially measured then) multiply per capita EF with population size;

(b) With reference to an aquatic food-production system, explain how renewable natural capital can be sustainably managed. **[7]**

a. sustainable resource management prevents resource/natural capital depletion... / allows full recovery of ecosystems affected by extraction and use of resources... / ...so that the future generations can also benefit from it;
b. renewable natural capital can be generated and/or replaced as fast as it is being used / includes living species/e.g. fish and ecosystems that use solar energy and photosynthesis;
c. estimate maximum sustainable yield (MSY) of fish/marine animal population;
d. avoid overfishing/tragedy of commons / catch restricted to less or equal to MSY;
e. international/national policies/coordination dictating use of quotas/MSY;
f. reduce by-catch;
g. implement sustainable fishing methods (e.g. spearfishing, satellite detection of boats and fish stocks, not fishing a single fish species) / avoid non-sustainable fishing methods (e.g. longlining, bottom trawling);
h. international regulation of fishing grounds / designation of exclusion areas (MPAs);
i. avoid catch of younger fish / increase mesh size of nets / ban fishing in breeding season;
j. education on sustainability principles for fishermen/aquaculturists;
k. stricter monitoring/fining of illegal fishing;
l. legal framework requiring sustainability certification of marine products sold / social responsibility of enterprises involved in fisheries and aquaculture;
m. polyculture approach in aquaculture / feces fed to algae used as fish food;
n. applying sustainable closed-system technologies (in aquaculture) / e.g. recirculating tanks/flow-through systems/inland ponds/raceways / power by renewable energy;
o. reduced stock density in aquaculture (prevents disease spreading);
p. reduced use of antibiotics/pesticides/fertilizers to reduce pollution/contamination of nearby habitat/indigenous species;
q. encourage/fund scientific research on growth rate/productivity/survival/health of fish species raised in captivity;
r. treat aquaculture effluent with bioremediation/absorbing materials/settling ponds/use vegetation as filters;
s. optimize feed composition to reduce food waste / use of probiotics to reduce phosphorus load in fish excrement;

*Accept points of equal significance relating to other renewable natural capital, e.g. algae cultivation, river/lake ecosystems, wetlands, estuaries.*

(c) Human population dynamics are influenced more by social, cultural, political and economic factors than by resource availability.

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** of population dynamics; carrying capacity; ecological footprint; limits to growth; Malthus v Boserup; population policies; pro-natal & anti-natal; contraception; tax incentives; abortion policies; marital age; female emancipation; literacy; religions/ideologies; migrations; wars; child labour; importation of resources; density dependent factors; resource exploitation; sustainable yields; demographic transition; renewability of resources; recycling; etc
- **breadth in addressing and linking** population dynamics (growth and decline) with a wide range of factors including social (e.g. role of women), cultural (e.g. religious imperatives), political (e.g. population policies), economic (e.g. tax incentives), resource availability (e.g. food production, energy, water, pollution management) etc
- **examples** of named social, cultural, political, economic factors that influence population growth in a range of different named countries and societies (MEDCs and LEDCs, Western and Eastern, tropical and temperate) along with examples of different resources that may limit population growth, and different management strategies addressing the availability of resources.
- **balanced analysis** of the extent to which sociopolitical factors are more or less influential than resource availability on the growth and/or decline of human populations considering both the pros and cons for the argument selected.
- **a conclusion that is consistent with and supported by analysis and examples given, e.g.** Human populations in the latter stages of demographic transition are largely regulated by sociopolitical factors and generally it is only the populations at earlier stages of the DTM that are literally limited by resource factors such as famine and water scarcity.

*Please see markbands on page 21.*

**5.** (a) Outline the differences between anthropocentric and ecocentric value systems. **[4]**

*Anthropocentrism **[2 max]***

a. sustainable management is a duty of human societies / environmental manager;
b. population control given equal weight to resource use;
c. strong legal regulation by authorities / imposing environmental taxes, fees, compensations;
d. it is moral for human societies to benefit from natural capital;

*Ecocentrism **[2 max]***

e. nature/ecosystems should be left alone with minimal interference / deep ecologist;
f. self-reliant communities (population controlled by carrying capacity) / use of small-scale technology;
g. self-imposed constraint in resource use;
h. holistic world view / spiritual dimensions to natural systems/intrinsic value / prioritizes bio-rights;

(b) Evaluate the use of an Environmental Impact Assessment (EIA) to ensure the sustainability of a new development project. **[7]**

*Definition **[1 max]***

sustainability is the use and management of resources that allows full natural replacement of the resources exploited / full recovery of the ecosystems affected by their extraction and use / so that future generations may also use them;

*Pros **[4 max]***

a. EIA provides to decision-makers the relevant information on the current situation (baseline study);
b. identifies/predicts the possible environmental impact before the onset of a project;
c. suggests the possible management strategies that would mitigate/prevent any adverse effects of a project;
d. holds policy-makers/entrepreneurs accountable for any decision they will eventually make (in follow-up assessment);
e. takes into consideration social and economic impacts as well/e.g. social acceptance, deterioration of property value/life quality;
f. may be effective in stopping a potentially harmful project;

*Cons **[4 max]***

g. may not prevent the implementation of a project, even if it has severe negative impacts;
h. requires technical expertise that might not be available in all countries/situations;
i. if funded by the enterprise developing the project, it might be biased;
j. in most countries, the legal/regulatory framework is not well established / lack of standards/official training for practitioners;
k. some environmental factors/impacts may not be readily quantified / e.g. life/landscape quality / may fail to properly study some environmental factors;
l. may not include socio-economic impacts;
m. it may be more profitable for an enterprise to pay a fine for ignoring EIA's precautions;
n. may delay the implementation of a project due to time consuming procedure.

*Conclusion **[1 max]***

Despite the shortcomings of an EIA, becoming a legal requirement for major projects has reduced the adverse environmental impacts/resulted in higher social responsibility of enterprises / Even a "perfectly" implemented EIA may not guarantee the future sustainability of a project, as environmental conditions may change (e.g. climate change).

(c) Urbanization has had a greater effect on the quality and availability of freshwater resources than agricultural activities.

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

*The following guide for using the mark bands 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** of urbanization, waste-water treatment; leaching of heavy metals; sedimentation; suspended solids; landscape changes; well-drilling; aquifers; urban growth; grey water cycling; acid precipitation; reverse osmosis; pesticide pollution; bioaccumulation; biomagnification; irrigation; flooding; drip irrigation; leaching of fertilisers; eutrophication;
- **breadth in addressing and linking** urbanisation and agricultural activities with a range of associated impacts on quality and availability of freshwater including pollution; waste disposal; sustainable management; overexploitation; development of irrigation/drinking systems/dams etc
- **examples** of named pollutants from urban and agricultural sources; named strategies for sustainable management of water in urban and agricultural contexts; named countries/societies in which issues arise;
- **balanced analysis** evaluating the relative impact (negative or positive) of both urbanisation and agriculture on water quality and availability and the extent to which these may be mitigated through sustainable management
- **a conclusion that is consistent with and supported by analysis and examples given,** e.g. although urbanization creates a broader range of negative effects on freshwater quality than agriculture it also provides methods for the production of freshwater from sewage and sea water.

*Please see markbands on page 24.*

**6.** (a) Outline how species diversity in an ecosystem can be measured. **[4]**

a. species diversity in communities is a product of two variables: the number of species (richness) and their relative proportions (evenness);
b. name an appropriate index, e.g. Simpson's diversity index / Shannon's index;

*To calculate Simpson's Index:*

c. the area must be sampled, e.g. using quadrats placed randomly or systematically/pitfall trap/mark–recapture;
d. several samples need to be taken and the data pooled (to give a better estimate of overall diversity);
e. the number of individuals of <u>each</u> species (abundance) should be noted in each sampling plot;
f. there is no necessity to be able to identify all the species, (provided they can be distinguished from each other);

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

g. calculate diversity index by using a valid formula, like
*n* = the total number of organisms of a particular species
*N* = the total number of organisms of all species
[***Note****: credit only if all symbols are explained; accept different formulas as found in literature*]
h. with this index, the higher the value of *D*, the higher the species diversity;

***Note:*** *Accept any other relevant measurement to those given.*
*Do NOT credit Lincoln's index formula.*

(b) Explain how the movement of tectonic plates has influenced biodiversity and evolution. **[7]**

a. plate tectonic movement may lead to divergence of continents/growth of mountain ranges/opening of oceans/formation of islands…;
b. …which separates populations/species from each other / isolates gene pools…;
c. …leading to <u>divergent</u> evolution/action of natural selection/genetic drift / accumulating different mutations over (geological) time…;
d. …as they have to adapt to different habitats/climates/environmental pressures (in order for fitter species to survive)…
e. ...causing <u>speciation</u> (thus, increasing biodiversity);
f. ...or may shift population in harsher climatic/habitat conditions, causing their extinction (thus reducing biodiversity);
g. plate tectonic movement may lead to formation of land bridges / closing of oceans…;
h. …which brings different populations/species in contact / opens novel migration routes…;
i. …leading to interspecific competition / competitive niche exclusion…;
j. …which might cause the extinction of less fit species (reducing biodiversity);
k. …also leading to hybridization/interbreeding of related species / increased gene exchange/flow…;
l. …which may either reduce genetic differences / lump related species (thus, reducing biodiversity);
m. …or create a new species better adapted to intermediate/new habitat / e.g. introgression in plants (thus, increasing biodiversity);

***Note**: Do NOT credit description of evolutionary process (mutations / natural selection / survival of fittest / fitter genes dominating a population / speciation) outside the context of plate tectonics movement.*

(c) Discuss the effectiveness of habitat-based conservation in relation to the impacts of climate change. **[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** of habitat-based conservation; species-based conservation; reserves; national parks; size; shape; edge effects; corridors; buffer zones; ecotourism; climate change; precipitation patterns; global warming; biome shifts; migrations; extinctions; salinity change; melting glaciers; hazardous weather events; droughts; rising sea levels; salt intrusion etc
- **breadth in addressing and linking** a good range of features of habitat-based conservation including design and management of reserves and their relevance in addressing a range of impacts from climate change including those leading to loss of biodiversity and changing distribution patterns.
- **examples** of named conservation areas from a variety of named regions/countries and examples of named species impacted by climate change along with relevant named organisations currently addressing habitat conservation (e.g. World Wildlife Fund for Nature, Greenpeace, Friends of the Earth International and Earth First!)
- **balanced analysis** evaluating the degree to which the various aspects of conservation areas can or cannot effectively address the threats of climate change including both strengths and limitations of habitat-based conservation.
- **A conclusion that is consistent with and supported by analysis and examples given**, *e.g.* habitat-based conservation strategies are effective, especially when contrasted to species approach, but cannot compensate for climate change impacts on their own; there needs to be international cooperation and political will toward mitigating climate change altogether.

*Please see markbands on page 21.*

**7.** (a) Outline **four** characteristics of a highly productive soil. **[4]**

a. presence of sufficient basic nutrients (minerals) / e.g. nitrates, phosphates, potassium;
b. contains adequate organic/humus content to retain moisture/good water-holding/infiltration capacity;
c. pH is optimal for plants grown (usually 5.5 to 7.0);
d. loamy soil/ balanced clay, silt, sand composition…;
e. …leading to optimal soil properties: balanced drainage/infiltration/permeability / adequate porosity/protection from water-logging;
f. thick topsoil / deep soil layers provide higher water/nutrient holding ability / better plant support / less water-logging;
g. rich microbiota/decomposing microorganisms/nitrogen-fixing bacteria (including symbiotic Rhizobia)/mycorrhizal fungi / high decomposing activity / high biological mixing;
h. absence of toxic substances;
i. presence of adequate secondary nutrients (minerals) / e.g. sulphates, magnesium/calcium/iron/copper salts;

***Note**: Do NOT credit soil colour*

(b) Compare and contrast the movement of energy and matter within an ecosystem. **[7]**

*Similarities ("Compare")* ***[4 max]:***

a. both move/flow between/across (biotic and/or abiotic) storages/compartments / e.g heat loss from an organism's body and biomass moving up the food chain / solar energy heating the oceans and nutrient intake by a plant;
b. both move/flow within (biotic and/or abiotic) storages/compartments / e.g. water moving from roots to leaves (within plant storage) / light passing through the atmosphere;
c. Both transfers may occur simultaneously/ e.g. river flow, wind advection, chemical energy in ingested biomass/decomposed feces;
d. both may be transformed during their movement (transfer) / e.g. solar energy heats the atmosphere and plant biomass becomes animal biomass up the food chain;
e. both follow the First Law of Thermodynamics / neither energy nor matter may be destroyed or created / both are conserved during their movement;
f. both follow the Second Law of Thermodynamics / any process involving either energy or matter movement will lead to increase in the total entropy (disorder) of the system / energy "lost" as heat and materials disintegrate;
g. both are important ecosystem inputs / organisms would die/ecosystems would collapse without either energy or material input;
h. both may leave ecosystems as outputs / e.g. heat loss and migration/leaching;

*Differences ("Contrast")* ***[4 max]:***

i. there's continuous influx/input of solar energy in Ecosphere /ecosystems…
j. …whereas matter inflow is virtually zero in ecosphere (as Earth is a closed system) / very limited in open (eco)systems;
k. there's continuous heat loss/radiation from ecosystems/Ecosphere /energy output is also the reflection of light/albedo... ;
l. ...whereas loss of matter from ecosystems is relatively insignificant / e.g. in the form of immigration/leaching / matter output is virtually zero in ecosphere (as Earth is a closed system);
m. matter is mostly cycled (i.e. biogeochemical cycles) within the ecosphere…;
n. … whereas energy follows a uni-directional (and irreversible) movement: solar to chemical to heat / moves mostly as chemical energy within ecosystems / also stored as thermal energy inside bodies (living or inanimate);

***Note****: Allow credit for points of equal significance and validity if response compares and contrasts valid examples of movements, e.g. solar radiation/heat loss vs. precipitation/wind.*
*No need to explicitly mention whether KS refers to similarity or difference.*
*Do NOT credit that matter is tangible, whereas energy is intangible, as this is a property of their nature not their movement.*

(c) To what extent are food production systems impacted by anthropogenic (human-caused) changes to the atmosphere. **[9]**

*The following guide for using the mark bands suggests certain features that may be offered in responses. The five headings coincide with the criteria in each of the mark bands (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 mark band and the specific mark within that band.*

*Answers may include:*

- **understanding concepts and terminology** of food production systems; subsistence; commercial; intensive; extensive; terrestrial; aquatic; acid rain; global warming; climate change; precipitation patterns; hazardous weather events; inundation; ocean acidification; ozone depletion; tropospheric ozone; photochemical smog;
- **breadth in addressing and linking** a wide range of anthropogenic impacts on the atmosphere's composition and temperature with their associated impacts (both positive and negative) on a wide range of food production systems in different environments/regions.
- **examples** of named impacts on named food production systems in named locations and societies due to named anthropogenic influences on the atmosphere.
- **balanced analysis** evaluating the extent to which anthropogenic impacts on the atmosphere do or do not influence food production systems either positively or negatively.
- **a conclusion that is consistent with and supported by analysis and examples given,** *e.g.* There are a wide range of anthropogenic influences on the atmosphere that impact both terrestrial and aquatic food production systems and although some impacts may positively affect productivity, the great majority tend to reduce it.

*Please see markbands on page 21.*

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