Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2023

Environmental systems and societies

Standard level

Paper 1

13 pages

Subject details: Environmental systems and societies SLP1 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions
- The maximum total = **[35]**.

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

When using marking points:

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 **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded**

iv. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

When using markbands (Only 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 underlined 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.

1. (a) With reference to Fig 2(b), outline one difference between the climates of Crescent City and Desert Center

a. rainfall is higher in Crescent City / rainfall is lower in Desert Center;
b. wider variation in rainfall through the year in Crescent City / minimum variation in rainfall in Desert Centre;
c. (maximum/minimum) temperature is higher in Desert Center / (maximum/minimum) temperature is lower in Crescent City;
d. annual temperature range is greater in Desert Center / annual temperature range is smaller in Crescent City; **[1]**

Do not accept only 'warmer/drier climate'. The response should be a comparative for credit not just a description of the climate at each location.

(b) With reference to Fig 2(b) and 2(c), state the biome found around Crescent City.

a. coniferous forest; **[1]**

Do not accept only 'forest'

2. (a) Using Figure 3 and the identification key below, identify species A and B.

a. Species A: Sitka spruce (*Picea sitchensis*);
b. Species B: western hemlock (*Tsuga heterophylla*); **[2]**

Note: only mark the first answer if more than one species is named.

(b) With reference to Figures 4(b) and 4(c), state the species interaction between the giant sequoia (*Sequoiadendron giganteum*) and the long-horned beetle (*Phymatodes nitidus*)

a. mutualism; **[1]**

Do not credit only 'symbiosis' or just a description of the interaction.

(c) State one value of the giant sequoia (*Sequoiadendron giganteum*).

a. cultural/aesthetic/spiritual value (for Californians);
b. ecosystem/ecological/environmental;
c. economic/market value;
d. intrinsic value;
e. future/existence value; **[1]**

Do not credit examples of the different values eg 'acts as a carbon sink/provides a habitat'.

(d) With reference to Figures 4(a) and 4(d), identify one reason why the giant sequoia (*Sequoiadendron giganteum*) is listed as endangered in *the International Union of Conservation of Nature (IUCN) Red List of Threatened Species*.

a. loss of habitat / reduction in quality of habitat / fragmentation of habitat;
b. reduction in population size;
c. small geographic range / reduction in geographic range / area of Giant sequoia groves is small;
d. small number of mature/adult individuals / small population size;
e. probability of extinction; **[1]**

Do not accept only 'population size/deforestation'.
Do not accept 'found in middle of California / only one big Giant sequoia grove'.

3. (a) State the trend in number of individual wildfires in Figure 5(b).

a. steady-state (equilibrium) / stable / fluctuating (around 8000) / falls and rises; **[1]**

Do not accept an overall increase/decrease/unstable/no trend.

(b) With reference to Figures 5(a) and 5(b), suggest why the area burnt in 2020 was greater than the area burnt in 2013.

a. drier/windier conditions led to larger (individual) fires;
b. drier/windier conditions allowed (individual) fires to burn longer;
c. drier/windier conditions made it more difficult to put out (individual) fires;
d. insufficient control burning prior to 2020 allowed vegetation to accumulate and led to more intense fires/fires which spread more easily/over larger areas;
e. low number of fires in 2019 allowed vegetation to accumulate and in 2020 led to more intense fires/fires which spread more easily/over large areas / less vegetation prior to the fires in 2013 led to smaller fires/less intense fires than in 2020;
f. COVID contributed to less fire fighters leading to larger (individual) fires/fires burning longer; **[1]**

Note: *Do not accept there were more fires, as the number is the same.*
Do not accept only 'it was drier/windier in 2020'.
Do not accept 'it was due to urbanization/global warming/higher temperature'.

(c) Explain how wildfires act as a positive feedback mechanism for global warming.

a. smoke from fires adds (black) carbon/soot to the atmosphere (which absorbs incoming solar radiation reducing albedo);
b. more UV reaches the ground, which absorbs the energy and re-releases it as longwave radiation/heat;
c. this results in an increase in global temperatures/global warming;
d. hotter and drier conditions/global warming increases the risk of more fires; **[3]**

OR

e. CO_2 is released by burning trees/wildfires;
f. CO_2 is a greenhouse gas (which absorbs outgoing longwave radiation);
g. GHGs contribute to global warming;
h. hotter and drier conditions/global warming increase the risk of more fires; **[3]**

OR

i. fewer trees reduce the carbon sink/more CO_2 in the atmosphere due to less photosynthesis;
j. CO_2 is a greenhouse gas (which absorbs outgoing longwave radiation);
k. GHGs contribute to global warming;
l. hotter and drier conditions/global warming increases the risk of more fires; **[3]**

Note: *Accept any other appropriate positive feedback loop.*
Do not credit 'wildfires directly increase global temperatures by the heat they release'.

(d) Describe the process of succession after a wildfire has occurred in the forest.

a. removal of trees open the canopy, allowing sunlight to reach the forest floor/removing limiting factor of shade conditions;
b. burning trees produce nutrient-rich ash increasing soil fertility;
c. growth of seeds which survived the fire/released by the fire/were blown/carried in from surrounding unburnt areas;
d. rapid growth of annual plants / in early stages of succession there are pioneer species/r-selected species;
e. replaced in time by slower growing species / change from r-selected species to K-selected species;
f. climax community of (coniferous) forest reached after many years;
g. large time delay due to slow growth of climax community;
h. each new sere changes the abiotic conditions, allowing for different plants to survive / as conditions change some species will outcompete/replace others; **[3]**

4. (a) With reference to Figures 6(a) and 6(b), identify one conflict over freshwater resources in California.

a. agricultural irrigation v. urban demand/protected rivers/endangered species/environment;
b. hydroelectric power/hydropower generation v. agricultural irrigation/urban demand/protected rivers/endangered species/environment;
c. urban demand v. protected rivers/endangered species/environment;
d. conflict over transfer of water from source area (Sierra Nevada);
e. conflict between farmers (for irrigation);
f. conflict between different users in urban areas (residential v. industrial use); **[1]**

Do not accept answers that refer to problems of supply rather than conflicts between different users. Eg.: 'snow in Sierra Nevada mountain is decreasing due to global warming reducing possible supply of water / water transfers are powered by electricity'.

(b) With reference to Figure 6(c), outline two ways in which individuals in California could meet the 2030 target for indoor daily water use.

a. grey-water/water recycling could reduce use by providing a reusable source;
b. rainwater capture on buildings could be used to flush toilets/water gardens reducing demand;
c. water meters could be adopted to encourage less water usage / water meters could measure use with fines for exceeding allocated amount/with bonuses for people who reduce use;
d. government could set a quota on amount of water that can be used / use of water restrictions e.g. ban on using hose pipes/washing cars/watering lawns;
e. increasing the price of water to encourage less usage/waste / water tariff rates that increase as use increases;
f. use of more efficient water-saving appliances e.g. washing machines/low flush toilets/low flow shower heads;
g. practising individual conservation techniques e.g. turning off the tap when brushing teeth, taking showers instead of baths, having shorter showers, not using water in gardens/swimming pools etc.;
h. repair leaky taps/pipes/water system within the household;
i. education/campaigns to teach people how to stop wasting water; **[2]**

Award max one mark for examples of practising individual conservation techniques.
Do not accept 'repair leakages in infrastructure/mains water pipes'.
Do not accept only 'education/increase public awareness/management/change in lifestyle/policies/regulations'.

(c) Using Figure 6(c), calculate the percentage decrease in mean daily water use per person between 1990 and 2020.

a. ((1050-454)/1050 x 100) = 56.76 / 57 / 56.8 (%); **[1]**

5. (a) With reference to Figure 7(b), state the relationship between irrigation water salinity and crop yield potential.

a. inverse / negative;
b. as (irrigation water) salinity increases, crop yield potential decreases / as salinity decreases, crop potential increases; **[1]**

Note: *Do not accept in the converse. e.g. 'as crop yield potential decreases it causes the salinity to increase'.*

(b) Explain how irrigation has reduced soil fertility in the Central Valley.

a. irrigation water is often pumped up from underground/from wells;
b. groundwater contains (mineral) salts / water used for irrigation may contain salts/be saline;
c. in areas of high evaporation/dry/semi-arid climates, water evaporates from the surface, leaving salts behind;
d. the dissolved sodium (Na^+) and chloride (Cl^-) ions can displace other mineral nutrients in the soil needed for plant growth, such as potassium (K) and phosphorus (P) / minerals required for plant growth are replaced ;
e. salin(is)ation of soils/over time the salts build up, leading to levels higher than macroinvertebrates/decomposers can tolerate;
f. reduction in macroinvertebrates/decomposers may reduce nutrient cycling;
g. excessive irrigation can lead to leaching of nutrients from the soil (reducing soil fertility) / irrigation can lead to erosion of fertile top soil;
h. excessive irrigation can lead to water-logging/rise in water table and poor aeration of the soil, reducing nutrient cycling;
i. irrigation leads to an increase in plant growth that utilizes/absorbs nutrients from the soil (hence reducing soil fertility over time); **[3]**

Note: *do not accept just "salin(is)ation" or "leaching" as this does not explain why loss of soil fertility occurs.*

(c) Evaluate one strategy that almond farmers in the Central Valley could use to increase sustainability.

Note: *Do not credit 'reduction in use of pesticides' as a strategy on its own. It should be considered as a component of Option 3: organic production when considering advantages/disadvantages with potential max 3 marks.*

Option 1: shift to drought-tolerant/drought-resistant crops;
Advantages:
reduces water use by irrigation;
reduces salin(is)ation of soils;
reduces potential groundwater contamination;
reduces ground subsidence due to high extraction;
Disadvantages:
growing less economically valuable crops reduces income;
other crops may not grow as well, reducing income;

Option 2: use better irrigation techniques/trickle-drip irrigation/micro-irrigation/precision irrigation technique;
Advantages:
uses less water / reduces water losses;
reduces salin(is)ation of soils;
reduces soil erosion;
Disadvantages:
irrigation systems are expensive;
prone to clogging/dysfunction / can require high maintenance;
still involves irrigation in a semi-arid climate so still needs water;

Option 3 : move to organic production of almonds;
Advantages:
reduces pesticides found on food (human health);
reduces pesticides harming bees/non-target species/contamination of water/soil;
prevents the bioaccumulation of pesticides/residues within organisms;
growing interest in organic food will increase demand/income;
Disadvantages:
may reduce overall harvest, reducing income;
more expensive to produce;

Option 4: polyculture/crop rotation;
Advantages:
reduces levels of pests/disease / reduces needs for fertiliser/pesticides due to companion planting/crop rotation;
provides greater biodiversity for beneficial insects/pollinators;
diversification increases resilience with changing weather conditions;
increases yield (per hectare) / increase in potential farm income;
replenishes nutrients/soil fertility e.g. growing leguminous crops, reduces need for (inorganic) fertilisers;
Disadvantages:
can be more difficult to harvest almonds due to reduced space around trees;
can reduce productivity of almond trees due to competition for space/water/mineral nutrients;
requires more knowledge about growing other crops;
may need more land/equipment/resources;
other crops may have less monetary value/reduction in income;

Option 5 soil conservation techniques/terracing/contour ploughing/wind breaks/mulching;
Advantages
reduces loss of soil to wind/water erosion;
reduces loss of water;
mulching adds nutrients to the soil;
Disadvantages
increase cost of terracing/planting trees/mulching;
loss of productive land to wind breaks;

Option 6: Integrated pest management/control / biological control of pests;
Advantages:
reduces use of chemical pesticides and associated impact on non-target species/contamination of water/soil;
slows the development of pesticide resistance;
cheaper than using chemical pesticides/conventional pest eradication methods;
Disadvantages:
close monitoring is required;
does not completely eradicate pests / some crop losses will occur;
biological control may only be effective in certain environmental situations;
takes time to establish;
education of farmers is required to implement effectively;
some biological control agents can become invasive;

Conclusion [1 max]: requires a balanced argument and a clear value judgement, such as, “while more efficient irrigation systems can be expensive to install, the reduction in salin(is)ation of soils boosts productivity, resulting in greater income for farmers in the long run.”
The conclusion is not mandatory. **[4]**

Note: *reserve one mark for the strategy, maximum two for advantages, maximum two for disadvantages. Alternatively, one mark for a balanced conclusion with a minimum one mark each for advantages and disadvantages.*
Accept ECF for advantages and disadvantages where an incorrect strategy is given.
Accept other reasonable strategies eg use of grey-water /recycled water.
Do not assume students will know that almonds grow on trees.

6. Outline two factors that have influenced the choice of energy sources adopted by California, as shown in Figure 8(b).

a. availability of renewable/natural resources e.g. windy/sunny climate/presence of natural gas/biomass / limited/reduction of hydropower due to increasing drought / high agricultural activity produces material for biomass;
b. looking for energy security as they do not wish to import energy from Mexico in the future;
c. renewables may be cheaper to generate / improvements in technology are reducing cost of renewables / California can financially afford to use nuclear power/develop renewables / opt for natural gas because it is relatively cheap;
d. to meet GHG emission reduction targets, California may replace coal with cleaner burning gas/nuclear / to meet renewable energy targets/GHG emission reduction targets/carbon-free electricity target, California may use renewable energy sources;
e. natural gas is more reliable than renewables/does not depend on weather;
f. strong anti-pollution laws/campaigns/cultural attitudes may be leading them away from burning fossil fuels/toward renewables / (environmental values which lead to) improving sustainability by opting for renewables;
g. nuclear energy use is relatively low due to concerns over safety/nuclear waste; **[2]**

Do not accept statements copied directly from the Resource Booklet e.g. 'California has plan to produce 100% carbon-free electricity by 2045'.
Do not accept just 'geographical location/accessibility/cost/insolation/water shortage'.
Do not accept 'availability of renewable resource' without a specific example.
Do not accept 'natural gas is easier to extract'.

7. With reference to the information in the resource booklet, discuss the effectiveness of California's actions in mitigating climate change.

Is effective [4 max]

a. California is the top producer of renewable energy in the USA, reducing GHG emissions / large proportion (54%) of electricity comes from renewable sources which reduces GHG emissions / move to 100% renewable electricity sources reduces future GHG emissions;
b. California has reduced use of coal to less than 1% (by increasing use of renewable energy) which reduces CO_2/GHG emissions;
c. by 2035 all new sales of cars will be 100% carbon-free, reducing GHG emissions;
d. cutting power to homes during strong winds/burying power lines/campaigns will reduce risk of wildfires, which reduces release of CO_2/protects carbon sinks;
e. new development must consider fire risk hazards in impact assessments;
f. large number of Californians are vegetarian, which reduces meat consumption and therefore reduces release of methane ;
g. protecting giant sequoia trees/wetlands helps to protect carbon sink/absorb CO_2;
h. reduce use of water (per person) reduces the energy/electricity needed for water pumps/distribution and may lower CO_2/GHG emissions;

Is not effective [4 max]:

i. change in government may change policies in the future;
j. 40% of electricity is still produced by natural gas, which is a fossil fuel and therefore emits GHG when burnt;
k. cannot produce enough electricity to meet demand, as need to import energy from Mexico and out of state (don't know how that energy is produced);
l. people will still be able to purchase cars from neighbouring states and drive them in California / citizens will still be able to drive older carbon-fueled vehicles;
m. power cuts during high fire hazard periods mean electric cars cannot be charged, so this is not an effective solution;
n. population is growing, suggesting more cars on the road in future/residential GHG production will increase;
o. wildfires are increasing, which will add CO_2 to the atmosphere;
p. wildfires will reduce carbon sinks / wildfires reduce number of trees and therefore the absorption of CO_2;
q. agricultural output is a major cause of GHG, and California is a major producer of food / transportation of farm produce (e.g. almonds/meat) produces CO_2/GHGs;
r. water transfers/pumping require high levels of energy, which will increase energy demand in the future due to increased drought conditions (which may involve burning fossil fuels);

Conclusion [1 max]: requires a balanced argument and a clear value judgement, such as, "While California's move to renewable electricity generation will greatly reduce the combustion of fossil fuels, the large number of forest fires will reduce its ability to mitigate climate change". **[6]**

Accept other reasonable responses supported by the information in the resource booklet.
Note: *Do not accept conclusions which do not refer to California's actions, such as, "California cannot stop climate change."*