2226 – 4622M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2026

Environmental systems and societies

Higher level

Paper 1

20 pages

Subject details: Environmental systems and societies HLP1 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions
- The maximum total = **[70]**.

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.

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) Using **Figure 2(d)**, identify the abiotic factor that most limits productivity and biodiversity in the Atacama Desert surrounding the city of Antofagasta. **[1]**

Average annual precipitation/precipitation/rainfall/water availability;

Note to examiners: *If two abiotic factors are given, mark only the first response.*

(b) Using **Figure 2(d)**, evaluate **one** appropriate renewable option for electrical energy in terms of energy security and economic benefit for Antofagasta and the economy of northern Chile. **[4]**

Solar

Advantages [3 max]:

a. 7–9 hours of sunlight (with low precipitation so few clouds) make solar energy generation/production (of electricity) a viable option;
b. Cool average temperatures (e.g. less than 25°C) make the solar panels work efficiently, improving energy security;
c. Marginal/inexpensive land available (for solar panels) in the Atacama Desert / solar panels can be installed on undeveloped land/roofs, generating income for the area;
d. Once constructed, a solar facility/plant produces (relatively) inexpensive energy (compared to non-renewables)/has low maintenance costs;
e. Mines/the city require large/substantial amounts of electricity providing a market / excess energy produced can be sold internationally/exported (generating income);
f. Producing energy locally would decrease need to import more resources, increasing reliability of supply/reducing dependency on imports/reducing costs from imports;
g. Diversification of energy sources increases reliability of supply and therefore energy security;
h. Construction/maintenance of solar farms could provide local people with jobs (boosting the economy);
i. Small-scale solar farms/individual production could bring electricity to remote communities (in the Atacama Desert), increasing energy security;
j. Advances in thermal energy storage (e.g. sand batteries) make it more reliable, increasing energy security;

Disadvantages [3 max]:

k. Initial construction of solar plant is expensive/costly / funds used for initial construction could be better used for other purposes in the region which would enhance economic development more effectively;
l. Energy needs to be supplemented during periods of no/low production, which increases costs;
m. Low energy efficiency of solar power may be insufficient to power mines/industry;
n. Solar energy is dependent on sunlight, reducing reliability / Variability of supply/intermittent supply requires energy to be supplemented, which means energy is unreliable;
o. Large-scale solar farms (in the mountains) may cause visual pollution, reducing income from tourism;
p. Large-scale solar farms require significant amounts of land, which means it cannot be used for other economic purposes (e.g. agriculture or urban development);

continued

Wind Farms

Advantages [3 max]:

a. (Coastal) winds are strong enough for wind power generation (4-6 m/s) / Coastal areas typically have consistent/onshore winds, creating reliable energy;
b. Marginal/inexpensive land available (for wind farms) in the Atacama Desert / free offshore space is available (for wind farms);
c. Once constructed, a wind farm produces (relatively) inexpensive energy (compared to non-renewables);
d. Construction/maintenance of wind farms could provide local people with jobs;
e. Small-scale wind production could bring electricity/power to remote communities (in the Atacama Desert), increasing energy security;
f. Land used for wind farms can also be used for agriculture, which generates additional incomes/diversifies income;
g. Mines/the city require large/substantial amounts of electricity providing a market / excess energy produced can be sold internationally, generating income;

Disadvantages [3 max]:

h. Initial construction of wind farms is expensive/costly;
i. Wind is unreliable, which means mines/industry/urban areas would need to supplement wind energy with other sources, making it more expensive/reducing energy security / winds are stronger in southern Chile, so it may be better economically to spend the money on developing wind energy elsewhere;
j. Wind farms offshore/at sea may interfere with fishing industry/shipping lanes/boats;
k. Wind farms may be considered visual pollution, reducing income from tourism;

***Note to examiners**: Figure 2(b) only provides evidence for evaluation of solar/wind. No marks are awarded if a different renewable is discussed (e.g. hydropower, tidal, geothermal). Maximum 3 marks if only advantages or disadvantages are addressed. Statements must address either energy security or cost to be awarded the mark. One mark can be awarded for a balanced conclusion with a clear opinion, e.g. While the initial cost of wind farms can be expensive, overall, they are an appropriate approach to energy security as once built they will generate essentially free electricity, also benefiting the economy.*
Do not accept "solar/wind energy is cheap".

(c) With reference to **Figure 2(e) and Figure 2(f)**, outline the role of differences in air density on the average annual temperature of Antofagasta. **[2]**

a. Cold ocean current/Humboldt Current results in cooler/denser air along the coast;
b. Cool/dense air pushes the less dense/warmer air up into the mountains;
c. Cooler/denser air moderates/cools the climate along the coast (during the summer months);
d. Annual temperature range is less extreme on the coasts than inland due to the moderating influence of the cooler ocean air;

***Note to examiners:** Response must refer to both air density and temperature to gain full marks.*

(d) Using **Figure 2(g)**, identify the ecosystem with the highest carbon storage in the Punta Arenas region. **[1]**

a. Peatlands and tundra;
b. Forests and shrublands;
c. Steppes and grassland;

Note to examiners: *All responses are acceptable based on how the student interprets "region" in the question. Do not accept only part of the response e.g. "peatlands", "tundra"*

(e) Using **Figure 2(d) and Figure 2(g)**, explain how the carbon storage process is influenced by climate in the ecosystems around Punta Arenas. **[2]**

a. Cold/cool temperatures decrease the rate of carbon capture due to limited photosynthesis;
b. Cold/cool temperatures reduce losses of carbon to the atmosphere through respiration/decomposition (so more carbon is stored);
c. Permafrost (of tundra)/frozen ground (in the tundra/at high altitudes) prevents decomposition (of stored carbon) and thus keeps carbon from entering the atmosphere;
d. Low sunlight availability/seasonality of sunlight availability results in a reduction in photosynthesis and therefore less carbon storage (by plants);
e. High rainfall/precipitation leads to greater/more photosynthesis and therefore more carbon capture (by plants);
f. Cold water has a higher carbon storage capacity;
g. As the climate warms, permafrost may thaw, leading to the release of stored carbon/methane into the atmosphere;

Note to examiners: *Do not accept responses which simply identify the level of productivity of the ecosystem without an appropriate link to climate.*

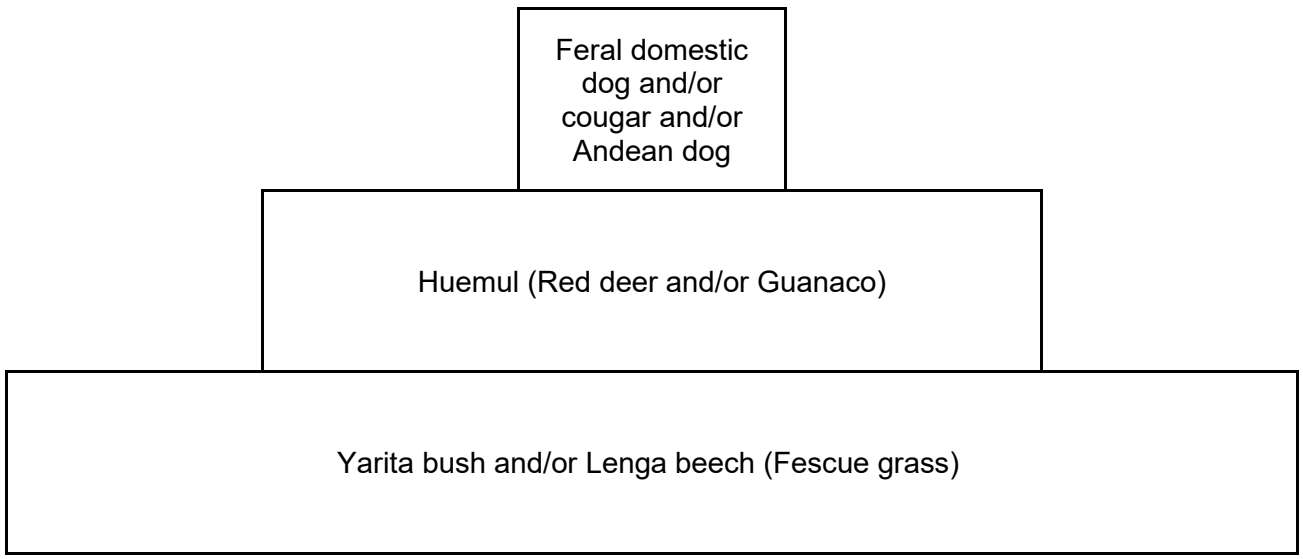
(f) With reference to **Figure 2(h) and Figure 2(i)**, explain how topographical factors in the region impact the development of a sustainable forestry industry. **[3]**

a. Selective cutting/harvesting/removal of trees/planting is more difficult/expensive on steep/mountain slopes;
b. Tree removal/harvest exposes the soil and alters infiltration (and percolation), leading to increased run-off of water/decreasing water storage which impacts re-growth;
c. Regrowth of new/planted trees is limited/slowed by loss of soil/organic material/nutrients due to landslides/erosion/runoff down the slopes;
d. Mountainside/topography/steep slope makes erosion worse/soil replacement slower;
e. Access roads (to move product/trees/equipment) are more difficult to build/maintain due to erosion/steepness;
f. Mountain-based tourism creates land-use conflicts with forestry (due to different value systems);
g. As mountain regions are typically sparsely populated, there is land available for developing forestry;

Note to examiners: Allow any other reasonable points linked to the difficulties of forestry in mountain environments/topography. Accept points in the converse, e.g. "flatter/less steep regions are easier to access and therefore less expensive to develop." Do not double-credit alternate arguments.

2 (a) Using **Figure 3(a) and Figure 3(b)**, draw a pyramid of energy that includes the huemul. **[1]**

Pyramid should have three (or four) levels, with the organisms placed in the appropriate step/level, e.g. bottom step – Yarita bush, Lenga beech, (Fescue grass), second step - Huemul, Red deer, Guanaco, top step - Andean fox, Feral domestic dog, Cougar (Cougar could possibly be on a fourth level).



Note to examiners: *Pyramid must have clear levels or steps. Do not accept food chains. Students can approach this question in a variety of ways. Accept any response which either shows clear steps (to indicate the loss of energy at each trophic level) or a triangle which indicates the 90% loss of energy with each transfer. The species must be named (e.g. do not accept "leaves and plants", "dog"), but the student can identify any or all species which interact with the huemul.*

(b) With reference to **Figure 3(b)**, outline how the spread of feral red deer across the Andes could impact the huemul population positively and negatively. **[2]**

Positive impact [1 max]:

- predators may focus on red deer rather than huemul, reducing deaths;
- increased conservation efforts (due to publicity of feral deer spread) which protects huemul/habitat/food source;

Negative impact [1 max]:

- (interspecific) competition with red deer for food/habitat/niche could reduce huemul population/breeding success;
- humans engaging in (red deer) culling programs could shoot a huemul by error (as they inhabit a similar habitat);
- diseases that develop in red deer could move to/infect huemul;

Note to examiners: *Response must have one positive and one negative impact for full marks to be awarded.*

(c) With reference to **Figure 3(d)**, describe how global warming could impact the carrying capacity of huemul in their natural habitat. **[3]**

a. Warmer temperatures/global warming increases primary productivity/plant growth/photosynthesis;
    i. This provides more food resources for the huemul;
    ii. increasing carrying capacity;
b. Warmer temperatures/global warming increases primary productivity/plant growth/photosynthesis;
    i. This might result in greater competition as red deer numbers also increase;
    ii. decreasing carrying capacity;
c. Global warming/warmer temperatures will cause glaciers to melt/retreat;
    i. Exposing more potential habitat for the huemul;
    ii. increasing carrying capacity;
d. Global warming/higher temperatures could increase wildfires/drier conditions/drought;
    i. This would decrease food resources/destroy habitat;
    ii. decreasing carrying capacity;
e. Global warming leads to climate change, which may decrease precipitation;
    i. This would decrease plant productivity/photosynthesis resulting in less food availability;
    ii. Reducing carrying capacity;

Note to examiners*: Do not credit the limiting factor effect (i. and ii.) without a valid accompanying link to global warming.*
Score only one description of global warming impact. Accept any other reasonable impacts of global warming on the carrying capacity.

(d) With reference to **Figure 3(b), Figure 3(d) and Figure 3(e)**, outline the effectiveness of a specific *in situ* conservation strategy to improve the IUCN category of the huemul. **[4]**

a. Give the huemul protected status;
   i. This can be done through legislation;
   ii. Makes poaching/hunting illegal;
   iii. Allows the huemul population to increase;
   iv. Raises awareness of huemul, could generate more funds for conservation through tourism;
   v. Can be difficult to police/ensure protection as the huemul is found in high altitude environments;
   vi. Can be expensive to hire conservation officers to monitor/protect species;
   vii. The huemul already has protected status but is still endangered, so protection has not been effective;

b. Increase number of wildlife refuges/protected areas;
   i. This increases area of occupancy/food resources/carrying capacity;
   ii. This decreases potential habitat destruction (from logging/agriculture)/preserves habitat;
   iii. Provides protected areas for other species, benefiting overall biodiversity;
   iv. Could reduce interactions with humans/tourists, reducing stress / reduces illegal hunting/poaching;
   v. May involve relocation of local inhabitants, creating conflict / political challenges / may create conflict with local inhabitants due to loss of ancestral lands/traditional grazing areas;
   vi. Requires funding for purchase of land/employing officers to manage the park/enforce wildlife protection measures;
   vii. Large number of wildlife refuges already in place, but still endangered, so it has not been effective;

c. Build wildlife corridors;
   i. Wildlife corridors link fragmented habitat;
   ii. Increases potential for genetic diversity in huemul;
   iii. Higher genetic diversity results in greater species resilience to disease/stress;
   iv. May involve relocation of local inhabitants, creating conflict;
   v. Edge effect difficult to manage, may not be effective;
   vi. Can lead to easier movement of disease/invasive species;

d. Remove invasive species;
   i. Active removal/relocation of competition/red deer;
   ii. Reduces competition for food resources/habitat;
   iii. Against biorights of the red deer / unethical to cull one species to protect another;
   iv. Eradication programmes may be expensive;

e. Implement research programmes;
   i. Allows scientists to learn more about huemul needs;
   ii. Increases success rates of other interventions;
   iii. Funding for research can be expensive;
   iv. Can provide important information for the success of additional captive breeding programmes;

Note to examiners: *Reserve one mark for naming the in-situ conservation technique, and three marks for expansion. A conclusion is not required for an 'outline' command term but can be rewarded. Accept any other appropriate in-situ conservation technique (e.g. pest exclusion fencing). Do not accept explicitly ex situ strategies.*

(e) With reference to **Figure 3(c) and Figure 3(d)**, discuss how the concepts of instrumental and intrinsic value are not exclusive when applied to the huemul. **[2]**

Instrumental value [1 max]:

a. Huemul have instrumental value as something to observe/view for the tourism industry/as money is raised by tourism;

Intrinsic value [1 max]:

b. Huemul have intrinsic value as a (distinctive/recognizable) native/endemic species;
c. Huemul have intrinsic value as they have biorights/the right to exist/are wild/beautiful;
d. Huemul have intrinsic value as they are culturally important to Chile/are on the coat of arms;
e. Huemul have intrinsic value as they take part in ecological interactions;

***Note to examiners**: A conclusion is not required.*

(f) Using the information in **Figure 3(f) and Figure 3(g)**, outline the evidence that Chile is making progress towards UN Sustainable Development Goal (SDG) 15. **[1]**

a. The large number of parks, reserves, protected areas and monuments support the 'protect' aspect;
b. Expanding national parks helps halt biodiversity loss/promote biodiversity;
c. Rewilding previously developed land supports the restoration of ecosystems/reverses land degradation;
d. Reserves are managed by the government/National Forest Corporation/Ministry of Agriculture to ensure they are sustainably used;

***Note to examiners:** Answer must link the evidence to how it supports SDG15, e.g. linked to the ideas of 'protect', 'restore' or 'sustainable use'. Do not accept the reverse argument (e.g. Not supporting SDG15) as the question asks for examples of support.*

3. (a) Using the information in **Figure 4(a)**, calculate the percentage increase in the number of aquaculture locations, assuming all those awaiting approval are granted permission to proceed. **[1]**

(176+58=234)
((234-58) / 58 x 100 = 303.448)
303 / 303.4 / 303.45 / 303.448 (%);

***Note to examiners:** units are not required. Do not accept 303.5, as this is incorrect rounding.*

(b) With reference to **Figure 4(a) and Figure 4(b)**, describe the impacts of aquaculture operations and fishing on the tourism industry in the Francisco Coloane Marine Park (FCMP). **[2]**

a. Presence of boats used by the aquaculture and fishing operations (moving within the park);
   May make the preserve less natural/untouched/appealing leading to less/decline in tourists/tourist income;
b. Bycatch/Ghost nets from fishing;
   May kill marine mammals, decreasing tourism industry;
c. Overfishing/bottom trawling within the region / disease from aquaculture can spread into wild populations / Introduction of exotic species (escaped from aquaculture nets) can outcompete local/native fish / hypoxic/dead zones from poorly-managed aquaculture can cause coastal eutrophication;
   Reducing food sources for target organisms for tourism (e.g. whales and dolphins);
d. Potential for sport fishing in the reserve;
   May allow expansion of tourism activity/increase potential income for tour operators;
e. Aquaculture pens/operations are a long way from the FCMP;
   Therefore, having little to no impact on the tourism industry;

Note to examiners: *Allow description of any valid aquaculture or fishing disturbance/activity as long as it is linked to the tourism industry. Do not accept references to climate change/global warming. Do not award 2 marks unless the activity is linked to a specific impact on the tourism industry.*

(c) With reference to **Figure 4(a)**, list **two** stakeholders whose cooperation could aid in the recovery of the demersal fisheries. **[1]**

a. Fishing/aquaculture companies/fishermen;
b. Local/indigenous people/consumers;
c. Aquatic or fish scientists/scientific groups;
d. Government/politicians;
e. Chilean Fisheries Service;
f. Protest groups/protestors/environmental groups/NGOs;
g. FCMP/KNP;
h. Ecotourism companies;

Note to examiners*: two correct responses are required for one mark. Do not accept "ecotourists". Mark only the first two responses.*

(d) With reference to **Figure 4(a) and Figure 4(b)**, outline **two** challenges in the use of maximum sustainable yield (MSY) as a guide to the management of demersal fisheries by the Chilean Fisheries Service. **[2]**

a. Fish populations are difficult to measure (e.g. they move, they live in an inaccessible space) so data may not be accurate / determining MSY is limited by the quality of the data available, which may be inaccurate/too simple/estimate/may not take into account complex food web interactions;
b. Anthropogenic activities (e.g. overfishing, disruption of habitat, bycatch) disrupt food webs/reproduction of the target species, impacting the ability of fish stocks to recover;
c. Fish populations fluctuate naturally year-by-year, but measurements of fish stocks are taken infrequently, which could result in setting the MSY too high/too low;
d. Taking the maximum number each year does not provide a buffer for natural events (e.g. predation, disease, El Niño, La Niña), resulting in a decline in fish stocks over time;
e. Employment needs/increased demand for fish due to population growth makes quota regulation and monitoring a political issue;
f. Enforcement of quotas is difficult, resulting in MSY being exceeded;

***Note to examiners**: responses must be linked to challenges related to the use of MSY (e.g. inaccuracy of data, and inaccurate data being used to guide quotas). Mark only the first two responses.*

4. (a) Identify **one** trend in glacial loss percentage from **Figure 5(a)**. **[1]**

a. In four out of the five glacier size categories, the ice loss is increasing over time/the greatest loss of ice occurred in the 2015-2020 period;
b. Larger glaciers have a lower percentage loss than smaller glaciers;
c. Smaller glaciers have a higher percentage loss than larger glaciers;

***Note to examiners:** mark first answer only. Students may either refer to a trend over the glacial size categories (spatial trend) or a trend within a category (temporal trend). Do not accept responses which discuss a single data point.*

(b) With reference to **Figure 5(c)**, identify **two** forms of natural capital provided by glaciers. **[2]**

a. Freshwater/water;
b. Nutrients;
c. Sedimentary material / rocky material and clay;

***Note to examiners**: mark first two answers only. Award the mark for the identified natural capital, even if the student links it to natural income (e.g. water for hydropower). Do not accept responses which are natural income (e.g. tourism, hydroelectric power generation, etc.)*

(c) Using **Figure 5(c)**, describe **two** negative impacts of glacier retreat on the local human communities. **[2]**

a. Less water/freshwater available for human needs/agriculture/irrigation;
b. Less water available for hydropower generation/hydroelectricity (reducing energy available for industry/mining);
c. Loss of nutrients (after the glaciers have disappeared) reducing productivity/crop yields;
d. Increased erosion/runoff (due to lack of ground cover) will remove topsoil/O-A horizon/soil which reduces productivity/food availability;
e. Area becomes more susceptible to landslides potentially destroying infrastructure/roads/industry/housing;
f. Increased flash flood/flood potential (when a lake bursts its sides/boundaries) which can destroy/damage infrastructure/farms/buildings/livestock/crops / flash floods can result in human deaths;
g. Land degradation/risks from retreating glaciers/erosion/landslides can reduce the tourism industry/recreation/hiking;
h. Reduction in albedo which can lead to increased summer temperatures for local communities, resulting in deaths/loss of work productivity due to heat;
i. Melting glaciers will result in sea level rise and may force coastal communities to relocate due to flooding/flood risk;

Note to examiners: *Mark only the first two responses. Accept other valid and reasoned human-related impacts explicitly linked to glacial retreat.*

(d) Using **Figure 5(d) and Figure 5(e)**, discuss the sustainability of desalination of sea water as a climate change adaptation strategy for mines in Chile. **[4]**

Pros (desalination as a sustainable option) [3 max]:

a. Seawater is a renewable resource, so will not run out (making it sustainable for long term use) / seawater is resilient to climate change (which provides stable water access for mines);
b. Power/energy (for desalination) could be provided by renewable/tides/solar/wind energy;
c. Reduction in demand on freshwater aquifers/surface water will allow them to recharge/refill (which is socially and environmentally more sustainable);
d. Desalination plants to supply mines could also provide additional freshwater for local communities;

Cons (challenges to desalination as a sustainable option) [3 max]:

e. High financial cost to build/maintain/run the desalination plants / high financial cost to develop the necessary infrastructure (e.g. pipelines);
f. Desalination has a high energy demand/requires a source of electricity to run the plants, which might be (environmentally) unsustainable if this is done with fossil fuels;
g. The environmental damage caused by disposal of brine may impact local fishing/aquaculture/tourism, reducing economic income in other industries / disposal of brine residue can negatively impact local ecosystems / building of infrastructure can result in environmental damage;

Note to examiners: *Full marks can be awarded without a conclusion, as long as both pros and cons are considered. A balanced conclusion with a clear value judgement may be credited, e.g. While desalination could provide more water for mining, reducing demand on stressed aquifers, overall, it is not a sustainable adaptation strategy to climate change impacts as the high costs would make the resource too expensive to be competitive globally.*

5. (a) In addition to assessing environmental concerns, environmental impact assessments (EIAs) investigate the social impacts of a development project. Identify a potential negative social impact related to developing an open pit copper mine in the Atacama Desert. **[1]**

a. Construction of mine/mine infrastructure (e.g. tailings ponds, pipelines, roads) results in loss of land (e.g. used for traditional practices/housing/agriculture);
b. Reduced water availability for business/food production / contamination of fresh water reduces water security;
c. Large numbers of labourers from outside the community may disrupt existing social networks/communities/culture;
d. Visual pollution reduces local enjoyment of the region;
e. Construction may cause social conflict between the mine owners and local people/ecologists;

Note to examiners*: Allow other reasonable responses which clearly link aspects of open pit development (e.g. roads/infrastructure) to a negative social impact. Do not accept health-related impacts.*

(b) Prior to opening in 1990, the Escondida mine studied the sea squirt (*Pyura stolonifera*), shown in **Figure 6(g)**, to monitor the impact of dumping mine tailings in the Pacific Ocean. Evaluate the choice of using the sea squirt as an indicator species as part of the mine's EIA. **[4]**

Positives [3 max]:

a. They are sedentary/don't move, making them easy to count/observe / they live in shallow water so easy to count/observe / Fairly large size so easy to count/observe;
b. They are found together/live in colonies which allows larger sample sizes for population studies, increasing validity/reliability;
c. Their habitat is close to shore, where tailings would typically be dumped / their habitat covers a wide range of depths where the tailings may be dumped;
d. They are filter feeders/pass ocean water through their body during feeding so would be impacted negatively by toxic chemicals;
e. Higher up the food chain so may show effects of biomagnification;

Negatives [3 max]:

f. Food of organism is not clearly linked to potential toxins from mine tailings;
g. Toxins in mine tailings may not dissolve in ocean water so have no effect on sea squirts;
h. Mine tailings could be dumped away from animal location;
i. As it is sedentary, impacts are only being assessed locally / there could be other impacts of mine tailings further away;
j. Only assesses environmental impact for ocean, does not address EI of mine on land or air;
k. Other factors may be involved in their absence from a region, not just mine tailings;
l. Sea squirts are not sedentary as juveniles, and therefore may absorb pollutants from a different location than where they settle as adults (potentially skewing results);

Note to examiners: *Full marks may be gained without a conclusion, but there must be some evidence of an opinion in the responses to meet the requirements of the command term 'evaluate'. A balanced conclusion may be credited but is not required, e.g. While sea squirts are easy to find and monitor for toxins, overall they are not useful as indicator species as they might not be found in all of the places mine tailings are dumped along the coastline.*

(c) Using **Figure 6(d) and Figure 6(e)**, outline **two** potential human health impacts of the mines on the residents of the city of Calama. **[2]**

a. Mining chemicals/leachate/heavy metals from the tailing ponds may get into local water supplies/may biomagnify in food sources, resulting in illness/disease/death of humans;
b. If the mine uses up local water (sources), there will be less fresh water for human needs leading to dehydration/death;
c. (Toxic) dust from dry tailings/rock crushing/mines can be breathed in, causing lung disease/asthma/eye irritation / emissions from smelting could result in smog/tropospheric ozone creation, causing lung damage/asthma/heart disease/eye irritation;
d. Noise from mine operations could disrupt sleep patterns/stress humans;
e. Less water may be available for irrigation/agriculture, reducing food security/crop yield, leading to malnutrition/famine;

Note to examiners: *do not accept greenhouse gas emissions/CO_2 cause health problems.*

(d) Using **Figure 6(e) and Figure 6(f)**, describe how globalization in the copper production industry has impacted Chile. **[2]**

a. increased global demand resulting in more extraction and therefore greater income for the country / (international) exports result in income for the country;
b. increased global demand resulting in more mines being built, causing increased environmental degradation/water shortages/reducing water security;
c. limited value for Chile's economy as the processing is done in other countries/value-added is limited to the sale of the raw ore;
d. construction of ports for the export of copper can increase overall trade/provide facilities for cruise ships for the tourism industry;
e. Improvements in transportation (e.g. faster shipping times) allow Chile to access further markets;
f. Competition from other copper-producing regions can reduce value of copper, negatively impacting the economy;
g. Copper prices are set internationally/by international markets, so Chile has less control over the value of its resource;
h. May be more investment (FDI) from international corporations/TNCs;
i. Interruptions to supply chains can occur due to interconnected/interdependent nature of copper trade, making the trade vulnerable to external factors;
j. Off-shoring of polluting copper processing reduces air/water pollution within Chile;
k. Increased trade with other countries can strengthen/improve international relations;

Note to examiners: *Accept any other reasonable response which connects globalization with an impact on Chile.*

(e) Outline how the mining regulations in Chile demonstrate principles of environmental law. **[6]**

a. Mining regulations are written/set by the government, which is the basis of environmental law;
b. Mining companies are required to submit EIAs (which help to protect biodiversity);
c. EIAs also measure/mitigate for social impacts, which implies environmental justice/social sustainability;
d. Chile banned dumping of mine tailings into the ocean, to protect biodiversity/prevent degradation of the ecosystem;
e. Chile is a member of the United Nations, and therefore should be working towards meeting Sustainable Development Goal 15 (SDG15) to protect biodiversity/avoid land degradation;
f. Strict laws on emissions capture by smelting factories addresses (transboundary) pollution;
g. Laws on emissions capture by smelting factories protect society, improving social and environmental sustainability;
h. Economic strategies are used alongside regulations to ensure sustainable management of mining (e.g. using funds from mining to develop green hydrogen as an energy source, carbon taxes, polluter-pays principle);
i. Environmental law is designed to ensure sustainable management of resources, but the development of non-renewable resources is not sustainable;
j. Not all elements of the mining process are covered by environmental laws/regulations, as mine tailings are not included in waste laws/use of water is not regulated;

Note to examiner: *Accept any reasonable point which connects the principles of environmental law to mining in Chile.*

6. (a) Using **Figure 7(a)**, identify the largest source of electrical energy in Chile in 2015. **[1]**

Coal;

(b) Using **Figure 7(a) and Figure 7(b)**, discuss possible reasons why the value of the coal mining industry in Chile has changed. **[2]**

a. Increased adoption of alternative/renewable energy sources over time has changed/impacted the value of coal (mining industry);
b. Chile has signed/supported (international) agreements to decrease carbon footprint/be carbon neutral by 2050/close all plants by 2040 thereby changing/impacting the value of the industry;
c. Education/campaigns/shifts in environmental value systems/ethics in the country have turned public opinion towards renewables/away from fossil fuels/coal changing the value of the industry;
d. As coal resources start to run out/access becomes more difficult, the cost of extraction becomes more expensive changing/impacting the value of the resource;
e. Introduction of carbon tax has increased the costs of coal impacting/changing the value of the coal mining industry;
f. Advancements in technology have potentially made renewable energy sources cheaper than coal changing demand/changing its value;
g. Coal may change in value if (global) political instability restricts availability of imports of fossil fuels;

Note to examiners: *Do not accept just a list of reasons without stating there has been a change in value. The response does not require a direction of change.*
Allow other reasonable responses that reference change in value.
As this is a two-mark question, both increases and decreases or a conclusion are not required.

(c) Compare and contrast the trends in renewable electricity production from 2011 to 2023, as shown in **Figure 7(a)**. **[3]**

Compare [2 max]:
a. Wind (production) and solar (production) have both increased over time/since 2012;
b. Both wind and solar (production) increase slowly when they are first adopted;

Contrast [2 max]:
c. Hydropower (production) has remained relatively steady, but solar and wind energy have increased / Hydropower has had periods of decreasing/fluctuating production, but solar and wind energy have constantly increased;
d. Overall, solar (production) has increased more rapidly than wind (production);
e. During the early period/2011-2014, wind energy began to increase while solar energy stayed at very low levels of production;
f. Wind has increased over time but accounts for the smallest proportion of renewable energy;

Note to examiners: *Max 2 points if response is only compare or only contrast. Do not accept responses which describe individual trends without some comparison/contrast.*

(d) Deduce **one** reason why CO_2 emissions are greater from transport than from industry, as shown in **Figure 7(c)**. **[2]**

Transportation emissions are high [1 max]:

a. Transport/vehicles may not have strong regulatory controls to reduce CO_2 emissions;
b. There may be a large number of private vehicles in Chile which burn fossil fuels/emit CO_2;
c. Economic activities/tourism locations/cities are separated by great distances/exports need to move resources long distances, resulting in high carbon emissions / Large numbers of flights due to long distances/large numbers of tourists increase carbon emissions/greater fossil fuel consumption;
d. Electric/non-fossil fuel vehicles are not practical/too expensive for long distances/heavy loads;
e. Driving at higher altitudes makes engines less efficient at burning gasoline, resulting in high carbon emissions;

Industry emissions are low [1 max]:

f. There is not a large amount of polluting industry in Chile / Chile has off-shored its high carbon emission industries overseas;
g. High carbon emission industries have decreased with economic development (e.g. replaced by service industries);
h. Industry uses a range of energy sources/renewables (which may not produce CO_2) / Some of the energy used by industry may be included in the category for 'electricity and heat producers', reducing the emissions under the 'industry' category;
i. Industry may have strong environmental controls to reduce carbon emissions;
j. Industry may use CCS to reduce carbon emissions;

***Note to examiners**: one mark is reserved for why transportation emissions are high, and one mark is reserved for why industry emissions are low. This can also be presented in one comparative statement.*

7. In view of Chile's economic dependence on natural capital, discuss the potential for the country to meet its carbon neutral goal. **[6]**

Positives [4 max]:

a. Chile is actively rewilding degraded areas/replanting logged areas, which increases carbon storage/removes CO_2 from the atmosphere / Incentives are offered to private landowners to preserve existing forests/create new forests, which increases carbon storage/carbon sinks;
b. Chile is rapidly increasing renewable energy which decreases the burning of fossil fuels/the release of CO_2 / Coal-burning power stations are being phased out, reducing CO_2 emissions;
c. Chile has implemented a carbon tax to help reduce emissions;
d. High level of public concern around climate change may support/rapidly advance government carbon-neutral policies;
e. Chile requires all new mines or expansions to undergo an environmental impact assessment (EIA), which may address/involve CO_2 mitigation;
f. Environmental regulations require smelters to capture 95% of emissions (which would reduce the release of CO_2 into the atmosphere);
g. Chile is part of an international group aiming to decarbonize industries, which would help reduce carbon emissions;
h. Chile is using money generated by the mining industry to develop green hydrogen as an energy source, which would decrease reliance on fossil fuels/burning fossil fuels;

Negatives [4 max]:

i. Heavy dependence on copper mining involves the use of large machinery which burns fossil fuels and releases CO_2 / processing of copper demands large amounts of energy which may involve the combustion of fossil fuels and the release of CO_2;
j. Chile is removing native species and replacing them with more economically valuable species, which might have lower carbon storage capabilities / Chile has lost 577 ha of forested area, reducing carbon storage;
k. Forestry is allowed within national reserves, which would decrease carbon sinks/photosynthesis;
l. Transport related to tourism could increase the carbon footprint of the country due to the burning of fossil fuels;
m. Export of copper/fish involves transportation, increasing the carbon footprint of the country due to the burning of fossil fuels;
n. Increasing use of desalinated water by the mining industry requires large energy inputs, which may involve the burning of fossil fuels and therefore increase CO_2 emissions;
o. Aiming for 70% renewable energy by 2030 (instead of 100%) would make it more difficult to reach its carbon neutral target / Non-renewable energy still accounts for a significant portion of energy production, emitting CO_2;
p. Carbon-neutral policies may have a negative impact on income from industries relating to natural capital/extraction of natural resources (resulting in push-back from industry/stakeholders against carbon emissions controls);

Note to examiners: *Accept any other reasonable response which links natural capital or natural income to Chile's potential to meet its carbon neutral target. Reserve one mark for a balanced conclusion which has a clear value statement addressing the question of carbon neutrality, and supported by evidence from the resource booklet. Do not credit the conclusion if only one side of the argument is presented.*

Conclusion examples [reserve 1 mark]:

While Chile is making progress in terms of reducing its carbon emissions from electricity generation, overall, it is not likely to reach carbon neutrality by 2050 due to its heavy dependence on copper and fish exports for economic growth.

While Chile depends heavily on the export of natural capital such as copper, overall, they are making good progress towards their target of carbon neutrality due to the protection of forests and rewilding of degraded areas, as well as the rapid growth of renewable energy sources.