International Baccalaureate®
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Environmental systems and societies

Higher and Standard level

Specimen papers HP1, HP2, SP1 and SP2

For first examinations in 2026

CONTENTS

Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Higher level
Paper 1

Specimen paper

Candidate session number

2 hours

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions. Refer to the resource booklet which accompanies this question paper.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[70 marks]**.

Answer **all** questions. Answers must be written within the answer boxes provided.

1. (a) With reference to **Figure 1(d)**, identify the climate classification for the city of Thimphu. [1]

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(b) Describe how global warming might alter the distribution of biomes within Bhutan. [2]

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2. (a) With reference to **Figure 2(a)**, calculate the doubling time of the urban population in Bhutan. [1]

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(b) Outline **two** possible reasons why the urban population growth rate is higher than Bhutan's total population growth rate. [2]

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(This question continues on the following page)

(Question 2 continued)

(c) Describe **two** potential environmental impacts caused by the rapid population growth in Thimphu. [2]

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(d) With reference to **Figure 2(b)**, identify Bhutan's stage on the demographic transition model (DTM). [1]

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3. (a) With reference to **Figure 3(a)**, identify the main source of energy used in Bhutan. [1]

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(b) Using **Figure 3(c)**, calculate the reduction in total energy demand for 2040, in million kWh, if energy efficient practices were implemented. [1]

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(c) Evaluate Bhutan's energy policy. [6]

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will not be marked.

4. (a) Using **Figure 4(c)**, state the number of months per year that PM2.5 levels exceed the WHO 24-hour exposure guideline. [1]

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(b) Outline why Thimphu has higher levels of PM2.5 between November and February. [3]

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(c) Outline how activities outside Bhutan can contribute to PM2.5 levels within Thimphu. [2]

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(d) Describe how PM2.5 levels in Thimphu could be managed. [4]

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5. (a) With reference to **Figures 5(a)** and **5(b)**, outline **three** potential environmental problems associated with the Memelakha open-air landfill in Thimphu. [3]

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(b) Evaluate the sustainability of Bhutan's waste management programme. [6]

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6. (a) Outline **two** ways that Thimphu could improve water security. [2]

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(b) Identify **one** issue that could stop the improvement of the water supply in Thimphu. [1]

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(c) Outline **two** factors that may increase the risk of flash flooding in Thimphu. [2]

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7. (a) With reference to **Figure 7(a)**, describe the pattern of forest cover change. [2]

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(b) Identify **one** economic value of Bhutan's forests as natural capital. [1]

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(c) Evaluate the use of the wildlife corridors shown in **Figure 7(b)**. [3]

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8. (a) Outline the value of identifying a region as a biodiversity hotspot. [2]

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(b) Outline **one** reason why the black-necked crane could be considered a flagship species. [1]

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(c) Describe a method to estimate the number of black-necked cranes in the Phobjikha Valley. [3]

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(d) Outline the challenges of protecting a migratory species such as the black-necked crane. [2]

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9. (a) Using **Figure 9(a)**, **calculate** the average annual increase in CO_2 emissions, in million tonnes, between 2009 and 2017. [1]

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(b) With reference to **Figure 9(b)**, **interpret** the trend in the ecological reserve between 2009 and 2017. [3]

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(c) With reference to **Figure 9(c)**, **discuss** the value of international agreements in addressing the issue of carbon neutrality. [4]

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10. (a) **State** a method that can be used to assess psychological well-being as shown in **Figure 10**. [1]

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(b) **Discuss** the use of the Gross National Happiness (GNH) Index in place of Gross Domestic Product (GDP) as an economic tool to promote sustainable development. [6]

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will not be marked.

Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Higher level
Paper 1

Specimen paper

2 hours

Instructions to candidates

- Do not open this booklet until instructed to do so.
- This booklet contains all the resources to answer paper 1.

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Figure 1(a): World map showing the location of Bhutan

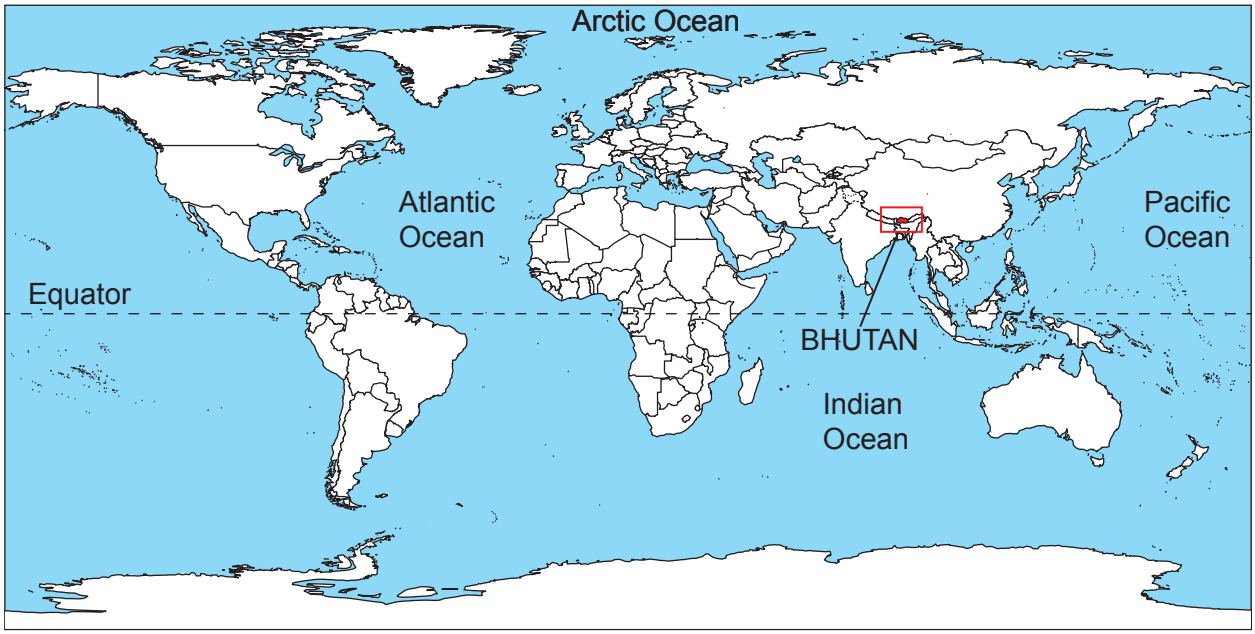


Figure 1(b): Map showing the location of Bhutan

Figure 1(c): Fact file on Bhutan

- The terrain is mostly mountainous with some fertile valleys and grasslands.
- Steep mountains make construction of roads and infrastructure difficult and expensive.
- Glaciers cover approximately 10 % of land. Melting glaciers and unpredictable rainfall have increased risk of flash floods and landslides.
- Fast flowing rivers are used for providing hydroelectric power.
- By law, at least 60 % land area must be forested. In 2021, over 70 % of the land area was forest.
- In 2018, 14 % of land was used for agriculture.
- Bhutan uses Gross National Happiness (GNH) rather than Gross Domestic Product (GDP) to measure its progression and guide its development strategy.

Figure 1(d): Map of climate classification

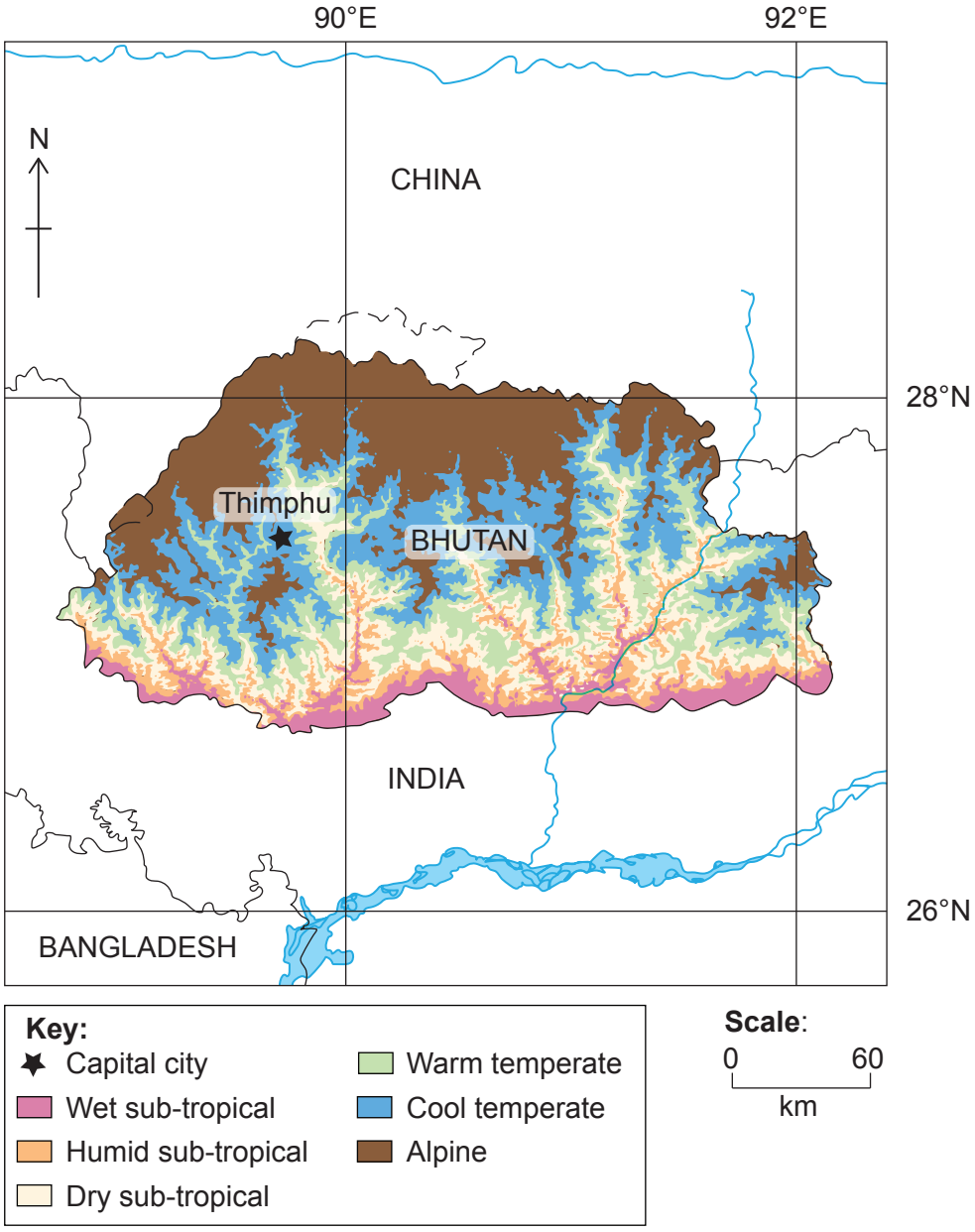


Figure 2(a): Fact file on demography of Bhutan, 2021

Total population	783200
Total population growth rate	0.99 %
Birth rate	16.17 per 1000 population
Death rate	6.28 per 1000 population
Total fertility rate	1.8 children per woman
Life expectancy	71.5 years
Urban population	43 % of total population
Urban population growth rate	2.52 %

Figure 2(b): Population pyramid for Bhutan, 2021

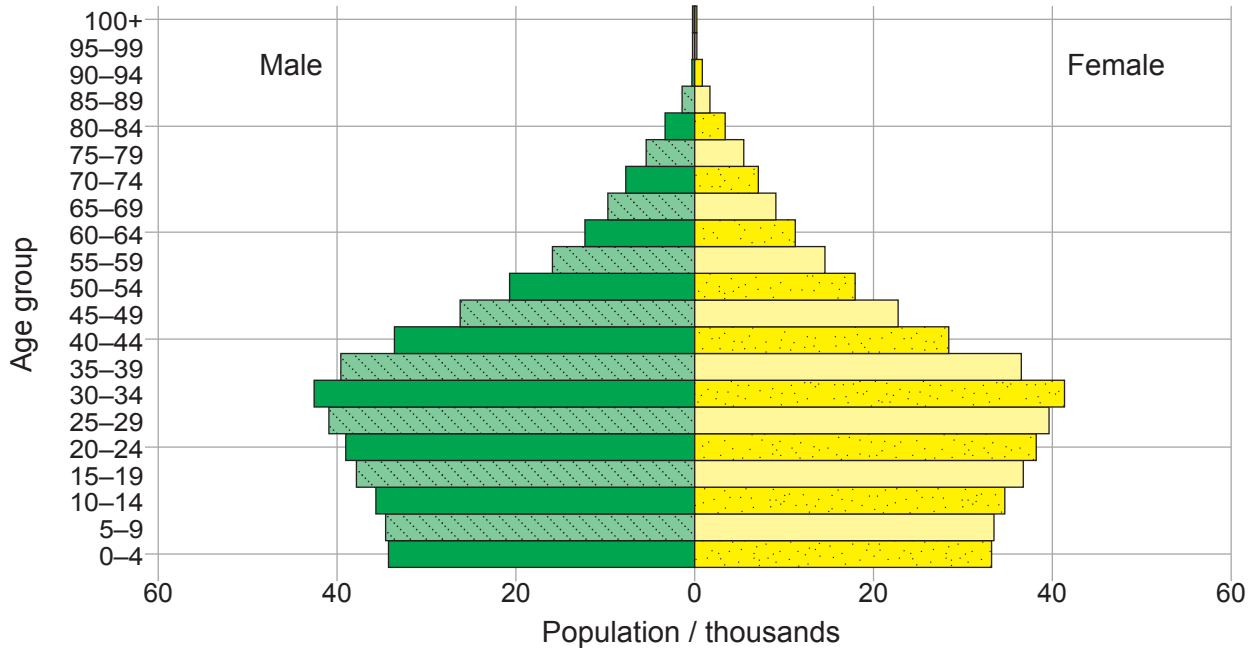


Figure 3(a): Sources of energy used in Bhutan, 2016

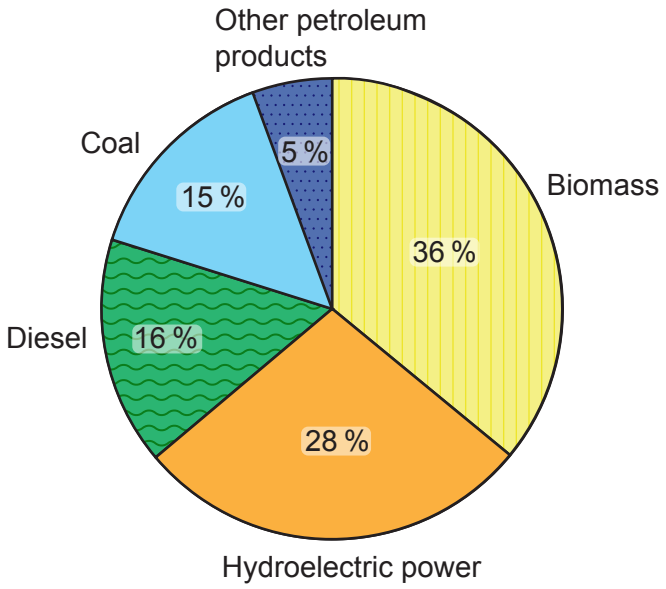


Figure 3(b): Fact file on Bhutan's energy

- Over 99 % of electricity is generated from hydroelectric power.
- Between 2003 and 2017 access to electricity increased from 30 % to 100 % of the population.
- In 2021 Bhutan only used 6.5 % of its hydroelectric power potential. The country plans to build more dams to generate hydroelectric power and export electricity to India and Bangladesh.
- Bhutan exports approximately 75 % of its electricity, representing 40 % of total exports.
- Bhutan intends to diversify its energy sources by increasing the use of hydrogen, solar, and wind.
- Bhutan imports petrol, wood and charcoal for use as fuel.

Figure 3(c): Residential energy demands in Bhutan: (a) without adopting energy-efficient practices and (b) adopting energy-efficient practices

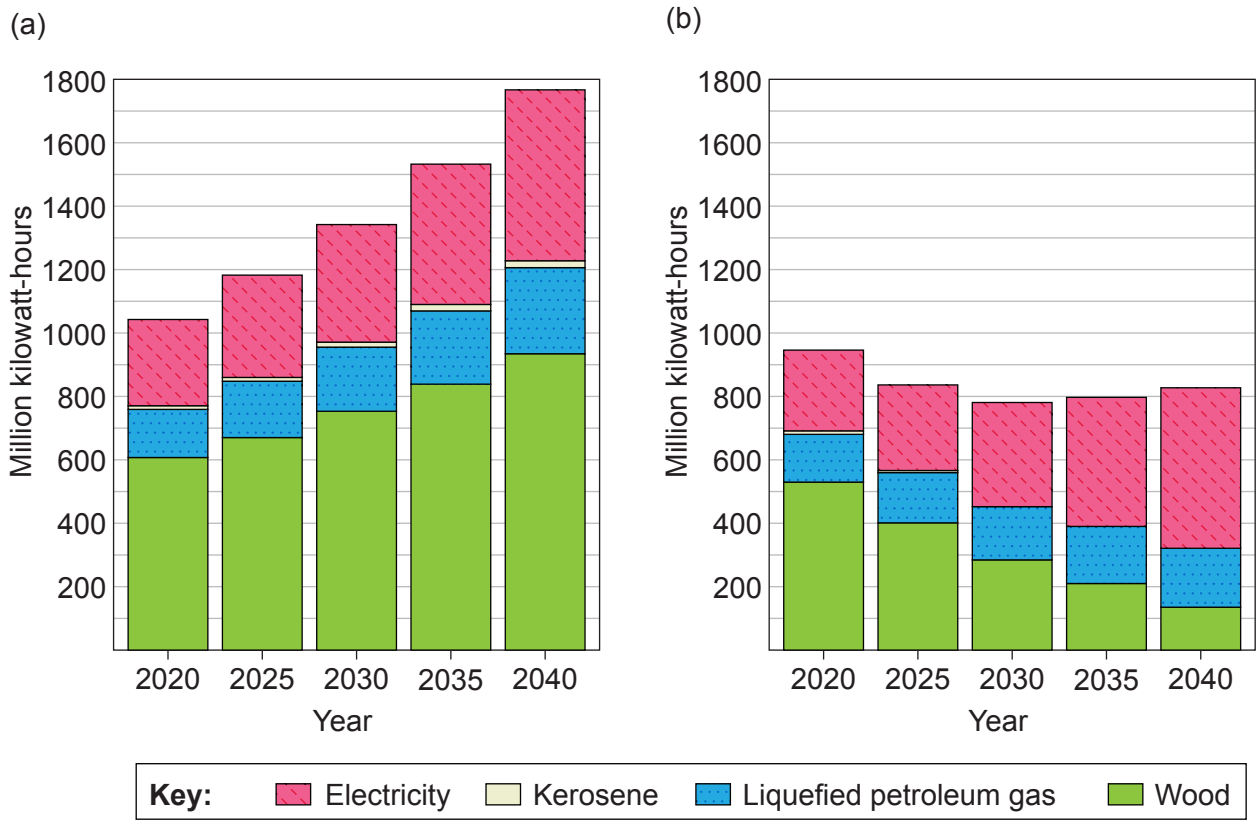


Figure 4(a): The city of Thimphu is located on the Thimphu River at an altitude of 2000m above sea level and is surrounded by mountains

Figure 4(b): Climate data for Thimphu

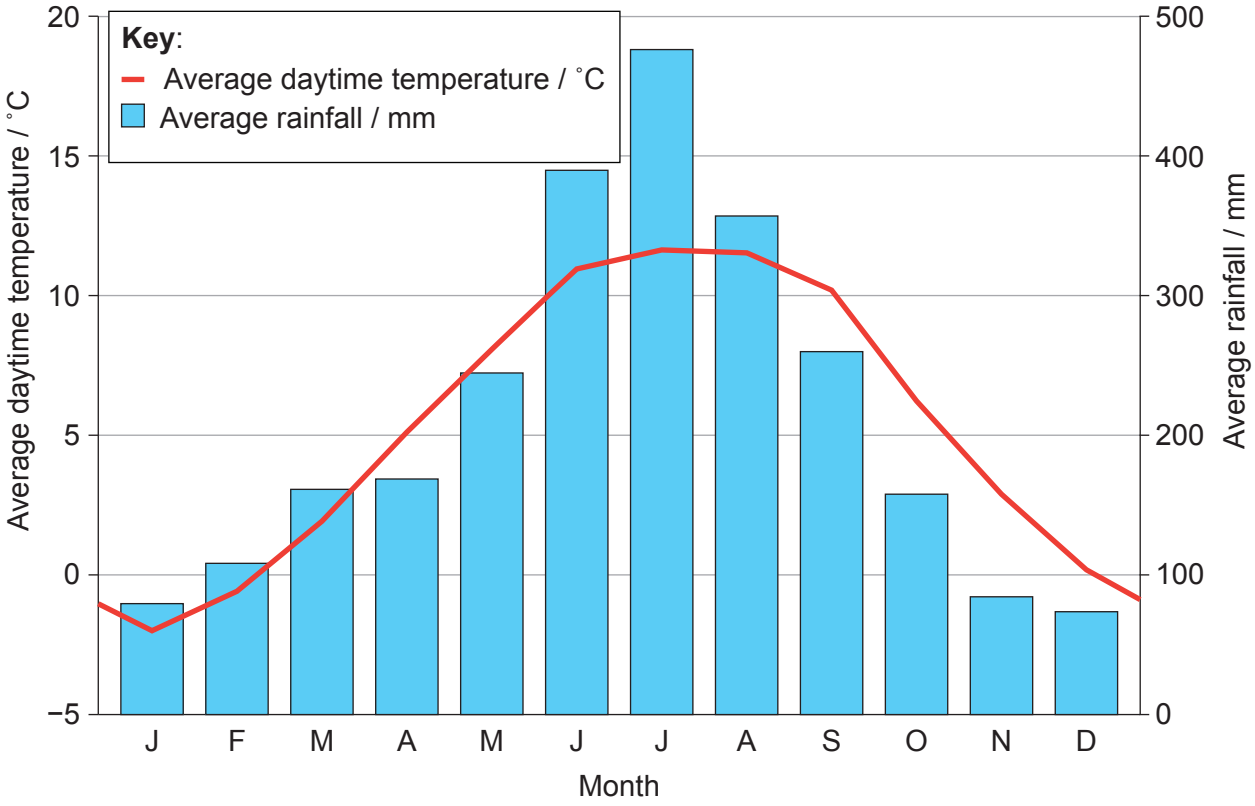


Figure 4(c): Mean measures of PM2.5 in Thimphu, 2016–2018

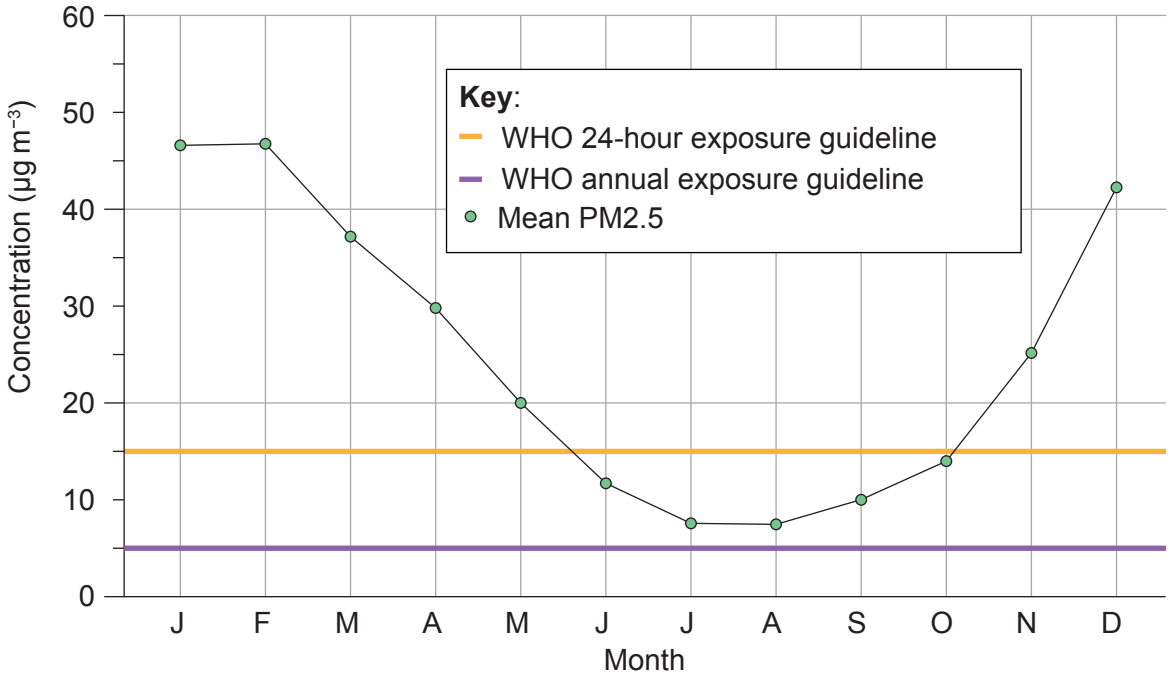


Figure 4(d): Fact file on air quality in Thimphu

- Sources of air pollution include the construction industry, vehicle emissions, wood-burning stoves for cooking and heating, and burning of household and farm waste.
- Vehicle ownership more than doubled between 2008 and 2018. Over half of the cars in Bhutan are in Thimphu.
- Temperature inversions occur in the winter.
- Pollution from outside the country also influences the air quality in Thimphu.

Figure 5(a): Waste management in Thimphu

- Composition of waste in Thimphu: 58 % organic, 9 % paper, 13 % plastic and 20 % other.
- Historically, burning and illegal open dumping of waste has been an issue.
- The Memelakha open-air landfill in Thimphu started in 1994 with an intended lifespan of 8 years, but continues to be used. It was built without any lining or gas vents.

Figure 5(b): Memelakha open-air landfill in Thimphu

Figure 5(c): Historical reasons for not using waste collection services

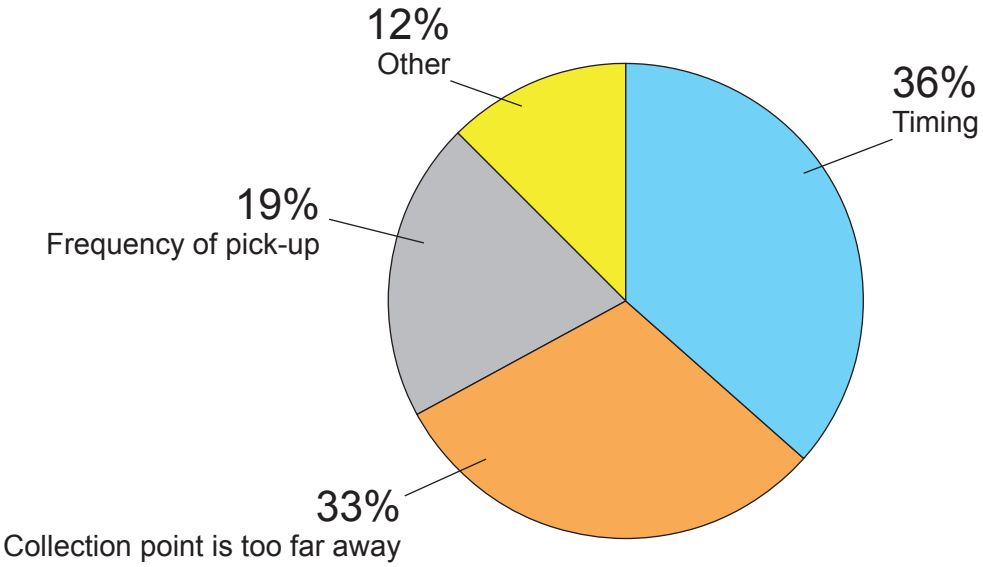


Figure 5(d): Waste Management Flagship Programme launched in 2019

- Aims to achieve zero waste in Bhutan and reduce the amount of waste going to landfill from 80 % to less than 20 % by 2030 by:
  - Segregating waste at source (e.g. using colour coded bins for different waste types).
  - Providing adequate collection facilities and waste drop-off centres.
  - Constructing facilities to segregate waste and recover any material that can be re-used, recycled and composted.
  - Having final disposal facilities e.g. landfills and incineration plants.
  - Providing education and raising public awareness to support the strategy.
- The 'zero waste hour' was introduced to encourage everyone to spend one hour on the second day of each month to clear waste material from their neighbourhood.

Figure 6: Fact file on water in Thimphu

- Thimphu experiences both water scarcity and floods.
- In 2018, approximately 76 % of households in Thimphu had a piped drinking water supply. This piped supply is not reliable and therefore many people store water in tanks.
- Parts of the water distribution system are in poor condition and it is estimated that 30–40 % of water is lost through leaking pipes.
- Many people buy water from private suppliers (who use water trucks to distribute water to homes).
- In winter, water supplies drop in volume and distribution pipes often freeze.
- In winter, snow has been used as a source of water; however in recent years there has been a reduction in snowfall.
- Water drainage throughout the city is inadequate resulting in parts of the city suffering from flash floods during the summer.

Figure 7(a): Change in forest cover between 1930 and 2014

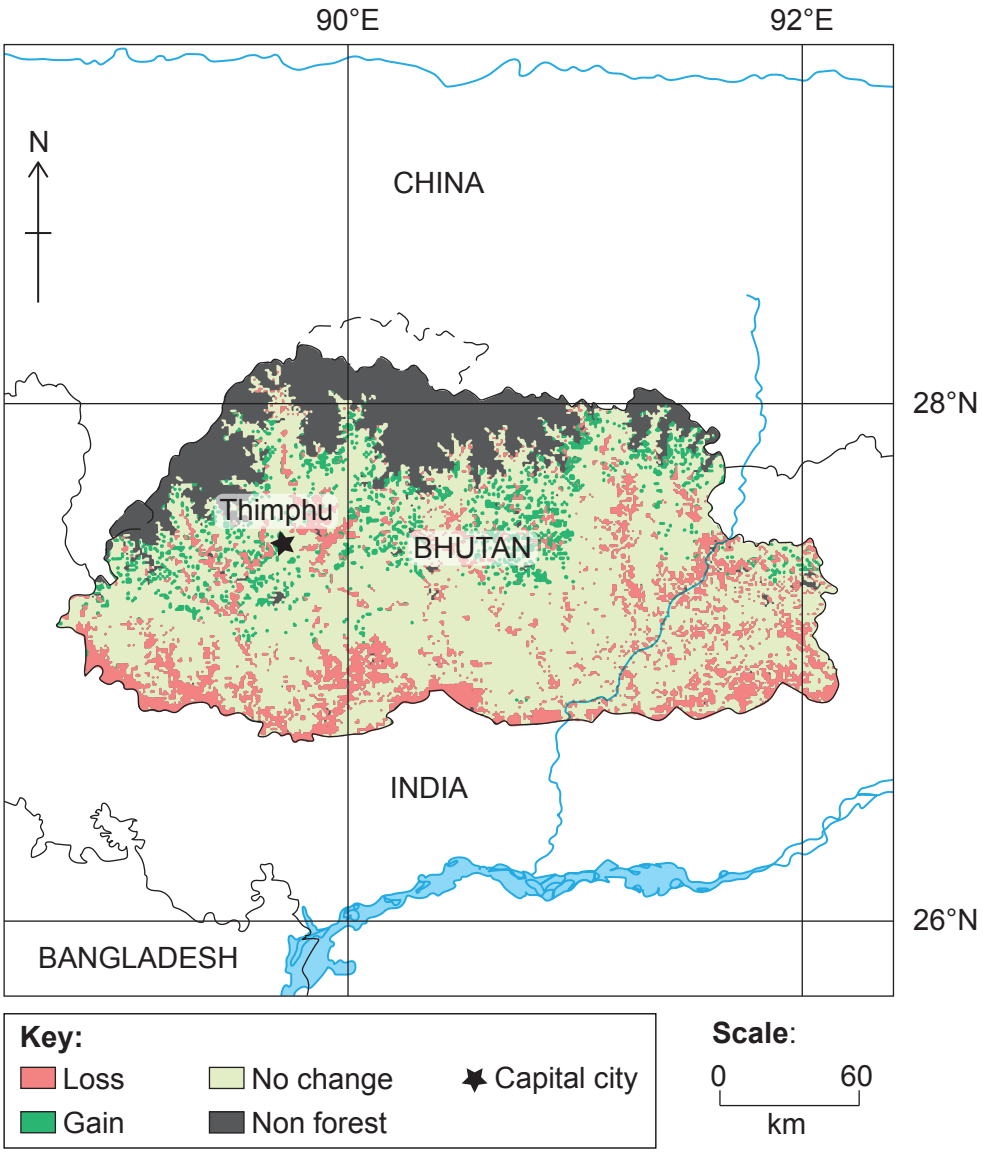


Figure 7(b): Protected areas and wildlife corridors within Bhutan

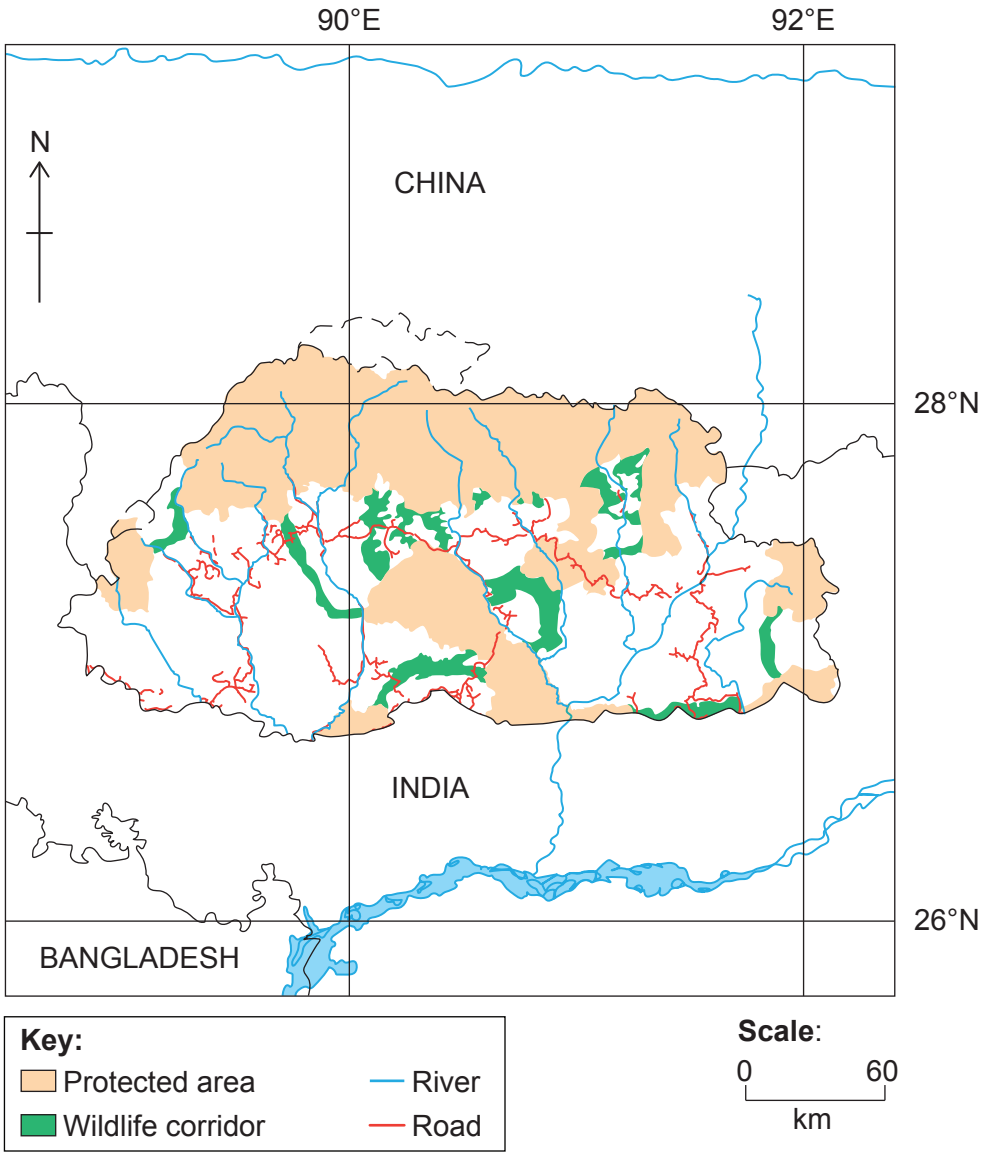


Figure 8(a): The Eastern Himalaya biodiversity hotspot and the winter range and breeding range of the black-necked crane

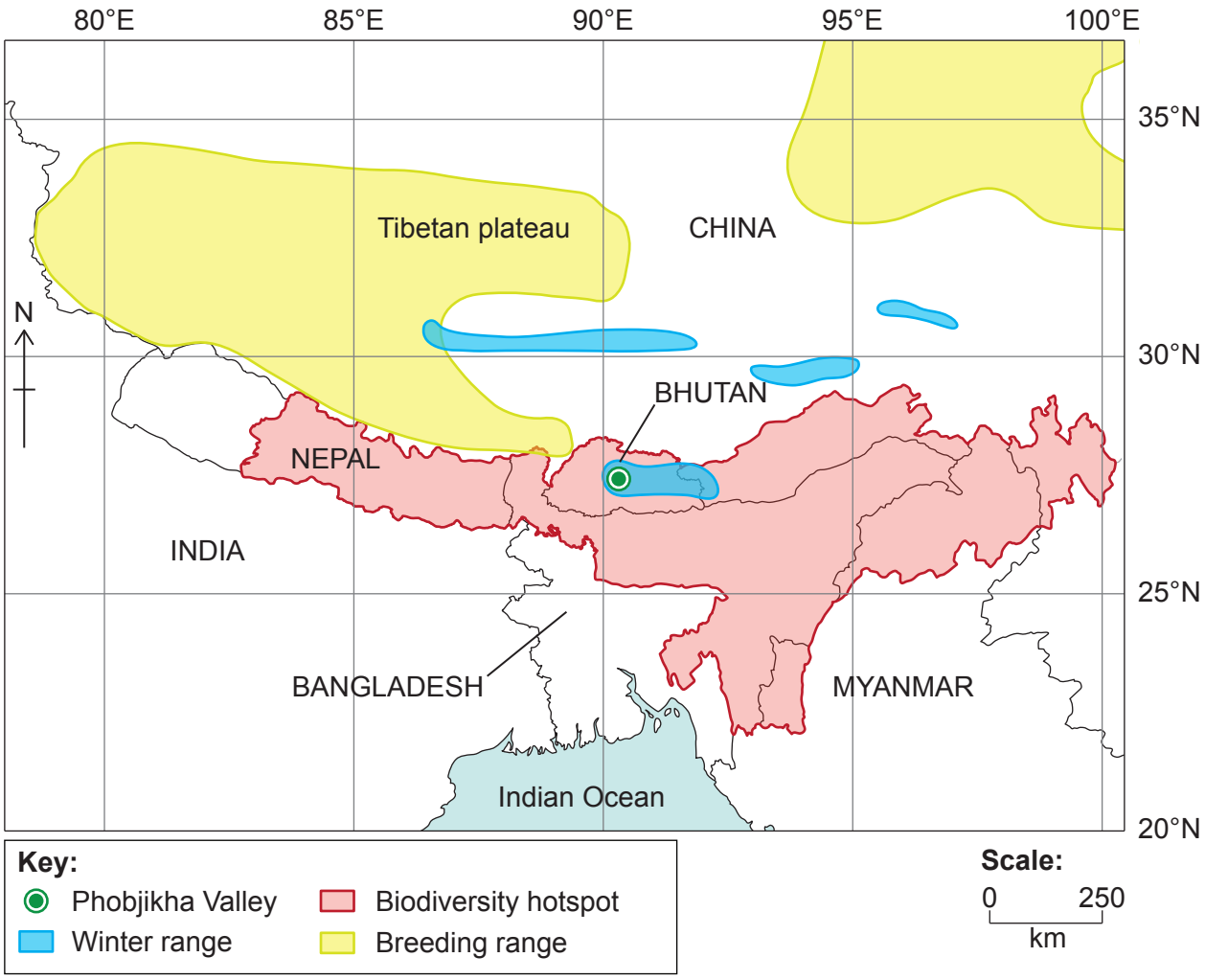


Figure 8(b): Black-necked crane (*Grus nigricollis*)

Figure 8(c): Fact file on the black-necked crane (*Grus nigricollis*)

- *The International Union for Conservation of Nature (IUCN) Red List of Threatened Species* classified the black-necked crane as 'near threatened' in 2020.
- In winter about 500 cranes migrate from the Tibetan plateau to the Phobjikha Valley in Bhutan, where they gather in the wetlands until spring.
- The cranes attract tourism to the Phobjikha Valley, which has financially benefited locals e.g. providing accommodation for tourists.
- The black-necked crane is highly regarded and has great cultural significance in Bhutan.

Figure 9(a): Annual CO_2 emissions for Bhutan, 1990–2017

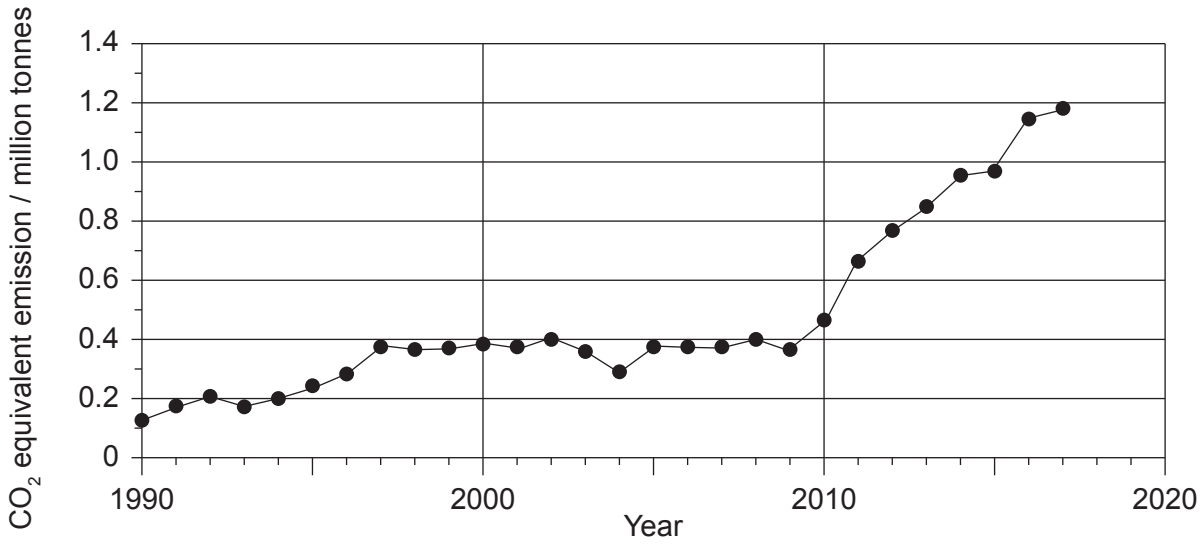


Figure 9(b): Bhutan's ecological footprint and biocapacity, 1990–2017

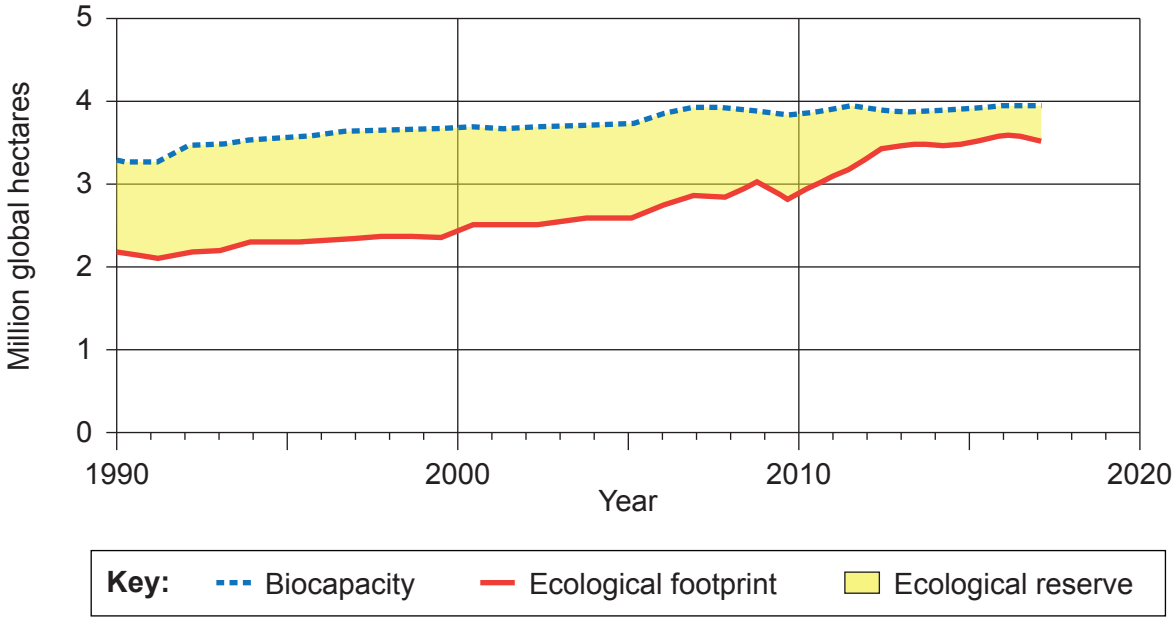
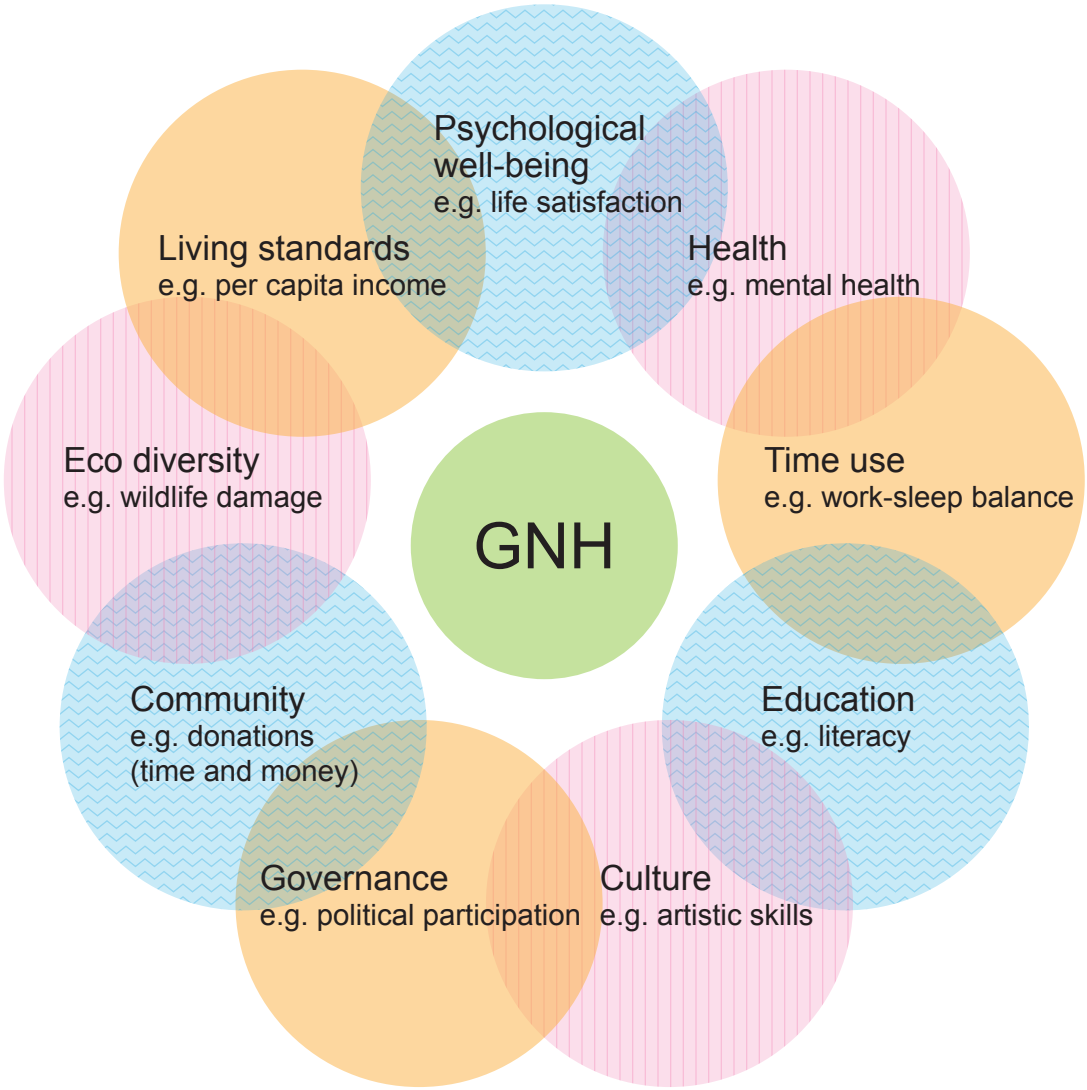


Figure 9(c): Fact file on Bhutan's carbon status

- Bhutan is carbon negative because:
  - Forest absorbs three times the CO_2 levels generated by the population.
  - Bhutan exports hydroelectric power which offsets carbon dioxide production outside the country.
- During COP26 in 2021, Bhutan, together with Suriname and Panama, signed a declaration requesting economically advantageous trade arrangements in return for maintaining their carbon negative status.

Figure 10: The Gross National Happiness (GNH) Index is determined by measuring nine domains



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References:

Figure 1(b) CIA, n.d. *Bhutan*. [image online] Available at: https://www.cia.gov/the-world-factbook/countries/bhutan/map/ [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 1(d) Rai, G, 2020. *Map of Bhutan showing different agro-ecological zones and 20 districts*. [image online] Available at: https://www.researchgate.net/figure/Map-of-Bhutan-showing-different-agro-ecological-zones-and-20-districts-The-location-of_fig1_344137812 [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 2(b) CIA, n.d. *2023 population pyramid*. [image online] Available at: https://www.cia.gov/the-world-factbook/countries/bhutan/#people-and-society [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 3(a) IRENA, 2019. *Figure 1. Fuel mix in the economy (toe)*. [image online] Available at: https://www.irena.org/publications/2019/Dec/Renewables-Readiness-Assessment-Kingdom-of-Bhutan [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 3(c) Zam, K., Gupta, M.K., and Uddin, S.M.N., 2021. The residential energy futures of Bhutan. *Energy Efficiency*. [image online] Available at: https://link.springer.com/article/10.1007/s12053-021-09948-x [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 4(a) Uddin, K., n.d. *Settlement of Bhutan's capital, Thimphu*. [photograph] Available at: https://www.gettyimages.co.uk/detail/photo/settlement-of-bhutans-capital-thimphu-royalty-free-image/1171472214 [Accessed 18 September 2023]. SOURCE ADAPTED.

Figure 4(b) Climate Data, n.d. *Climate Graph // Weather by Month Thimphu*. [image online] Available at: https://en.climate-data.org/asia/bhutan/thimphu-district/thimphu-5977/#climate-graph [Accessed 5 September 2023]. SOURCE ADAPTED.

Figure 4(c) Climate Data, n.d. *Data and graphs for weather & climate in Thimphu*. [online] Available at: https://en.climate-data.org/asia/bhutan/thimphu-district/thimphu-5977/ [Accessed 18 September 2023]. SOURCE ADAPTED.

Figure 5(b) Schoolmeester, T., 2018. *Waste at Memelakha landfill in Thimphu*. [photograph] Available at: https://www.grida.no/resources/13256 [Accessed 5 September 2023]. SOURCE ADAPTED.

Figure 5(c) Zero Waste Bhutan, n.d. *Reasons for not using waste management services (proportion)*. [image online] Available at: https://zerowastebhutan.gov.bt/homepage/about [Accessed 5 September 2023]. SOURCE ADAPTED.

Figure 7(a) Chintala, S.R., Satish, K., Chandra, J., Diwakar, P., Murthy, Y. and Dadhwal, V., 2016. *Forest cover change in Bhutan, 1930–2014*. [image online] Available at: https://www.researchgate.net/figure/Forest-cover-change-in-Bhutan-1930-2014_fig11_309881350 [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 7(b) Thinley, P. and Lassoie, J., 2013. *Map of Bhutan's protected areas network prepared by Department of Forests & Park Services, Thimphu, Bhutan*. [image online] Available at: https://www.researchgate.net/figure/Map-of-Bhutans-protected-areas-network-prepared-by-Department-of-Forests-Park_fig2_313774103 [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 8(a) Wikipedia, n.d. *A political/geographical representation of the Eastern Himalayas*. [image online] Available at: https://en.wikipedia.org/wiki/Eastern_Himalayas [Accessed 5 September 2023]. SOURCE ADAPTED.

IUCN, n.d. *Geographic range*. [image online] Available at: https://www.iucnredlist.org/species/22692162/180030167 [Accessed 5 September 2023]. SOURCE ADAPTED.

Figure 8(b) sabirmallick, 2013. *Black-necked Crane stock photo*. [photograph] Available at: https://www.istockphoto.com/photo/black-necked-crane-gm187354029-28821384 [Accessed 5 September 2023]. SOURCE ADAPTED.

Figure 9(a) Nordic Asia Impact, 2020. *Annual CO2 emissions of Bhutan*. [image online] Available at: https://nordicasiaimpact.org/a-technical-and-environmental-review-of-present-and-future-prospect-of-bhutanese-hydropower/ [Accessed 5 September 2023]. SOURCE ADAPTED.

Figure 9(b) Global Footprint Network, n.d. *Bhutan*. [image online] Available at: https://data.footprintnetwork.org/?_ga=2.140915762.1256538132.1638461366-864422584.1637422406#/countryTrends?cn=18&type=BCtot,EFCtot [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 10 Gross National Happiness USA, n.d. *GNH*. [image online] Available at: https://gnhusa.org/wp-content/uploads/2016/11/gnh-domains.png [Accessed 5 September 2023]. SOURCE ADAPTED.

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2026

Environmental systems and societies

Higher level

Paper 1

16 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Associated shortcut
	Correct point – 1 mark will be added to the score for each tick placed up to the maximum for the question part. Please make sure that the number of ticks = the number of marks	
	**Used if the answer is worth zero marks**	
	Unclear	
	Benefit of the doubt	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Too vague	
	No working shown	
	SLP2 ONLY Expression of ideas	
	Ellipse. Dynamic; can be used to surround an area of the candidate's answer	
	Dynamic, vertical wavy line that can be expanded (to highlight a section of irrelevant work for instance)	
	Dynamic, horizontal wavy line that can be expanded (to highlight a section of irrelevant work for instance)	
	DOT. Valid part (to be used when more than one element is required to gain the mark e.g. Drawings)	
	Or words to that effect /OWTTE	
	Cross. Incorrect point (will not remove marks).	
	Advantage / pro (to identify elements in an unclear discussion when pairs are required).	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
	Difference (to identify elements in an unclear comparison)	

Annotation	Explanation	Associated shortcut
sim	Similarity (to identify elements in an unclear comparison)	
ECF	Error carried forward	
EG	Example / reference	
ND	No definition	
NExa	No examples	
	Highlighting areas of text	
	On page comment. Allows comments to be entered in speech bubbles on the candidate response. Can be used for additional marking comments, it can be linked to a specific tick if that is appropriate. You might like to have a word document of regularly used comments that can be copied and pasted into the text box.	
	H line. Underline tool – dynamic, horizontal line that can be expanded (to highlight a section of irrelevant work for instance)	
SEEN	**You MUST use this to indicate that blank pages and continuation sheets have been seen.**	

You **must** make sure you have looked at all pages. Please put the SEEN annotation on any blank page, to indicate that you have seen it.

Examiners should be aware that in some cases, candidates may take a different approach, which if appropriate should be rewarded. If in doubt, check with your team leader.

In the case of an “identify” question read all answers and mark positively up to the maximum marks. Disregard incorrect answers. In all other cases where a question asks for a certain number of facts *eg* “describe two kinds”, mark the **first two** correct answers. This could include two descriptions, one description and one identification, or two identifications.

It should be recognized that, given time constraints, answers for part (c) questions are likely to include a much narrower range of issues and concepts than identified in the markband. There is no “correct” answer. Examiners must be prepared to award full marks to answers which synthesize and evaluate even if they do not examine all the stimulus material.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

4. Personal codes/notations are unacceptable.

5. Where an answer to a part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an “NR” in the mark panel on the right-hand side of the screen.

6. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

7. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “seen” on any page that contains no other annotation.

8. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

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.

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) Cool temperate; **[1]**

(b) Warmer temperatures may result in biomes moving north/sub-tropical conditions covering a larger area of Bhutan;
Warmer temperature may result in biomes moving higher in altitude/reducing the size of the alpine biome;
More rainfall may result in the increase in area of the wet sub-tropical biome/reducing the size of the dry sub-tropical biome;range of biome/habitat types (mountains to semi-arid shrubland and coastal dunes)

Marking note: accept other reasonable responses which relate to the distribution of the biomes **[2]**

2. (a) (70/2.52=) 27.78 / 27.8 / 28 years **[1]**

(b) Rapid in-migration/immigration from rural areas;
Immigration to urban areas from other countries;
Higher fertility rate/higher birth rates in urban areas;
Lower mortality rates due to improved access to healthcare; **[2]**

(c) Deforestation (and loss of biodiversity/habitat) due to increased need for land for additional housing/additional infrastructure/growing food/increased demand for wood for heating/cooking;
Increased soil erosion (and fouling of rivers) due to reduced protection of soil from forests;
Increased air pollution due to traffic congestion/burning of biomass;
Increased water pollution due to insufficient sewerage;
Changing flood characteristics (and impact on riverine environments) due to increased impermeability (due to building);

Accept other reasonable responses. **[2]**

(d) Stage 3

Marking note: the top of the pyramid is concave which reflects the high death rates which are typically found in Stage 2. It is not yet Stage 4 as there are insufficient people in the 50+ age categories. This pyramid reflects a country transitioning from Stage 2 to Stage 4. **[1]**

3. (a) Biomass (36%) **[1]**

(b) (1760-830=) 930 (million kWh);
Marking note: accept answers between 910-950 (million kWh) **[1]**

(c) *Positives [4 max]*

- Electricity is almost entirely generated by hydropower, which is a renewable source of energy;
- More dams will reduce the risk of flooding;
- Dams provide lakes for fishing/water supply/wildlife/recreation;
- Exporting electricity provides income to the country, which increases development/can be used to improve living conditions;
- Plans to increase use of renewables is good in terms of energy security/energy independence from imports / increasing renewables reduces dependency on fossil fuels, which produce GHG/contribute to global warming;
- Implementation of energy efficiency will reduce demand (by at least 50%) by 2040;

Negatives [4 max]

- Still depends heavily on biomass, which might lead to high rates of deforestation;
- Still imports/uses significant amounts of fossil fuels/petrol/wood/charcoal which emit carbon dioxide/GHGs/PM2.5;
- Building more dams leads to flooding large areas that can potentially cause seismic movement;
- Hydropower is linked to rise in methane emissions due to anaerobic decomposition (of flooded forests);
- Building dams results in loss of biodiversity/loss of habitat/changes in the riverine environment downstream / loss of farmland/settlements/relocation of communities;
- Dams can block fish/river species migratory routes;
- Reliance on hydropower questionable under climate change scenarios / reduction in glacier melt in the future (due to climate change) may reduce availability of hydropower;
- Implementation of other renewables is vague/no timeline provided;

Reserve one mark for the conclusion [1 max]:
The conclusion should have a clear value statement about Bhutan's energy policy for the future, considering both negatives and positives of the plan. For example:
"While Bhutan's plans to continue to develop renewables will allow for greater energy security in the future, there are concerns relating to the loss of glaciers as a source of energy (hydroelectric power) with climate change / Although building of dams can result in loss of local habitats and biodiversity, the replacement of fossil fuels can make a greater overall contribution to the mitigation of climate change and subsequent conservation of biodiversity around the world." **[6]**

4. (a) Seven/7; **[1]**

(b) Thimphu is located in a mountain valley allowing temperature inversions to occur;
During the winter months the sun would be lower in the sky, and therefore not penetrate the valleys, creating colder conditions in the valley compared to the mountain slopes;
The colder air is dense/stable, and therefore pollution remains in the valley (resulting in higher levels) / in the summer months, the sun is higher in the sky and would therefore warm the valley floors, which would mean temperature inversions would occur less frequently in the summer;
Increased combustion of fossil fuels due to colder temperatures increasing the proportion of particulates in the atmosphere;
Less rainfall in the winter months to wash out particulate matter from the atmosphere; **[3]**

(c) *Specified source of PM2.5 [1 max]:*
- Volcano emissions/forest fires/combustion of fossil fuels/combustion of wood in locations outside of Bhutan (neighbouring countries);

Transboundary movement of pollution [1 max]:
- Brought into Thimphu by (prevailing) wind; **[2]**

(d) Needs to be a multi-pronged approach of public awareness, initiatives and government regulations and enforcement;
Creating traffic reduction-strategies during the winter months such as limiting driving to alternate days/ reducing speed limits/banning (diesel) cars from city;
Have warning systems for high-pollution days to avoid premature deaths;
Phase-out fossil-fuel use, replace with renewables/electrification from hydropower;
Poster/advertising campaign to encourage reduction in travel (ie. car-pooling);
Requiring catalytic converters in cars to reduce toxic emissions;
Provide free/cheap public transportation (electric) within the main part of Thimphu to reduce emissions;
Invest in tree-planting within the city/green roofs to absorb toxic emissions;
Encourage cycling/walking through the creation of bicycle lanes/pedestrian areas in the worst-polluted sections;
Strong pollution control laws on industries burning fossil fuels;
Government incentives/tax breaks for using renewable energy (such as installing solar panels on private residences);
Deal with international pollution through agreements, legislation etc; **[4]**

5. (a) Contamination of groundwater/soil through leachate;
Release of methane gas/carbon dioxide from decomposition of the organic waste, which is/are greenhouse gases, contributing to global warming;
Lack of venting may lead to the buildup of gases, with risk of damage from fire and explosions;
Visual pollution if wind/animals carry the waste into the surrounding area;
Air pollution from trucks/lorries driving to/from the open-air landfill;
Noise pollution from trucks/lorries driving to/from the open-air landfill;
Potential toxins/poisoning of wildlife which eat waste matter / increase in pests from the open-air landfill; **[3]**

(b) *Positives [4 max]*

- Focuses on individual responsibility to reduce waste at source;
- Advertising brings community involvement into the programme, which increases its chances of success;
- Greater access to collection points/more frequent collection will reduce illegal dumping of waste;
- Incineration could potentially be used for waste-to-energy;
- Zero-waste hour reduces the visual impact of the pollution already present in the region / zero hour can help change individual attitude towards waste disposal that encourages behavioural change;
- Job creation at the sorting centres;
- Recycling and re-use reduces waste going to landfill;

Negatives [4 max]

- Does not come into effect until 2030, which does not address the issues already present;
- The current landfill is already over-capacity, so where will the SDW go until 2030;
- Zero-waste will not be achieved as the plan still accepts 20% going to landfill;
- Still relying on landfill, which is potentially damaging to the groundwater, soil and wildlife;
- Incineration may lead to greater issues with air pollution in urban areas;
- Recycling is only effective if there is a market for the recycled products;
- Does not address the issue of illegal dumping;

Reserve one mark for the conclusion [1 max]:
The conclusion should have a clear value statement about Bhutan's waste programme, considering both negatives and positives of the plan. For example:
"While Bhutan's waste management programme involves community engagement, the fact that it will still rely heavily on landfill and incineration means that environmental contamination has not been addressed / While Bhutan will still rely on landfill in the future, the emphases on community involvement and recycling means that the country will be able to greatly reduce the amount of waste going to the landfill."

Note: sustainability may include aspects relating to social, environmental, economic and political **[6]**

6. (a) Ensure pipes are not leaking, to reduce loss / fix leaking pipes to reduce water loss;
Encourage water savings through public announcements / engage local communities to reduce water use / encourage the use of water saving devices (eg water efficient shower heads/tap aerators);
Have strict pollution controls/water treatment to ensure source is not contaminated;
Store water during spring melt in reservoirs to ensure supply in drier periods;
Install water meters in individual homes to encourage conservation (due to higher costs for excess use);
Use grey water recovery systems to reduce consumption of freshwater supplies (eg. use shower water to flush toilets);
Centralize water distribution/remove private water supply companies to ensure water costs are affordable for all citizens / government cap on water price making water affordable;
Heat distribution pipes in winter / bury them deeper underground to ensure they do not freeze and cut-off supplies; **[2]**

(b) Cost of water treatment may be too high;
Infrastructure of water distribution may be old/inefficient, requiring investment/high costs to repair/improve;
Reduction in snowfall (due to climate change) has reduced a traditional water source / in the long term, reductions in water availability due to glacial melt may put Thimphu at greater risk;
Rapid growth of the city is exceeding capacity / rapid development increases demands on water supply, exceeding capacity; **[1]**

(c) Increased impermeability/decreased permeability of the soil due to concrete/asphalt/buildings which results in greater surface runoff;
Poor drainage within the city/lack of stormwater drains to remove excess water quickly;
Thin soils/exposed rock in mountainous areas / steep slopes reduce infiltration capacity, resulting in more surface runoff;
(climate change / global warming lead to) Rapid glacial melt / heavy rainfall could suddenly increase river flows;
Deforestation on the slopes above Thimphu greatly reduces infiltration/interception/uptake by trees;
Collapse of hydroelectric dams; **[2]**

7. (a) Forest loss occurring mainly in the southern parts of the country/along the southern border with India/south of 27°N;
Forest loss around Thimphu;
Forest gain occurs mainly in the northern parts of the country/north of 27°N/just south of the non-forest areas/just south of the Alpine climate areas/areas of higher elevation;
Forest loss along the (Dangme Chnu) river valley in the east; **[2]**

(b) Tourism / logging / timber / charcoal / berries/fruit/food to sell / rubber

Marking note: accept any other reasonable responses which relate to economic value **[1]**

(c) *Strengths [2 max]*

- Allows migration between areas and reduces isolation of populations;
- Migration increases genetic diversity/gene pool;
- provide protected areas for movement of organisms / allows for seasonal migration;
- Reduces the need for larger protected areas / may be easier to manage than larger protected areas;

Limitations [2 max]

- Corridors may not have the same level of protection as protected areas;
- Roads cross the corridors, which may result in road kill;
- Corridors are too narrow for territorial animals (such as tigers);
- Can allow spread of disease/invasive species from one protected area to another;
- Could increase threat from predators based in other reserves; **[3]**

8. (a) Recognition of the high levels of endemic biodiversity are under threat;
Results in more funds being raised/focuses funds to protect the region;
May raise international awareness of the value of the region in need of protection;
Informs political direction/decision making;
May intensify scientific research into the biodiversity and ecology of the region; **[2]**

(b) Black-necked crane has spiritual/cultural value for the Bhutanese and therefore will be more effective in fund-raising campaigns than other organisms;
Black-necked crane has striking appearance/behaviour which attracts tourists/ecotourism;
Black-necked crane has striking appearance which is good for advertising/fundraising/logos;
Action taken to improve survival of Black-necked crane will benefit the whole ecosystem; **[1]**

(c) Take aerial/air photos/drone photos of the area;
Count all cranes within each photo;
Place a grid over the photo and randomly select one grid;
Repeat counting to allow an average number to be determined;
Extrapolate over the entire area;
Repeat at different times / days / seasons (migratory) / years
OR
Capture using (mist) nets;
Mark using leg rings/wing tags;
Release into the same environment;
Recapture using same method after a period of time / repeat;
Estimate proportion of population tagged to calculate total / apply Lincoln Index; **[3]**

(d) Difficulty in obtaining international/trans-boundary agreements (due to different value systems);
May be killed/hunted along the migratory path if they rest in/pass through transit countries where they are not protected;
Not all birds follow the same migratory path/they may end up in multiple countries;
Many natural risks to migrating species along route, eg storms, predation, lack of shelter; **[2]**

9. (a) (1.18-0.38)/(2017-2009)= 0.8/8 =0.1 (million tonnes per year)

Accept range 0.09 to 0.11 (million tonnes per year) **[1]**

(b) *reserve one mark for recognition of trend:*

- Bhutan's ecological reserve is decreasing;

2 max for explanation/conclusion:

- The EF is rising more quickly than the biocapacity;
- The biocapacity is increasing due to forest planting/land use change;
- Rising standards of living/increased use of water/rising CO2 levels/importation of fossil fuels/increasing landfill, etc. are contributing to a larger EF; [this is using the knowledge and understanding of the two factors that determine the ecological reserve]
- (If this continues) Bhutan may become unsustainable in the future / EF may exceed the biocapacity; **[3]**

(c) *Arguments for [3 max]*

- COP events can produce binding international agreements;
- Because COP events are organised by United Nations, they have some international recognition;
- Global warming is an international phenomenon and therefore needs international cooperation;
- The negotiation of international agreements raises the profile of global warming issues globally;
- Preferential trade arrangements may allow Bhutan to offset these costs/loss of income;
- Agreements can be made such that equity can be promoted between MEDCs and LEDCs;
- Such agreements may encourage other LEDCs to work towards carbon neutral/negative states for equal preferential trade arrangements, which will benefit the entire planet by mitigating greenhouse gases;

Arguments against [3 max]

- International agreements can take a long time to become established;
- Other countries without the benefit of Bhutan’s forests would be disadvantaged, which creates unfair trading practices/which would not be allowed under international trade law;
- Being carbon negative does not guarantee social equality or justice, and therefore the country may be benefitting from inappropriate practices (such as child labour);
- Remaining carbon negative is already in Bhutan’s interests as it encourages international tourism, so should not receive further benefits;

Note to examiners: there must be at least one counter-argument for full marks to be awarded. A well-balanced conclusion with a clear value statement can be credited for the fourth mark, but it is not required. **[4]**

10. (a) Questionnaires/surveys/interviews;
Statistics from hospitals/psychiatric facilities;
Statistics on suicide/jail populations; **[1]**

(b) *Arguments for [4 max]*

- GNH ensures that the environment, society and the economy are equally valued;
- Ensures development raises the standard of living without reducing the quantity or quality of resources for future generations;
- In addressing wider community issues it is more in line with Sustainable Development Goals;
- In addressing ecological diversity, it also addresses planetary boundary issues;
- GNH is a multi-factor tool having several similarities with Doughnut Economics;
- Reduces the emphasis on economic development (which is seen in GDP per capita);
- Emphasises community involvement, which typically results in more successful actions;

Arguments against [4 max]

- Seven of the nine aspects relate to social well-being, which diminishes the importance of the economy and the environment;
- Many of the aspects are based on personal perception, which can vary enormously/would be difficult to measure;
- Nine different elements would be too difficult to balance in terms of planning for development;
- Changing values of the Bhutanese (with continued globalization/exposure to other cultures) may be difficult to factor into the development plan;
- Economic development is required in order to raise standard of living, which the Bhutanese may care about;

Reserve one mark for the conclusion [1 max].
The conclusion must be balanced, presenting arguments for both sides, with a clear value judgement. For example:
"Using GNH as a tool to drive policy will enable Bhutan to develop in a sustainable manner, even though it may be difficult to balance all of the elements / Using GNH as a tool for sustainable development is a nice idea, but the complications of measuring and balancing all nine elements will mean that decisions are unlikely to be made as there will be too many stakeholders".

Marking note: Accept any other reasonable responses. **[6]**

Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Higher level
Paper 2

Specimen paper

Candidate session number

2 hours 30 minutes

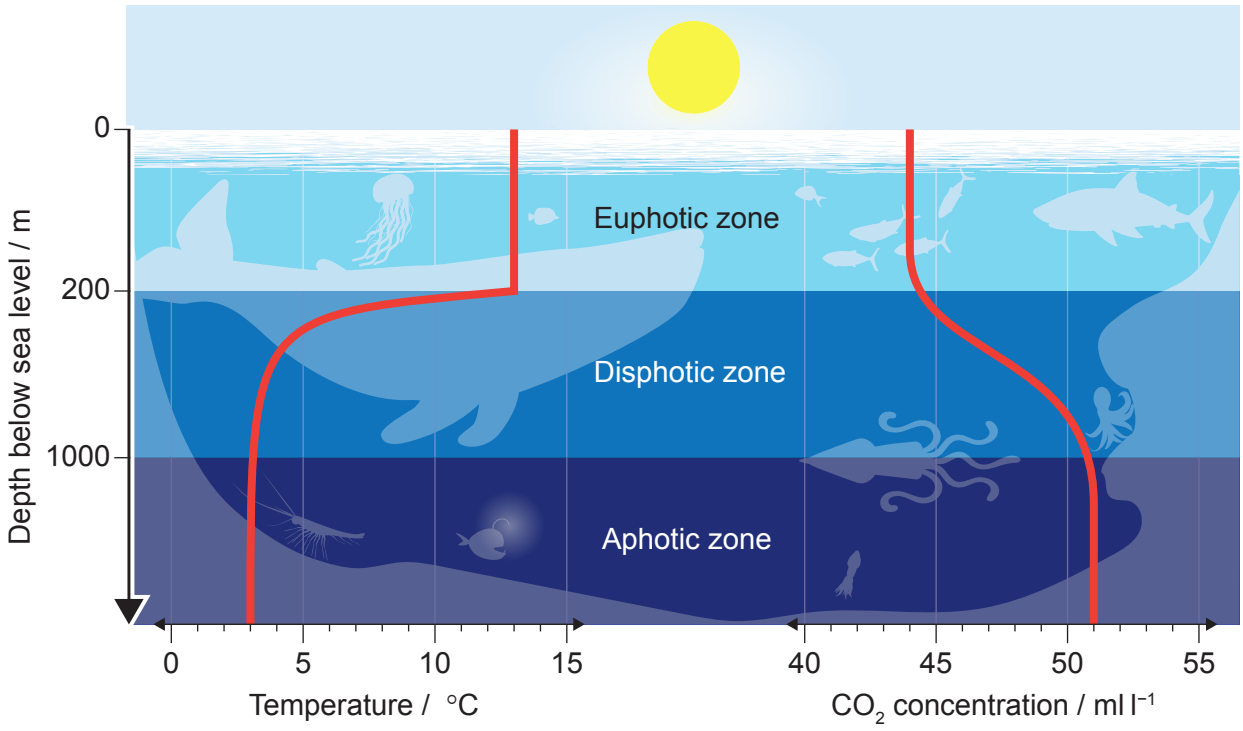
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

Figure 1: Variation of temperature and dissolved CO_2 concentration with ocean depth



1. (a) Describe the variation in temperature from 0 to 1000 m depth below sea level, shown in **Figure 1**. [2]

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(b) Explain which zone in **Figure 1** would have the greatest primary productivity. [2]

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(This question continues on the following page)

(Question 1 continued)

(c) Outline why upwellings can increase productivity just below sea level. [1]

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(d) Outline **one** impact that global warming might have on water density just below sea level in **Figure 1**. [1]

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(e) Outline the relationship between temperature and concentration of dissolved carbon dioxide in the ocean, shown in **Figure 1**. [1]

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(f) Explain different ways that the continued combustion of fossil fuels could affect the ability of oceans to act as a carbon sink. [5]

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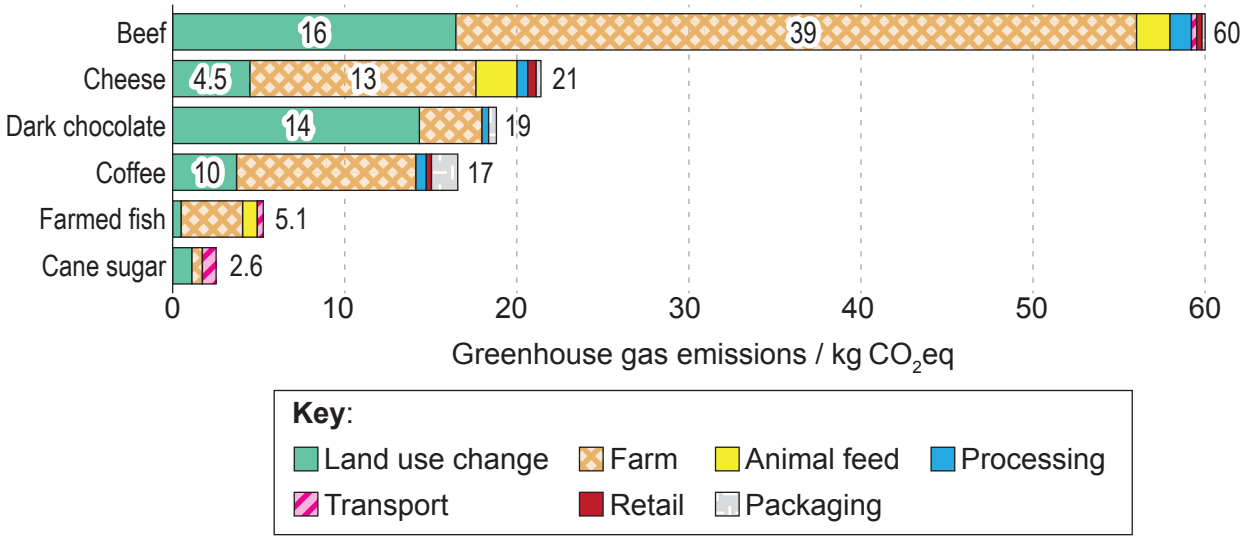
Figure 2: Greenhouse gas emissions in kilogram CO_2 equivalent per kilogram of selected food items at different stages in the supply chain



2. (a) Using **Figure 2**, calculate the percentage of kg CO_2eq emissions from land use change for beef. [1]

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(b) Suggest **one** reason why cane sugar produces the highest percentage of kg CO_2eq from transport. [1]

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(Question 2 continued)

(c) Distinguish between the kg CO_2eq emissions from cheese and dark chocolate. [2]

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(d) Outline **two** reasons why beef produces more kg CO_2eq emissions than farmed fish. [2]

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(e) Suggest **one** way that kg CO_2eq emissions can be reduced in the production of beef. [1]

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Please **do not** write on this page.

Answers written on this page
will not be marked.

Figure 3(a): The Great Pacific Garbage Patch (GPGP) in which ocean currents cause plastic waste to accumulate

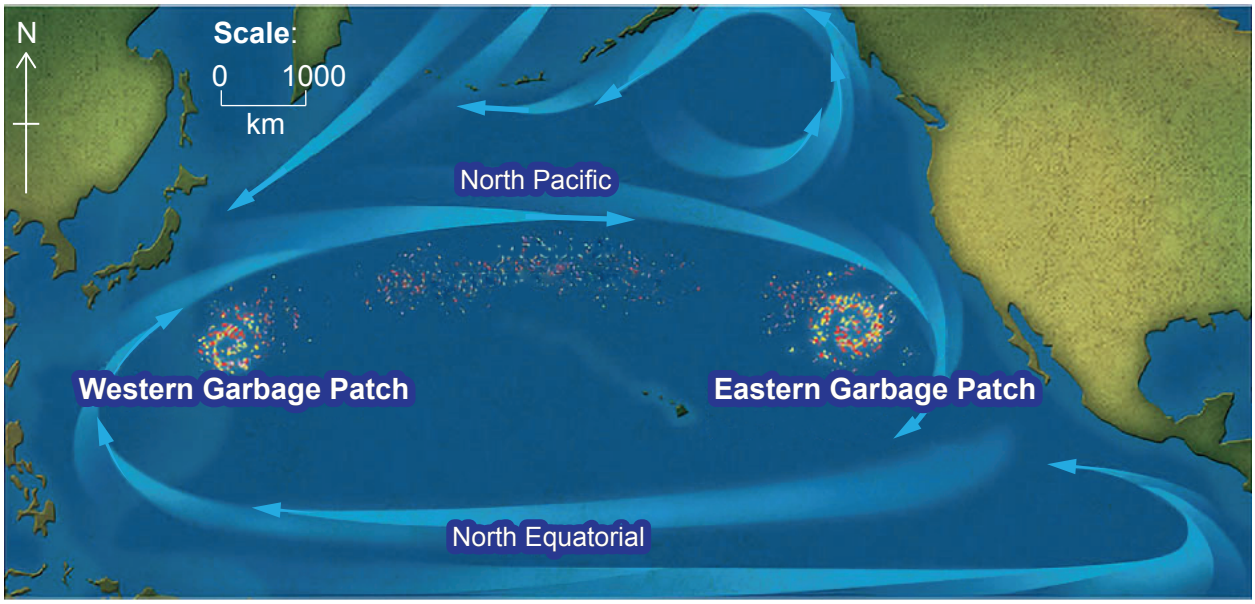
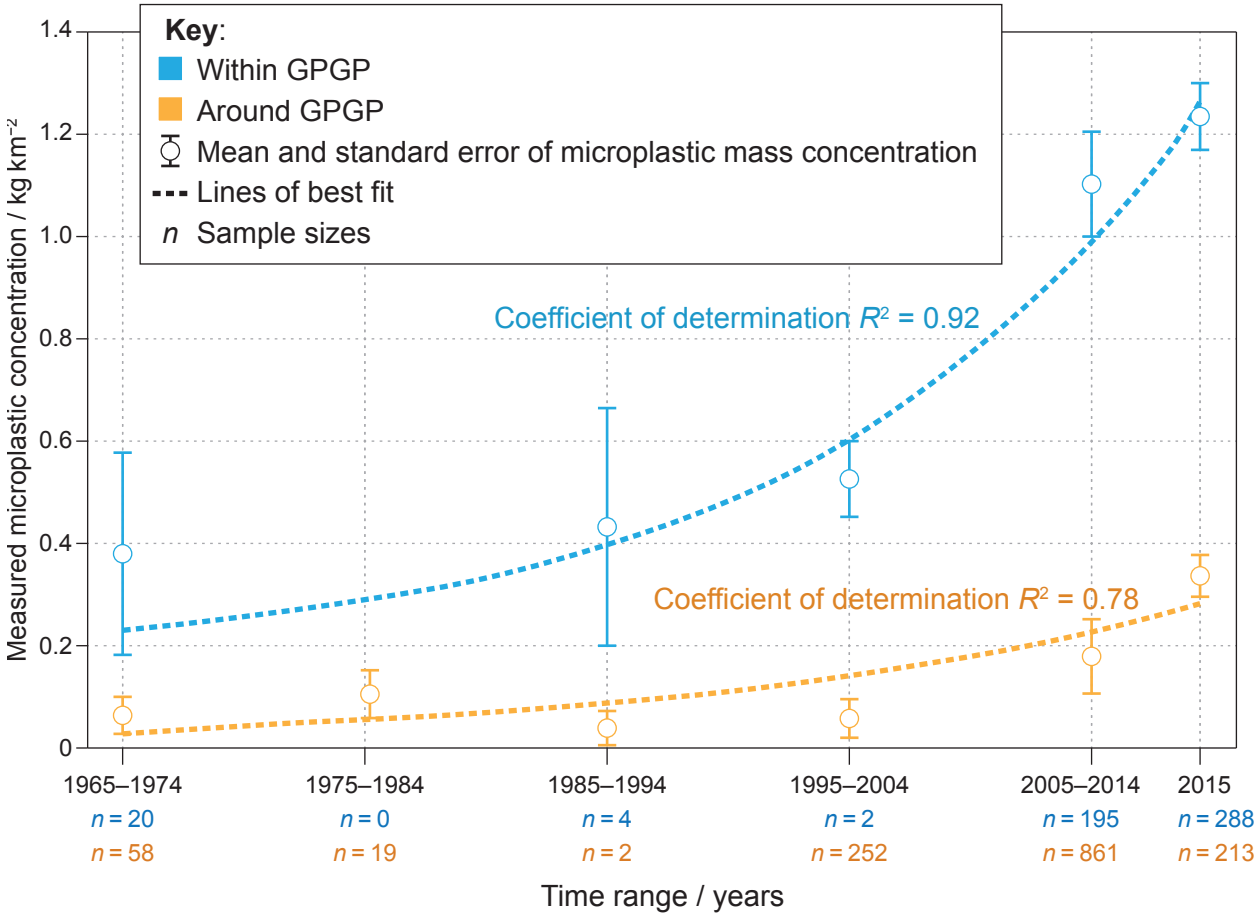


Figure 3(b): Mean and standard error of microplastic concentration within and around the eastern portion of the GPGP



3. (a) Outline the overall trend in microplastic concentration over time within the GPGP, as shown in **Figure 3(b)**. [1]

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(b) Describe the significance of the coefficient of determination (R^2) **within** the GPGP shown in **Figure 3(b)**. [2]

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(c) With reference to **Figure 3(b)**, suggest why the results from around the GPGP are more reliable than those from within the GPGP. [1]

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(d) Outline reasons why microplastics in the GPGP may have the greatest impact on species at higher trophic levels. [2]

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(Question 3 continued)

(e) Using **Figure 3(b)**, outline **one** reason why fish found in the GPGP in 2015 may have a higher concentration of toxins from microplastics than in 1995. [1]

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(f) Explain how the accumulation of microplastic in the GPGP demonstrates the concept of the Tragedy of the Commons. [4]

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Figure 4(a): Proportion of tree cover and percentage of the population with a low income in Portland, Oregon, USA

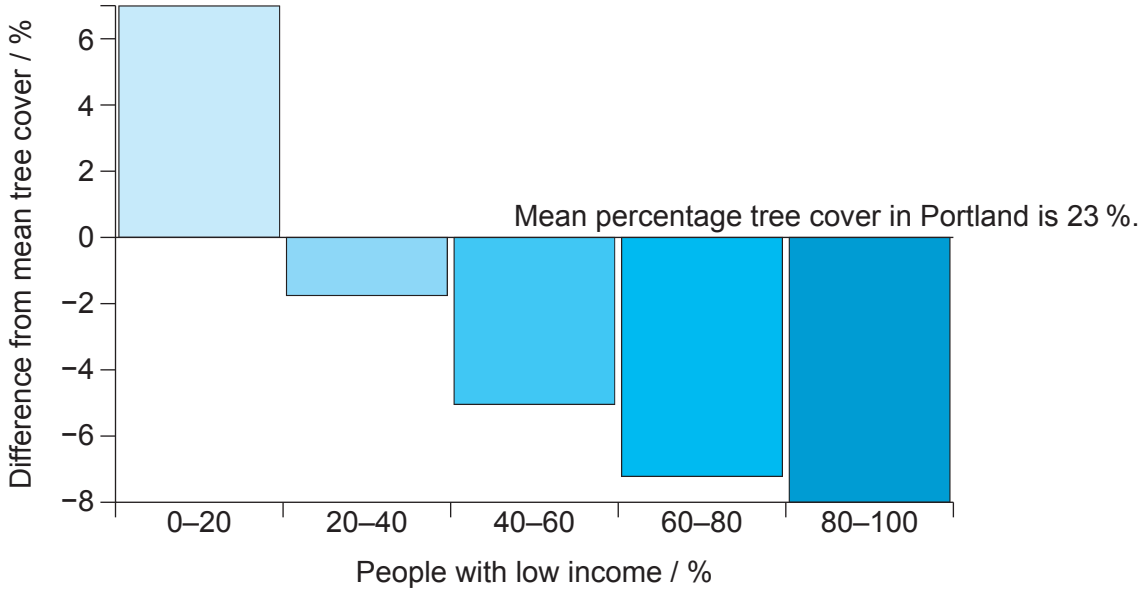
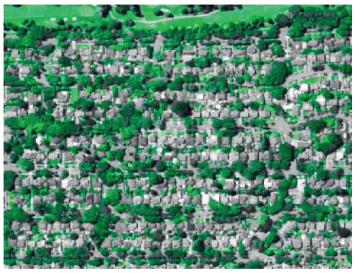


Figure 4(b): Satellite images of areas of relatively low- and high- median income in Portland, Oregon, USA

High income



Low income

4. (a) (i) Using **Figure 4(a)**, state the relationship between percentage of tree cover and percentage of people with low income in Portland, Oregon. [1]

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(Question 4 continued)

(ii) Suggest **two** reasons for the relationship between percentage of tree cover and percentage of people with low income in Portland, Oregon. [2]

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(b) With reference to **Figures 4(a)** and **4(b)**, describe **two** socio-economic impacts that people living in low income areas might experience. [2]

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(c) Discuss how the pursuit of environmental justice in Portland could also address climate change. [5]

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Section B

Answer **two** questions. Answers must be written within the answer boxes provided.

5. (a) Identify **four** significant individuals or events and their impacts on the development of the environmental movement. [4]

(b) With reference to both carbon and nitrogen cycles, distinguish between stores, sinks and sources. [7]

(c) Discuss the evidence suggesting human activity has given rise to what may be considered a new geological epoch. [9]

6. (a) Outline how the concept of product stewardship may contribute to the sustainable use of resources. [4]

(b) Explain how different agricultural practices may influence sustainability. [7]

(c) Evaluate the role of national legislation and international agreements in achieving sustainability. [9]

7. (a) Outline how the flow of energy along a food chain demonstrates the second law of thermodynamics. [4]

(b) Evaluate the strategies that have been used to protect stratospheric ozone. [7]

(c) Discuss how different ethical views regarding the relationship between humans and nature may influence approaches to conservation. [9]

Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

Figure 1 National Ocean Service, n.d. *What is a thermocline?* [image online] Available at: https://oceanservice.noaa.gov/facts/thermocline.html [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 2 Ritchie, H., 2020. You want to reduce the carbon footprint of your food? Focus on what you eat, not whether your food is local. *Our World in Data*. [image online] Available at: https://ourworldindata.org/food-choice-vs-eating-local [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 3(a) National Ocean Service, n.d. *The Great Pacific Garbage Patch*. [image online] Available at: https://oceanservice.noaa.gov/podcast/june14/mw126-garbagepatch.html [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 3(b) Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose. B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo. S., Schwarz. A., Levivier. A., Noble. K., Debeljak. P., Maral. H., Schoeneich-Argent. R., Brambini. R., and Reisser. J., 2018. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific Reports*. [image online] Available at: https://www.nature.com/articles/s41598-018-22939-w [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 4(a) Tree Equity Score, n.d. *Tree Equity Score Locality Report*. [image online] Available at: https://www.treeequityscore.org/reports/place/portland-or [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 4(b) Ramspott, F., n.d. *Portland 3D Render Satellite View Topographic Map Horizontal - stock photo*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/portland-3d-render-satellite-view-topographic-map-royalty-free-image/653909454 [Accessed 23 September 2023]. SOURCE ADAPTED.

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2026

Environmental systems and societies

Higher level

Paper 2

20 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Associated shortcut
	Correct point – 1 mark will be added to the score for each tick placed up to the maximum for the question part. Please make sure that the number of ticks = the number of marks	
	**Used if the answer is worth zero marks**	
	Unclear	
	Benefit of the doubt	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Too vague	
	No working shown	
	SLP2 ONLY Expression of ideas	
	Ellipse. Dynamic; can be used to surround an area of the candidate's answer	
	Dynamic, vertical wavy line that can be expanded (to highlight a section of irrelevant work for instanc(e)	
	Dynamic, horizontal wavy line that can be expanded (to highlight a section of irrelevant work for instanc(e)	
	DOT. Valid part (to be used when more than one element is required to gain the mark e.g. Drawings)	
	Or words to that effect /OWTTE	
	Cross. Incorrect point (will not remove marks).	
	Advantage / pro (to identify elements in an unclear discussion when pairs are require(d).	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are require(d)	
	Difference (to identify elements in an unclear comparison)	

Annotation	Explanation	Associated shortcut
sim	Similarity (to identify elements in an unclear comparison)	
ECF	Error carried forward	
EG	Example / reference	
ND	No definition	
NExa	No examples	
	Highlighting areas of text	
	On page comment. Allows comments to be entered in speech bubbles on the candidate response. Can be used for additional marking comments, it can be linked to a specific tick if that is appropriate. You might like to have a word document of regularly used comments that can be copied and pasted into the text box.	
	H line. Underline tool – dynamic, horizontal line that can be expanded (to highlight a section of irrelevant work for instanc(e)	
SEEN	**You MUST use this to indicate that blank pages and continuation sheets have been seen.**	

You **must** make sure you have looked at all pages. Please put the SEEN annotation on any blank page, to indicate that you have seen it.

Examiners should be aware that in some cases, candidates may take a different approach, which if appropriate should be rewarded. If in doubt, check with your team leader.

In the case of an “identify” question read all answers and mark positively up to the maximum marks. Disregard incorrect answers. In all other cases where a question asks for a certain number of facts *eg* “describe two kinds”, mark the **first two** correct answers. This could include two descriptions, one description and one identification, or two identifications.

It should be recognized that, given time constraints, answers for part (c) questions are likely to include a much narrower range of issues and concepts than identified in the markband. There is no “correct” answer. Examiners must be prepared to award full marks to answers which synthesize and evaluate even if they do not examine all the stimulus material.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

4. Personal codes/notations are unacceptable.

5. Where an answer to a part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an “NR” in the mark panel on the right-hand side of the screen.

6. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

7. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “seen” on any page that contains no other annotation.

8. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

Subject details: Environmental systems and societies HLP2 Markscheme

Mark allocation

Candidates are required to answer:
- **ALL** questions in Section A **[40]** and **TWO** questions in Section B **[40]**.
- The maximum total = **[80]**.

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 forwar(d) 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) Describe the variation in temperature from 0 to 1000 m depth below sea level, shown in **Figure 1.** **[2]**

a. steady temperature/no change in the first 200 m;
b. Initial rapid decrease but rate slowing from 200–1000 m;
c. decrease from 13°C to 3°C with depth;

(b) Explain which zone in **Figure 1** would have the greatest primary productivity. **[2]**

a. euphotic zone because it has the most sunlight/warmer temperatures;
b. more sunlight/warmer temperatures will increase the rate of photosynthesis;

(c) Outline why upwellings can increase productivity just below sea level. **[1]**

a. upwellings bring nutrients from the bottom, which can increase productivity / nutrients can be limiting factors for productivity in aquatic ecosystems;
b. upwellings result in phytoplankton blooms, which result in large gatherings of herbivores/zooplankton/fish;

(d) Outline **one** impact that global warming might have on water density just below sea level in **Figure 1**. **[1]**

a. decreased density as warmer water is less dense than colder water (water is most dense at 4°C);
b. decreased density as melting glaciers/ice caps dilute salinity;

(e) Outline the relationship between temperature and concentration of dissolved carbon dioxide in the ocean, shown in **Figure 1**. **[1]**

a. As the temperature decreases, concentration of dissolved CO_2 in water increases;
b. As the temperature increases, concentration of dissolved CO_2 in water decreases;

(f) Explain different ways that the continued combustion of fossil fuels could affect the ability of oceans to act as a carbon sink. **[5]**

a. combustion of fossil fuels releases CO_2 into the atmosphere which is absorbed by the oceans;
b. as more CO2 is absorbed, oceans will reach a saturation point, where no more CO_2 can be absorbed;
c. CO_2 in the atmosphere increases global temperatures resulting in increased ocean temperatures;
d. warmer oceans cannot hold as much CO_2 /can release CO_2 into the atmosphere;
e. warmer temperatures might increase rate of photosynthesis in oceans, which will increase the absorption of CO_2;
f. increased CO_2 dissolved in water increases ocean acidification, acidification will reduce phytoplankton/photosynthesis decreasing CO_2 uptake;
g. warmer temperatures reduce upwelling/increases stratification, which reduces nutrients available for photosynthesis and therefore reduces the uptake of CO_2 ;
h. Altered Ocean Circulation: The excess heat generated from burning fossil fuels contributes to global warming, which can disrupt ocean circulation patterns. These changes in ocean currents impact the distribution of nutrients, affecting the efficiency of carbon sinking processes.
i. Sea Level Rise: Rising sea levels can result in coastal erosion, flooding, and the loss of important coastal ecosystems that play a role in carbon sequestration.

2. (a) Using **Figure 2**, calculate the percentage of kg CO_2eq emissions from land use change for beef. **[1]**

16/60 x 100 = 26.7%

(b) Suggest **one** reason why cane sugar produces the highest percentage of kg CO_2eq from transport. **[1]**

a. sugar is a key ingredient in many other products that are made in different parts of the world;
b. most sugar can only be grown in certain regions but is used globally;
c. travels through / processed in a series of locations;

(c) Distinguish between the kg CO_2eq emissions from cheese and dark chocolate. **[2]**

a. cheese has greater total kg CO_2eq emissions than dark chocolate;
b. chocolate has a greater percentage/more emissions from land use than cheese;
c. dark chocolate has no emissions from animal feed whereas cheese does have animal feed emissions;
d. cheese has a greater percentage/more emissions from the farm than chocolate;

(d) Outline **two** reasons why beef produces more kg CO_2eq emissions than farmed fish. **[2]**

a. land use change is much higher, because animals need more land modified than fish;
b. use of fossil fuels to heat barns;
c. produce methane (included in CO_2eq);
d. beef requires more processing;

(e) Suggest one way that kg CO_2eq emissions can be reduced in the production of beef. **[1]**

a. select of breed of cattle that produces less methane;
b. use feed that produces less methane;
c. grow locally produced feed;
d. use energy efficient equipment;
e. reduce use of fertilizers in production of feed / reduce use of packaging;

3. (a) Outline the overall trend in microplastic concentration over time **within** the GPGP, as shown in **Figure 3(b)**. **[1]**

Plastic concentration is growing exponentially / at an accelerating rate over time;

(b) Describe the significance of the coefficient of determination (R^2) **within** the GPGP shown in Figure 3(b). **[2]**

a. the coefficient of determination/R^2 represents how well the data points fit the line of best fit;
b. 0.92 is close to 1 indicating a close fit between points and line;
c. because of the high R^2 the line is a good model for predicting future trends;

(c) With reference to **Figure 3(b)**, suggest why the results from around the GPGP are more reliable than those from **within** the GPGP. **[1]**

a. around is more reliable because it has a larger sample size (except for 2015)/converse;
b. around is more reliable because it has less variation/SE/smaller error bars;

(d) Outline reasons why microplastics in the GPGP may have the greatest impact on species at higher trophic levels. **[2]**

a. microplastics are ingested at the lower trophic levels;
b. microplastics can carry / act as a vector for toxins;
c. toxins from POPs can bioaccumulate in prey;
d. toxins from POPs can biomagnify along food chains;

(e) Using **Figure 3(b)**, outline one reason why fish found in the GPGP in 2015 may have a higher concentration of toxins from microplastics than in 1995. **[1]**

a. fish in 2015 would be exposed to a higher concentration of microplastics than in 1995;
b. fish in 2015 would have had a greater length of exposure to microplastics / toxins will have bioaccumulated and biomagnified for a longer period;
c. microplastics have been around for longer, therefore may have absorbed more toxins;

(f) Explain how the accumulation of microplastic in the GPGP demonstrates the concept of the tragedy of the commons. **[4]**

a. tragedy of the commons describes negative outcomes of a shared common resource;
b. Consider adding marking point : The tragedy of the commons arises because there is no clear ownership or responsibility for the GPGP.
c. the ocean/organisms/fish/natural resources from the ocean are the commons in this example;
d. individuals/countries might only create a small amount of plastic;
e. the combined effect has an appreciable impact on the oceans/fish/shared resources in the ocean;
f. people act in their own self interest, without considering how their actions will affect others;
g. results in the widespread impact on natural systems and human food sources;
h. people/governments often favour short-term gain (over long-term environmental solutions) / (*e.g.* out of sight, out of mind)

Note: max [2] if GPGP is not mentioned in response

4. (a) (i) Using Figure 4(a), state the relationship between percentage of tree canopy and percentage of people with low income in Portland, Oregon. **[1]**

Negative correlation / as the % of people with low income increases, the % of tree canopy decreases;

(ii) Suggest two reasons for the relationship between percentage of tree canopy and percentage of people with low income in Portland, Oregon. **[2]**

a. low income areas tend to have greater population/housing density, therefore less space for trees;
b. land/property value of areas with trees is higher than areas with fewer trees so only higher income people can live there;
c. lower priority for maintaining/planting trees in areas with a higher % of people with low income;
d. maintaining trees/parks can be expensive, so higher income people can afford them;
e. parks/greenspaces tend to be on the edge/outside city centre and low income people can't afford transportation into city centre for work;

Note: Accept any valid suggestion for relationship

(b) With reference to **Figures 4(a)** and **4(b)**, describe **two** socio-economic impacts that people living in low income areas might experience. **[2]**

a. higher electricity costs for cooling because fewer trees to provide shade;
b. higher heating costs in winter because fewer trees to block wind;
c. fewer parks to enjoy nature/exercise / poor health, eg causing obesity / increased medical costs;
d. increased mental health issues / nature deficit disorder in children;
e. lower health outcomes due to lack of green space/trees to mitigate air pollution;
f. increased noise pollution because no trees to block noise;

Note: Accept any two valid descriptions of socio-economic impacts

(c) Discuss how the pursuit of environmental justice in Portland could also address climate change. **[5]**

Positive: max [3]

a. giving those who are marginalized a voice can increase the likelihood of local government planting trees in low income neighbourhoods;
b. improving the wellbeing of people can empower them to take action against climate change;
c. investing in planting trees in low income areas could mitigate climate change/absorb CO2;
d. investing in planting trees in low income areas could help poorer areas be better adapted to increasing temperatures/effects of climate change;
e. investing in planting trees in low income areas could improve health/save money over time, allowing low income families the means to reduce their carbon footprint;
f. empowering communities with knowledge about climate change and its impacts, can foster grassroots movements and collective action

Negative: max [3]

a. governments may be elected for short periods and have different agendas, whereas climate change needs a long-term approach;
b. investing in trees might distract from more immediate needs of those in poverty;
c. improvements in health/financial position in low income areas could lead to more consumption, increasing carbon footprints;
d. scale of climate change is too large to be adequately addressed by one city;
e. not all actions for environmental justice directly address climate change;

Note: Accept other reasonable arguments
Allow [1] for an appropriate conclusion supported by evidence.

Section B

5. (a) Identify **four** significant influences and their impacts on the development of the environmental movement. **[4]**

a. Greta Thunberg raising international awareness of climate change;
b. Rachel Carson's Silent Spring raising awareness of damage from pesticides;
c. James Lovelock's Gaia hypothesis promoting holistic perspective of environment;
d. Fukushima nuclear disaster raising awareness of environmental impact of nuclear accidents;
e. Al Gore's documentary "Inconvenient Truth" raising awareness of global environmental issues;
f. UN Climate Change Conferences promoting international agreements to address climate change;
g. Production of plant-based 'meats' to promote a vegetarian diet;
h. Development of Carbon Capture and Sequestration technology to address climate change;

Credit can be awarded for other examples of similar significance.

(b) With reference to both carbon and nitrogen cycles, distinguish between stores, sinks and sources. **[7]**

a. Stores of matter remain in steady state/equilibrium with the environment;
b. Sinks involve a net accumulation of the element;
c. Sources involve a net release of the element into the surrounding environment;
d. Major stores of carbon cycle include the atmosphere, soils and fossil fuels;
e. Major sinks of carbon are plants that absorb CO_2 in photosynthesis;
f. Major sources of carbon are living organisms through respiration/combustion of fossil fuels;
g. Major store of nitrogen is in the atmosphere;
h. Major sinks for nitrogen are plants absorbing nitrates/Haber process;
i. Major sources of nitrogen are decomposers/denitrifying bacteria;

Credit may be given if any of the marking points are explicitly conveyed by means of a clearly labelled diagram.

(c) Discuss the evidence suggesting human activity has given rise to what may be considered a new geological epoch. **[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 demonstrate:

- **understanding concepts & terminology** of Holocene epoch; Anthropocene epoch; rock strata; stratigraphic records; records of historic atmospheric CO_2 levels; Industrial Revolution; global equilibrium/disequilibrium; non-native species fossil records; deposits from nuclear testing; modification of terrestrial and marine sedimentary systems and the presence in rock of minerals created solely or primarily from human activity; geological cooling and warming cycles in climate etc
- **breadth in addressing and linking** different strands and sources of evidence for and against an Anthropocene epoch.
- **examples** of relevant evidence from rock strata; ice cores; fossil records, pollen analysis etc
- **balanced analysis evaluating** extent to which the Anthropocene epoch is, or isn't, a viable hypothesis.
- **a conclusion that is consistent with, and supported by analysis and examples given** eg The great diversity of geological records available demonstrate major alternating cycles within climate and biosphere, but the evidence for an accelerated change over the last 10,000 years that correlates quite precisely with human industrialisation seems too much of a coincidence to allow for any other conclusion than a current Anthropocene epoch.

Please see markbands on page 19.

6. (a) Outline how the concept of product stewardship may contribute to the sustainable use of resources. **[4]**

a. responsibility is given to designers/producers to reduce impact and use of raw materials/incorporate recycled materials;
b. responsibility is given to sellers to accept back old products/packaging for recycling;
c. responsibility is given to users to recycle/reuse/reduce;
d. select environmentally/locally produced products;
e. reduce impact at all stages of life-cycle / “cradle to grave”;
f. fines/disincentives can be used to enforce compliance;
g. it promotes a circular/more sustainable economy

(b) Explain how different agricultural practices may influence sustainability. **[7]**

a. intensive farming require large inputs of energy/chemicals etc that are unsustainable;
b. extensive farming uses fewer inputs but takes over larger area of ecosystems;
c. crop farming harvests at lower trophic levels than animal husbandry so is more sustainable;
d. industrial/commercial farming depends on heavy machinery/fossil fuels so is less sustainable;
e. subsistence farming tends to involve minimal interference/small scale of environmental impacts;
f. irrigation systems tend to use unsustainable quantities of water;
g. rain-fed agriculture/hydroponics have a far smaller water footprint;
h. vertical/indoor farming can be very efficient/sustainable use of space;
i. foraging in natural ecosystems creates minimal environmental impact;
j. soil conservation measures (eg terracing/wind breaks etc) can increase sustainability of soil;

(c) Evaluate the role of national legislation and international agreements in achieving sustainability. **[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 demonstrate:

- **understanding concepts & terminology** of national v international legislation; united nations; international laws, protocols, conventions, agreements etc; national constitutions; international conventions; transboundary issues; management of freshwater supply; fisheries; trade in species; climate crisis; mineral cycles; planetary boundaries; ecocentric v anthropocentric governance; etc
- **breadth in addressing and linking** different international bodies/agreements and local action groups/societies with environmental sustainability issues.
- **examples** of legislation at local and international level in context of a variety of sustainability issues etc
- **balanced analysis evaluating** both the strengths and weaknesses of local v global legislation.

- **a conclusion that is consistent with, and supported by analysis and examples given** eg International legislation is essential in addressing major environmental issues of sustainability that have global implications, but local governance is vitally important in applying such principles to local conditions and inciting local engagement and ownership of them.

Please see markbands on page 19.

7. (a) Outline how the flow of energy along a food chain demonstrates the second law of thermodynamics. **[4]**

a. With each transformation along a food chain some available energy is lost;
b. energy is lost as heat through respiration;
c. commonly 90% lost with each transfer / 10% retained at each trophic level;
d. Biomass has low entropy;
e. energy is transformed as it passes along the food chain;
f. Heat increases the entropy of the environment;
g. So with each transformation there is an increase in entropy (as stated by second law);

(b) Evaluate the strategies that have been used to protect stratospheric ozone. **[7]**

strengths: [max 4]
a. international treaty, Montreal Protocol, introduced a ban on use of CFCs;
b. Montreal Protocol was one of few treaties ratified by all countries;
c. It has been successful in reducing CFC production;
d. Alternatives to CFCs, eg HCFCs/HFCs have been introduced;
e. Replacement with HCFCs has reduced impact on ozone;
f. There is some evidence that the ozone depletion is being reduced/that ozone layer will be restored within four decades;
g. Catalytic converters can reduce release of N oxides;

limitations: [max 4]
h. Many, but not all countries have complied/implemented the protocol;
i. HCFCs are greenhouse gases adding to problem of global warming;
j. HCFCs are also ozone depleting (but to a lesser extent than CFCs)
k. There is a black market in CFCs so they continue to be used;
l. CFCs impact on ozone is a circular process so existing CFCs continue to break down ozone;
m. Nitrogen oxides (from fossil fuel combustion) continue to deplete ozone;

[conclusion:]

Note: Award [max 1] for suitable conclusion supported by argument

(c) Discuss how different ethical beliefs regarding the relationship between humans and nature may influence approaches to conservation. **[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 demonstrate:

- **understanding concepts & terminology** of ecocentrism; extreme and moderate anthropocentrism; technocentrism; intrinsic and instrumental value; light green to deep green ethics; deontology; consequentialism; virtue ethics; in situ v ex situ conservation; flagship/keystone species; botanic gardens; zoos; CITES; seed banks; reserves etc
- **breadth in addressing and linking** different ethical positions and perspectives with different strategies for conservation.
- **examples** of different ethical approaches, value systems and conservation strategies.
- **balanced analysis evaluating** the extent to which different ethical positions may give rise to different conservation approaches.
- **a conclusion that is consistent with, and supported by analysis and examples given** eg The position that nature is largely to be considered a resource for human exploitation may give rise to the technocentric perspective that nature primarily has an instrumental value and conservation can best be achieved by scientific strategies like seed banks and genetic engineering to preserve those resources valuable to humans whereas more deep green ethicists would favour conserving the entire environment through reserves and national parks.

Please see markbands on page 19.

Section B, part (c) markbands

Marks	Level descriptor
0	The response does not reach a standard described by the descriptors below and is not relevant to the question.
1–3	The response contains: • minimal evidence of knowledge and understanding of ESS issues or concepts • fragmented knowledge statements poorly linked to the context of the question • some appropriate use of ESS terminology • no examples where required, or examples with insufficient explanation/relevance • superficial analysis that amounts to no more than a list of facts/ideas • judgments/conclusions that are vague or not supported by evidence/argument.
4–6	The response contains: • some evidence of sound knowledge and understanding of ESS issues and concepts • knowledge statements effectively linked to the context of the question • largely appropriate use of ESS terminology • some use of relevant examples where required, but with limited explanation • clear analysis that shows a degree of balance • some clear judgments/conclusions, supported by limited evidence/arguments.
7–9	The response contains: • substantial evidence of sound knowledge and understanding of ESS issues and concepts • a wide breadth of knowledge statements effectively linked with each other, and to the context of the question • consistently appropriate and precise use of ESS terminology • effective use of pertinent, well-explained examples, where required, showing some originality • thorough, well-balanced, insightful analysis • explicit judgments/conclusions that are well-supported by evidence/arguments and that include some critical reflection.

Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Standard level
Paper 1

Specimen paper

Candidate session number

1 hour

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions. Refer to the resource booklet which accompanies this question paper.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

Answer **all** questions. Answers must be written within the answer boxes provided.

1. (a) With reference to **Figure 1(e)**, identify the climate classification for the city of Thimphu. [1]

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. . . . . .

(b) With reference to **Figures 1(d)** and **1(e)**, outline the relationship between altitude and climate. [1]

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2. (a) With reference to **Figure 2(a)**, calculate the doubling time of the population of Bhutan. [1]

. . . . . .

. . . . . .

(b) With reference to **Figure 2(b)**, identify Bhutan's stage on the demographic transition model (DTM). [1]

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(c) Outline **three** reasons for the trend observed in the population age groups under 30 years old shown in **Figure 2(b)**. [3]

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3. (a) With reference to **Figure 3(a)**, identify the main source of energy used in Bhutan. [1]

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(b) Evaluate hydroelectric power as a source of energy in Bhutan. [3]

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(c) Using **Figure 3(c)**, calculate the reduction in total energy demand for 2040, in million kWh, if energy-efficient practices are implemented. [1]

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(d) With reference to **Figure 3(c)**, suggest **two** reasons why energy demand is predicted to rise after 2030, despite Bhutan adopting energy-efficient practices. [2]

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4. (a) Suggest **two** reasons for the changes in forest cover shown in **Figures 4(a)** and **4(b)**. [2]

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(b) Evaluate the use of the wildlife corridors shown in **Figure 4(c)**. [3]

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5. (a) Using **Figure 5(a)**, construct a food chain with four trophic levels. [2]

(b) Describe **two** methods to confirm the presence of pygmy hogs in Bhutan. [2]

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(c) Outline **three** reasons why the continued survival of the pygmy hog is at risk. [3]

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6. (a) With reference to **Figure 6**, state **one** reason why biocapacity is increasing. [1]

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(b) With reference to **Figure 6**, outline how the changes in ecological footprint and biocapacity affect the sustainability of Bhutan. [2]

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7. To what extent has Bhutan been successful in the sustainable management of its resources? [6]

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Please **do not** write on this page.

Answers written on this page
will not be marked.

Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Standard level
Paper 1

Specimen paper

1 hour

Instructions to candidates

- Do not open this booklet until instructed to do so.
- This booklet contains all the resources to answer paper 1.

0000 –

Figure 1(a): World map showing the location of Bhutan

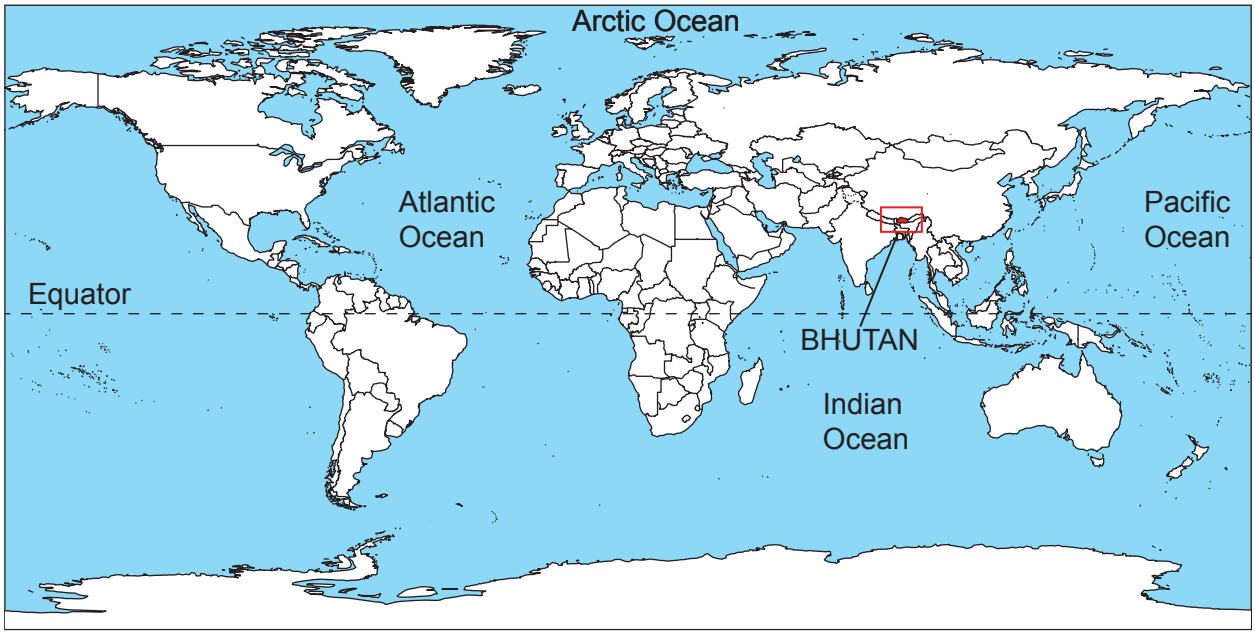


Figure 1(b): Map showing the location of Bhutan

Figure 1(c): Fact file on Bhutan

- The terrain is mostly mountainous with some fertile valleys and grasslands.
- Steep mountains make construction of roads and infrastructure difficult and expensive.
- Glaciers cover approximately 10 % of Bhutan's land. Melting glaciers and unpredictable rainfall increase risk of flash floods and landslides.
- Fast flowing rivers are used for providing hydroelectric power.
- By law, at least 60 % of the land area must be forested. In 2021, over 70 % of the land area was forest.
- In 2018, 14 % of land was used for agriculture.
- In 2022, Bhutan was carbon negative (more carbon dioxide was removed from the atmosphere than produced).

Figure 1(d): Elevation map of Bhutan

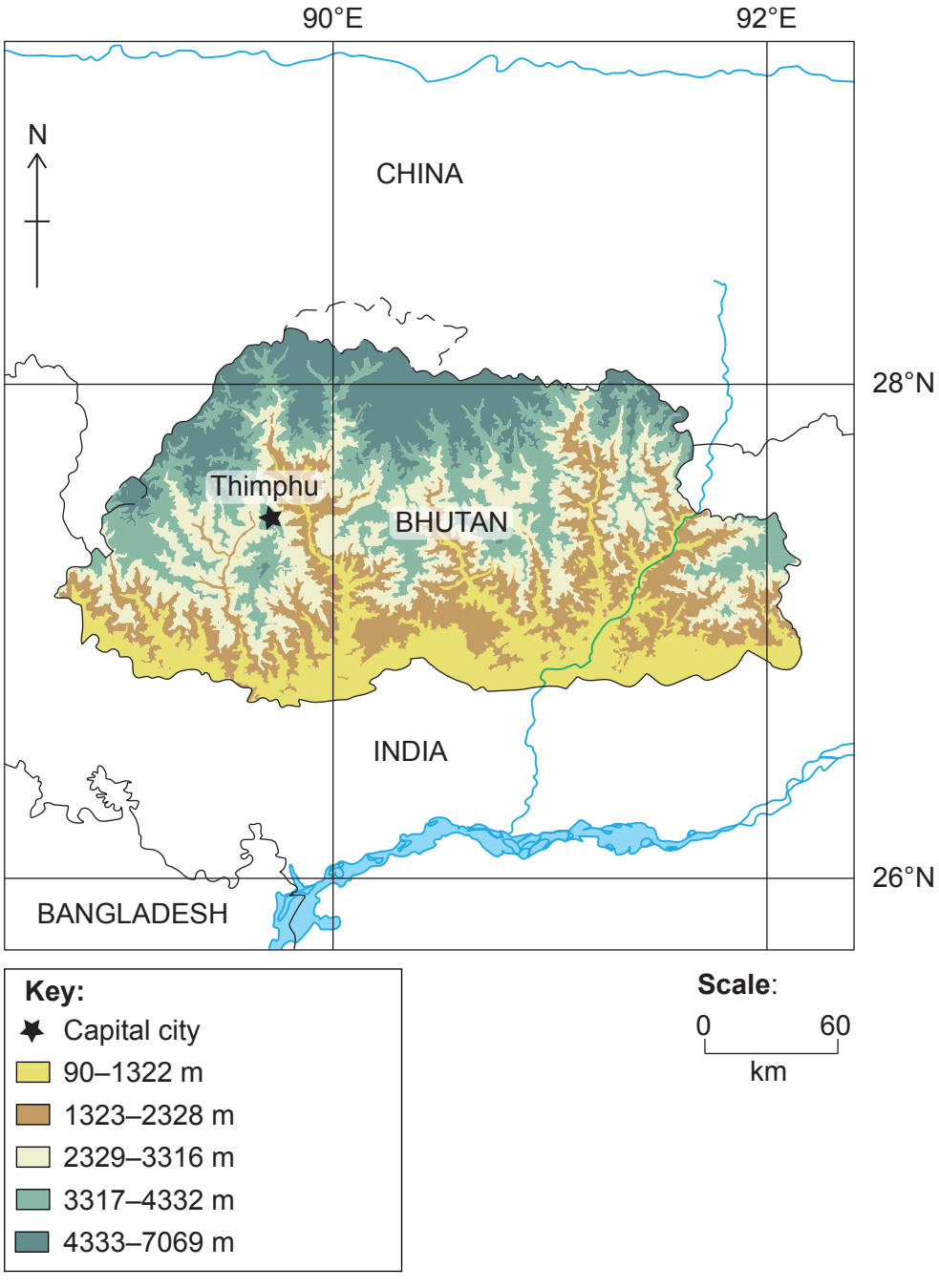


Figure 1(e): Climate classification map of Bhutan

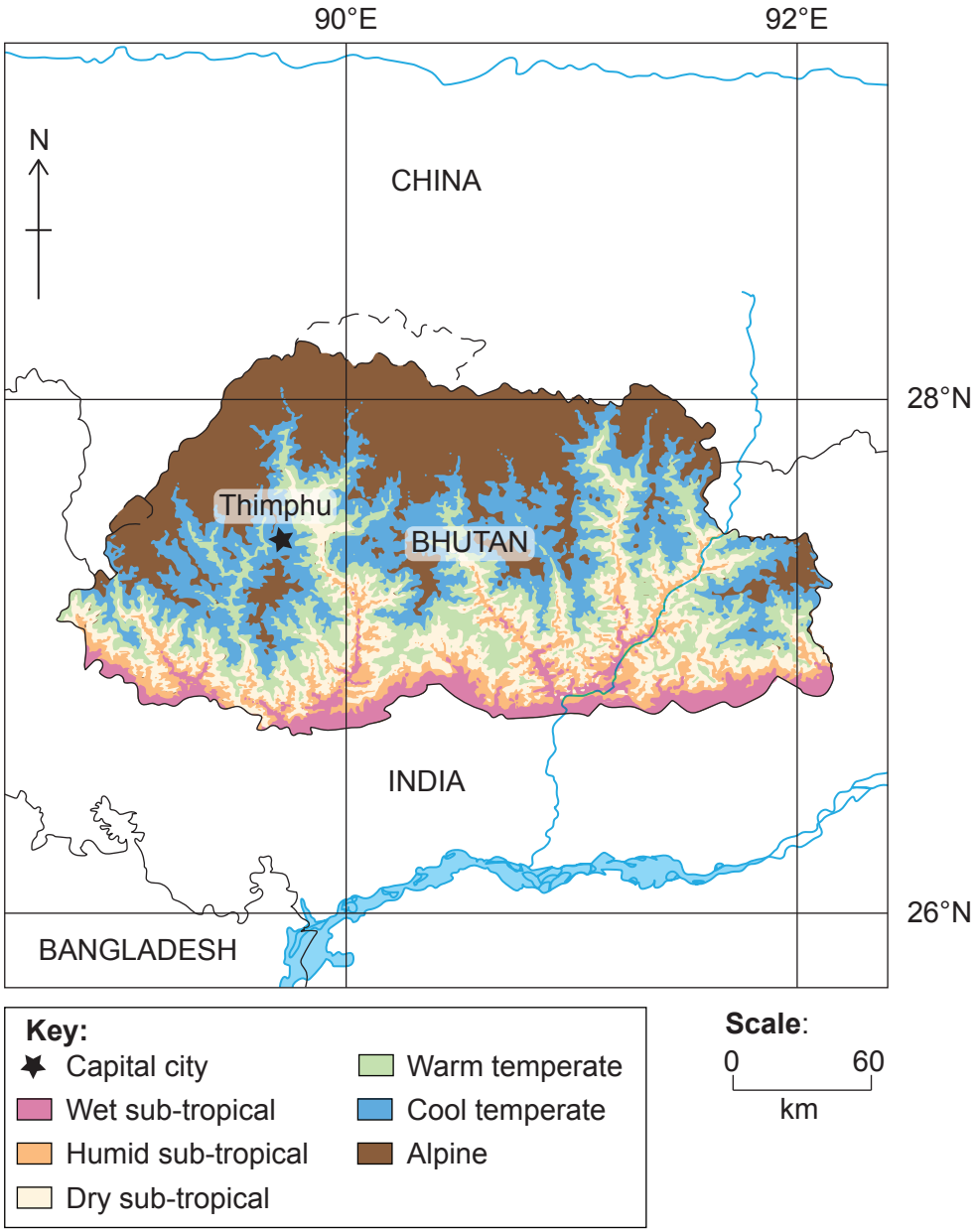


Figure 2(a): Fact file on demography of Bhutan, 2021

Total population	783 200
Natural increase rate	0.989 %
Birth rate	16.17 per 1000 population
Death rate	6.28 per 1000 population
Total fertility rate	1.8 children per woman
Life expectancy	71.5 years
Population of Thimphu	100 000

Figure 2(b): Population pyramid for Bhutan, 2021

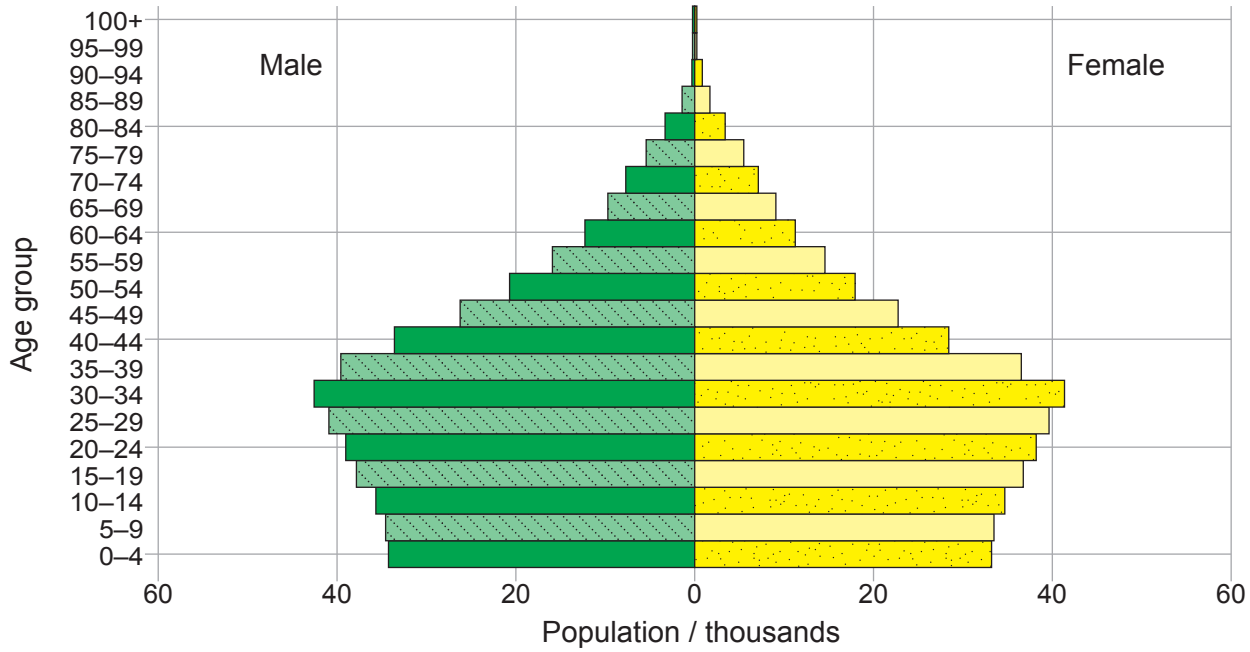


Figure 3(a): Sources of energy used in Bhutan, 2016

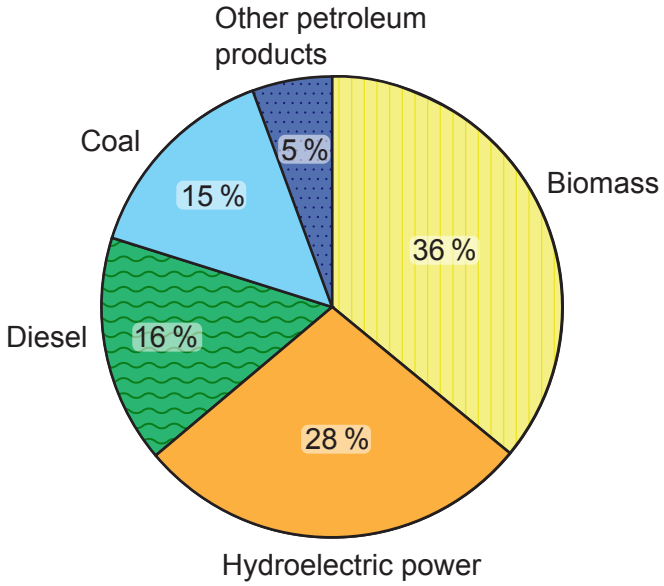


Figure 3(b): Fact file on Bhutan's energy

- Over 99 % of electricity is generated from hydroelectric power.
- Between 2003 and 2017, access to electricity increased from 30 % to 100 % of the population.
- In 2021, Bhutan only used 6.5 % of its hydroelectric power potential. The country plans to build more dams to generate hydroelectric power and export electricity to India and Bangladesh.
- Bhutan exports approximately 75 % of its electricity, representing 40 % of total exports.
- Bhutan intends to diversify its energy sources by increasing the use of hydrogen, solar and wind.
- Bhutan imports petrol, wood and charcoal for use as fuel.

Figure 3(c): Residential energy demands in Bhutan: (a) without adopting energy-efficient practices and (b) adopting energy-efficient practices

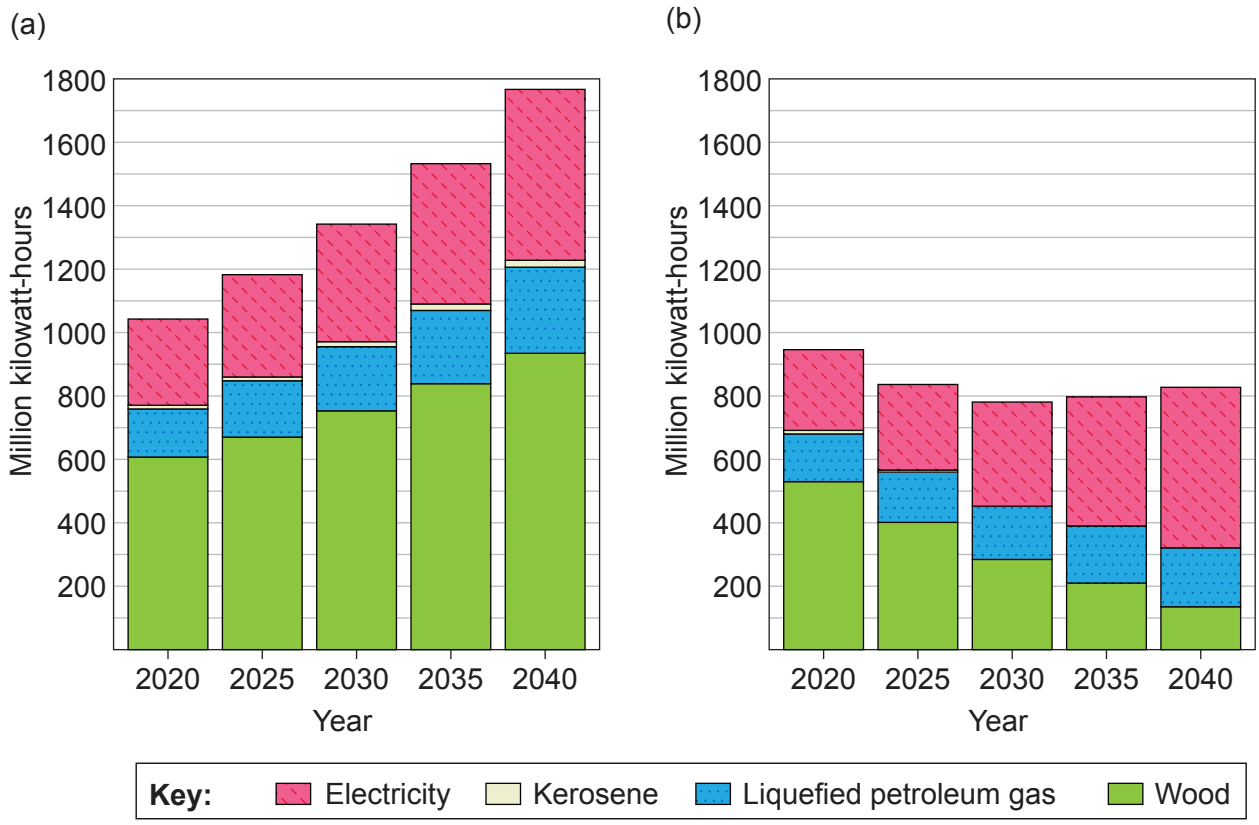


Figure 4(a): Change in forest cover in Bhutan, 1930–2014

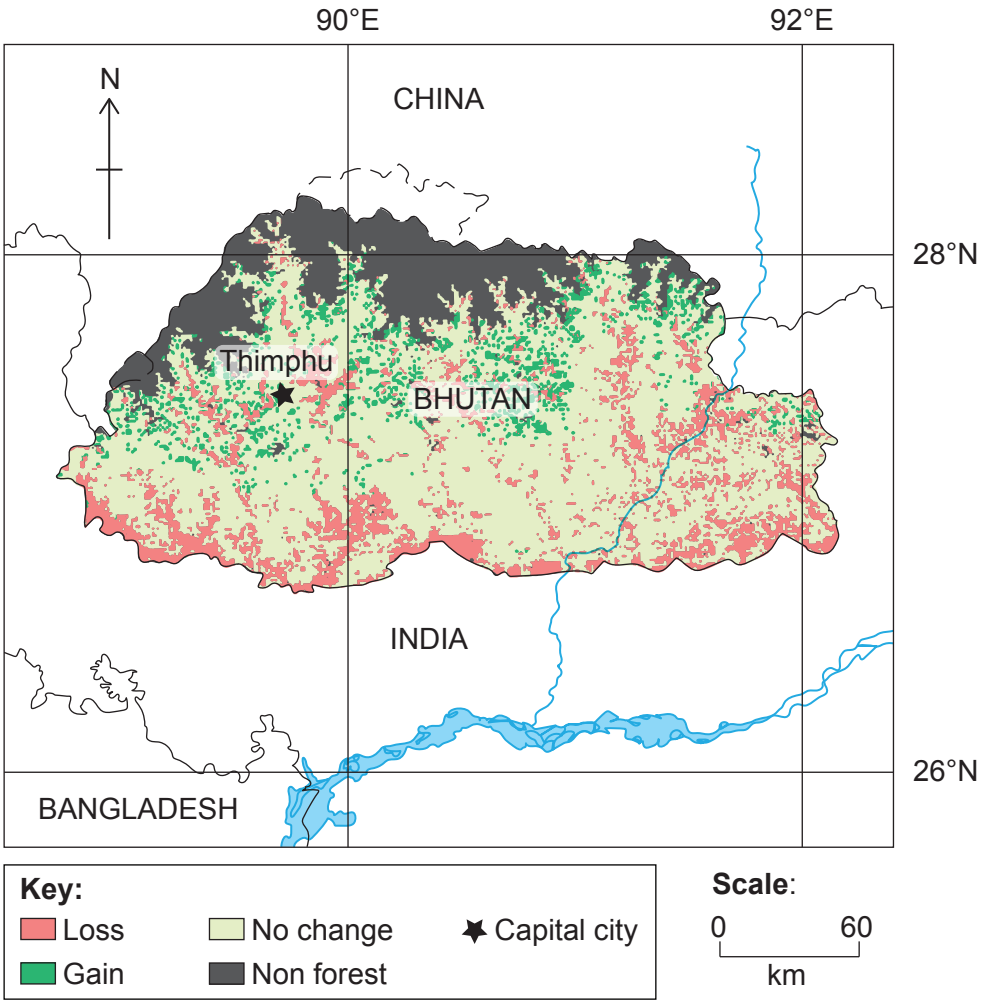


Figure 4(b): Percentage of forest cover in Bhutan, 1990–2020

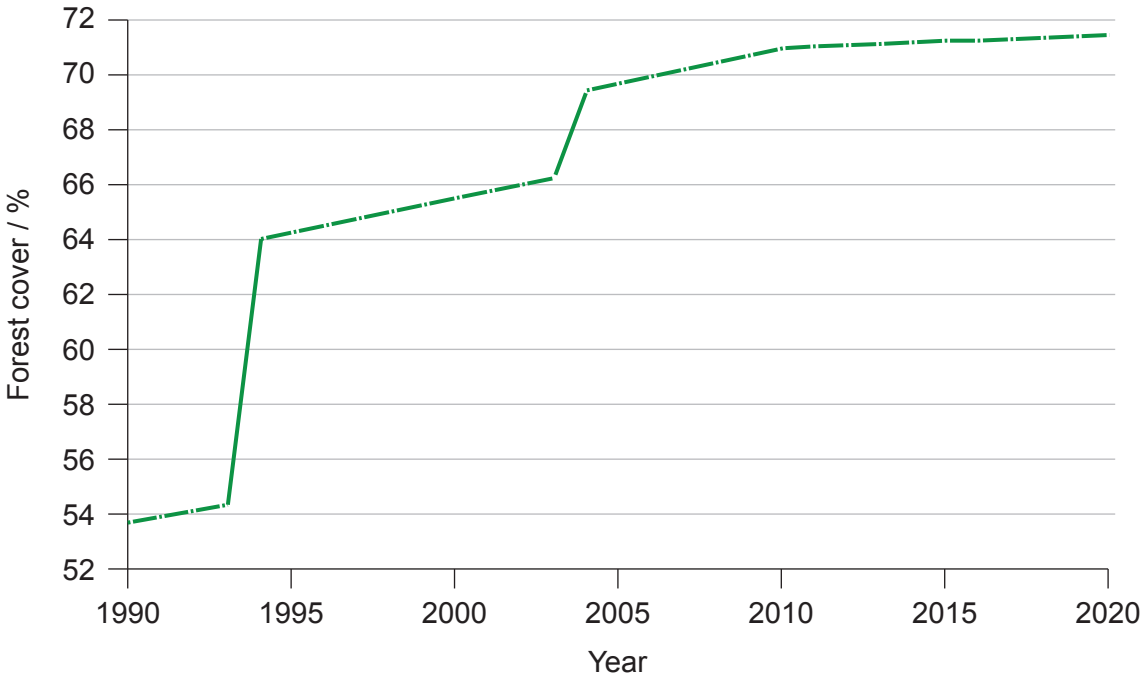


Figure 4(c): Protected areas, wildlife corridors and historic habitats of the pygmy hog in Bhutan

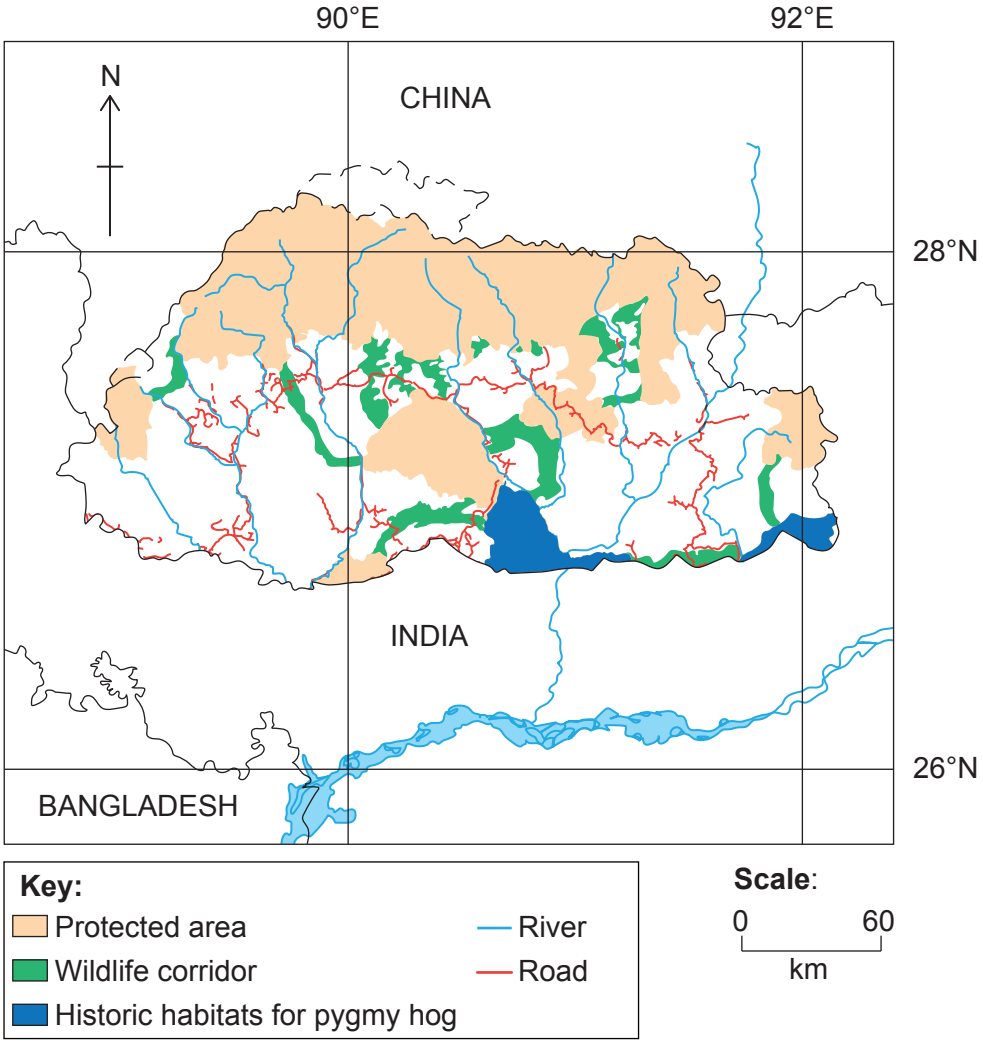


Figure 5(a): A simplified food web from southern Bhutan

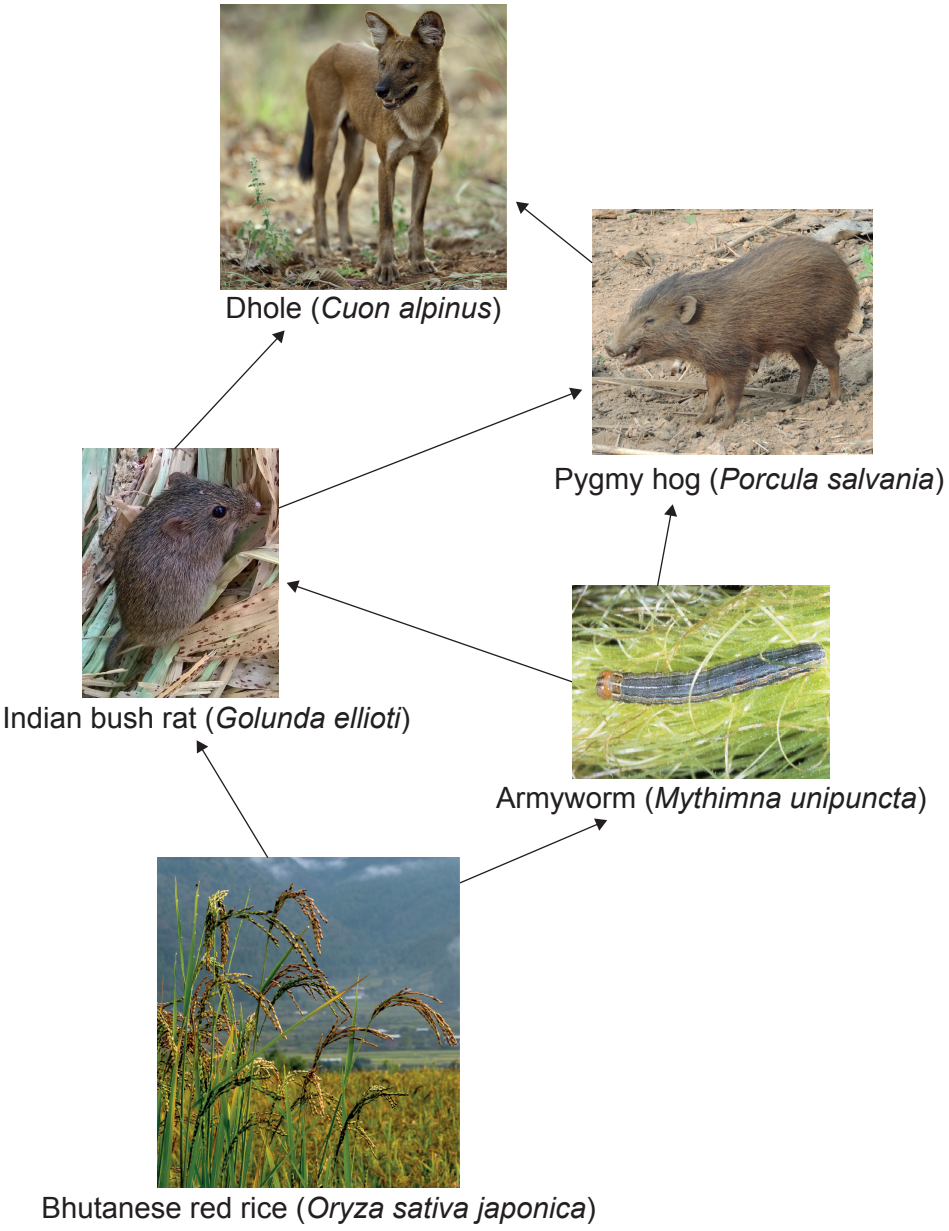
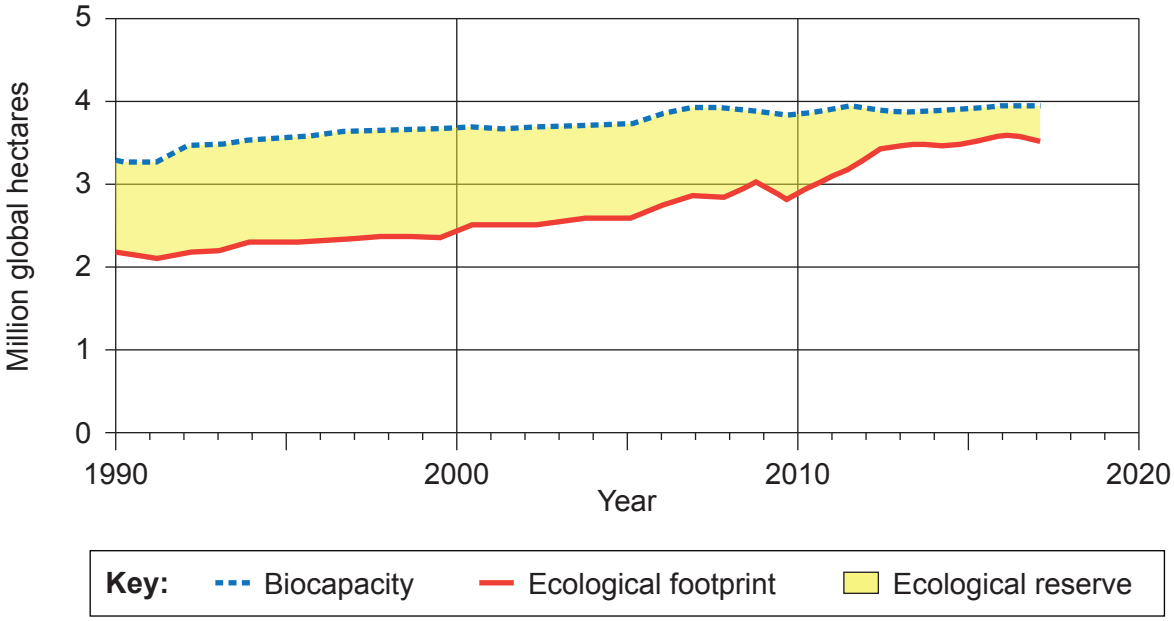


Figure 5(b): Fact file on pygmy hog (*Porcula salvania*)

- They are the world's smallest species of wild pig (20–30 cm in height).
- Captive breeding and release programmes were set up in India in 2008.
- They were reassessed from critically endangered to endangered on *The International Union for Conservation of Nature (IUCN) Red List of Threatened Species* in 2016.
- There are an estimated 100–250 mature individuals globally, but the population in Bhutan is unknown.
- Their habitat is grasslands in southern Bhutan and northern India.
- They are protected in India and Bhutan.

Figure 6: Bhutan's ecological footprint and biocapacity, 1990–2017



Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

Figure 1(b) CIA, n.d. *Bhutan*. [image online] Available at: https://www.cia.gov/the-world-factbook/countries/bhutan/map/ [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 1(d) Bazile, D., 2020. *Elevation map of Bhutan with the location of the two study sites*. [image online] Available at: https://www.researchgate.net/figure/Elevation-map-of-Bhutan-with-the-location-of-the-two-study-sites-Elaborated-by-the-1-st_fig1_338635957 [Accessed 18 September 2023]. SOURCE ADAPTED.

Figure 1(e) Rai, G, 2020. *Map of Bhutan showing different agro-ecological zones and 20 districts*. [image online] Available at: https://www.researchgate.net/figure/Map-of-Bhutan-showing-different-agro-ecological-zones-and-20-districts-The-location-of_fig1_344137812 [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 2(b) CIA, n.d. *2023 population pyramid*. [image online] Available at: https://www.cia.gov/the-world-factbook/countries/bhutan/#people-and-society [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 3(a) IRENA, 2019. *Figure 1. Fuel mix in the economy (toe)*. [image online] Available at: https://www.irena.org/publications/2019/Dec/Renewables-Readiness-Assessment-Kingdom-of-Bhutan [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 3(c) Zam, K., Gupta, M.K., and Uddin, S.M.N., 2021. The residential energy futures of Bhutan. *Energy Efficiency*. [image online] Available at: https://link.springer.com/article/10.1007/s12053-021-09948-x [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 4(a) Chintala, S.R., Satish, K., Chandra, J., Diwakar, P., Murthy, Y. and Dadhwal, V., 2016. *Forest cover change in Bhutan, 1930–2014*. [image online] Available at: https://www.researchgate.net/figure/Forest-cover-change-in-Bhutan-1930-2014_fig11_309881350 [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 4(b) The World Bank, n.d. *Forest area (% of land area) – Bhutan*. [image online] Available at: https://data.worldbank.org/indicator/AG.LND.FRST.ZS?end=2020&locations=BT&start=1990&view=chart [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 4(c) Thinley, P. and Lassoie, J., 2013. *Map of Bhutan's protected areas network prepared by Department of Forests & Park Services, Thimphu, Bhutan.* [image online] Available at: https://www.researchgate.net/figure/Map-of-Bhutans-protected-areas-network-prepared-by-Department-of-Forests-Park_fig2_313774103 [Accessed 4 September 2023]. SOURCE ADAPTED.

Figure 5(a) Rane, A., n.d. *Wild Dog ,Tadoba - stock photo*. [photograph] Available at: https://www.gettyimages.co.uk/detail/photo/wild-dog-tadoba-royalty-free-image/483199914 [Accessed 21 September 2023]. SOURCE ADAPTED.

Johnsingh, A. J. T., 2014. *File:Pygmy hog in Assam breeding centre AJT Johnsingh.JPG*. [photograph] Available at: https://commons.wikimedia.org/wiki/File:Pygmy_hog_in_Assam_breeding_centre_AJT_Johnsingh.JPG [Accessed 21 September 2023]. SOURCE ADAPTED.

Joshi, V., 2016. *Indian bush rat*. [photograph] Available at: https://openverse.org/image/cc4eb9b0-97f5-48d7-bd47-b92bafc7f426?q=indian%20bush%20rat [Accessed 21 September 2023]. SOURCE ADAPTED.

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Yang, M., 2015. *Bhutan Rice Fields, Paro Valley Sep 2015 - stock photo*. [photograph] Available at: https://www.gettyimages.co.uk/detail/photo/bhutan-rice-fields-paro-valley-sep-2015-royalty-free-image/504254662?phrase=bhutanese+red+rice+plant [Accessed 21 September 2023]. SOURCE ADAPTED.

Figure 6 Global Footprint Network, n.d. *Bhutan*. [image online] Available at: https://data.footprintnetwork.org/?_ga=2.140915762.1256538132.1638461366-864422584.1637422406#/countryTrends?cn=18&type=BCtot,EFCtot [Accessed 4 September 2023]. SOURCE ADAPTED.

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2026

Environmental systems and societies

Standard level

Paper 1

12 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Associated shortcut
	Correct point – 1 mark will be added to the score for each tick placed up to the maximum for the question part. Please make sure that the number of ticks = the number of marks	
	**Used if the answer is worth zero marks**	
	Unclear	
	Benefit of the doubt	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Too vague	
	No working shown	
	SLP2 ONLY Expression of ideas	
	Ellipse. Dynamic; can be used to surround an area of the candidate's answer	
	Dynamic, vertical wavy line that can be expanded (to highlight a section of irrelevant work for instance)	
	Dynamic, horizontal wavy line that can be expanded (to highlight a section of irrelevant work for instance)	
	DOT. Valid part (to be used when more than one element is required to gain the mark e.g. Drawings)	
	Or words to that effect /OWTTE	
	Cross. Incorrect point (will not remove marks).	
	Advantage / pro (to identify elements in an unclear discussion when pairs are required).	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
	Difference (to identify elements in an unclear comparison)	

Annotation	Explanation	Associated shortcut
sim	Similarity (to identify elements in an unclear comparison)	
ECF	Error carried forward	
EG	Example / reference	
ND	No definition	
NExa	No examples	
	Highlighting areas of text	
	On page comment. Allows comments to be entered in speech bubbles on the candidate response. Can be used for additional marking comments, it can be linked to a specific tick if that is appropriate. You might like to have a word document of regularly used comments that can be copied and pasted into the text box.	
	H line. Underline tool – dynamic, horizontal line that can be expanded (to highlight a section of irrelevant work for instance)	
SEEN	**You MUST use this to indicate that blank pages and continuation sheets have been seen.**	

You **must** make sure you have looked at all pages. Please put the SEEN annotation on any blank page, to indicate that you have seen it.

Examiners should be aware that in some cases, candidates may take a different approach, which if appropriate should be rewarded. If in doubt, check with your team leader.

In the case of an “identify” question read all answers and mark positively up to the maximum marks. Disregard incorrect answers. In all other cases where a question asks for a certain number of facts *eg* “describe two kinds”, mark the **first two** correct answers. This could include two descriptions, one description and one identification, or two identifications.

It should be recognized that, given time constraints, answers for part (c) questions are likely to include a much narrower range of issues and concepts than identified in the markband. There is no “correct” answer. Examiners must be prepared to award full marks to answers which synthesize and evaluate even if they do not examine all the stimulus material.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

4. Personal codes/notations are unacceptable.

5. Where an answer to a part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an “NR” in the mark panel on the right-hand side of the screen.

6. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

7. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “seen” on any page that contains no other annotation.

8. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

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) Cool temperate; **[1]**

(b) As elevation increases, temperature decreases (highest elevations have alpine climate/moves from sub-tropical to cool temperate);
As elevation decreases, temperatures increases (lowest elevations are wet sub-tropical);
In the lower elevations (150 m–1800 m), the precipitation decreases (moves from wet sub-tropical to dry sub-tropical); **[1]**

2. (a) (70/((16.17-6.28)/10)=) 70.77/70.8/71 years;
(70/0.989=) 70.77/70.8/71 years; **[1]**

(b) Stage 3

Marking note: the top of the pyramid is concave which reflects the high death rates which are typically found in Stage 2. It is not yet Stage 4 as there are insufficient people in the 50+ age categories. This pyramid reflects a country transitioning from Stage 2 to Stage 4. **[1]**

(c) Reduction in births due to increased access to contraception;
Reduction in births due to improved child survival/decrease in infant/child mortality;
Reduction in need for more children to work in rural areas/on farms;
Reduction in births due to increased education of women/greater career opportunities for women and therefore later start to child-bearing;
Reduction in births due to cultural shift towards smaller families/anti-natalist government policies;
Reduction in births due to less interference/imposition resulting from Religious grounds. **[3]**

3. (a) Biomass (36%) **[1]**

(b) *Arguments for: max [2]*

- *Reduces need to use fossil fuels that generate greenhouse gases which contribute to global warming / hydropower is a renewable source of energy;*
- *It can be a low-cost source of electricity once the dam and power station is built which means it is more affordable;*
- *Dams control water levels in the reservoir, which reduce the risk of flash flooding;*
- *Dam can also increase water resources (for urban use/irrigation/industry);*
- *Reservoir can provide an ecosystem for fisheries;*
- *Reservoir can provide area for water-based recreational activities;*

Arguments against: max [2]

- *Reduction in glacial melt in the future (due to climate change) may reduce the availability of hydropower;*
- *The creation of reservoirs floods large areas, reducing biodiversity/destroying habitat;*
- *The creation of reservoirs floods large areas, which may require relocation of communities;*
- *Dam/reservoir can potentially cause seismic activity;*
- *The migratory routes for river organisms/fish may be disrupted;*
- *The dams change the riparian areas down-river/flow characteristics down-river, which can negatively affect biodiversity/wildlife;*
- *The initial cost of creating a dam can be extremely expensive, which may be difficult for Bhutan to afford;*
- *The dams may be located high in the mountains, far from the need for electricity (resulting in a loss of power as it needs to be transported via power lines over long distances);*
- *May result in the displacement of people;*
- *May result in the increase of insect vectors of certain pathogens (like plasmodium – malaria);*

Note: a well-balanced conclusion may be credited in a response that includes both a pro and con in the evaluation. **[3]**

(c) (1760-830=) 930 (million kWh);
Marking note: accept answers between 910-950 (million kWh) **[1]**

(d) Rising standard of living (in Bhutan) will mean greater demand for appliances/electronic goods, resulting in rising demand;
Population growth continues, therefore increasing demand;
Greater industrial development, with greater electricity needs; **[2]**

4. (a) Clearing/removal of forests for agriculture;
Clearing/removal of forests for heat/cooking fuel/building;
Clearing/removal of forests for increasing urbanisation;
Clearing/removal of forests for road infrastructure/highways;
Planting of forests to meet the government laws of minimum 60% forest cover;
Increase in forests due to natural regrowth of forests/succession;

Note: answer must indicate direction of change and the cause of the change for the mark. **[2]**

(b) *Strengths [2 max]*

- Allows migration between areas and reduces isolation of populations;
- Migration increases genetic diversity/gene pool;
- provide protected areas for movement of organisms / allows for seasonal migration;
- Reduces the need for larger protected areas / may be easier to manage than larger protected areas;

Limitations [2 max]

- Corridors may not have the same level of protection as protected areas;
- Roads cross the corridors, which may result in road kill;
- Corridors are too narrow for territorial animals (such as tigers);
- Can allow spread of disease/invasive species from one protected area to another;
- Could increase threat from predators based in other reserves; **[3]**

5. (a) Bhutanese red rice → Indian bush-rat → pygmy hog → dhole
Bhutanese red rice → armyworm → pygmy hog → dhole

Note: one mark for four valid trophic levels, one mark for arrows showing correct direction of flow of energy. **[2]**

(b) Camera traps / sound recorder distributed in appropriate habitat areas;
Look for field signs such as tracks/foraging marks/droppings/hair/scat;
Collect secondary evidence from locals/farmers / use citizen science to collect data on sightings;
Trap and radio tag to find family units;
Examination of predator scat (dhole and other predators); **[2]**

(c) Poaching can continue even despite protected status;
Natural predation (by dholes/other predators);
Loss of habitat through change in land use, e.g. agriculture, reforestation;
Loss of habitat through climate change (as the area may become drier/due to greater risk of fires);
Loss of genetic diversity through captive breeding (which may have a limited genetic variability);
Limited distribution so at risk of extinction; **[3]**

6. (a) Reforestation/afforestation / greening of urban areas;
Intensification of agriculture / boosting productivity of green areas;
Melting glaciers exposing new land to succession; **[1]**

(b) As EF increases, sustainability is reduced;
Biocapacity is higher than EF, so Bhutan is currently sustainable;
As EF approaches biocapacity, sustainability is reduced;
Only considers environmental aspects (not economic, social); **[2]**

7. *Arguments for: [max 4]*

- Laws to ensure the country remains covered in forests / increase in forest cover over time;
- Greater emphasis on using renewable sources of energy and moving away from biomass/fossil fuels for energy reduces carbon dioxide emissions;
- Importing wood protects Bhutan's forests from being cut down;
- Emphasising energy efficiency will reduce demands for more electricity to be generated, protecting forest resources;
- Trees are being planted in higher altitude areas, which protects against landslides;
- The overall increase in forest cover (since 1990 from below 54% to over 70% in 2020) has increased carbon sinks/absorption of carbon dioxide;
- The overall increase in forest cover has increased natural habitats for wildlife;
- Over 50% of the country is protected/protected areas are connected with wildlife corridors, which means wildlife resources are protected;
- Working to re-introduce endangered pygmy hogs / have protection for endangered species;
- The country's biocapacity is growing, which means the resources are being well-managed;

Arguments against: [max 4]

- Increasing risk of flash flooding and landslides means they are not managing water resources properly;
- (Despite the falling birth rates) the population continues to grow, putting greater pressure on their resources;
- Creating dams to export electricity causes damage to the environment/floods large areas adversely impacting biodiversity;
- Use of imported wood/petrol/charcoal contributes to emission of carbon dioxide and climate change;
- Roads intercept wildlife corridors which may contribute to wildlife fatalities/deter animal migration;
- Forest loss in the south of the country means that forest protection is not consistent / growth in agriculture is still resulting in forest loss;
- The EF is rising faster than biocapacity, which means resources are being used at a faster rate than they are being created;

Note: Award max [5] if there is no conclusion/opinion.

Conclusion *[max 1]*:
For example "While there is still some forest loss occurring in Bhutan, its long-term goal of developing renewable resources and protecting forests to remain carbon negative means that the country has been successful in the sustainable management of its resources. / While Bhutan has laws protecting its forests, there is still forest loss in the south and the overall ecological reserve is declining suggesting that Bhutan is not managing its resources sustainably.
A valid conclusion should be credited if it includes a value judgement (on whether Bhutan has been successful in the management of its resources), is explicit, balanced (addresses both sides of the argument) and supported by evidence. Do not credit the conclusion is only one side of the argument has been considered within the overall response.

Marking note: Accept any other reasonable responses. **[6]**

Diploma Programme
Programme du diplôme
Programa del Diploma

Environmental systems and societies
Standard level
Paper 2

Specimen paper

Candidate session number

2 hours

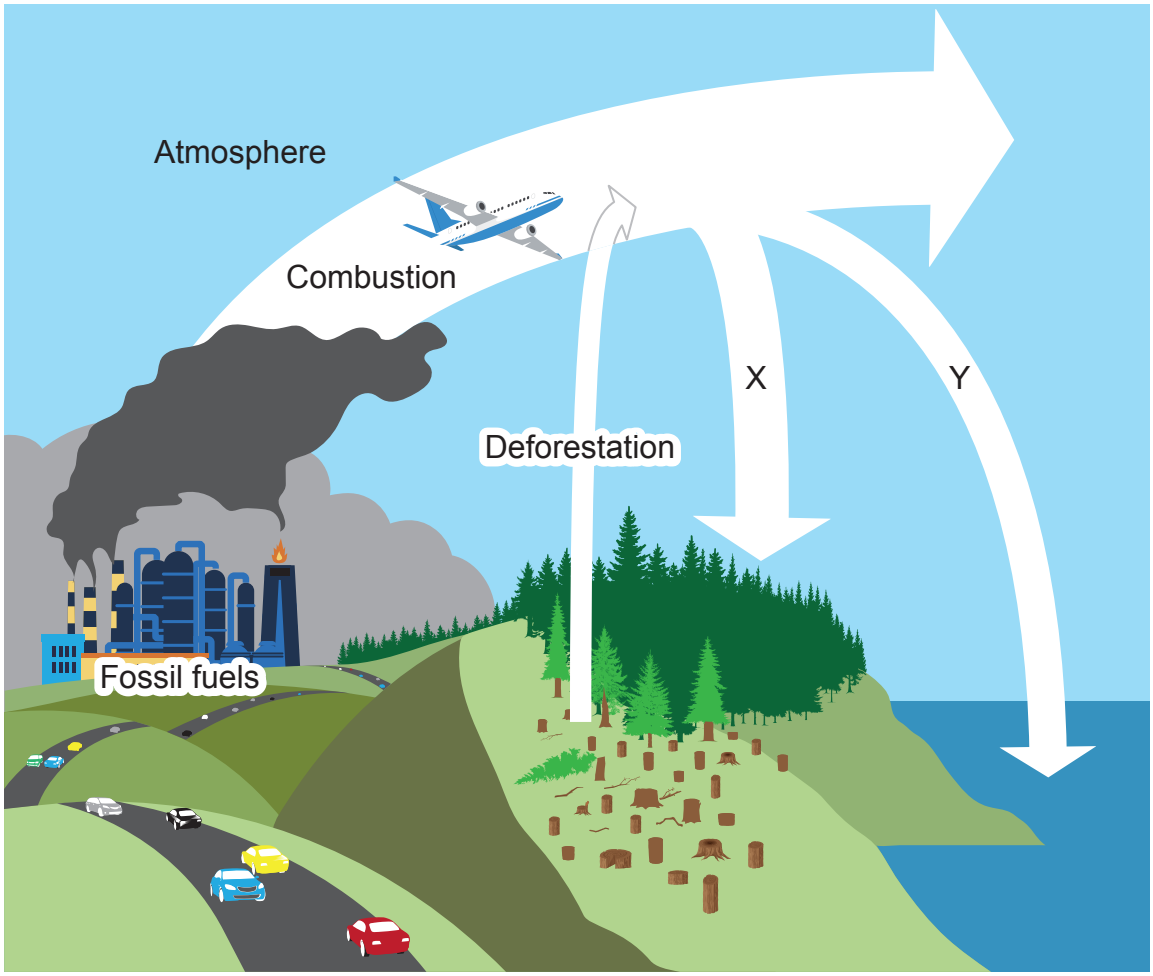
Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[60 marks]**.

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

Figure 1: A simplified carbon cycle showing emissions and natural absorption of carbon equivalents in gigatons



1. (a) Identify the flows X and Y shown in **Figure 1**. [2]

X . . . . . .

Y . . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) Describe the impacts of increasing flow Y on marine ecosystems. [3]

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(c) Outline **two** measures that can alleviate the effects of human activities on the carbon cycle. [2]

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(d) Discuss how an individual's vulnerability to the effects of climatic change can influence their views on the control of carbon emissions. [4]

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Please **do not** write on this page.

Answers written on this page
will not be marked.

Figure 2(a): The Great Pacific Garbage Patch (GPGP) in which ocean currents cause plastic waste to accumulate

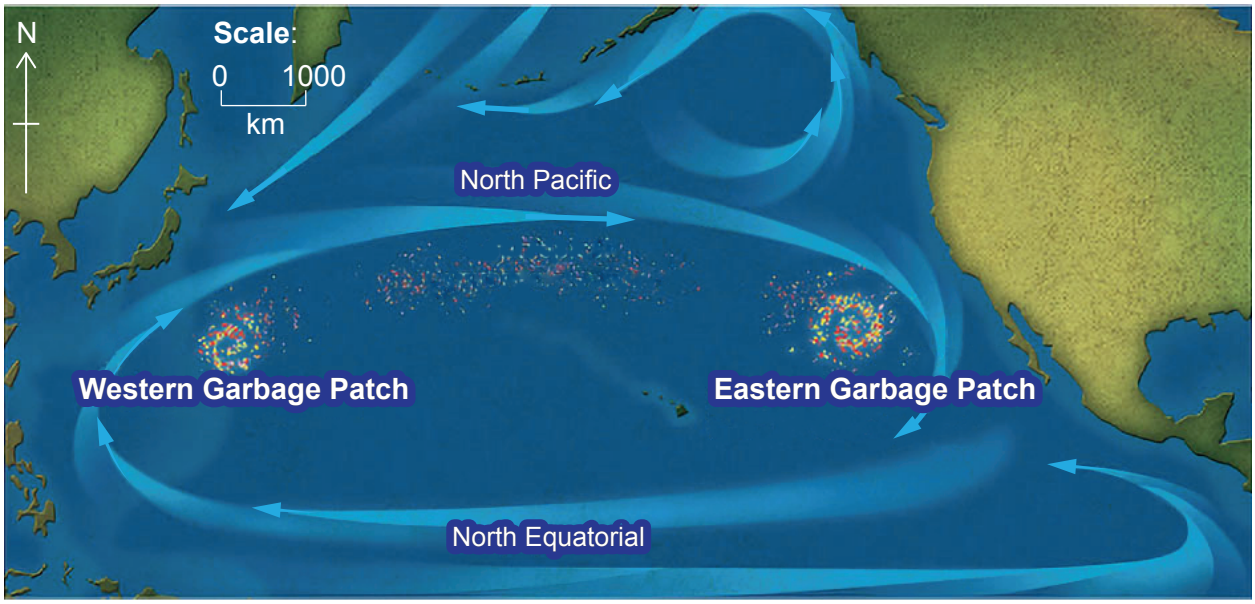
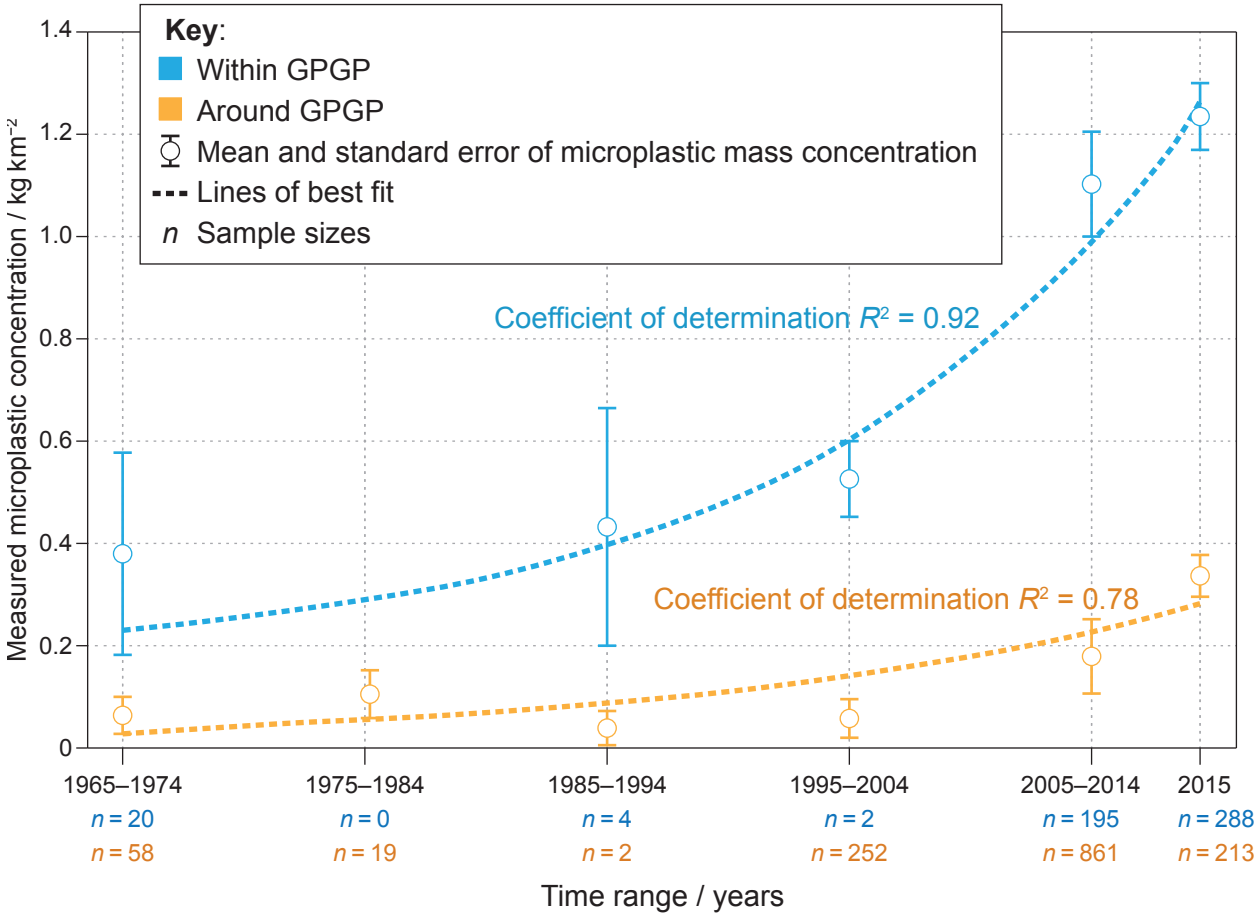


Figure 2(b): Mean and standard error of microplastic concentration within and around the eastern portion of the GPGP



2. (a) Outline the overall trend in microplastic concentration over time within the GPGP, as shown in **Figure 2(b)**. [1]

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(b) Describe the significance of the coefficient of determination (R^2) **within** the GPGP, as shown in **Figure 2(b)**. [2]

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(c) State a possible source of the plastic waste found in the GPGP. [1]

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(Question 2 continued)

(d) Outline reasons why microplastics in the GPGP may have the greatest impact on species at higher trophic levels. [2]

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(e) To what extent might plastic recycling provide a solution to the issue of microplastics in the ocean? [5]

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Figure 3(a): Proportion of tree cover and percentage of the population with a low income in Portland, Oregon, USA

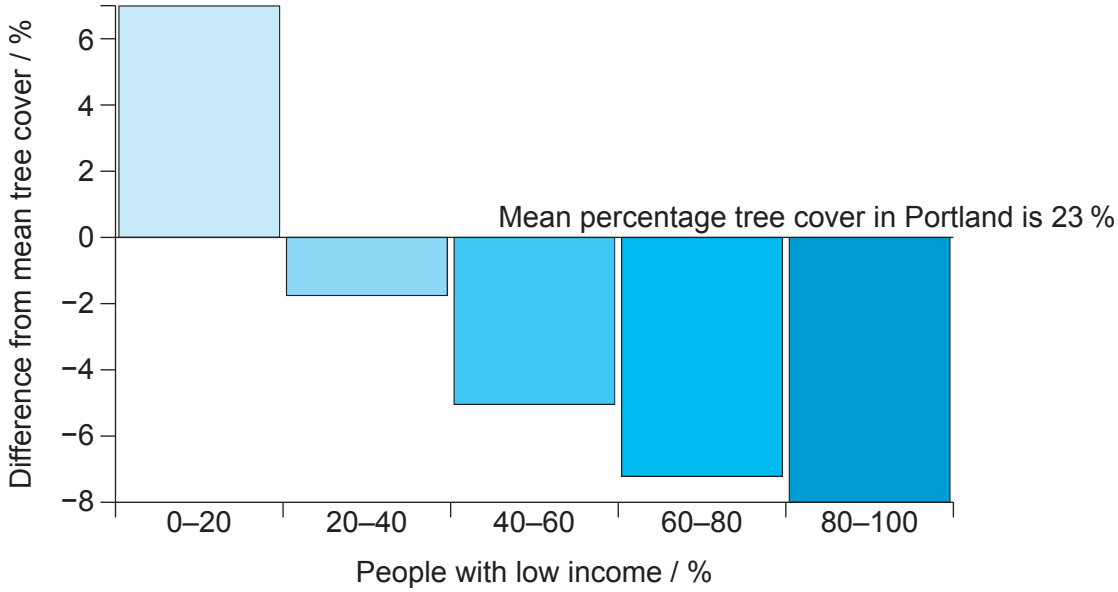
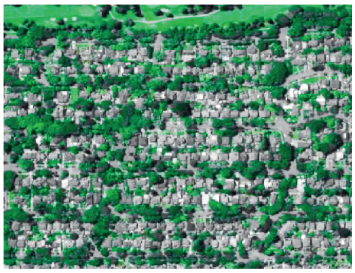


Figure 3(b): Satellite images of areas of low- and high-median income in Portland, Oregon, USA

High income



Low income

3. (a) (i) Using **Figure 3(a)**, state the relationship between the percentage of tree cover and the percentage of people with low income in Portland, Oregon. [1]

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(Question 3 continued)

(ii) Suggest **two** reasons for the relationship between the percentage of tree cover and percentage of people with low income in Portland, Oregon. [2]

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(b) With reference to **Figures 3(a)** and **3(b)**, describe **two** socio-economic impacts that people living in low-income areas might experience. [2]

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(c) Discuss how the pursuit of environmental justice in Portland could also address climate change. [5]

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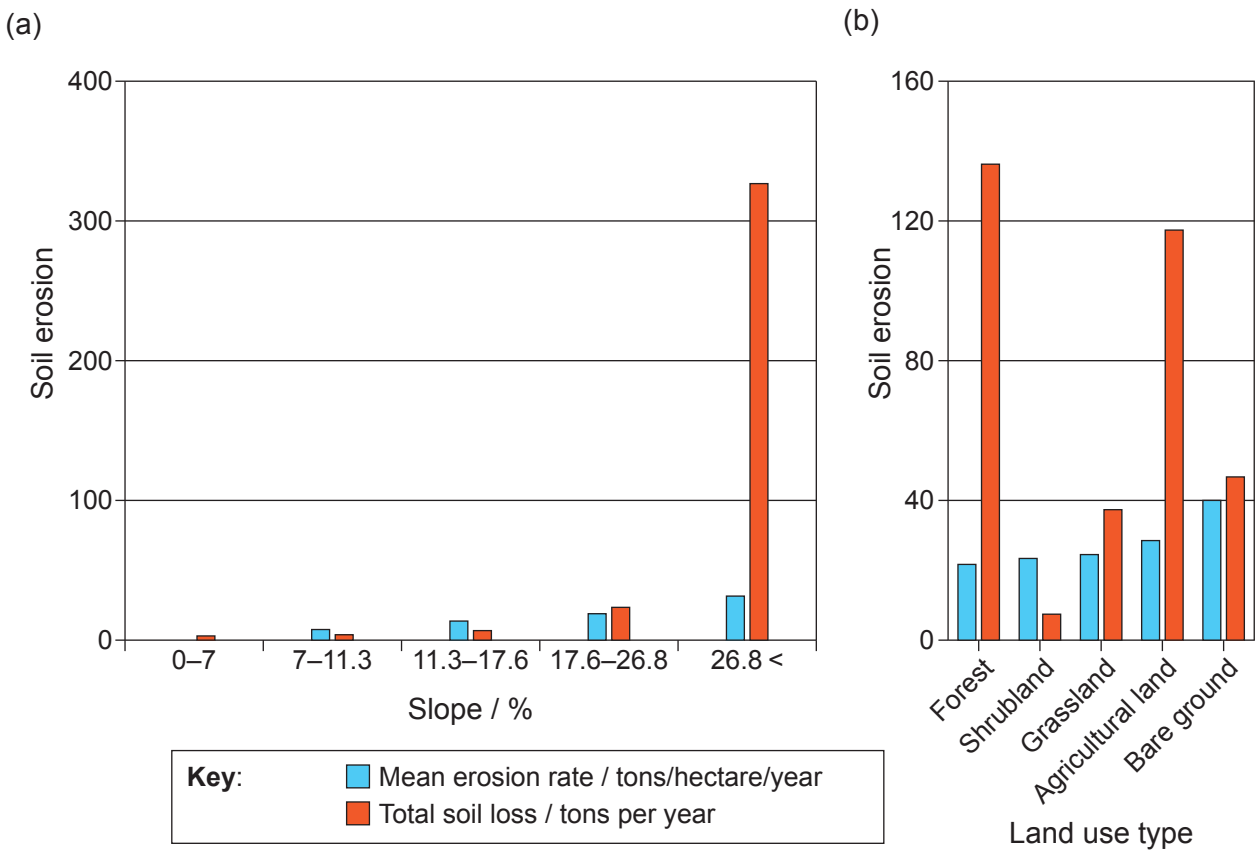
Figure 4: Soil erosion rate in Nepal by (a) slope and (b) land use type



4. (a) State the relationship between slope percentage and total soil loss shown in **Figure 4(a)**. [1]

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(b) State **one** factor, other than slope, that may increase the rate of soil erosion. [1]

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(Question 4 continued)

(c) Suggest why forest has the lowest mean erosion rate but the highest total soil loss shown in **Figure 4(b)**. [2]

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(d) Explain how conservation techniques can mitigate soil erosion on agricultural land. [4]

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Section B

Answer **one** question. Answers must be written within the answer boxes provided.

5. (a) Outline **four** different values provided by the resources of a lake ecosystem. [4]

(b) Discuss, with reference to named examples, the differences between zonation and succession. [7]

(c) Evaluate how different environmental value systems may attempt to manage terrestrial food production. [9]

6. (a) Outline how energy is transferred and transformed in an ecosystem. [4]

(b) Using examples, explain how negative and positive feedback mechanisms can influence equilibria in the environment. [7]

(c) To what extent are different models useful in the study of ecosystems? [9]

Disclaimer:

Content used in IB assessments is taken from authentic, third-party sources. The views expressed within them belong to their individual authors and/or publishers and do not necessarily reflect the views of the IB.

References:

Figure 1 bonezboyz, n.d. *Passenger aircraft in different views. Set of airplane in flat style - stock illustration*. [image online] Available at: https://www.gettyimages.co.uk/detail/illustration/passenger-aircraft-in-different-views-set-of-royalty-free-illustration/1282451576 [Accessed 6 September 2023]. SOURCE ADAPTED.

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Figure 2(a) National Ocean Service, n.d. *The Great Pacific Garbage Patch*. [image online] Available at: https://oceanservice.noaa.gov/podcast/june14/mw126-garbagepatch.html [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 2(b) Lebreton, L., Slat, B., Ferrari, F., Sainte-Rose. B., Aitken, J., Marthouse, R., Hajbane, S., Cunsolo. S., Schwarz. A., Levivier. A., Noble. K., Debeljak. P., Maral. H., Schoeneich-Argent. R., Brambini. R., and Reisser. J., 2018. Evidence that the Great Pacific Garbage Patch is rapidly accumulating plastic. *Scientific Reports*. [image online] Available at: https://www.nature.com/articles/s41598-018-22939-w [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 3(a) Tree Equity Score, n.d. *Tree Equity Score Locality Report*. [image online] Available at: https://www.treeequityscore.org/reports/place/portland-or [Accessed 6 September 2023]. SOURCE ADAPTED.

Figure 3(b) Ramspott, F., n.d. *Portland 3D Render Satellite View Topographic Map Horizontal - stock photo*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/portland-3d-render-satellite-view-topographic-map-royalty-free-image/653909454 [Accessed 23 September 2023]. SOURCE ADAPTED.

Figure 4 Koirala. P., Thakuri. S., Joshi. S., and Chauhan, R., 2019. Estimation of Soil Erosion in Nepal Using a RUSLE Modeling and Geospatial Tool. *Geosciences (Switzerland)*. [image online] Available at: https://www.researchgate.net/figure/Bar-diagram-showing-soil-erosion-rate-of-Nepal-by-a-Slope-b-LULC_fig5_332078772 [Accessed 6 September 2023]. SOURCE ADAPTED.

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2026

Environmental systems and societies

Standard level

Paper 2

18 pages

The following are the annotations available to use when marking responses.

Annotation	Explanation	Associated shortcut
	Correct point – 1 mark will be added to the score for each tick placed up to the maximum for the question part. Please make sure that the number of ticks = the number of marks	
	**Used if the answer is worth zero marks**	
	Unclear	
	Benefit of the doubt	
	Irrelevant, a significant amount of material that does not answer the question	
	Contradiction	
	Too vague	
	No working shown	
	SLP2 ONLY Expression of ideas	
	Ellipse. Dynamic; can be used to surround an area of the candidate's answer	
	Dynamic, vertical wavy line that can be expanded (to highlight a section of irrelevant work for instance)	
	Dynamic, horizontal wavy line that can be expanded (to highlight a section of irrelevant work for instance)	
	DOT. Valid part (to be used when more than one element is required to gain the mark e.g. Drawings)	
	Or words to that effect /OWTTE	
	Cross. Incorrect point (will not remove marks).	
	Advantage / pro (to identify elements in an unclear discussion when pairs are required).	
	Disadvantage / con (to identify elements in an unclear discussion when pairs are required)	
	Difference (to identify elements in an unclear comparison)	

Annotation	Explanation	Associated shortcut
sim	Similarity (to identify elements in an unclear comparison)	
ECF	Error carried forward	
EG	Example / reference	
ND	No definition	
NExa	No examples	
	Highlighting areas of text	
	On page comment. Allows comments to be entered in speech bubbles on the candidate response. Can be used for additional marking comments, it can be linked to a specific tick if that is appropriate. You might like to have a word document of regularly used comments that can be copied and pasted into the text box.	
	H line. Underline tool – dynamic, horizontal line that can be expanded (to highlight a section of irrelevant work for instance)	
SEEN	**You MUST use this to indicate that blank pages and continuation sheets have been seen.**	

You **must** make sure you have looked at all pages. Please put the SEEN annotation on any blank page, to indicate that you have seen it.

Examiners should be aware that in some cases, candidates may take a different approach, which if appropriate should be rewarded. If in doubt, check with your team leader.

In the case of an “identify” question read all answers and mark positively up to the maximum marks. Disregard incorrect answers. In all other cases where a question asks for a certain number of facts *eg* “describe two kinds”, mark the **first two** correct answers. This could include two descriptions, one description and one identification, or two identifications.

It should be recognized that, given time constraints, answers for part (c) questions are likely to include a much narrower range of issues and concepts than identified in the markband. There is no “correct” answer. Examiners must be prepared to award full marks to answers which synthesize and evaluate even if they do not examine all the stimulus material.

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use RM™ Assessor annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

4. Personal codes/notations are unacceptable.

5. Where an answer to a part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an “NR” in the mark panel on the right-hand side of the screen.

6. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. RM™ Assessor will only award the highest mark or marks in line with the rubric.

7. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp “seen” on any page that contains no other annotation.

8. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the “CON” stamp.

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) Identify the flows X and Y shown in **Figure 1**. **[2]**

X	photosynthesis;
Y	dissolving / absorption / in solution

(b) Describe the impacts of increasing flow Y on marine ecosystems. **[3]**

a. Increased dissolving of CO_2 would increase dissolved CO_2 concentration in oceans;
b. Increased CO_2 concentration in oceans increases ocean acidity / increase of carbonic acid;
c. Decreases in pH can decrease the concentration of carbonate ions;
d. Less carbonate is available for marine organisms to build calcium carbonate shells/slows growth of coral skeletons etc. / shells start to dissolve;
e. Resulting in the death/decrease in population of shelled organisms, shortening the food chain;
f. loss of coral reduces habitat for other species;
g. ocean acidification can cause coral bleaching.

(c) Outline two measures that can alleviate the effects of human activities on the carbon cycle. **[2]**

a. Low-carbon technologies (e.g. wind/solar) reduce the need to burn fossil fuels;
b. Reduction in fossil-fuel burning through carbon taxes/carbon trading;
c. Reduction of soil disruption/deforestation reduces the amount of carbon released from soil/biological storages;
d. Carbon capture through reforestation increases the carbon sequestered from atmosphere/stored in trees;
e. Artificial sequestration (e.g. carbon capture storage/artificial trees) to reduces carbon in atmosphere;

Note: Accept any reasonable measure.

(d) Discuss how an individual's vulnerability to the effects of climatic change can influence their views on the control of carbon emissions. **[4]**

a. Younger generations might be more concerned/motivated to deal with climate change as they have longer to live with the consequences / older generations might be less concerned as they won't have to live as long with the consequences;
b. Older generations might be just as concerned as younger generations as they worry about their children/grandchildren;
c. People from developing nations/lower economic status might be more concerned as they have limited financial means to adapt to the consequences / often suffer the worst effects of climate change;
d. People from developed nations/higher economic status might be motivated to invest in solutions to protect assets/business/economy;
e. There is still money to be made at all economic levels in new technologies/strategies that are aimed at a greener economy;
f. People with chronic illness/disability potentially or partially linked to climate change impacts (e.g. lung disease from smog) may be more concerned about controlling emissions;
g. People who live in coastal areas/low lying nations might be more concerned about controlling climate change because they are already feeling effects of flooding / those inland might not be as concerned as they don't feel the effects of flooding/coastal inundation;
h. Individuals who profit from fossil fuels might be less committed to controlling carbon emissions since their livelihood might depend on it;
i. Individuals of any economic status/job/location/age are still capable of empathy and can still be concerned about climate change;

Notes: Award [3] max if no apparent balance to analysis

[1] for a clearly argued opinion or conclusion supported by appropriate evidence

2. (a) Outline the overall trend in microplastic concentration over time **within** the GPGP, as shown in **Figure 2(b)**. **[1]**

Plastic concentration is growing exponentially / at an accelerating rate over time;

(b) Describe the significance of the coefficient of determination (R^2) **within** the GPGP, as shown in **Figure 2(b)**. **[2]**

a. the coefficient of determination/R^2 represents how well the data points fit the line of best fit;
b. 0.92 is close to 1 indicating a close fit between points and line;
c. because of the high R^2 the line is a good model for predicting future trends;

(c) State a possible source of the plastic pollution found in the GPGP. **[1]**

Plastic from effluent / laundry products / beauty products / dumped waste / jetsam / discarded fishing gear / shipping disasters / lost containers / any plausible origin;

(d) Outline reasons why microplastics in the GPGP may have the greatest impact on species at higher trophic levels. **[2]**

a. microplastics are ingested at the lower trophic levels;
b. microplastics can carry / act as a vector for toxins;
c. toxins from POPs can bioaccumulate in prey;
d. toxins from POPs can biomagnify along food chains;

(e) To what extent might plastic recycling provide a solution to the problem of microplastics in the ocean? **[5]**

Part of the solution:

a. Recycling can keep plastics out of landfills, which if not properly managed can contribute to microplastic pollution in the ocean through groundwater, run-off, etc.;
b. Recycling can limit the quantity of new plastics being made, reducing the potential for microplastic pollution;
c. Recycling can be profitable, which may discourage people from discarding/throwing away plastics;

Part of the problem:

a. Many plastics cannot be easily recycled / too expensive to recycle and end up in landfills;
b. Plastic recycling is often shipped between countries for processing, increasing the risk of accidents/plastic being lost to the environment;
c. Recycling doesn't discourage the use of plastics;
d. Recycling doesn't remove existing microplastics from the ocean;

[1] for a clearly argued opinion or conclusion supported by appropriate evidence

3. (a) (i) Using **Figure 3(a)**, state the relationship between the percentage of tree cover and the percentage of people with low income in Portland, Oregon. [1]

Negative correlation / as the % of people with low-income increases, the % of tree canopy decreases;

(ii) Suggest two reasons for the relationship between the percentage of tree cover and percentage of people with low income in Portland, Oregon. [2]

a. low income areas tend to have greater population/housing density, therefore less space for trees;
b. land/property value of areas with trees is higher than areas with fewer trees so only higher income people can live there;
c. lower priority for maintaining/planting trees in areas with a higher % of people with low income;
d. maintaining trees/parks can be expensive, so higher income people can afford them;
e. parks/greenspaces tend to be on the edge/outside city centre and low income people can't afford transportation into city centre for work;

Accept any valid suggestion for relationship

(b) With reference to **Figures 3(a)** and **3(b)**, describe **two** socio-economic impacts that people living in low-income areas might experience. [2]

a. Higher electricity costs for cooling because fewer trees to provide shade;
b. Higher heating costs in winter because fewer trees to block wind;
c. Fewer parks to enjoy nature/exercise / poor health, eg causing obesity / increased medical costs;
d. increased mental health issues / nature deficit disorder in children;
e. Increase respiratory illnesses/health issues due to lack of green space/trees to mitigate air pollution;
f. Increased noise pollution because no trees to block noise eg causing lack of sleep/anxiety/lost work days;

Note: Accept any two valid descriptions of socio-economic impacts

(c) Discuss how the pursuit of environmental justice in Portland could also address climate change. [5]

Positive: max [3]

a. giving those who are marginalized a voice can increase the likelihood of local government planting trees in low income neighbourhoods;
b. improving the wellbeing of people can empower them to take action against climate change;
c. investing in planting trees in low income areas could mitigate climate change/absorb CO_2;
d. investing in planting trees in low income areas could help poorer areas be better adapted to increasing temperatures/effects of climate change;
e. investing in planting trees in low income areas could improve health/save money over time, allowing low income families the means to reduce their carbon footprint;

Negative: max [3]

a. governments may be elected for short periods and have different agendas, whereas climate change needs a long-term approach;
b. investing in trees might distract from more immediate needs of those in poverty;
c. improvements in health/financial position in low income areas could lead to more consumption, increasing carbon footprints;
d. scale of climate change is too large to be adequately addressed by one city;
e. not all actions for environmental justice directly address climate change;

Note: Accept other reasonable arguments

Allow [1] for an appropriate conclusion supported by evidence.

4. (a) State the relationship between slope percentage and total soil loss shown in **Figure 4(a)**. [1]

The greater the slope percentage, the more soil erosion occurs;

(b) State one factor, other than slope, that may increase the rate of soil erosion. [1]

precipitation, wind, loss/lack of vegetation cover, tillage;

(c) Suggest why forest has the lowest mean erosion rate but the highest total soil loss shown in **Figure 4(b)**. [2]

a. forest vegetation/roots hold soil together / reduces precipitation impact / reduces runoff (so mean erosion rate is low);
b. high proportion/large area of land covered by forest (so total soil loss is high);

(d) Explain how conservation techniques can mitigate soil erosion on agricultural land. [4]

a. Reforestation /afforestation/planting hedges/vegetation around agricultural land increases soil nutrients/cycling for stronger soils, thus decreasing soil erosion;
b. Improved farming methods (ex. crop rotation/terraced farming/cover crops, etc.) of agricultural land can improve soil nutrients/cycling / drainage and decrease soil erosion;
c. Physical barriers/windbreaks in agricultural areas vulnerable to wind/rain will reduce soil erosion;
d. Improvements in drainage/irrigation will reduce erosion from water;
e. Laws/legislation restricting the number/size of farms in areas can allow for natural vegetation/ecosystem development to improve soils and decrease likelihood of soil erosion;
f. Planting more drought-resistant crop varieties in drier regions will help water retention in soils, reducing the potential for wind erosion
g. Reducing the use heavy farm machinery will reduce physical erosion / soil compaction, allowing for better water infiltration and nutrient cycling;

Note: Accept any reasonable points

Section B

5. (a) Outline four different values provided by the resources of a lake ecosystem. [4]

a. Economic value eg water supply/fish;
b. Ecological value eg biodiversity/habitat;
c. Social value eg recreation/water sports;
d. Spiritual value eg site of sacred significance;
e. Intrinsic value eg biorights of species;
f. Scientific value eg rare species/potential sources of medicine/use for research;
g. Technological value eg store of potential hydroelectric power;
h. Aesthetic value eg tourism/landscape;

Note: response must give an appropriate example of a resource for each value

(b) Discuss, with reference to named examples, the differences between zonation and succession. [7]

Zonation e.g. mountainside/rocky shore/lake margin etc;
a. there is an environmental gradient of abiotic factors;
b. species will colonise the area wherever abiotic factors are favourable;
c. because different species have different niche requirements, they will colonise different points along gradient;
d. …so the pattern of biotic components will change over distance/spatial distribution;

Succession e.g. after a fire/lithosere/psammosere/hydrosere;
a. Pioneers species colonise virgin habitat;
b. They change the physical/abiotic conditions of habitat;
c. …such that other species can colonise (that couldn't before);
d. The community displace the previous species through competition;
e. The process continues toward a climax community;
f. …thus the community changes over time;

Note: max [6] if key concluding point of contrast is omitted, i.e. zonation over distance vs succession over time

Max [4] if only one concept is addressed

(c) Evaluate how different environmental value systems may attempt to manage terrestrial food production. **[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 demonstrate:

- **understanding concepts & terminology** of land use change; anthropocentrism; environmental pollution standards; food miles; food labelling; maximum sustainable yield; ecocentrism; local, small-scale subsistence food production; technocentrism; economic growth and commercialisation; genetic engineering; intensive farming; deforestation; overgrazing; over-tillage; vertical agriculture etc
- **breadth in addressing and linking** different value systems and different approaches to terrestrial food production and their implications for sustainable food production.
- **examples** of value systems; food production strategies; aspects of sustainable food production (environmental/economic/social) etc
- **balanced analysis evaluating** extent to which different value systems would be effective or not in managing sustainable terrestrial food production.
- **a conclusion that is consistent with, and supported by analysis and examples given** eg Technocentric approaches may appear to be the least concerned with sustainability but, actually, with appropriate anthropocentric controls, they have many strategies in which far greater efficiency can be achieved which goes a long way to achieving sustainability.

Please see markbands on page 18.

6. (a) Outline how energy is transferred and transformed in an ecosystem. **[4]**

transfer: [max 3]

a. biomass is transferred from trophic level to trophic level by feeding;
b. dead organisms are transferred to the decomposing community;
c. energy can be transferred out of/into the ecosystem by migration, wind, erosion;
d. Latent energy may be transferred as water changes state;

transform: [max 3]

a. In photosynthesis/first trophic level, solar/light energy is transformed to biomass/chemical energy;
b. At each trophic level some biomass is respired to provide energy for active processes/work;
c. Some biomass is eaten and transformed into new biomass;
d. chemical energy is transformed to heat energy through respiration/decomposition;

Credit may be given where the above marling points are conveyed in an effective labelled diagram.

(b) Using examples, explain how negative and positive feedback mechanisms can influence equilibria in the environment**.** **[7]**

negative feedback max [4]

a. occurs when the increase/deviation in some factor leads to its decrease/inhibition of deviation;
b. eg increase in prey leads to increase in predators...
c. ...which leads to subsequent decrease in prey …
d. so equilibrium is maintained.

positive feedback max [4]

a. occurs when increase/deviation in some factor promotes further increase/deviation;
b. deviation continues until a tipping point and a new equilibrium is reached;
c. eg increase in global temperature leads to increase in evaporation;
d. ...water vapour (a GHG) further increases global temperature...;
e. so system departs further from equilibrium.

Award [5] max for responses with no valid examples.

Award [6] max for responses with only one valid example

(c) To what extent are different models useful in the study of ecosystems? **[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 demonstrate:

- **understanding concepts & terminology** of food chains; food webs; pyramids of numbers, biomass & productivity, S & J growth curves; r & K-selected species; predator-prey curves; negative & positive feedback; diversity indices; biotic indices; etc
- **breadth in addressing and linking** a range of different models and their usefulness in understanding the functioning and quality of ecosystems.
- **examples** of specific numeric/graphical/conceptual models relevant to study of ecosystems etc
- **balanced analysis evaluating** extent to which models promote understanding of ecosystems or misunderstanding through inaccuracy/oversimplification.
- **a conclusion that is consistent with, and supported by analysis and examples given** eg Although models can never contain the full reality of the systems they represent, ecology is a study of relationships and models are essential in highlighting these relationships in a way that would otherwise be lost in the overwhelming complexity of natural ecosystems.

Please see markbands on page 18.

Section B, part (c) markbands

Marks	Level descriptor
0	The response does not reach a standard described by the descriptors below and is not relevant to the question.
1–3	The response contains: • minimal evidence of knowledge and understanding of ESS issues or concepts • fragmented knowledge statements poorly linked to the context of the question • some appropriate use of ESS terminology • no examples where required, or examples with insufficient explanation/relevance • superficial analysis that amounts to no more than a list of facts/ideas • judgments/conclusions that are vague or not supported by evidence/argument.
4–6	The response contains: • some evidence of sound knowledge and understanding of ESS issues and concepts • knowledge statements effectively linked to the context of the question • largely appropriate use of ESS terminology • some use of relevant examples where required, but with limited explanation • clear analysis that shows a degree of balance • some clear judgments/conclusions, supported by limited evidence/arguments.
7–9	The response contains: • substantial evidence of sound knowledge and understanding of ESS issues and concepts • a wide breadth of knowledge statements effectively linked with each other, and to the context of the question • consistently appropriate and precise use of ESS terminology • effective use of pertinent, well-explained examples, where required, showing some originality • thorough, well-balanced, insightful analysis • explicit judgments/conclusions that are well-supported by evidence/arguments and that include some critical reflection.