OXFORD AQA
INTERNATIONAL QUALIFICATIONS

INTERNATIONAL A-LEVEL

GEOGRAPHY

GG03

Paper 3 Physical Geography 2

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same, correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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International A-level Geography mark scheme

How to mark

Aims

When you are marking your allocation of scripts your main aims should be to:

- recognise and identify the achievements of students
- place students in the appropriate mark band and in the appropriate part of that mark band (high, low, middle) for **each** Assessment Objective
- record your judgements with brief notes, annotations and comments that are relevant to the mark scheme and make it clear to other examiners how you have arrived at the numerical mark awarded for each Assessment Objective
- ensure comparability of assessment for all students, regardless of question or examiner.

Approach

It is important to be **open-minded** and **positive** when marking scripts.

The specification recognises the variety of experiences and knowledge that students will have. It encourages them to study geography in a way that is relevant to them. The questions have been designed to give them opportunities to discuss what they have found out about geography. It is important to assess the quality of **what the student offers**.

Do not mark scripts based on the answer **you** would have written. The mark schemes have been composed to assess **quality of response** and not to identify expected items of knowledge.

Assessment Objectives

This component requires students to:

AO1	Demonstrate knowledge and understanding of places, environments, concepts, processes, interactions and change, at a variety of scales.
AO2	Apply knowledge and understanding in different contexts to interpret, analyse and evaluate geographical information and issues.
AO3	Use a variety of relevant quantitative, qualitative and fieldwork skills to: • investigate geographical questions and issues • interpret, analyse and evaluate data and evidence • construct arguments and draw conclusions.

The marking grids

Do not think of levels equaling grade boundaries.

Depending on the part of the examination, the levels will have different mark ranges assigned to them. This will reflect the different weighting of Assessment Objectives in particular tasks and across the examination as a whole.

Using the grids

Having familiarised yourself with the descriptors and indicative content, read through the answer and annotate it (as instructed below) to identify the qualities that are being looked for and that it shows. You can now check the levels and award a mark.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptors for that level. The descriptors for the level indicate the different qualities that might be seen in the student's answer for that level. If it meets all the descriptors for the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptors and the answer. With practice and familiarity you will find that for better answers you will be able to skip through the lower levels of the mark scheme quickly.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best-fit approach for defining the level and then use the variability of the response to help decide the mark within the level.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark.

It is often best to start in the middle of the level's mark range and then check and adjust. If there is a lot of indicative content fully identifiable in the work you need to give the highest mark in the level. If only some is identifiable or it is only partially fulfilled, then give the lower mark.

The exemplar materials used during standardisation will also help. There will be an answer in the standardising materials that will correspond with each level of the mark scheme. This answer will have been awarded a mark by the lead examiner. You can compare the student's answer with the example to determine if it is of the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the lead examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

In addition to the levels descriptors, question specific indicative content is provided as a guide for examiners. This is not intended to be exhaustive and you must credit other valid points.

An answer that contains nothing of relevance to the question must be awarded no marks.

Annotating scripts

You should write a summative comment at the end for each Assessment Objective and indicate the marks for each Assessment Objective being tested at the end of the answer in the margin in sequence. It is vital that the way you arrive at a mark should be recorded on the script. This will help you with making accurate judgements and it will help any subsequent markers to identify how you are thinking. Please do not write negative comments about students' work or their alleged aptitudes.

Section A – Water, Carbon and Life on Earth **Total for this section: 40 marks**

Question	Part	Marking guidance	Total marks
01	1	**Which of the following is a store of water in the lithosphere?** Key – B: Water in between layers of rock	1 AO1=1

Question	Part	Marking guidance	Total marks
01	2	**Which of the following is the definition of interception?** Key – C: Vegetation catches water before the water reaches the ground.	1 AO1=1

Question	Part	Marking guidance	Total marks
01	3	**Which of the following is a natural driver of change in the carbon cycle?** Key – D: Weathering	1 AO1=1

Question	Part	Marking guidance	Total marks
01	4	**What is 'carbon sequestration' in oceans?** Key – D: The taking in of carbon by sea creatures	1 AO1=1

Question	Part	Marking guidance	Total marks
01	5	**What role does dust in the atmosphere play in cloud formation?** Key – B: They cause condensation around them.	1 AO1=1

Question	Part	Marking guidance	Total marks
02		**Analyse the data shown in FIGURE 1.**	**6** **AO3=6**

Level	Marks	Descriptor
2	**4–6**	**AO3** – Clear analysis of the quantitative evidence provided which makes appropriate use of data to support. Clear connections between different aspects of the data.
1	**1–3**	**AO3** – Basic analysis of the quantitative evidence provided which makes limited use of data to support. Basic or limited connections between different aspects of the data.
0	**0**	No creditable content.

Indicative Content

This question requires analysis of the relationship between Forest Carbon Stock for the UK areas. Links should be made between the data provided. For maximum marks, all aspects; change over time and regional patterns) should be used as well as specific data. There is no credit for explanation.

AO3

General Trends:

- Growth from 1990 to 2009: The total value rises from 16.5 mt (1990) to a peak of around 20.5 mt (2008, 2009 and 2010) driven by increases in England and Scotland.
- Decline from 2010 onwards: With the sharpest drop in 2012, especially in Scotland. After peaking, there is a consistent decrease, reaching 19 mt in 2020.
- By 2020, the total UK value had declined to 19 mt, primarily due to reductions in Scotland and England, while Wales and Northern Ireland made a much smaller contribution to change.

Regional Observations:

- England: The largest contributor, accounting for over 40–45% (9–11 mt) of the total in all years.
- Scotland: The second-largest contributor, making up about 25–30% (5.5–7 mt) of the total.
- Wales: A smaller contributor, averaging around 8–9% (1–1.5 mt) before 2012 and about 6–7% afterwards.
- Northern Ireland: Consistently the smallest contributor, contributing about 3–4% (0.5–1 mt). Consistently low at around 0.6 mt.
- England: Experiences a slight decline after 2011, stabilizing at around 11 mt from 2018.
- Wales: Relatively stable over time, with values fluctuating slightly between 1.5–1.7 mt before 2011. Declines to 1.2 mt (2014).
- Scotland: Increases steadily from 5.5 mt (1990) to a peak of 7 mt (2009). Experiences a significant decline after 2011, dropping to 6 mt (2020).

Overall:

- 2008–2010: The UK reaches its highest value (20.5 mt) then begins to decline.
- England, Wales, and Scotland all peak around this time, while Northern Ireland remains stable.
- 2012: A sharp drop is observed across the UK, with significant decreases in England, Wales, and Scotland.

Credit any other valid response.

Level 2 candidates should demonstrate analytical skills. They also need to be able to demonstrate links between the data provided.

Question	Part	Marking guidance	Total marks
03		**Examine the impact of changes in the water cycle over time on EITHER sustainable water supply OR flooding.** **You should refer to a case study of a river catchment at a local scale you have studied.** **AO1** – Knowledge and understanding of the impact of humans on a river catchment, linked to knowledge and understanding of methods to increase sustainable supply or decrease flooding. **AO2** – Application of knowledge and understanding to the scale or significance of the human impact and if it can be kept to a minimum.	**9** **AO1=4** **AO2=5**

Level	Marks	Descriptor
3	**7–9**	**AO1** – Demonstrates detailed knowledge and understanding of the impact(s) of humans on a river catchment, linked to knowledge and understanding of methods to increase sustainable supply or decrease flooding. **AO2** – Applies knowledge and understanding to the novel situation, offering detailed examination, drawn appropriately from the context provided. Connections and relationships between different aspects of study are thorough and relevant.
2	**4–6**	**AO1** – Demonstrates clear knowledge and understanding of the impact(s) of humans on a river catchment, linked to knowledge and understanding of methods to increase sustainable supply or decrease flooding. **AO2** – Applies knowledge and understanding to the novel situation, offering clear examination, drawn appropriately from the context provided. Connections and relationships between different aspects of study are evident and relevant.
1	**1–3**	**AO1** – Demonstrates basic knowledge and understanding of the impact(s) of humans on a river catchment, linked to knowledge and understanding of methods to increase sustainable supply or decrease flooding. **AO2** – Applies limited knowledge and understanding to the novel situation, offering some basic examination. Connections and relationships between different aspects of study are basic with limited relevance. Analysis and evaluation are basic and of limited relevance.
0	**0**	No creditable content.

Indicative Content

AO1

Answers relating to Sustainable Water Supply:

Human impacts
- Abstraction of water from river systems – withdrawals exceeding the river's natural replenishment rates (base flow)
- Pollutants
- Bank erosion
- Habitat loss
- Leaching of nutrients and agrochemicals
- Climate change

Depending on the case study chosen, aspects that could be developed include:

Water Resource Management
- **Efficient Water Utilisation:** Promote the efficient use of water across agriculture, industry, and domestic sectors through water-saving technologies and practices, such as drip irrigation and water-efficient fittings.
- **Sustainable Abstraction Policies:** Implement regulatory frameworks to control water abstraction rates. Maintain environmental flow requirements to support aquatic ecosystems.
- **Monitoring and Regulation:** Regularly assess both water quality and quantity, setting statutory limits on pollutants and extraction volumes to prevent over-abstraction and degradation of watercourses.

Land Use Planning and Management
- **Riparian Buffer Zones**
- **Managing Urban Expansion**
- **Sustainable Agricultural Practices**

Pollution Mitigation
- **Minimising Agricultural Runoff**
- **Reducing Industrial Discharges**
- **Advanced Wastewater Treatment**

Ecosystem Restoration and Conservation
- **Wetland Restoration**
- **Conservation of Habitats**

Climate Change Adaptation
- **Flood and Drought Risk Management**
- **Adaptive Water Resource Planning**

AO2

- Implementing water-efficient practices is generally cost-effective and can be applied across sectors. However, initial investment in technologies like water-efficient irrigation systems may be a barrier for some users. Behavioural changes are often needed to sustain water-saving practices. There can also be limits to water-saving technologies in certain climates or industries.
- Regulatory frameworks for water abstraction are well established in many regions, though enforcement can be challenging in areas with illegal or unregulated water use. Climate change and

seasonal variability can make setting fixed abstraction limits difficult, necessitating adaptive management approaches.
- There can be gaps in data coverage, and monitoring alone is ineffective without appropriate regulatory enforcement.
- Buffer zones are highly effective at filtering pollutants, stabilising riverbanks, and providing wildlife habitats. They are a low-cost solution with significant ecological benefits. Establishing buffer zones is straightforward, though it requires land to be set aside, which may conflict with agricultural or development interests. The effectiveness of buffer zones can vary based on vegetation type, soil composition, and buffer width. Maintenance is needed to keep buffers functional.
- Sustainable urban Drainage Systems (SuDS) can be incorporated into new developments relatively easily, but retrofitting existing urban areas is more challenging and costly. In densely built-up areas, space for SuDS can be limited, reducing their overall impact on catchment-scale water quality.
- Changing farming practices can be cost-neutral or even cost-saving for farmers over time, but may require training and incentives to encourage adoption. Adoption can be slow, especially if farmers face short-term economic pressures or lack knowledge about sustainable methods.
- Industries may resist adopting expensive pollution control technologies, so incentives or penalties may be needed. Some pollutants, such as microplastics or emerging contaminants, may be difficult to eliminate with existing treatment technologies.
- Wetland restoration can be a cost-effective measure for improving ecosystem health, though it requires land availability and may compete with agricultural or development interests. Restoring wetland functions in heavily modified landscapes can be complex, and full ecological functionality may take time to develop.
- Integrated Catchment Management (ICM) ensures that the interconnected aspects of water management, land use, and socio-economic factors are considered together, leading to more sustainable outcomes. Implementation across diverse groups can be challenging, particularly in large catchments.

Developed answers will generally argue that significant reductions in human impact are achievable, but complete elimination is challenging due to natural and human factors.

Developed answers may consider the entire drainage basin (Integrated Catchment Management (ICM)), coordinating policies across sectors such as agriculture, forestry, industry, and urban planning.

Max Level 2 if no reference to a specific river catchment.

Answers relating to Flooding:

AO1

Natural Flood Changes
- **Seasonal changes:** Changes in evaporation rate, precipitation intensity and type, type of trees- deciduous lose their leaves- and saturated ground.
- **Restoration of Floodplains:** Reconnect rivers with their natural floodplains to allow floodwaters to spread out and be temporarily stored during high flows. This slows down the movement of water downstream, reducing peak discharge and lowering the risk of flooding in urban areas.
- **Wetland Creation and Restoration:** Enhance or restore wetlands within the catchment to increase water storage capacity. Wetlands act as natural 'sponges', absorbing excess water during periods of heavy rainfall and releasing it gradually, which helps to attenuate flood peaks.

Sustainable Land Use and Agricultural Practices
- **Riparian Buffer Zones**
- **Contour Ploughing and Terracing**

- **Cover Cropping and Agroforestry**

Catchment Management and Urban Planning
- **Sustainable urban Drainage Systems (SuDS)**
- **Green Belt and Land Zoning Policies**
- **River Channel Restoration**
- **Flood Storage and Flow Diversion**
- **Washlands**
- **Flood Relief Channels and Diversion Schemes**

Early Warning Systems and Flood Resilience
- **Flood Warning Systems**
- **Community Flood Plans and Emergency Preparedness**

Climate Change Adaptation
- **Future-Proofing Flood Management Infrastructure**
- **Flexible Water Management Practices**

AO2

- Floodplain restoration is feasible in rural areas but challenging in urban regions due to land scarcity. It requires sufficient space and cooperation from landowners, which can be contentious. Wetland restoration may not suit developed or heavily farmed areas, takes time to establish, and requires maintenance for flood management.
- Buffer zones are easy to implement but occupy agricultural land, potentially reducing productivity. They are most effective for small-scale floods and offer limited protection during extreme weather. Contour ploughing and terracing suit agricultural areas but need changes to traditional practices and may be ineffective in flat landscapes or large-scale flooding.
- Agroforestry provides long-term benefits and integrates well with farming but needs planning, investment, and time for trees to mature. It may not suit all crops or systems. Sustainable urban Drainage Systems (SuDS) work well in new developments but are costly and challenging to retrofit. Urban space limitations can reduce their capacity to manage flood risks.
- Green belt and zoning policies are effective but may face resistance from developers prioritising land value. River channel restoration works in rural areas but is difficult in urban settings where rivers are heavily modified. Flood storage and diversion schemes suit agricultural lands but require agreements with landowners and may not handle extreme floods.
- Flood relief channels involve expensive engineering, land acquisition, and potential environmental disruption. Early warning systems are cost-effective but depend on reliable communication. They cannot prevent flooding and are less effective for flash floods.
- Community engagement is low-cost and empowers locals but depends on participation and predictable flood events. Climate adaptation in planning is now standard but raises costs and faces challenges from uncertain projections, potentially leading to outdated infrastructure.
- Early warning systems need effective communication methods.
- Effective flood management often requires a combination of these measures tailored to local conditions.

Developed answers will generally argue that significant reductions in human impact are achievable, but complete elimination is challenging due to natural and human factors.

Developed answers may consider adopting an ICM approach that considers the entire drainage basin, recognising that actions taken in the upper catchment can have significant effects downstream.

Max Level 2 if no reference to a specific river catchment.

Question	Part	Marking guidance	Total marks
04		**Evaluate how climate change threatens the role tropical rainforests have in supporting life on Earth.** **AO1** – Knowledge and understanding of the role that tropical rainforests have in supporting life on earth. Knowledge and understanding of how climate change will affect this role. **AO2** – Application of knowledge and understanding to evaluate how much of a threat climate change is to the role tropical rainforests have in supporting life. The response should come to a view with regard to the strength and importance of those changes.	**20** **AO1=10** **AO2=10**

Level	Marks	Descriptor
4	**16–20**	**AO2** – Detailed evaluative conclusion that is rational and firmly based on knowledge and understanding which is applied to the context of the question. **AO2** – Detailed, coherent and relevant analysis and evaluation in the application of knowledge and understanding throughout. **AO2** – Full evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Detailed, highly relevant and appropriate knowledge and understanding of place(s) and environments used throughout. **AO1** – Full and accurate knowledge and understanding of key concepts and processes throughout. **AO1** – Detailed awareness of scale and temporal change which is well integrated where appropriate.
3	**11–15**	**AO2** – Clear evaluative conclusion that is based on knowledge and understanding which is applied to the context of the question. **AO2** – Generally clear, coherent and relevant analysis and evaluation in the application of knowledge and understanding. **AO2** – Generally clear evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Generally clear and relevant knowledge and understanding of place(s) and environments. **AO1** – Generally clear and accurate knowledge and understanding of key concepts and processes.

		AO1 – Generally clear awareness of scale and temporal change which is integrated where appropriate.
2	**6–10**	**AO2** – Some sense of an evaluative conclusion partially based upon knowledge and understanding which is applied to the context of the question. **AO2** – Some partially relevant analysis and evaluation in the application of knowledge and understanding. **AO2** – Some evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Some relevant knowledge and understanding of place(s) and environments which is partially relevant. **AO1** – Some knowledge and understanding of key concepts, processes and interactions and change. **AO1** – Some awareness of scale and temporal change which is sometimes integrated where appropriate. There may be a few inaccuracies.
1	**1–5**	**AO2** – Very limited and/or unsupported evaluative conclusion that is loosely based upon knowledge and understanding which is applied to the context of the question. **AO2** – Very limited analysis and evaluation in the application of knowledge and understanding. This lacks clarity and coherence. **AO2** – Very limited and rarely logical evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Very limited relevant knowledge and understanding of place(s) and environments. **AO1** – Isolated knowledge and understanding of key concepts and processes. **AO1** – Very limited awareness of scale and temporal change which is rarely integrated where appropriate. There may be a number of inaccuracies.
0	**0**	No creditable content.

Indicative Content

AO1

- **Role of Tropical Rainforest Water Cycle in supporting life:**
  Evapotranspiration: Tropical rainforests contribute significantly to the global water cycle through the process of evapotranspiration, whereby water is absorbed by plants and subsequently released into the atmosphere as water vapour. This process helps to maintain high levels of humidity in the atmosphere and promotes cloud formation, which in turn influences regional and global precipitation patterns.
  Precipitation Feedback Loops: The continuous process of evapotranspiration and high rainfall creates a positive feedback loop, where the rainforest generates much of its own precipitation. This is crucial in maintaining the local climate, as the moisture released by the forest contributes to regular and abundant rainfall, which supports the rich biodiversity and ensures the sustainability of the ecosystem.
  Water Infiltration and River Systems: The dense root networks of rainforest vegetation facilitate water infiltration into the soil, promoting groundwater recharge and reducing surface runoff. This regulation of water flow helps to sustain river systems that originate in tropical rainforest regions, such as the Amazon, Congo, and Mekong rivers. These rivers support human populations, agriculture, and other ecosystems downstream.
- **Role of Tropical Rainforest Carbon Cycle in supporting life:**
  Carbon Sequestration: Tropical rainforests are referred to as 'carbon sinks' because they absorb large amounts of carbon dioxide (CO_2) from the atmosphere during photosynthesis. This process converts atmospheric carbon into organic matter, which is stored in the biomass of trees, shrubs, and other vegetation. The substantial biomass of tropical rainforests enables them to store vast quantities of carbon.
  Carbon Storage in Biomass and Soil: Accumulation of leaf litter, dead wood, and other organic materials on the forest floor contributes to soil carbon storage.
  Carbon Release through Decomposition and Respiration: When organic matter decomposes, some of the carbon is returned to the atmosphere as CO_2, while the rest is incorporated into the soil. This dynamic equilibrium between carbon absorption and release helps to regulate the global carbon cycle.
- **Role of Tropical Rainforest Climate Regulation in supporting life:**
  Drought and Rainfall Patterns: Tropical rainforests help stabilise rainfall patterns not only within their immediate regions but also across larger areas due to their impact on atmospheric circulation. For example, moisture generated by the Amazon rainforest is carried by winds to other parts of South America, influencing precipitation patterns as far away as the Andes Mountains.
- **Role of Tropical Rainforest in supporting biodiversity and human life:**
  Biodiversity Hotspots: Tropical rainforests are some of the most biodiverse ecosystems on Earth, harbouring an estimated 50% of the world's species.
  Soil Fertility and Nutrient Cycling: The rapid decomposition rates in tropical rainforests, facilitated by warm and humid conditions, ensure efficient nutrient cycling. Decomposed organic matter quickly releases nutrients back into the soil, where it is readily absorbed by plant roots.
  Human Dependence: Tropical rainforests provide a range of resources essential for human life, including timber, medicinal plants, and food. They also support indigenous communities who depend on the forest for their livelihoods, maintaining cultural practices and traditional knowledge. Many communities around the world rely on river systems that are fed by tropical rainforest watersheds. The forests help to regulate the flow of these rivers, reducing the risk of flooding during the rainy season and maintaining water availability during dry periods. This regulation is crucial for agriculture, hydropower generation, and freshwater supplies.

Threats from Climate Change:

- Rising temperatures can lead to heat stress in tropical rainforest plants.
- As temperatures rise, some plant and animal species may struggle to survive in their current locations and may migrate to cooler areas, such as higher elevations.

- Climate change is causing shifts in rainfall patterns, leading to more intense storms or longer dry spells. Tropical rainforests rely on consistent, high levels of rainfall, and changes in precipitation can disrupt the water cycle, affecting plant growth and animal life. Reduced rainfall can also lead to drier conditions, which make forests more vulnerable to fires.
- Drought conditions can reduce soil moisture and limit the availability of water for trees, potentially leading to widespread tree mortality.
- Climate change is increasing the likelihood of fires by causing drier conditions and longer droughts. This not only destroys large areas of forest but also releases stored carbon into the atmosphere.
- Fires can have long-term ecological impacts by altering soil properties, killing tree seedlings, and reducing canopy cover. This can hinder forest regeneration and allow invasive species to take hold, further degrading the ecosystem.
- Tropical rainforests act as significant carbon sinks, absorbing carbon dioxide from the atmosphere and storing it in biomass and soil. However, climate change-induced stress, such as droughts and heatwaves, can weaken trees and slow down the rate of photosynthesis, reducing the forest's ability to sequester carbon.
- Coastal mangrove rainforests, which provide important coastal protection and support unique biodiversity, are particularly vulnerable to sea-level rise.
- For tropical rainforests located in low-lying coastal areas, rising sea levels due to climate change pose a direct threat. Flooding can submerge large areas of forest, while saltwater intrusion can damage freshwater ecosystems, affecting species that are not adapted to saline conditions.

AO2

- Tropical rainforests play a vital role in supporting life on Earth, acting as critical components of both the water and carbon cycles, and maintaining the planet's environmental stability.
- They play a crucial role in mitigating the greenhouse effect and regulating the Earth's climate.
- Stored carbon can remain sequestered for centuries, making rainforests a vital component in stabilising atmospheric carbon levels.
- Tropical rainforests significantly influence both global and regional climates. Their role in sequestering carbon helps to reduce the concentration of greenhouse gases in the atmosphere, thereby mitigating global warming. Furthermore, the high rates of evapotranspiration and subsequent cloud formation help to cool the Earth's surface by reflecting solar radiation and maintaining atmospheric moisture levels.
- Reduced rainfall disrupts the water cycle by decreasing soil moisture, reducing river flow, and limiting the availability of water for plants and animals. This could affect not just local ecosystems but also regional and global weather patterns.
- Increased temperatures.
- Heat Stress on Vegetation: Many species are adapted to relatively stable temperature conditions, so even a small increase can disrupt photosynthesis and reduce plant growth. Heat stress can weaken plants, making them more susceptible to disease and pests.
- Shifts in Species Distribution: As temperatures rise, some plant and animal species may struggle to survive in their current locations and may migrate to cooler areas, such as higher elevations. This can lead to changes in the composition of rainforest communities and potentially reduce biodiversity, as some species may not adapt or migrate fast enough.
- Prolonged Droughts: Increased frequency and duration of droughts in tropical regions can severely affect rainforest ecosystems. This loss of vegetation further disrupts the water cycle and diminishes the forest's ability to generate its own rainfall through evapotranspiration.
- When trees die due to drought, heat stress, or fires, the carbon stored in their biomass is released back into the atmosphere as CO_2, contributing to the greenhouse effect. This creates a negative feedback loop, where increased atmospheric CO_2 leads to further climate change, which in turn damages the rainforest.
- As water levels increase, mangroves may struggle to keep pace with sediment accumulation, leading to erosion and habitat loss.

- As rainforests degrade and lose their ability to sequester carbon, the resulting increase in atmospheric CO_2 accelerates climate change. This feedback loop exacerbates the problem, making it harder to stabilise global temperatures.
- The loss of biodiversity threatens the overall stability of the rainforest ecosystem, as complex interactions between species (such as pollination, seed dispersal, and predation) are disrupted. This not only affects the forest itself but also has broader consequences for human populations who rely on these services for clean water, agricultural productivity, and livelihoods.

Developed answers may consider other human threats such as:
- deforestation and land-use change
- socio-economic pressures
- the concept of tipping points

Some answers may consider that the threat posed by climate change to tropical rainforests is profound and growing. However, the extent to which rainforests can continue to support life on Earth depends on the intensity of climate change and the measures taken to mitigate its effects.

Addressing the root causes of climate change by reducing greenhouse gas emissions on a global scale is essential to preserving tropical rainforests.

Section B – Ecosystems Under Stress **Total for this section: 40 marks**

Question	Part	Marking guidance	Total marks
05	1	**Which of the following describes an example of BOTH an input to AND an output from an ecosystem?** Key – C: **Input:** Sunlight used by plants; **Output:** Oxygen released during photosynthesis	1 **AO1=1**

Question	Part	Marking guidance	Total marks
05	2	**Which of the following is a definition of 'net primary production'?** Key – A: The amount of energy that plants produce after they use some of the energy for themselves	1 **AO1=1**

Question	Part	Marking guidance	Total marks
05	3	**Which of the following is an impact of wildfires on ecosystems?** Key – A: Wildfires can encourage new growth by clearing dead vegetation.	1 **AO1=1**

Question	Part	Marking guidance	Total marks
05	4	**Which of the following is a definition of 'nutrient cycling'?** Key – A: The breaking down of organic matter, transferring nutrients back into the soil and promoting plant growth.	1 **AO1=1**

Question	Part	Marking guidance	Total marks
05	5	**'Algal blooms reduce the amount of sunlight that can enter the water and slow the growth of underwater plants. The decline in plant biomass leads to less competition for nutrients. As a result, there is further growth of algal blooms.'** **This is an example of which of the following?** Key – C: Positive feedback	1 **AO1=1**

Question	Part	Marking guidance	Total marks
06		**Analyse the data shown in FIGURE 2.**	**6** **AO3=6**

Level	Marks	Descriptor
2	**4–6**	**AO3** – Clear analysis of the quantitative evidence provided which makes appropriate use of data to support. Clear connections between different aspects of the data.
1	**1–3**	**AO3** – Basic analysis of the quantitative evidence provided which makes limited use of data to support. Basic or limited connections between different aspects of the data.
0	**0**	No creditable content.

Indicative Content

This question requires analysis of the relationship between hard coral cover and bleaching events and the spatial analysis of these across the reef. Links should also be made between the data provided. For maximum marks, all three elements should be used as well as use of specific data. There is no credit for explanation.

AO3

- The lack of severe bleaching across all regions suggests a relatively stable coral health status in this database.
- The **Northern Great Barrier Reef is in the best condition** and is the only area with some 76%+ hard coral cover.
- The **Central and Southern regions show some level of bleaching**.
- The Central barrier reef area has the most reefs surveyed and is proportionally the longest stretch of coastline.

Hard Coral Cover
- All three regions have reefs with varying hard coral cover levels, mostly in the 11–30% range.
- Only one region has reefs with 76–100% coral cover, which suggests that high coral coverage is rare or absent in the surveyed areas.
- The Central and Northern Barrier Reefs appear to have more reefs with 31–50% hard coral cover compared to the Southern region.

Coral Bleaching
- Northern Region: No bleaching observed, suggesting this area is in good condition.
- Central Region: Some bleaching (1–30% affected).
- Northern Great Barrier Reef:
  - none of the 26 surveyed reefs showed any bleaching.
- Central Barrier Reef:
  - 7 reefs (21%) had 11–30% of their area affected by bleaching
  - 18 reefs (55%) had 1–10% of their area affected by bleaching
  - 7 reefs showed no bleaching.

- Southern Great Barrier Reef:
  - 7 reefs (25%) had 1–10% of their area affected by bleaching
  - 21 reefs showed no bleaching.

Question	Part	Marking guidance	Total marks
07		**The introduction of new species into an ecosystem can be planned or unplanned.** **Examine the impact of the introduction of new species on an ecosystem at a local scale.** **AO1** – Knowledge and understanding of the impact(s) of planned/unplanned species on an ecosystem **AO2** – Application of knowledge and understanding to the scale or significance of the impact of planned/unplanned species on local ecosystems.	**9** **AO1=4** **AO2=5**

Level	Marks	Descriptor
3	**7–9**	**AO1** – Demonstrates detailed knowledge and understanding of the impact(s) of planned/unplanned species on an ecosystem. **AO2** – Applies knowledge and understanding to the novel situation, offering detailed examination, drawn appropriately from the context provided. Connections and relationships between different aspects of study are thorough and relevant.
2	**4–6**	**AO1** – Demonstrates clear knowledge and understanding of the impact(s) of planned/unplanned species on an ecosystem. **AO2** – Applies knowledge and understanding to the novel situation, offering clear examination, drawn appropriately from the context provided. Connections and relationships between different aspects of study are evident and relevant.
1	**1–3**	**AO1** – Demonstrates basic knowledge and understanding of the impact(s) of planned/unplanned species on an ecosystem. **AO2** – Applies limited knowledge and understanding to the novel situation, offering some basic examination. Connections and relationships between different aspects of study are basic with limited relevance. Analysis and evaluation are basic and of limited relevance.
0	**0**	No creditable content.

Indicative Content

AO1

- **Increased Biodiversity:** In some cases, the introduction of new species can enhance local biodiversity by filling ecological niches. For instance, the introduction of honeybees for agricultural purposes has improved pollination rates for various crops and flowering plants. This has led to increased yields and greater floral diversity in many regions.
- **Loss of Native Species:** The introduction of non-native species can result in competition with native species for resources. For instance, the grey squirrel in the UK, which has outcompeted the native

red squirrel for food and habitat. This competition has led to a significant decline in red squirrel populations, putting them at risk of extinction in some areas.

- **Altered Food Webs:** The introduction of new species can disrupt existing food webs. For instance, the introduction of the Nile perch to Lake Victoria in East Africa led to the decline of numerous native fish species. As the Nile perch became a dominant predator, it significantly altered the lake's food web, contributing to the extinction of around 200 endemic cichlid species.
- **Nutrient Cycling Changes:** Certain introduced plant species can influence nutrient cycling within an ecosystem. For example, the invasive plant West Indian Lantana in many tropical regions alters soil chemistry and reduces nitrogen availability. This change affects the growth of native vegetation, leading to shifts in plant community composition and overall ecosystem functioning.
- **Erosion and Sedimentation:** Invasive species may also impact erosion and sedimentation patterns. The introduction of zebra mussels, which filter large quantities of water, leading to clearer waters that allow more light penetration, which can encourage the growth of aquatic plants and disrupt local ecosystems.
- **Habitat Modification**
- **Agricultural Effects**
- **Human Health Risks**

Planned species reintroduction example

The Eurasian Beaver was reintroduced to Scotland in 2009 after a 400-year absence.

- Beavers are considered 'ecosystem engineers' because of their ability to modify habitats by building dams, creating ponds, and changing water flows.
- By slowing water flow, beaver dams can reduce erosion and trap sediments, which helps to purify water. However, these changes can also disrupt existing aquatic ecosystems by altering the species composition in rivers and streams.
- While beavers are not significant vectors of disease, their activities can alter wetland conditions, potentially affecting water-borne diseases.

Unplanned species introduction

- Japanese knotweed was introduced to the UK in the 19th century as an ornamental plant.
- It is known for its ability to form dense thickets, which can outcompete native vegetation for light, space, and nutrients. This often leads to a reduction in local biodiversity, as the growth of other plants is suppressed and habitats for native wildlife are lost.
- The plant's extensive root system can stabilize soil in some cases, potentially reducing erosion on riverbanks. However, when it dies back in winter, areas previously covered by knotweed can be left exposed to erosion, impacting soil structure and local waterways.
- Japanese knotweed releases chemicals into the soil that inhibit the growth of other plants, which can alter the composition of plant communities and disrupt natural succession processes.
- Japanese knotweed is notorious for its impact on property values.
- The cost of controlling Japanese knotweed in the UK is substantial, with estimates suggesting that annual management expenditures exceed £165 million. Methods include chemical treatments, excavation, and biological controls.
- The plant's aggressive root system can grow through cracks in concrete, tarmac, and building foundations, causing damage to infrastructure. This necessitates costly repairs and ongoing maintenance, particularly in urban areas where knotweed can disrupt roads, railways, and flood defences.

AO2

- **Irreversibility of Changes:** The impacts of introduced species can be irreversible. Once established, species like the cane toad in Australia can be extremely difficult to eradicate. Their introduction has led to severe declines in native amphibian populations, fundamentally altering local ecosystems and making recovery nearly impossible.

- **Ecosystem Resilience:** The introduction of non-native species can affect the resilience of ecosystems. For instance, the introduction of the brown tree snake to Guam has led to the decline of native bird populations and other species. The loss of these native species reduces biodiversity and resilience, making the ecosystem more vulnerable to further disturbances.
- **Control and Management Costs:** The introduction of invasive species often requires substantial financial resources for management and control. For example, the control of the invasive kudzu vine in the southeastern United States has necessitated extensive eradication efforts due to its rapid growth and ability to outcompete native plants, resulting in significant costs for landowners and government agencies.
- **Habitat loss/modification** can lead to the feedback loops as the entire community of organisms relying on those native plants for habitat and food dynamics will change.

Evaluation of reintroduction of planned species, eg Eurasian Beaver

- Their activities have been shown to increase habitat diversity, benefiting a range of species such as amphibians, fish, and invertebrates by creating new wetland areas. Beaver activity in the Knapdale Forest has led to increased aquatic plant diversity and provided suitable breeding grounds for birds like herons.
- While the reintroduced beaver population enhances genetic diversity compared to complete absence, managing genetic diversity is still a concern. The current population may face challenges due to limited genetic variation, which could affect resilience to disease or environmental changes.
- The presence of beavers has attracted wildlife enthusiasts, boosting eco-tourism in areas like Knapdale. This increased tourism has economic benefits for local businesses, including accommodations, guided tours, and wildlife photography.
- Public support for beaver reintroduction has been mixed. While conservationists and many local communities view beavers as a symbol of ecological restoration, some landowners express concern over the practical implications of having beavers on their land.
- Beaver reintroduction has cultural resonance, reconnecting people with a landscape reminiscent of historical ecosystems before human-driven extinctions.
- No major disease outbreaks linked to beavers have been reported in Scotland.
- While the reintroduction of beavers has meant substantial ecological benefits, there are significant economic and social challenges that require careful management and stakeholder involvement. With appropriate measures in place, beaver reintroduction can serve as a model for restoring other native species in the UK.

Evaluation of introduction of unplanned introduction of invasive species eg Japanese Knotweed

- Approximately 5% of homes across the UK are currently affected by Japanese knotweed, either directly or neighbouring an affected property, typically impacting property prices by around 5% – or up to 10% in severe cases – so whilst not completely widespread this is a significant local issue in some areas.
- Japanese knotweed releasing chemicals into the soil makes it particularly challenging to manage ecologically, as the suppression of other species persists even after the plant is removed.
- While some concerns about its structural impacts are legitimate, the perception that knotweed is ‘unstoppable’ can lead to unnecessary panic and drastic measures that are not always the most effective for control.
- While Japanese knotweed itself is not directly harmful to humans, the chemical treatments used for its control (eg herbicides) may raise health concerns among the public. Additionally, improper handling during removal can inadvertently contribute to its spread.
- Government policies and initiatives have been developed to encourage the control of invasive species like knotweed. For example, some local authorities offer advice and assistance to help residents manage the plant, while government funding supports large-scale eradication projects. Monitoring the spread of knotweed across the UK and ensuring compliance with control measures requires significant resources, and penalties for non-compliance are not always strictly applied.

- Japanese knotweed can regenerate from tiny fragments, making complete eradication extremely difficult. Ineffective or improperly executed control efforts can lead to further spread, as disturbance of the plant often stimulates growth.
- Repeated use of herbicides may lead to resistance in knotweed populations. This would make chemical treatments less effective over time, necessitating the development of alternative management strategies such as biological control.
- In areas where knotweed has been removed, restoration of native vegetation can be challenging. The soil may be left in a poor condition.

Max L2 if no case study.

Question	Part	Marking guidance	Total marks
08		**To what extent is economic development a bigger threat to the tropical rainforest than to the savanna biome?** **AO1** – Understanding of the threats of economic development to the tropical rainforests and the savanna biome. Awareness of measures to manage these impacts. **AO2** – Application of knowledge and understanding to assess the scale of impacts on the tropical rainforest and savanna biome, and the success of measures to manage impacts.	**20** **AO1=10** **AO2=10**

Level	Marks	Descriptor
4	**16–20**	**AO2** – Detailed evaluative conclusion that is rational and firmly based on knowledge and understanding which is applied to the context of the question. **AO2** – Detailed, coherent and relevant analysis and evaluation in the application of knowledge and understanding throughout. **AO2** – Full evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Detailed, highly relevant and appropriate knowledge and understanding of place(s) and environments used throughout. **AO1** – Full and accurate knowledge and understanding of key concepts and processes throughout. **AO1** – Detailed awareness of scale and temporal change which is well integrated where appropriate.
3	**11–15**	**AO2** – Clear evaluative conclusion that is based on knowledge and understanding which is applied to the context of the question. **AO2** – Generally clear, coherent and relevant analysis and evaluation in the application of knowledge and understanding. **AO2** – Generally clear evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Generally clear and relevant knowledge and understanding of place(s) and environments. **AO1** – Generally clear and accurate knowledge and understanding of key concepts and processes. **AO1** – Generally clear awareness of scale and temporal change which is integrated where appropriate.

2	**6–10**	**AO2** – Some sense of an evaluative conclusion partially based upon knowledge and understanding which is applied to the context of the question. **AO2** – Some partially relevant analysis and evaluation in the application of knowledge and understanding. **AO2** – Some evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Some relevant knowledge and understanding of place(s) and environments which is partially relevant. **AO1** – Some knowledge and understanding of key concepts, processes and interactions and change. **AO1** – Some awareness of scale and temporal change which is sometimes integrated where appropriate. There may be a few inaccuracies.
1	**1–5**	**AO2** – Very limited and/or unsupported evaluative conclusion that is loosely based upon knowledge and understanding which is applied to the context of the question. **AO2** – Very limited analysis and evaluation in the application of knowledge and understanding. This lacks clarity and coherence. **AO2** – Very limited and rarely logical evidence of links between knowledge and understanding to the application of knowledge and understanding in different contexts. **AO1** – Very limited relevant knowledge and understanding of place(s) and environments. **AO1** – Isolated knowledge and understanding of key concepts and processes. **AO1** – Very limited awareness of scale and temporal change which is rarely integrated where appropriate. There may be a number of inaccuracies.
0	**0**	No creditable content.

Indicative Content

AO1

Deforestation Rates

- Economic development often leads to deforestation in tropical rainforests at alarming rates. For instance, in Brazil, large areas of the Amazon rainforest have been cleared for agriculture, particularly for soybean production and cattle ranching. In the last 50 years, Brazil's Amazon has lost about 20% of its forest cover. An estimated 80 000+ square metres of forest land is lost every year for meat production, 80% of which occurs in the Amazon. This level of deforestation not only destroys biodiversity but also contributes to climate change by releasing stored carbon dioxide into the atmosphere.
- While savannas also face deforestation, particularly for agricultural expansion and urban development, the rates are generally lower compared to tropical rainforests. For example, the East African savannas have seen land conversion for pastoralism and agriculture, but they are less frequently cleared entirely than rainforests, often remaining more intact.

Biodiversity Loss

- Tropical rainforests are some of the most biodiverse ecosystems on Earth, hosting around 50% of the world's plant and animal species despite covering only about 7% of the planet's land surface. Economic development leads to habitat fragmentation, making it difficult for species to survive. For example, the introduction of roads for logging or mining can isolate populations of species like the jaguar and the orangutan, increasing their risk of extinction. In the Amazon, over 20% of species are threatened due to habitat destruction driven by economic activities.
- While savannas also host diverse flora and fauna, their species are often more adapted to the changing conditions of their environment. The African elephant faces threats from poaching and habitat loss.

Climate Change Contributions

- Economic activities such as logging, agriculture and mining significantly contribute to greenhouse gas emissions when rainforests are cleared. The Amazon rainforest plays a crucial role in carbon sequestration, and its destruction releases significant amounts of CO_2. Deforestation in tropical regions accounts for approximately 10% of global carbon emissions.
- The savannas can also act as carbon sinks to some extent, particularly through the management of grasslands. Large-scale cattle ranching in savannas can contribute to methane emissions.

Water Cycle and Soil Degradation

- The disruption of the water cycle due to deforestation is more pronounced in tropical rainforests. Rainforests play a vital role in maintaining local and regional rainfall patterns through transpiration. The loss of trees can lead to reduced precipitation, soil erosion, and decreased water quality. For instance, the loss of rainforest cover in Indonesia for palm oil plantations has led to severe flooding and water scarcity issues in surrounding areas.
- The loss of vegetation in the savanna can impact local water availability, but it does not have the same immediate global repercussions as rainforest deforestation.

Economic Incentives and Sustainable Practices

- Illegal logging, mining, and agricultural expansion frequently occur without regard for environmental impact. In contrast, some initiatives aim to promote sustainable practices, such as eco-tourism and agroforestry.
- There are more examples of sustainable practices being integrated into land use in savanna regions, such as rotational grazing and wildlife tourism. In Kenya, the coexistence of wildlife and pastoralists has been promoted through community-based conservation efforts, allowing for economic development while preserving ecosystems.

Mitigation efforts

- **Agroforestry and Permaculture:** Planting trees alongside crops supports biodiversity and soil health, and reduces deforestation. Permaculture integrates natural systems into farming for sustainability.
- **Zero-Deforestation Cattle Agreement:** Ensures meat production in the Amazon avoids newly deforested areas through supply chain monitoring and certification.
- **Protected Areas:** Large portions of the Amazon and other ecosystems are designated as protected areas or parks to limit logging, mining, and farming, though enforcement remains a challenge.
- **Technology for Monitoring:** Satellite imagery and programs like PRODES track deforestation in real time, allowing authorities to address illegal activities quickly.
- **Restoration Projects:** Tree planting and natural regeneration in degraded areas restore biodiversity and sequester carbon.
- **Community Conservancies:** In Kenya and Botswana, these conservancies provide alternative livelihoods like eco-tourism, share revenue with locals, and incentivize wildlife protection.
- **Anti-Poaching Measures:** Enhanced ranger patrols, aerial surveillance, drones, and GPS tracking combat poaching of species like elephants and rhinos.
- **Wildlife Corridors:** Protecting migration routes ensures species like wildebeest can move freely, maintaining ecological balance.
- **Sustainable Grazing Practices:** Rotational grazing prevents overgrazing, allowing pastures to recover and reducing soil erosion.
- **Savanna Reforestation:** Planting trees carefully in savannas boosts carbon storage without disrupting the ecosystem

AO2

Economic development in savanna areas may threaten certain species, but the overall biodiversity loss is less dramatic than in tropical rainforests.

- **Deforestation in Tropical Rainforests:**
  Rainforest deforestation leads to significant biodiversity loss and disrupts the water cycle, contributing heavily to global climate change. While Amazon deforestation is at a six-year low, rising gold mining activities remain a growing threat.
- **Greenhouse Gas Emissions:**
  Methane emissions from cattle ranching in savannas are a concern but are less significant than the carbon emissions from tropical rainforest deforestation and degradation.
- **Agricultural Expansion:**
  Large-scale agribusiness, such as soybean farming and cattle ranching, drives rainforest deforestation, while savannas face conversion for agriculture. However, the global emissions impact is greater in rainforests.
- **Economic Development:**
  Short-term economic gains in tropical regions often overshadow sustainable practices. Eco-tourism struggles to compete with more profitable but unsustainable industries.
- **Resilience of Savannas:**
  Savanna ecosystems are more resilient due to their adaptation to seasonal changes. Overgrazing and agricultural practices can degrade soil but typically have less severe consequences than rainforest deforestation.
- **Protected Areas:**
  Rainforest and savanna protected areas face illegal logging, mining, and encroachment. Enforcement challenges, political pressures, and land-use conflicts undermine conservation efforts.
- **Satellite Monitoring:**
  Real-time satellite tracking, such as Brazil's PRODES system, has improved the detection of deforestation hotspots, enabling more targeted interventions.

- **Anti-Poaching Measures:**
  Enhanced anti-poaching strategies, including ranger patrols, drones, and military involvement, have reduced poaching in countries like Botswana, where elephant and rhino populations are better protected.
- **Eco-Tourism Contributions:**
  Eco-tourism in countries like Kenya and Botswana supports wildlife conservation by funding anti-poaching efforts and community projects. However, tourism is vulnerable to global economic and political instability, and poorly managed infrastructure can harm habitats.
- **Sustainable Practices:**
  Agroforestry, sustainable cattle ranching, and tree-planting projects have shown promise in reducing deforestation and restoring degraded land. However, large-scale adoption is limited by financial and training barriers.
- **Wildlife Corridors:**
  Protecting migration routes in savannas, such as those used by wildebeest, maintains ecological balance and prevents habitat fragmentation.
- **Tree Planting in Savannas:**
  Reforestation projects in savannas must balance carbon storage with maintaining grassland ecosystems. Poorly planned efforts risk disrupting native ecology.
- **Long-Term Strategies:**
  Combining local initiatives, international support, and adaptive management is essential for effective conservation in both biomes. Continuous monitoring and flexible policies are critical to addressing emerging threats.

The threat of economic development to tropical rainforests compared to savanna biomes is significant, but the extent of this threat varies based on several factors, including land use, resource extraction, and human population pressures.

Both ecosystems face challenges from economic development, but tropical rainforests generally experience more severe impacts due to their ecological complexity and the intensity of human activities.

Max L2 if no examples.

Assessment Objective grid

	AO1	AO2	AO3	Total
Section A				
01.1	1			1
01.2	1			1
01.3	1			1
01.4	1			1
01.5	1			1
02			6	6
03	4	5		9
04	10	10		20
Section B				
05.1	1			1
05.2	1			1
05.3	1			1
05.4	1			1
05.5	1			1
06			6	6
07	4	5		9
08	10	10		20
Unit total	38	30	12	80