



Department of
Education

Year 12 ATAR Geography

Unit 3: Depth Study 1

Linking land cover and climate change



ATGEO

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Name

*ATGEO Geography ATAR 12
Unit 3 Depth Study 1:
Linking land cover and climate change*

Complete this workbook thoroughly and refer to this as revision notes for the course.

Work Schedule

- *Week 1 – Pages 1 - 24*
- *Week 2 –Pages 24 -30*
- *Week 3 – Pages 30 - 42*
- *Week 4– Pages 42 – 51*

To complete this Unit 3 Depth Study One, refer to;

Textbooks:

- *WA ATAR Geography Units 3 & 4 Second Edition GAWA (2017). (GAWA)*
- *Our Global Future (2nd Ed) Snell and Ford 2015. (Snell & Ford)*

Other recommended references include:

'Vital Signs of the Planet' 2020, *Global Climate Change*, NASA's Jet Propulsion Laboratory, California USA. <https://climate.nasa.gov/>

Bureau of Meteorology and CSIRO 2018, *Climate Change in Australia*, Australian Government, Australia, <http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2018.pdf>

Schools Curriculum and Standards Authority 2014, *Geography Past ATAR Course Exams 2016 - 2019*, Government of Western Australia, Australia, <https://www.scsa.wa.edu.au/publications/past-atar-course-exams/geography-past-atar-course-exams>

From the Syllabus (SCSA)

https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0007/10123/Geography-Y12-Syllabus-AC-ATAR-GD-june.pdf

Unit description

This unit focuses on the changing biophysical cover of the Earth's surface, the creation of anthropogenic biomes and the resulting impacts on either global climate or biodiversity. Land cover transformations have changed both global climate and biodiversity through their interaction with atmospheric and ecological systems. Conversely, climate change and loss of biodiversity are producing further transformations in land cover. Through applying the concept of sustainability, students are given the opportunity to examine and evaluate a program designed to address the negative effect of land cover change. Aspects of physical, environmental and human geography provide students with an integrated and comprehensive understanding of the processes related to land cover change, their local, regional and global environmental consequences, and possible sustainable solutions.

The Earth's surface is constantly changing and all environments are, to a greater or lesser extent, being modified by human activity. Students examine the processes causing change in land cover. The scale at which these processes are occurring is so extensive that very few truly 'natural' environments still exist and most are now, to some degree, anthropogenic in nature. Human action has altered local and regional climates and hydrology, damaged ecosystem services, contributed to the loss of biodiversity and altered soils.

This unit begins with an overview of land cover change drawn from different regions and countries. Two depth studies provide greater detail. The first study focuses on the interrelationship between land cover and either global climate change or biodiversity loss. The second study focuses on the evaluation of a local land cover change initiative designed to address either climate change or biodiversity loss.

In undertaking these depth studies, students develop an understanding of the use and application of geographical inquiry, tools such as spatial technologies, fieldwork and other skills, to investigate human environment systems.

Learning outcomes

By the end of this unit, students should be able to;

- understand the nature, extent and causes of the changing land cover of the Earth's surface, including the emergence of anthropogenic biomes, and evaluate projections of future changes in global land cover
- understand the local and regional effects of land cover change on ecosystems, and the interrelationships between land cover change and either global climate change or biodiversity loss
- understand and apply key geographical concepts as part of a geographical inquiry, including place, space, environment, interconnection, sustainability, scale and change
- evaluate the sustainability of a program aimed at alleviating the negative impacts of land cover change by considering its environmental, economic and social benefits and costs
- apply geographical inquiry and a range of skills, including spatial technologies and fieldwork, to evaluate land cover change and its consequences and sustainable solutions. (SCSA, 2015)

Depth Study 1: Linking Land Cover and Climate Change content

This is the examinable content from the syllabus.

Students complete **two** depth studies which are taught with the requisite geographical inquiry skills and additional geographical skills as described as part of this unit.

Students investigate the links between changes in land cover and changes in global climate

Global climate change

the spatial distribution of the world's rainfall and temperature patterns

- the key elements of the following natural systems: heat budget (including the greenhouse effect), hydrological cycle, carbon cycle and atmospheric circulation, and the ways in which they interact to influence the Earth's climate
- the causes (natural and anthropogenic) and rate of global climate change
- one major type of evidence for climate change through geological time
- one major type of evidence for climate change in recent human history
- the interrelationship between land cover change and climate, including changes to surface reflectivity (albedo) and the process of natural carbon sequestration
- the effects of climate change on land cover in natural and anthropogenic biomes (vegetation, ice sheets, glaciers, coastal systems and coral reefs, agriculture, urban settlements and industry)
- the projected impacts of global climate change

TASK 1: GLOSSARY – Prepare a glossary related to this section of the course.

Add these terms to your GLOSSARY.

Continue to add geographical terms as you work through this depth study.

Weather

The condition of the lower atmosphere at a particular place over the short term – over a day, a week or over the past month. (Harte, 2003) Weather conditions refer to the atmospheric conditions including precipitation, temperature, winds and humidity of a place.

Climate

The average weather conditions of a region over a longer period of time, typically a year. Seasonal patterns over a year and year to year climate variations indicate climate.

Climate Change

The long term change (decade to centuries) in the natural processes operating in the global atmosphere as seen in changes in temperature and precipitation.

Natural System

these drive the earth's climate. The main processes associated with the natural systems include the heat budget, hydrological cycle, carbon cycle and atmospheric circulation.

Greenhouse effect

Atmospheric greenhouse gases (including water vapour and carbon dioxide), trap heat energy in the atmosphere for a period of time.

Enhanced Greenhouse Effect

Human activities which increase the concentration of greenhouse gases in the atmosphere. This results in a retention of heat longer within the atmosphere.

Global distribution

The spatial distribution of geographical phenomena throughout the world, such as, temperature and rainfall patterns, deforestation and population.

Spatial distribution

The arrangement of geographical phenomena or activities across the Earth's surface. (SCSA)

Temporal distribution

The distribution of geographical phenomena over time. (SCSA)

Sustainability

“Meeting the needs of current and future generations through simultaneous environmental, social and economic adaptation and improvement.” (SCSA)

Linking Land Cover and Climate Change

Introduction to depth study one

The study of climate change involves identifying the natural systems that drive the earth’s climate. Evidence for long term climate changes over geological periods of time and recent human history will be discussed. While natural causes are attributed to climate change through geological time, more recent climatic change is strongly related to both natural causes and human activities.

Climate change due to changes in the natural systems has wide ranging impacts on world biomes, landscapes and anthropogenic biomes “Seeing how climate change is linked to land cover change is achieved through the study of the interrelationships and effects climate change has on natural and anthropogenic biomes.” (Our Global Future (2nd Ed) Snell and Ford p 42).

Refer to text (GAWA) Chapter 3, p 45-48

Global Climate

The global climate system is a combination of **interaction** between the different inputs from the solar system, atmospheric system, the hydrosphere, lithosphere and biosphere.

Refer to text (GAWA) Chapter 3, p 45-48

Identify main features of each of these “spheres” that influence the Earth’s climate.

Atmosphere	<p>Relatively thin layer of gases that surrounds land and ocean surfaces of the planet</p> <p>Linked to climate change via interactions with lithosphere, hydrosphere, biosphere,</p> <p>Composed of nitrogen 78%; oxygen 21%; carbon dioxide, water vapour, ozone, argon, trace gases 1%; aerosols such as water vapour, dust and volcanic emissions</p> <p>Changed over time – at present increased CO₂ added to other greenhouse gases due to human activity</p>
Lithosphere	
Hydrosphere	
Biosphere	

What is the difference between weather, climate and climate change?

Refer to text (GAWA) Page 45 - 46

Identify the elements of weather.

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Distinguish between weather and climate.

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Define and name a climate variation.

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Climate Change. Outline the changes that indicate a shift in climatic conditions over a longer term (decades to centuries).

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Syllabus Point

“The spatial distribution of the world’s rainfall and temperature patterns”

Refer to text (GAWA) Chapter 3 pages 48 Figure 3.2.1

Earth’s Climate

Climatic regions are areas that show similarities in both the pattern of average temperature and average precipitation annually and seasonally. The spatial distribution of these regions of similar climate is shown in Fig 3.2.1

The main factors that **cause** climatic conditions to vary around the globe can be summarised using the following acronym;

LAPDOG

- Latitude
- Altitude
- Prevailing Winds
- Distance from the Sea
- Ocean Currents and
- Great Mountain Barriers (Air forced to rise over mountain barriers to produce orographic rainfall).

Spatial Distribution of World Temperature

Refer to text (GAWA) Chapter 3 pages 46 Figure 3.1.3. *Global Temperature Patterns*

Describing spatial distribution: When describing the spatial pattern based on source material like the maps provided, use the legend to organise your points under areas of:

- High rainfall/temperature
- Medium rainfall/temperature
- Low rainfall/temperature

Task: Study the map (GAWA) Chapter 3 pages 46 Figure 3.1.3. showing the *Global Distribution of Annual Mean Temperature*

Describe the spatial pattern of temperature. Refer to location features (i.e., tropical, mid latitudes and polar latitude) and refer to the legend indicating annual mean temperature.

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Spatial Distribution of World Rainfall

Refer to text (GAWA) Chapter 3 pages 47 Figure 3.1.4.

Study the map showing the *Global Distribution of Average Annual Precipitation*

Describe the spatial pattern of precipitation (rainfall). Refer to location features (i.e., tropical, mid latitudes and polar latitude, continents, regions) and refer to the legend indicating average annual precipitation in mm.

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Summary – Refer to text (GAWA) p 45 - 48. Make brief notes that provide a summary in the following table.

Global Temperature Patterns	Global Rainfall Patterns

Syllabus Point - “The key elements of the following natural systems: heat budget (including the greenhouse effect), hydrological cycle, carbon cycle and atmospheric circulation, and the ways in which they interact to influence the Earth’s climate.”

Natural Systems that Drive the Earth’s Climate

The natural systems that operate within the climate system are the;

- heat budget (*including the greenhouse effect*)
- hydrological cycle
- carbon cycle and
- global atmospheric circulation

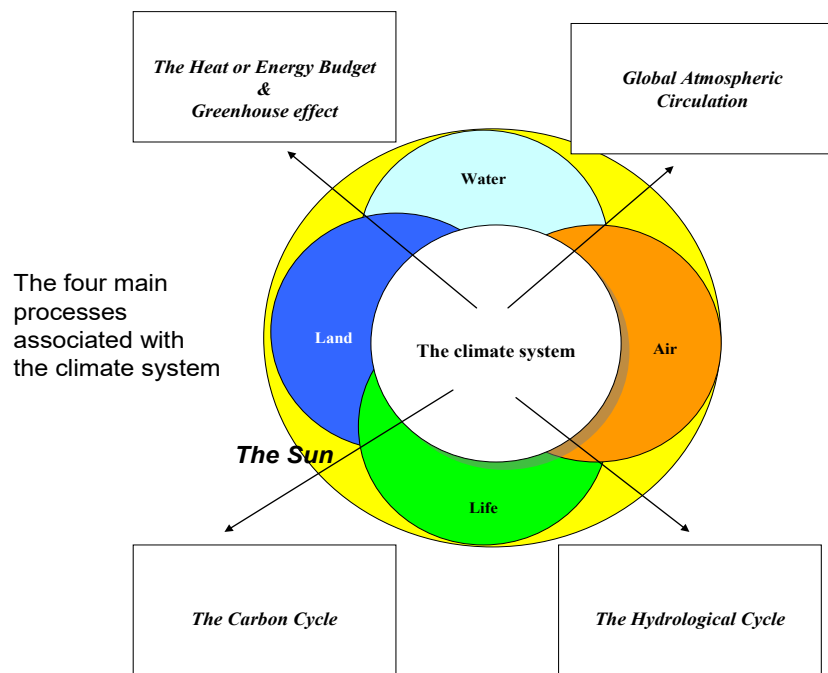


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Consider these questions in relation to the natural systems you will study:

- What are the key elements of each of the natural systems?
- What are the ways in which they interact to influence the earth’s climate?

Key elements of each of the natural systems.

1. The heat budget and the Earth’s climate.

Refer to text (GAWA) p 48-50.

The global heat budget is the balance between incoming and outgoing solar radiation. Incoming solar energy varies at different times of year and for different locations across the globe. The global heat budget indicates that the incoming solar radiation (short wave insolation) received by the Earth is equal to the outgoing heat (longwave radiation).

Earth's climate and the greenhouse effect

'What happens in the Greenhouse Effect?' Refer to the figure and information on this website:

<https://enhancedgreenhousegasemissions.weebly.com/enhanced-greenhouse-gas-effect.html>

Describe the natural greenhouse effect:

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Outline the benefit of the greenhouse effect:

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Identify the various greenhouse gases:

Did you know?

- **Water vapour** is the most important gas in the atmosphere and is responsible for **75%** of the greenhouse effect (GHE).
- **Carbon dioxide** is the next most important gas, contributing **10%** to the greenhouse effect.
- Changes in the **hydrological** cycle are usually in **response to greenhouse gas emissions** and provide **evidence of climate change**.
- Changes in the **carbon** cycle are a **driver of climate change**.
- **Carbon** is accumulating in the atmosphere and an **increasing contributor to greenhouse gas emissions**; water is not accumulating.

Refer to text (GAWA) Chapter 3 Page 49 Fig 3.2.2 The Heat Budget

Task: Study the diagram showing the Earth's heat Budget.

Add these terms to your glossary and define each using additional resources:

- Insolation
- Albedo
- Absorption
- Terrestrial (heat) radiation
- Conduction and convection
- Latent heat

TASK: Briefly *describe* the operation of the heat budget.

Paragraph 1 - begin with an opening statement:

The global heat budget is the balance between light energy reaching earth as _____ - _____ insolation and the outgoing energy being emitted in the form of long-wave _____.

Paragraph 2 – **Describe** by referring to the processes and percentage (%) of energy entering the atmosphere is dispersed.

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Paragraph 3 – **Describe** by referring to the processes and percentage (%) of heat energy transfer into the atmosphere.

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Paragraph 4 – Describe the role of the greenhouse effect as part of the heat budget. Identify the significant greenhouse gases.

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Refer to text (Snell & Ford) Page 45 Figure 2.4

The position of the Earth and energy input. Energy flows between latitudes.

There are significant seasonal and spatial variations of temperature patterns across the globe. The amount of insolation received at the Earth’s surface varies depending on latitude. This is because of the **angle of incidence** at which insolation strikes the Earth. The sun’s energy is more direct within the tropical lower latitudes. At higher latitudes, insolation strikes at an angle and therefore the radiation is spread over a wider area and is less intense. Seasonal changes in temperature occur throughout the year due to the movement of the Earth relative to the Sun. Between the Tropics of Capricorn and Cancer there is a year-round gain of insolation and the equator gains the most insolation of all of the global locations. The amount of insolation at the equator is greatest at the *equinoxes* when the sun is directly overhead.

Polar Regions

Task: Refer to text (Snell & Ford) page 45 Figure 2.4 the Figure showing energy flows between latitudes.

Identify the latitudes that experience an energy deficit (less heating).

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Identify the latitude that experience an energy surplus (greater heating).

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Task: Refer to text (Snell/ Ford) pp 45 – 48

List the temporal and spatial variations in the heat budget.

Temporal variation in the heat budget (over time).	Spatial (locational) variations in the heat budget.

Climate Change – a temporal variation. Provide notes (dot points) to identify main features of global warming over the past 7000 years.

Refer to text (Snell/ Ford) pp.47 – 48 or GAWA Text page 49 & 50.

Describe the effect of ALBEDO as a spatial variation. Provide a diagram to assist this description.

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2. Hydrological cycle and the Earth’s climate.

Refer to text (Snell/ Ford) p 49 Figure 2.11

The water cycle is the continuous movement of water between the geosphere and the atmosphere. The hydrological cycle is driven by the energy of the sun and atmospheric circulation, which moves water through the atmosphere.

There is a close relationship between the heat budget, the greenhouse effect and the water cycle.

View and take notes from this video: Earth’s Water Cycle (5:52 min)

<http://pmm.nasa.gov/education/videos/earths-water-cycle>

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Task: Study the diagram from the textbook showing the hydrological cycle. Add these terms to your glossary and define each:

- Evaporation
- Transpiration
- Condensation
- Advection
- Precipitation
- Cryosphere
- Infiltration
- Groundwater
- Runoff

Refer to text (GAWA) pp 49 -50.

Briefly DESCRIBE the operation of the hydrological cycle. Refer to the processes and forces involved in the movement of water through the Earth’s spheres.

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Describe the distribution of Earth’s water. **Refer to text (GAWA) Page 50. Refer to Fig 3.2.3.**

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Refer to text (Snell & Ford) p 49-54.

List the temporal and spatial variations in the hydrological cycle.

Temporal Variation in the hydrological cycle (over time)	Spatial (locational) Variations in the hydrological cycle

How climate change links to the hydrological cycle to transform land cover.

Climate change affects the operation of the hydrological cycle and the distribution of fresh water. Rates of precipitation and evaporation will change producing changes in land cover.

Climate predictions of higher rainfall in higher latitudes and some wet tropical low latitude regions indicate a 10 to 40 percent increase in stream flow. In contrast, mid-latitudes, dry tropics and Mediterranean climates will experience a decline in annual rainfall by 10 to 30 percent. Periods of drought in these regions and semi-arid regions will become longer and areas affected will become larger leading to a change in land cover. Changes in rainfall in some regions could result in shorter rainy seasons but with heavier falls leading to flooding.

Refer to text (Snell & Ford) p51. (Climate change)

Task: Refer to the changes in the hydrological cycle that have been evident in the Mediterranean region of the SW of WA. Make a series of factual statements including evidence.

Climate Region	Changes in the hydrological cycle
Mediterranean (mid latitudes) e.g. South West of Western Australia	

3. Atmospheric circulation and the Earth's climate

Refer to text (Snell & Ford) page 54 - 55

Sketch the diagram found in **Fig 2.18 page 55** and on the next page accurately label the following components:

- Global pressure systems
- World prevailing wind systems
- Air circulation in the atmosphere

Task: Add these terms to your glossary and define each: Add diagrams where relevant.

- Air Pressure
- High Pressure
- Low Pressure
- Thermal Equator (Intertropical convergence zone)
- Winds
- Coriolis Effect
- Air masses
- Polar front
- Air Currents
- Hadley Cell
- Jet streams

Refer to text (Snell & Ford) p.57 Figure 2.20 Seasonal movement of the pressure belts.

Complete notes relating to the atmospheric circulation in each of the regions indicated in the table.

Latitude - Northern and Southern Hemispheres	Wind and Pressure Belts - Characteristics and influences on climate
Equatorial region /Tropical wet/dry	
Mid latitudes /30 degrees	
Polar region / 60+ degrees	

Read text: GAWA pp 55-56 to identify and describe **three major interactions** between the **heat budget** and **atmospheric circulation**. The first has been completed for you.

1. Pressure Systems

The seasonal shift of the heat equator will influence the shift of the global pressure systems and prevailing wind belts between 15 – 29 degrees latitude north and south.

2. Prevailing Winds

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3. Air Currents

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4. The carbon cycle and the Earth’s climate.

*Carbon is within all living things including water, soils, rocks and atmosphere. Carbon deposits are **sinks**. Carbon exchanges between different sources and sinks through carbon **flows**. Carbon dioxide CO2 is stored in the atmosphere as a greenhouse gas and has an important effect on climate. Plants use carbon dioxide and sunlight to make their own food and grow. Plants containing carbon die and over millions of years may turn into fossil fuels, such as coal and oil.*

The CARBON CYCLE

Visit this National Ocean Service (NOAA) website and watch the video:

What is the Carbon Cycle (1:16 min) <https://oceanservice.noaa.gov/facts/carbon-cycle.html>

Task: Study the diagram showing the carbon cycle. Read text (GAWA) p 50-51.

Add these terms to your **glossary** and define each:

- Carbon dioxide (note the importance of this gas in the atmosphere)
- Source
- Sink
- Exchange
- Flux
- Sequester
- Fossil fuels
- Humus
- Anthropogenic emissions

Spatial Variations in the Carbon Cycle

Refer to text (Snell & Ford) p 60 -62 to complete the table.

Provide 2-3 main facts in each section to be completed.

Main sources and sinks	Variations of carbon distribution	Impact of increasing carbon on climate change
The atmosphere	Atmospheric carbon has increased over last 200 years from 280 ppm to 380ppm. Plays important role in heat budget as a greenhouse gas.	Enhanced greenhouse effect = global warming = variation in global temperature and precipitation patterns
Terrestrial Vegetation (photosynthesis)		Cutting down and burning of forests = enhanced greenhouse effect

<p>Soils and fossil carbon</p>	<p>Soils, rocks, fossil fuel deposits are main stores of carbon. Most of world’s carbon found in limestone where it is relatively stable. Fossil fuels e.g. coal, gas and oil store carbon that can readily be released into atmosphere by fires and car emissions etc. Soils such as permafrost soils lock away carbon but release it as they thaw</p>	<p>Burning of fossil fuels and melting of polar ice caps due to global warming = release of carbon = enhanced greenhouse effect</p>
<p>Oceans</p>		<p>Changes in ocean temperatures due to global warming = greater release of carbon = enhanced greenhouse effect</p>
<p>Anthropogenic carbon (linked to human activity) Note global or regional evidence</p>	<p>Increasing carbon released by industry, urban and agricultural, forestry and mining activities is greater than the capacity of vegetation and oceans to remove it = imbalance responsible for rise in CO2 levels and changes in greenhouse effect.</p>	<p>Human activities = increased release of CO2 into atmosphere = enhanced greenhouse effect</p>

Temporal (over time) changes in carbon cycle.

Refer to Text (Snell & Ford) p 60. Study Fig 2.23: *Changing atmospheric carbon dioxide levels.*

Describe the seasonal atmospheric carbon dioxide level change (winter and spring).

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TASK: Study the graph on the following website showing atmospheric carbon dioxide level over the last 10 000 years

https://climate.nasa.gov/climate_resources/24/graphic-the-relentless-rise-of-carbon-dioxide/

Describe the trend of CO₂ level from 100,000 years to current levels. Give evidence from the graph.

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What impact has changes to the carbon cycle had on climate and land cover change?

Refer to this website <http://shrinkthatfootprint.com/carbon-emissions-and-sinks>

Figure: Global Carbon Emissions and Sinks Since 1750 to answer the next three questions

Identify the various human activities that are a cause of the greatest carbon emissions since 1750.

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Permafrost is a subsurface material that remains below 0° C (32° F) for at least two consecutive years. Because permafrost soils remain frozen for long periods, they store large amounts of carbon. (<https://eo.ucar.edu/kids/green/cycles6.htm>). Twelve percent of carbon is sequestered in tundra soils. This is a **carbon sink**.

What will happen to the soil carbon in the tundra if soils defrost?

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How can this then become a global problem?

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Past Examination Extended Response: (12 marks)

Describe any two of the following natural systems:

- heat budget hydrological cycle carbon cycle atmospheric circulation.

Refer to the SCSA Geography WACE Exam Marking Guide- https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0005/458834/RATIFIED_Geography_Marking_Key_2017.PDF

page 13 https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0005/458834/RATIFIED_Geography_Marking_Key_2017.PDF

Key word:

Describe – provide characteristics and features.

Syllabus Point “The Natural Systems and the ways in which they interact to influence to Earth’s climate”

Global natural systems interact to produce the global climate system. The interactions between the heat budget, hydrological cycle, atmospheric circulation and the carbon cycle are evident in the wide variety of weather and climate experienced around the globe.

Task: Revision Summary; Refer to text (GAWA) p55 -56.

- Complete this table based on the summary provided in the text of this syllabus point.

Natural System link	Natural System interaction
1.Heat Budget -----Hydrological cycle	
2.Hydrological cycle ---Heat budget	
3.Heat budget ---Atmospheric circulation	

<p>4. Atmospheric circulation ---Heat budget</p>	
<p>5. Hydrological cycle ---atmospheric circulation</p>	
<p>6. Atmospheric circulation-----hydrological cycle</p>	
<p>7. Atmospheric circulation ----heat budget -- ---- carbon cycle</p>	

These factors include:

- Variations in the tilt of the earth’s axis and orbit
- Atmospheric carbon dioxide level variations which correlate with changes in Earth’s temperature
- Changes in albedo
- Variations in solar output associated with sunspot activity and less insolation from the sun.
- Volcanic eruptions and cloud cover associated with short term climate change
- Changes in the biosphere
- Plate tectonics – changing location of continents, oceans and redefining of landforms have affected the changing nature of climate over geological time.

Exam Tip: Learn at least TWO of the natural causes in detail.

1. Variations in solar output associated with sunspot activity.

Refer to text (GAWA) page 57. Refer to figure 3.3.2: Yearly averaged sunspot numbers 1690 - 2007

TASK: Discuss how variations in solar output affect climatic conditions on Earth. Be sure to include evidence of the period referred to as the **“Maunder Minimum”**.

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2. Volcanic eruptions and cloud cover associated with climate change.

Throughout the Earth’s history, there have been many significant **volcanic eruptions**.

Refer to text (GAWA) p 60-61 and figure 3.3.7.

TASK: Describe how volcanic activity has influenced climate. Refer to evidence.

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Anthropogenic Causes of Global Climate Change

Refer to text (GAWA) p 61-63

TASKS:

List the human activities that have caused anthropogenic global climate change.

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Identify the two main ways in which human activities affect the atmosphere and in turn climate.

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- 2

Study the table from **GAWA Text p 62** 'Natural and Anthropogenic sources of Greenhouse Gases' and identify the major sources of Australian greenhouse gas emissions.

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Identify and describe the relative contributions of each of the main greenhouse gases which have influenced anthropogenic climate change.

Refer to:

- The main sources of each of these greenhouse gases
- The change in contribution within the atmosphere pre 1750 (prior to the industrial revolution) and today (2015).

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Refer to text (GAWA) p56-63 to summarise - List the natural and anthropogenic causes of global climate change.

Natural Causes	Anthropogenic Causes

Past examination extended response:
 Explain the natural and anthropogenic causes of global climate change **or** biodiversity loss. (10 marks)

Note: You would select **global climate change** as that is the focus of your depth study 1. You can find an example from the SCSA 2016 Marking Guide
https://senior-secondary.scsa.wa.edu.au/_data/assets/pdf_file/0006/345237/Geography-Ratified-Marking-Key-2016.PDF page 11
https://senior-secondary.scsa.wa.edu.au/_data/assets/pdf_file/0006/345237/Geography-Ratified-Marking-Key-2016.PDF

Rate of global climate change.

The rate of global change climate through geological and recent times can be observed through **proxy data**, reflecting past geological times, while **precise instrument data**, collected over the last 100 years, has provided more recent evidence of the rate of climate change.

Refer to text (GAWA) p68 – 69; the section related to “*The Atmosphere*”.

TASKS:

Complete this table from the information you have read.

Time period	Global mean temperature	Source of evidence	Additional information

Refer to text (GAWA) Figure 3.4.7 “Observed global mean combined land and ocean surface temperature anomalies from 1850 – 2012”.

Describe the *trend* of the annual average temperature anomaly from 1850 – 2010 relative to 1961 – 1990.

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Refer to the **State of the Climate Report, 2018** (BOM) page 3.

<http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2018.pdf>

Note TWO key points related to the rate of global climate change.

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Syllabus Point - “One major type of evidence for climate change through geological time.”

Evidence for Climate Change through Geological Time

Geological time is measured in billions of years.

Refer to text (GAWA) p 64 – 68. Refer to figure 3.1.1, page 45 ‘Climate change over geological time’

The Earth’s climate has changed a number of times in the past.

TASKS:

Note four features of climate in the geological past.

- 1.
- 2.
- 3.
- 4.

Refer to text (GAWA) p 65 define the following terms:

Paleoclimatology

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Proxy Data

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Ice Core Data

Refer to text (GAWA) p 65 – 66. Refer to figure 3.4.3. “Ice Core Data”.

ONE type of evidence of climate change through geological time is **ice core samples**.

TASKS:

Identify the evidence ice cores samples give scientists about climate in the past geological times.

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Refer to text (GAWA) Fig. 3.4.3 p 65 – 66 Describe the **relationship** between atmospheric carbon dioxide and temperature.

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Identify the **correlation** as being a *strong positive* or a *strong negative correlation*.

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Refer to text (GAWA) Chapter 3 Page 63 Figure 3.4.1. "The evidence of climate change over geological time".

Identify the four other different types of evidence of climate change through geological time.

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Choose **TWO types of evidence**, from the four listed.

Choice ONE:

Describe the evidence referring to

- 1. Nature

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- 2. How is the data collected and analysed?

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- 3. Describe the major trends over geological time supported by this evidence.

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Choice TWO:

Describe the evidence referring to

- 1. Nature

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- 2. How is the data collected and analysed?

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- 3. Describe the major trends over geological time supported by this evidence

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***Examination tip - Know at least ONE type of evidence in detail.**

Syllabus Point - *“One major type of evidence for climate change in recent human history.”*

Recent evidence of climate change

When is recent human history? Evidence of recent climate change is provided through precise instrument weather measurements, collected **over the last 100 years.** The use of this “ direct data” provides evidence for climate change in recent human history.

Problems with the reliability of weather data include

- only 100 years of data collection
- uneven distribution of data collection stations
- variations in instruments used
- changes in the characteristics of the observing locations

Refer to text (GAWA) p 68 - 72

Task: Note four features of recent observed changes, within the past 100 years, in global climate. (GAWA Text p 69)

1.
2.
3.
4.

Find out the full names of these world organisations that have a significant role in investigating global changes in climate.

- IPCC
- NOAA
- NASA
- CSIRO
- BOM

Refer to text (GAWA) p 71 - 72 and refer to “State of the Climate 2018”

<http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2018.pdf> p 16.

Additionally, refer to Vital Signs of the Planet’ 2020, *Global Climate Change*, (Resources); NASA.

https://climate.nasa.gov/resources/graphics-and-multimedia/?page=0&per_page=25&order=pub_date+desc&search=&condition_1=1%3Ais_in_resource_list

Evidence of climate change in recent human history is evident in

- Temperature change and trends
- Rising sea levels
- Decline of sea ice and retreating glaciers.

***Examination tip - Know at least ONE type of evidence in detail.**

TASKS:

Describe the **decline of sea ice and retreating glaciers** as ONE type of evidence of climate change in recent human history.

Refer to this video https://www.youtube.com/watch?v=ye_UjS4qER0&feature=youtu.be

Outline **global** temperature patterns since 1850.

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View the image from NASA <https://earthobservatory.nasa.gov/images/145641/2019-arctic-sea-ice-minimum-is-second-lowest>

Take notes on the **regional variations** of the polar regions in the both northern and southern hemispheres

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Identify what technological method/s are used to monitor the declining sea ice and glacial retreat. Refer to where this information is available.

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Past examination short response- (4 marks)

Describe one (1) major type of evidence for climate change **or** loss of biodiversity through geological time. *2018 Geo WACE Exam.*

Note: You would select climate change, as this is the focus of this workbook on Unit 2 depth study 1. Be careful to note this evidence relates to the geological period.

A sample response can be found on page 7 (2018 Geo WACE Marking Guide)

https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0004/544108/2018_GEO_Ratified_Marking_Key.PDF

Syllabus Point - “The interrelationship between land cover change and climate, including changes to surface reflectivity (albedo) and the process of natural carbon sequestration.”

The interrelationship between land cover change and climate.

Climate change can affect land cover, creating **feedback loops** that can affect future climate changes. Land cover change, can affect climate and further impact on both the natural systems and natural and anthropogenic land cover.

Refer to text (GAWA) Topic 3.5. P 72 – 76. “The interrelationship between land cover change and climate”.

TASKS:

Provide examples of the effect of land cover change on the natural systems.

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Changes in albedo (surface reflectivity)

TASKS:

Define the term albedo.

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Outline the concept of albedo Refer to text (GAWA) p 72 – 73 and Fig 3.5.1 page 73 ‘Albedo of different surfaces’.

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Outline two ways in which **albedo** can change in each of the following spheres.

Refer to text (GAWA) p 72-73.

Cryosphere	Lithosphere

Describe ONE interrelationship between land cover change, albedo and climate.

Refer to text (GAWA) Fig 3.5.3. p73.

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Illustrate this interrelationship:

Outline ONE **positive feedback** between land cover change, **albedo** and climate.

Refer to text (GAWA) Fig 3.5.2. and Fig: 3.5.4. (P72-74)

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Illustrate this interrelationship:

Variations in regional climate change.

There can be **regional climate changes** where higher latitudes are experiencing warmer temperatures and increasing rainfall, while mid latitude are experiencing decreasing rainfall leading to prolonged drought conditions (e.g., SW of WA). Land cover change can influence changes to climate both in the short and long term, as changes in climate can influence land cover change.

The interrelationship between land cover change and climate is examined in respect to;

- changes to **surface reflectivity (albedo)** and
- the process of **natural carbon sequestration**.

Retreating glaciers and changes in albedo.

Albedo is a measure of reflectivity. The average albedo of the Earth is 30%. Reflectivity of fresh white snow is about 85%. As mountain glaciers and ice sheets melt, they cover less land and they reflect less insolation.

Use the following references to complete the task below.

Refer to the diagram "Retreating glaciers and changes in albedo". Refer to this video; "Arctic Sea Ice Reaches 2019 Minimum Extent" (NASA).

https://www.youtube.com/watch?v=ye_UjS4qER0&feature=youtu.be

TASKS:

Describe the impact that retreating glaciers are having on the albedo of the region affected.

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How does this impact on changes to temperature and precipitation of the region?

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Describe the impact on albedo and consequently climate, due to the clearing of natural vegetation give;

A Regional example:

Northern hemisphere in higher latitudes (forest);

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.....

A Local examples:

Clearing in WA wheat – belt; **Refer to text (Snell & Ford) p 81**

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Urban environments (e.g., Melbourne: 'Urban Heat Island Effect')

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Carbon Sequestration and links between climate and land cover change

The interrelationship between land cover change and climate also includes changes in the carbon cycle.

Refer to text (GAWA) p74-75; Changes in Carbon Sequestration.

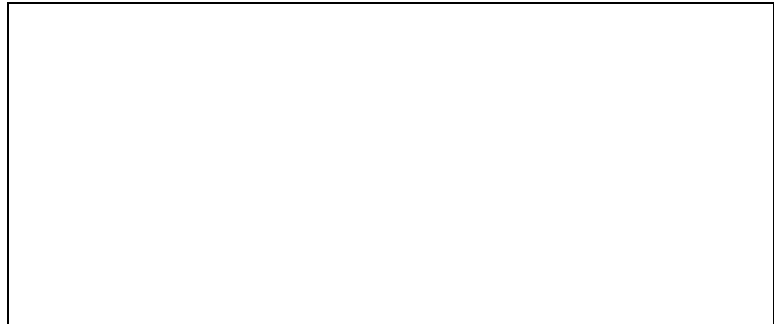
From your reading, add three facts to this summary:

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Outline ONE **negative feedback** between land cover change, **carbon sequestration** and climate. **Refer to text (GAWA) Fig: 3.5.6. (p75).**

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Illustrate this interrelationship:



Climate change can be viewed at **global, regional and local scales**. At global scale, land use and land cover change is responsible for releasing greenhouse gases to the atmosphere, thereby driving global warming.

TASKS:

Regional Example – Brazil Soy Farmers GAWA Page 75

Describe the impact of land cover change and climate change on the natural carbon sequestration.

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Refer to text (GAWA) p 74 – 76 and figure 3.5.8. ‘Anthropogenic carbon sources and natural carbon sequestration’. This is showing carbon stores and impact of land cover and land use.

Compare the impact of fossil fuel burning and land cover change has had on atmospheric CO2 emissions from 1840 – 2000 +

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In the period of 1840 -2000+, comment on the percentage distribution of anthropogenic CO2 in various “sinks”. Comment on the impact this will have on climate.

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Plan an extended response for the following: (dot points only)

Plan dot points for each paragraph (including introduction, 3- 4 body paragraphs and brief conclusion).

- (a) Explain the interrelationships between land cover change and climate with direct reference to surface reflectivity and the process of natural carbon sequestration. (20 marks) *2018 SCSA WACE Exam*

You can find a sample answer from SCSA 2018 Marking Key page 13. [https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0004/544108/2018 GEO Ratified Marking Key.PDF](https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0004/544108/2018_GEO_Ratified_Marking_Key.PDF)

Examples can include:

<p>Albedo</p> <ul style="list-style-type: none"> – Earth’s climate driven by sun’s energy – Changes in albedo – affect radiation balance – Retreating snow, ice sheets, glaciers – resulted in absorption of heat radiation by darker coloured surfaces – including oceans & vegetated land – Urbanisation – resulted in the absorption of heat by bitumen & cement (Urban Heat Island Effect) 	<p>Natural Carbon Sequestration</p> <ul style="list-style-type: none"> – Due to land cover change (agriculture, deforestation, urban settlement) – <i>Clearing of trees</i> (which store 300 billion tons of carbon) → Loss of carbon sinks → Loss of ecosystem service → Releases carbon sequestered (NT 2017)
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Planning framework: Structure an extended response.

1. Introduction	
2.	<p>Evidence – E.g. Western Australia</p> <ul style="list-style-type: none"> – The clearing of vegetation on sandy soils → rising albedo levels (14%) – Sandy soils have the ability to reflect 40% of the sun’s energy – They have become exposed with these clearings → This has resulted in a cooling effect
3.	Evidence
4.	Evidence
Conclusion	

Syllabus Point – “The effects of climate change on land cover in natural and anthropogenic biomes (vegetation, ice sheets, glaciers, coastal systems and coral reefs, agriculture, urban settlements and industry).”

The Effects of Climate Change on Land Cover in Natural Biomes:

Extended Response practice

32 (a) Describe the effects of either climate change or biodiversity loss on natural and anthropogenic biomes. (12 marks) *2017 SCSA WACE Exam.*

Refer to global, regional and / or local examples given in the sample answer on page 10.

https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0005/458834/RATIFIED_Geography_Marking_Key_2017.PDF

Refer to text (GAWA) p 81 -84.

TASK: Complete the table by providing notes related to each natural biome listed.

Refer to global, regional and /or local examples to support each.

- vegetation,
- ice sheets, glaciers,
- coastal systems and coral reefs

<p>The effects of climate change on Natural Biomes</p>	<p>Global, regional and/or local evidence</p>	<p>Projected (future) impacts.</p>
<p>Vegetation</p>	<p>GAWA Text figure 3.6.6. Page 80 Northern Hemisphere changes to plant growth</p>	
<p>Ice sheets, glaciers</p>	<p>Larsen Ice Sheet East Antarctic ice shelf</p>	
<p>Coastal systems and coral reefs</p>	<p>The Great Barrier Reef</p>	

Extra examples: Ice sheets, glaciers- East Antarctic ice shelf.

TASK:

Refer to text (GAWA) p 79 – 80 & 83 – 84 and additionally watch this video 'Loose Tooth' Iceberg" (Livescience; 2019). <https://www.livescience.com/giant-loose-tooth-iceberg-calves-antarctica.html>

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Coastal Systems and Coral Reefs:

Refer to text (GAWA) pp. 82 – 83 and pp. 12 - 14 from *The State of the Climate (BOM)* <http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2018.pdf>

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Rising temperatures - Why do a few degrees' matter?

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The Effects of Climate Change on Land Cover in Anthropogenic Biomes:

Refer to text (GAWA) p84 – 86.

TASK: Provide notes in the table related to each of the listed anthropogenic biomes.

Refer to global, regional and /or local examples to support each.

- *agriculture,*
- *urban settlements and*
- *industry*

<p>The effects of climate change on Anthropogenic Biomes</p>	<p>Global, regional and/or local evidence</p>	<p>Projected (future) impacts.</p>
<p><i>Agriculture</i></p>	<p>Northern Russia changes to climatic conditions</p>	
<p><i>Urban settlements</i></p>		
<p><i>Industry</i></p>		

Syllabus Point - “The projected impacts of global climate change.”

Refer to text (GAWA) pp 76- 77: Summarise the changes in the *global climate system*.

Heat Budget:

.....

Hydrological Cycle:

.....

Refer to the website; Vital Signs of the Planet (NASA) <https://climate.nasa.gov/effects/>

Take notes of the projected (future) effects of the climate change.

Refer to the full name of the IPCC.

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What does the IPCC state as projected impacts of climate change?

.....

TASKS: Complete the following table related to projected impacts of global climate change. Select **three** impacts from the details found within the website.

Vital Signs of the Planet (NASA) <https://climate.nasa.gov/effects/>

Projected impacts of global climate change.	Nature of Change
1.	
2.	
3.	

TASK: Outline how projected changes in climate will affect different parts of Australia.

Refer to text (GAWA) page 78 Fig 2.6.3 and State of the Climate (BOM) pp.22 - 23.

<http://www.bom.gov.au/state-of-the-climate/State-of-the-Climate-2018.pdf>

to complete the table.

Projected impacts of climate change. in Australia	Nature of Change
Temperature	
Rainfall	
Extreme Weather Events	
Oceans	

Projecting Future CO₂ Emissions

When predicting the future impacts of climate change, a range of carbon dioxide **emission scenarios** are considered. The emission scenarios are based on past and current trends. The United Nations recommendations for future targets, strive to lower global emissions to reduce current rates of global warming.

TASKS:

Refer to text (GAWA) Fig 3.6.13 page 86

Describe the FOUR emission pathways.

1

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2.....

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3.....

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4.....

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Effects

Refer to text (GAWA) Pages 78 – 79.

Identify the projected sea level rise based on current trends.

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What is the predicted sea level rise in Australia for the end of the 21st century?

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Past examination extended response:

Discuss **two (2)** projected impacts of **either** global climate change **or** loss of biodiversity.

Note, you will write a developed and well-structured discussion you can find a sample answer from [SCSA Geography WACE Exam 2016](https://senior-secondary.scsa.wa.edu.au/_data/assets/pdf_file/0006/345237/Geography-Ratified-Marking-Key-2016.PDF) on page 8.

[https://senior-](https://senior-secondary.scsa.wa.edu.au/_data/assets/pdf_file/0006/345237/Geography-Ratified-Marking-Key-2016.PDF)

[secondary.scsa.wa.edu.au/_data/assets/pdf_file/0006/345237/Geography-Ratified-Marking-Key-2016.PDF](https://senior-secondary.scsa.wa.edu.au/_data/assets/pdf_file/0006/345237/Geography-Ratified-Marking-Key-2016.PDF)

Practice Extended Response

Describe and account for the effects of climate change **or** biodiversity loss on land cover in **ONE** natural and **ONE** anthropogenic biome.

Refer to global, regional and / or local examples.

Note:

Natural biomes can include vegetation, ice sheets, glaciers, coastal systems and coral reefs.

Anthropogenic biomes can include agriculture, urban settlements and industry.

	Natural biomes	Anthropogenic biomes
Global climate change	<ul style="list-style-type: none"> • Habitat change. (e.g. loss of coral reef, warmer oceans) • Disruption of ecological processes. (e.g. reduction in ocean upwelling) • Migration of species. (e.g. shifting of ecological boundaries) • Extinction of species. (e.g. loss of critically endangered species) 	<ul style="list-style-type: none"> • Global warming. (e.g. rising average annual temperatures) • Increase in extreme weather events. (e.g. more frequent storms, heat waves) • Collapse of ecosystem services. (e.g. loss of resources, lower utility) Movement of people from the margins. (e.g. increased urbanisation, migration)

Directive terms within the question include:

- **Describe** – provide characteristics and features.
- **Account** – State reasons/ explain.

Use this framework to plan the facts, evidence related to this syllabus point. Refer to the selected evidence provided within the workbook.

1.Introduction	
2.	Evidence
3.	Evidence
4.	Evidence
Conclusion	

Consider the following for preparing an examination question.

- Use a framework to plan and structure an extended response.
- You should allocate 20 minutes to this extended response for 10 marks.
- Write out an extended response within the time allocation.
- Compare your response to the sample-marking guide provided.
- What mark would you allocate to your response?
- How could you improve your result?

You can find a sample answer from SCSA 2017 Geography WACE Exam on page 10.

https://senior-secondary.scsa.wa.edu.au/data/assets/pdf_file/0005/458834/RATIFIED_Geography_Marking_Key_2017.PDF

End of Workbook