Geography 11–12

Ecosystems and global biodiversity resource booklet

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# Rationale

This resource booklet is not a standalone resource. It has been designed for use by teachers with the geography Year 12 – Ecosystems and global biodiversity sample program. The material in this resource booklet is a sample and is intended to support teachers to develop contextually appropriate teaching and learning resources for their students’ needs. It is not intended to be taught exactly as it is presented in its current format. There are instructions for the teacher and instructions for the student throughout the resources and activities. Teachers using this resource should edit and refine to suit their students’ needs, interests, abilities and the texts selected.

The content in this resource booklet has been prepared by the HSIE curriculum team, unless otherwise credited. The HSIE curriculum team have created a series of other support resources for geography Year 12, including sample assessment schedules, scope and sequences and assessment tasks. [Planning, programming and assessing geography 11–12](https://education.nsw.gov.au/teaching-and-learning/curriculum/hsie/planning-programming-and-assessing-hsie-11-12/planning-programming-assessing-geography-11-12) contains key information to complement this resource.

Some of the information in this resource is collated from relevant NESA and department documentation. It is important that all users re-read and cross-reference the relevant syllabus, assessment and reporting information hyperlinked throughout. This ensures the content is an accurate reflection of the most up-to-date syllabus content. Links contained within this resource were correct as of 30 April 2024.

# Purpose, audience and suggested timeframes

The geography Year 12 Ecosystems and global biodiversity sample program is intended to encourage students to investigate the functioning of ecosystems and trends in global biodiversity. They examine the value of ecosystems and biodiversity, the global state of ecosystems and the role of Indigenous Peoples in contemporary management practices.

The program guides students through the study of ecosystem management, using coral reefs and tropical rainforests as case studies. The Great Barrier Reef (GBR) and The Tropical Rainforest Heritage of Sumatra (TRHS) have been used as case study ecosystems for this guide. Students develop critical thinking skills and gain a deeper understanding of the interconnectedness of people and places.

The timeframe is suggested as a 14-week program of approximately 3 to 4 lessons per week. Ecosystems and global biodiversity focus area is allocated 45 indicative hours of teaching time.

# Using this resource booklet

The program has been designed to align with the geography Year 12 sample scope and sequence which indicates this focus area is for delivery in Terms 2 and 3. It provides opportunities for the teacher to develop a rapport with their class while getting to know their needs, interests and abilities. Short, engaging materials have been selected to encourage the exploration of various ecosystems and global biodiversity.

This approach enables students to develop a strong foundation in geography Year 12 while helping the teacher assess their comprehension and skills. The resources and activities in this booklet can be used as:

* samples and models, tailoring them to address contextual needs and specific learning objectives
* stimulus during faculty meetings and/or planning days, refining them collaboratively to align with faculty or school goals, planning opportunities for team teaching, mentoring, lesson observation and sharing of student samples
* samples for students to foster a deeper understanding of ecosystems and global biodiversity
* a blueprint for designing student-specific tasks that cater to individual learning needs
* flipped learning materials to prepare students for class collaboration and/or revision activities
* an opportunity to backward map Years 7–10, using the strategies, texts, assessment practices, pedagogical practices and/or syllabus planning to ensure a cohesive and comprehensive learning experience in geography.

Controversial issues may be questions, subjects, topics or problems which create a difference of opinion, causing contention and debate within the school or the community. Controversial issues will differ across schools and communities.

In many of the topics covered within the HSIE syllabuses teachers are required to address controversial issues. Stage 6 geography has content that can be deemed controversial. As per the [Controversial issues in schools policy](https://education.nsw.gov.au/policy-library/policies/pd-2002-0045), teachers in HSIE must deliver lessons ensuring content is for ‘educational purposes consistent with the delivery of curriculum and provision of school programs and activities’.

The manner in which teachers approach the delivery of controversial issues in NSW public schools is guided by the Department of Education’s [Controversial issues in schools policy](https://education.nsw.gov.au/policy-library/policies/pd-2002-0045) and the [Code of Conduct policy](https://education.nsw.gov.au/rights-and-accountability/department-of-education-code-of-conduct). These documents call for a sensitive, objective and balanced approach to coverage of controversial issues. [Values in NSW public schools](https://education.nsw.gov.au/policy-library/policies/pd-2005-0131) is also a useful reference document which sets out the values to be promoted in classrooms.

## Activity 1 – food webs

Access the article on food webs from The [Nature Education Knowledge Project’s Food Web: Concept and Applications](https://www.nature.com/scitable/knowledge/library/food-web-concept-and-applications-84077181/). A food web is an important conceptual tool for illustrating the feeding relationships among species within a community, revealing species interactions and community structure and understanding the dynamics of energy transfer in an ecosystem. Read through relevant sections of the article and identify key species within your selected ecosystem. Ensure you cover various trophic levels, such as:

* producers (plants, algae)
* primary consumers (herbivores)
* secondary consumers (small carnivores)
* tertiary consumers (top predators)
* decomposers (fungi, bacteria).

Draw a food web by placing producers at the bottom and build upwards with each trophic level. Use arrows to represent the direction of energy flow from one species to another. You may use paper or digital drawing tools, for example, [Lucidchart](https://www.lucidchart.com/pages/), [Google Drawings](https://docs.google.com/drawings/).

* Include at least 8 species, incorporating a variety of producers, consumers and decomposers.
* Use coloured markers to differentiate between trophic levels. For instance, green for producers, blue for consumers and brown for decomposers.

Identify any keystone species in the food web. How does their removal affect the ecosystem?

* Describe the energy flow. How much energy is transferred between trophic levels? Refer to the 10% rule (only about 10% of energy is passed on to the next trophic level due to loss of heat between each stage).
* Discuss the impact of human activities on this food web (for example, deforestation, pollution, overfishing). How do these activities disrupt the energy flow?

Use the article to explore food web disruptions caused by invasive species or climate change. For example, create a new food web that shows the altered species interactions and explain how ecosystems can recover or further deteriorate.

Your teacher will split your class into 2 groups. Each group will research one of the chosen case studies. Complete the table below to help you understand the interconnectedness of species, energy flows and the role each trophic level plays.

Table 1 – interconnectedness of species

|  |  |  |  |
| --- | --- | --- | --- |
| Organisms | Category (plant, herbivore, carnivore, decomposer) | Role (producer, primary consumer, secondary consumer, tertiary consumer, decomposer) | How do they interact in the food chain? |
| Tiger | Carnivore | Tertiary consumer | A tiger is a tertiary consumer because it sits high in the food chain as a top predator, primarily feeding on primary and secondary consumers and returning nutrients through scat and leftover carcasses. This role helps regulate prey populations, preventing overgrazing by herbivores and supporting ecosystem health. |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

Present your food webs to the class and explain the ecosystem dynamics. Each group will compare different ecosystems, discussing similarities and differences in species roles, keystone species and energy flow efficiency.

## Activity 2 – food web quick quiz

Provided are questions to encourage you to think critically about the interconnectedness of species and energy flow within ecosystems.

* What would happen if the apex predator was removed from the food chain? Discuss the potential consequences on population balance and ecosystem stability.
* What is the role of decomposers in the food web? How do they contribute to nutrient cycling and energy flow?
* What is the 10% rule in energy transfer through trophic levels? Why is only 10% of energy passed to the next level and how does this affect the number of organisms at each level?
* How can human activities, such as deforestation, disrupt a food web? Provide examples and discuss potential long-term effects.
* Why are producers considered the foundation of any food web? What role do they play in supporting higher trophic levels?
* How does biodiversity enhance the resilience of a food web? Explain how the variety of species helps ecosystems recover from disruptions.
* What are trophic cascades and how do they affect entire ecosystems? Provide an example of how changes at one trophic level can ripple through the system (**hint:** refer to the video you watched about Yellowstone).
* How does habitat destruction affect food webs in different ecosystems? Discuss the consequences for species survival and energy flow.

**Teacher note:** check understanding and ask the following guiding questions.

* How might invasive species impact a food web? How could the introduction of a new species affect local biodiversity and energy flow?
* What happens when a keystone species is lost from an ecosystem? How do keystone species support the structure of a food web? Predict potential ecosystem collapse without them.
* In what ways can overfishing disrupt marine food webs? How could this effect cascading trophic levels?

Brainstorm solutions like species reintroduction, habitat restoration and conservation efforts.

## Activity 3 – volcanic activity in Sumatra and its broader environmental effects

Provided below is a brief overview of volcanic activity in Sumatra and its broader environmental effects, with a specific focus on volcanic ash and its impact on soil composition and microbial dominance. Use the following resources to support your research:

* [Smithsonian Institution National Museum of Natural History Global Volcanism Program](https://volcano.si.edu/)
* [Living with volcanoes](https://www.bgs.ac.uk/discovering-geology/earth-hazards/volcanoes/living-with-volcanoes/#:~:text=Volcanic%20deposits%20are%20enriched%20in,in%20years%20following%20an%20eruption.)
* [How volcanic ash can produce fertile soils - Allophane (3:07)](https://www.youtube.com/watch?v=aq-Uz0jnAZc)
* [Why Is Volcanic Soil So Fertile?](https://www.scienceabc.com/nature/why-is-volcanic-soil-so-fertile.html)

**Volcanic activity in Sumatra**

* Sumatra is located in the Pacific Ring of Fire, making it prone to volcanic eruptions. Major volcanoes like Mount Sinabung and Mount Merapi have had significant eruptions in recent history.
* Volcanic ash is a major by-product of these eruptions, consisting of fine particles of minerals, glass and rock that are ejected into the atmosphere and eventually settle on the ground.

**Environmental effects of volcanic activity**

* The deposition of volcanic ash can have both positive and negative impacts on ecosystems. Initially, the ash can be harmful, causing destruction to plant life and reducing sunlight, but over time it enriches the soil with minerals like phosphorus, potassium and other trace elements that enhance soil fertility.

**Volcanic ash and soil composition**

* Volcanic ash alters the chemical composition of the soil by adding nutrients that are essential for plant growth. The composition also affects the microbial community within the soil, leading to a shift in fungal and bacterial dominance.
* Fungi and bacteria play critical roles in the decomposition of organic matter and nutrient cycling. Volcanic ash, rich in minerals, can create a competitive environment where certain fungi (for example, *mycorrhizal* fungi) may thrive, while some bacteria might struggle to adapt.

**Shifts in fungal and bacterial dominance**

* Fungi – fungal dominance often increases in soils enriched by volcanic ash, as many fungi are better equipped to handle the high mineral content and changing pH levels. Fungi, such as *mycorrhizal* fungi, can form symbiotic relationships with plants, helping them absorb nutrients like phosphorus from the ash-enriched soil.
* Bacteria – volcanic ash can alter soil pH, which may reduce the diversity of bacteria. Certain types of bacteria that rely on more stable soil conditions may decrease, while others, particularly those adapted to extreme conditions, might proliferate.

These shifts in microbial communities can impact the entire ecosystem, affecting plant growth, decomposition rates and nutrient availability.

The following questions can be used to check understanding on volcanoes and their impact on soil.

* How does volcanic ash affect plant life immediately after a volcanic eruption and how does this impact change over time?
* In what ways does the addition of volcanic ash to the soil contribute to changes in soil fertility and composition?
* What role does fungi, specifically *mycorrhizal* fungi, play in ecosystems affected by volcanic ash and how do they contribute to nutrient cycling?
* How does volcanic ash influence the balance between fungal and bacterial communities in the soil and what are the broader ecological effects of this shift?

Other links to different examples:

* [Ten Thousand Years of Cultivation at Kuk Swamp in the Highlands of Papua New Guinea](https://press-files.anu.edu.au/downloads/press/n2540/html/ch08.xhtml?referer=&page=16)
* [FAO Volcanic eruption: what possible impact on agriculture and fisheries, and [Salmon’s life cycle and their incredible impact on our ecosystem (3:47)](https://www.bing.com/videos/riverview/relatedvideo?&q=impacts+of+salmon+on+soil&&mid=4E0847E586752E125FDA4E0847E586752E125FDA&&FORM=VRDGAR)](https://www.fao.org/newsroom/detail/tonga-volcanic-eruption-what-possible-impact-on-agriculture-and-fisheries/en#:~:text=Ashfall%20can%20have%20serious%20detrimental,of%20uncontaminated%20feed%20and%20water.)
* [Frontiers | Legacy of salmon-derived nutrients on riparian soil chemistry and soil fertility on the Central Coast of British Columbia, Canada](https://www.frontiersin.org/journals/forests-and-global-change/articles/10.3389/ffgc.2023.1010294/full).

## Activity 4 – HUGIN values and critical thinking

**Teacher note:** provided below are critical thinking prompts and opportunities for students to connect their learning with real-world case studies for each of the HUGIN (Heritage, Utility, Genetic diversity, Intrinsic and Natural change) values. For each section, students will complete the following tasks for each HUGIN value.

**Heritage values**

* Write an example of how an ecosystem (for example, a coral reef or rainforest) is important to the heritage of local Indigenous peoples or communities.
* Prompt – How do cultural practices or historical knowledge connect to these ecosystems?
* Example – the GBR has significant cultural value for the Torres Strait Islander peoples.

**Utility values**

* Identify one practical use of the ecosystem, such as tourism, fisheries or medicine.
* Prompt – How does this ecosystem support human needs and economic activities?
* Example – rainforests provide resources for pharmaceuticals and climate regulation.

**Genetic diversity values**

* Explain how the ecosystem serves as a genetic reservoir that helps species adapt to environmental changes.
* Prompt – What is the role of biodiversity in these ecosystems?
* Example – the Amazon rainforest is home to a vast number of species that contribute to genetic diversity.

**Intrinsic values**

* Discuss the inherent value of the ecosystem, independent of human use or benefit.
* Prompt – Why is the ecosystem important even if humans do not directly use its resources?
* Example – coral reefs contribute to planetary health by supporting marine life and maintaining ocean balance.

**Natural change values**

* Describe one way in which the ecosystem naturally evolves or provides important ecological services like carbon sequestration or water purification.
* Prompt – How does this ecosystem naturally adapt or change and what services does it provide?
* Example – mangrove forests help regulate floods and protect coastlines.

Map or graph one ecosystem showing species distribution or ecosystem services and make connections to the HUGIN values. Check understanding and ask this reflection question:

‘Which HUGIN value do you think is the most important to focus on in the conservation of this ecosystem? Why?’

## Activity 5 – definition and real-world examples of vulnerability and resilience

**Teacher note:** students will explore real-world examples of vulnerability and resilience affecting an ecosystem. Students will examine the factors influencing the ecosystem and apply these concepts to relevant case studies focusing on ecosystem and community responses to environmental change.

* Definition of vulnerability – vulnerability is the degree to which an ecosystem, community or individual is exposed to harm due to hazards or environmental changes. For example, coastal communities facing rising sea levels or coral reefs affected by ocean acidification are vulnerable due to the specific hazards they are exposed to.
* Definition of resilience – resilience as the ability of a system (ecosystem or community) to recover from disturbances or adapt to changing conditions while maintaining essential functions. For example, forests regrowing after wildfires or communities rebuilding after floods, illustrate resilience.
* Resilience-building factors that help ecosystems and communities recover and adapt include
* diversity (biological and social) – greater species diversity or community resource diversity improves adaptability and recovery
* connectivity – connections between ecosystems or support systems, like wildlife corridors or social networks, enhance resilience
* learning and adaptation – the ability of ecosystems and communities to learn from past disturbances and adapt for future challenges.
* Resilience-building factors, for example, the GBRs resilience to coral bleaching events, where certain coral species survive better and help in reef recovery.

Complete the table below:

Table 2 – definition and real-world examples of vulnerability and resilience

|  |  |  |  |
| --- | --- | --- | --- |
| Examples | Student-developed definition | Ecosystem 1 example | Ecosystem 2 example |
| Vulnerability |  |  |  |
| Resilience |  |  |  |

Questions to consider:

* What are some human-made factors that increase vulnerability in coastal areas?
* Can you think of any recent events where communities or ecosystems have been vulnerable to change? How did they respond?
* Why do you think diversity helps systems recover from disturbances?
* How might a community’s ability to adapt after a natural disaster contribute to their long-term survival?

## Activity 6 – interpreting and analysing climate graphs

**Teacher note:** provide explicit instruction for students to interpret and analyse climate graphs, recognise climate trends and their implications on human and environmental activities. Provided is a step-by-step breakdown instruction for students of how to read and interpret climate graphs.

**Introduction to climate graphs**

Climate graphs visually represent 2 critical aspects of climate for a specific location, temperature and precipitation. These graphs help geographers, scientists and others observe climate trends over a year.

* Temperature is usually represented as a line graph, helping to show fluctuations or patterns in the heat levels month by month.
* Precipitation is represented as bar graphs, indicating the amount of rainfall (or snow) over each month.

**Understanding the axes**

**Teacher note:** review how to interpret both the x-axis and y-axis of the climate graph.

* X-axis (horizontal axis) – represents the months of the year, often abbreviated (for example, Jan, Feb, Mar). Highlight that the climate graph spans from January to December, showing climate data for all seasons.
* Y-axis (vertical axis) – the graph has 2 Y-axes
* one side (usually the left) represents temperature in either degrees Celsius (°C) or Fahrenheit (°F), depending on the region
* the other side (usually the right) represents precipitation in millimetres (mm) or inches, indicating the amount of rainfall or snowfall in each month.

**Reading temperature and precipitation**

Looking at the line from left to right on the climate graph you will notice peaks and troughs. The peaks represent warmer periods, and the troughs represent cooler periods. On the graph highlight:

* highest temperature – identify the peak points
* lowest temperature – identify the lowest points in the line graph.

Calculate the average temperature range – calculate using the formula .

For precipitation, study the bars at the bottom of the graph. Taller bars indicate more precipitation, while shorter bars represent less rainfall. Highlight:

* wettest months – these are represented by the tallest bars
* driest months – these have the shortest bars or no bar (indicating no rainfall)
* the average monthly rainfall – calculate by tallying all monthly figures and dividing by 12.

**Identifying seasonal variations**

Climate graph reveals seasonal patterns, such as wet and dry periods, and hot and cold periods.

Looking at the climate graph:

* identify the months that receive more rainfall (wet season) and identify the months with the least rainfall (dry season)
* identify the months that have the highest temperature (summer) and identify the months with the coldest temperature (winter). Compare the temperature line to the precipitation graph to understand the correlation between rainfall and temperature.

Seasonal temperature trends show how temperature changes, often peaking in summer months and dropping in winter.

* These patterns can vary between hemispheres:
* In the Northern Hemisphere, which months are the hottest and which are the coldest?
* In the Southern Hemisphere, which months are the hottest and which are the coldest?

**Teacher note:** provide students with a current climate graph from a real location, such as Sydney or New York and guide them through the points.

**Example of reading a climate graph**

* Identify the month with the highest temperature and note how high the temperature gets.
* Find the wettest and driest months by analysing the bars representing precipitation.
* Discuss the relationship between temperature and precipitation. For example, in tropical climates, the wettest months might coincide with the highest temperatures.

**Practical application**

* Practice reading and interpreting climate graphs from different parts of the world, comparing tropical, temperate and arid climates. Look for patterns that indicate different climate zones.
* Make predictions based on the climate graph, such as the best months for agriculture, tourism or outdoor activities.

**Questions to reinforce learning**

**Teacher note:** ask the following questions to check for understanding.

* What does the line in the graph represent?
* How do you identify the month with the highest rainfall?
* How does the climate graph help us understand seasonal variations?

## Activity 7 – interpreting and analysing synoptic charts

Synoptic charts display weather systems, such as high and low pressure and can provide information about wind speed, wind direction and rainfall, helping forecasters predict changes in weather conditions.

**Introduction to synoptic charts**

**Teacher note:** check prior knowledge for interpreting and analysing synoptic charts.

**Key symbols and elements on a synoptic chart**

Below are the most important features on a synoptic chart, starting with the basics.

Isobars − these are lines that connect points of equal air pressure.

* Isobars help identify pressure systems and wind speed.
* Isobars are measured in hectopascals (hPa), and their patterns show how pressure is distributed across an area.

Wind speed and direction − wind patterns on synoptic charts are determined by the spacing of isobars and the use of wind barbs.

* When isobars are close together, it indicates stronger winds.
* Wind barbs are small lines extending from points on the map, indicating both the speed and direction of the wind. Longer lines represent stronger winds, and the direction of the barbs shows where the wind is coming from.

Pressure systems – synoptic charts display high-pressure and low-pressure systems.

* Low pressure (‘L’) – represents areas of rising air, often associated with cloud formation, storms and unsettled weather. They turn in a clockwise direction in the Southern Hemisphere and an anticlockwise direction in the Northern Hemisphere.
* High pressure (‘H’) – represents areas of sinking air, often associated with clearer skies and more stable weather. They turn in an anticlockwise direction in the Southern Hemisphere and a clockwise direction in the Northern Hemisphere.

**Introducing tropical cyclones**

Tropical cyclones are intense low-pressure systems that occur in tropical regions. They are characterised by:

* low pressure – at the core of the cyclone, the pressure is extremely low compared to the surrounding area
* strong winds – winds spiral around the centre due to the low pressure and the closer the isobars, the stronger the winds. The direction of winds is clockwise in the Southern Hemisphere and anticlockwise in the Northern Hemisphere
* heavy rainfall – cyclones bring torrential rains that can lead to flooding
* eye of the storm – the centre of the cyclone, known as the eye, is a region of calm weather with clear skies, surrounded by the most intense winds and rain, called the eye wall.

**Teacher note:** provide a synoptic chart featuring a tropical cyclone and highlight specific features below:

* low-pressure zone – cyclones are centred around a marked ‘L’ on the map, indicating a low-pressure area
* isobars – the isobars around a cyclone are very tightly packed, indicating strong winds
* cloud cover and precipitation – cloud cover and areas of precipitation are often indicated with symbols or shaded areas, showing the intensity of the weather system.

Provide students a synoptic chart showing a tropical cyclone near the GBR and the accompanying satellite image of the system.

* Using the synoptic chart and the satellite image locate the low-pressure system and calculate the latitude and longitude of the eye of the storm.
* Calculate the area of the cloud cover of the cyclone.
* Using the wind barbs, calculate the speed and direction of the wind at various points around the cyclone and the cyclones projected direction.

**Practise questions for students to reinforce learning**

* What do isobars represent on a synoptic chart?
* How can you tell if an area is experiencing strong winds?
* What does the ‘L’ symbol mean and what kind of weather is associated with it?
* How can you identify a tropical cyclone on a synoptic chart?
* What direction does a low-pressure system turn in the Southern Hemisphere?

## Activity 8 – Shifting Baseline Syndrome and the GBR

**Teacher note:** explain the concept of Shifting Baseline Syndrome (SBS) and its impacts on ecology, environmental management, policy and public perception using the example of declining fish populations or coral cover in the GBR.

**Definition of SBS** – SBS refers to the phenomenon where each generation accepts the environmental conditions that they are familiar with as ‘normal’, even if those conditions represent a significant decline from past ecosystems. Use visuals (before and after images) of ecosystems like the GBR or fish population graphs to show how ecosystems have degraded over time. Each new generation may have no direct knowledge of the previous, healthier state of the ecosystem, thus accepting a deteriorated environment as the baseline.

For example, coral cover in the GBR has declined over decades. Older generations recall the reef with much more biodiversity and vibrant coral, whereas younger generations may perceive the current state, with far fewer species and reduced coral cover, as ‘normal’.

Discuss the decline of fish populations globally, showing how older fishers experienced greater fish abundance, while newer generations see today’s lower catch rates as typical.

**How SBS manifests in ecological studies** – explain that SBS can skew ecological studies because the baseline conditions used for measuring ecosystem health may already represent a degraded state.

Discuss how this affects conservation baselines: scientists might underestimate the extent of degradation if they measure against a baseline that was already depleted.

Provide a brief activity where students compare historical and current data on fish populations or coral cover, discussing their observations of the change.

**Long-term consequences of SBS on environmental policy and management** – SBS can lead to weaker environmental policies, as decision-makers may underestimate the scale of the problem. For example, if they believe the current state of the reef is ‘healthy’, they might not implement strong conservation measures.

Students to read [Shifting baselines](https://outlookreport.gbrmpa.gov.au/values/2-biodiversity/22-legacies-and-shifted-baselines/222-shifting-baselines) and focus on answering the following questions:

* How does SBS manifest in ecological studies?
* What are the long-term consequences of SBS on environmental policy and management?
* How can SBS impact public perception and conservation efforts?
* How can we shift baselines to reflect healthier ecosystems and what role can we play in this?
* How does SBS manifest in ecological studies?
* What are the long-term consequences of SBS on environmental policy and management?
* How can SBS impact public perception and conservation efforts?

## Activity 9 – photo orientation and zoning map of the GBR

Provided below is a breakdown of how to use photo orientation and zoning maps, focusing on landmarks, shadows, sun angles and the zoning near the GBR.

### Photo orientation using landmarks, shadows and sun angles

**Introduction to photo orientation**

1. Explain the purpose of photo orientation – determining the direction a photograph was taken by analysing visual clues within the image, such as natural and man-made landmarks, shadows and the position of the sun.
2. Show students a sample photograph (for example, a coastal view of the GBR) and identify key features, such as mountains, coastlines or buildings, that can serve as landmarks.

**Using shadows and sun angles**

1. Explain that shadows can be used to infer the direction of sunlight. Shadows generally fall opposite to the direction of the sun. For example, if shadows are cast to the east, the sun is likely in the west.
2. Introduce the concept of sun angles based on the time of day

* In the morning, the sun rises in the east and in the afternoon, it sets in the west.
* At noon, the sun is generally overhead, so shadows are shorter or directly beneath objects.

1. Check understanding and ask students to estimate the time of day based on the length and direction of shadows in the photograph and infer the general orientation (for example, ‘The sun appears low in the west, casting long shadows eastward, this suggests the photo was taken in the afternoon facing west’.).

**Using known geographic features**

1. If the photo includes a recognisable geographic feature, such as an island or a reef, use a map or the students’ knowledge to help determine orientation. For example, ‘We can see Green Island to the north, so the photo was likely taken facing north’.
2. Cross-reference the photo with a map to confirm the location and orientation of major landmarks or geographic features.

### Zoning map of the GBR

**Introduction to zoning maps**

1. Introduce the concept of zoning and explain that zoning maps are used to manage human activities in sensitive areas like the GBR. Different zones regulate what activities can and cannot take place in certain areas.
2. Show a zoning map of the GBR, highlighting the different coloured zones that represent various management categories (for example, green – Marine National Park, light blue – general-use zones, dark blue – sensitive habitat protection and yellow – conservation park).

**Explanation of zoning categories**

1. Explain the key zoning categories and their purposes.

* Protected areas (no-take zones) – these areas have the strictest rules. Activities like fishing and extraction of resources are prohibited to allow ecosystems to regenerate and maintain biodiversity.
* Fishing zones – these zones permit regulated fishing, allowing sustainable use of marine resources while balancing conservation efforts.
* Tourism zones – these zones are designed for recreational activities, such as snorkelling, diving and boating, often near tourist destinations like islands or coral reefs.
* Scientific research zones – reserved for ecological research to monitor reef health, species and impacts of human activities.
* Conservation zones – areas where limited, low-impact activities may be allowed, but where the focus remains on conserving the marine environment.

**Using the zoning map to manage activities**

1. Show students specific regions on the zoning map (for example, the Whitsunday Islands or Cairns) and explain how zoning in these areas is used to manage different activities. For example, a green no-take zone might be adjacent to a tourism zone to balance conservation with economic benefits.
2. Discuss how zoning helps protect ecosystems, like the GBR, from overfishing, coral bleaching and the impacts of tourism, while still allowing for controlled human use.
3. Emphasise that zoning is a key tool in ecosystem management, helping authorities balance human activity with the need to preserve the natural environment.

**Check understanding**

As a class, examine different zones on the map and discuss what activities are allowed in each zone. For example, ‘In the no-take zone near Cairns, fishing is not permitted. How does this help protect the reef’s ecosystem?’. Check understanding and students to compare 2 zones (for example, a no-take zone and a tourism zone) and discuss how their management strategies differ. Ask questions, ‘How do the rules in tourism zones balance the economic benefits of tourism with the need for conservation?’. Students consider how zoning affects ecosystem health, biodiversity and the sustainable use of resources.

## Activity 10 – interconnectedness between Indigenous practices and contemporary conservation efforts

**Teacher note:** students explore the interconnectedness between Indigenous practices and contemporary conservation efforts, highlighting their role in promoting sustainable ecosystems. Use these questions to prompt whole-class discussions or [structured Socratic seminars](https://www.readwritethink.org/professional-development/strategy-guides/socratic-seminars#:~:text=The%20Socratic%20seminar%20is%20a,to%20the%20thoughts%20of%20others.). Encourage students to build on each other’s ideas and present counterpoints, promoting critical thinking about Indigenous practices in contemporary management practices. The following questions and prompts encourage deeper thinking about the broader benefits of Indigenous management practices.

* How do Indigenous management practices align with the principles of ecologically sustainable development?
* Provide examples of how traditional Indigenous practices, such as fire-stick farming, contribute to biodiversity conservation.
* How do Indigenous knowledge systems complement modern scientific approaches in managing ecosystems?
* What roles do Indigenous land management techniques play in enhancing the resilience of ecosystems to climate change?
* In what ways do Indigenous management practices reflect an understanding of long-term environmental sustainability?
* How do Indigenous concepts of stewardship and custodianship differ from contemporary conservation models?
* Why is it important to integrate Indigenous knowledge into global environmental management frameworks?
* How do Indigenous peoples’ practices help to maintain the balance in ecosystems that are vulnerable to human-induced changes?
* What are some modern challenges faced by Indigenous communities in practicing traditional management techniques today?
* How can governments and organisations collaborate with Indigenous groups to implement sustainable land and water management practices?

## Activity 11 – true or false and agree or disagree statements about the GBR

Provided is a set of true or false and agree or disagree statements designed to test students’ knowledge of the GBR, focusing on its size, location and global significance.

**True or false statements**

**The Great Barrier Reef:**

* is the largest coral reef system in the world
* is located off the coast of New Zealand
* covers an area of approximately 344,400 square kilometres
* is composed of over 2,900 individual reefs and 900 islands
* can be seen from outer space
* was designated a UNESCO World Heritage Site in 1981
* has little to no economic impact on the local region or Australia
* Great Barrier Reef Marine Park Authority (GBRMPA) is responsible for managing the reef
* supports around 1,500 species of fish and 400 species of coral
* contributes more than 6 billion AUD to the Australian economy annually
* coral bleaching only occurs in a small, isolated part of the reef
* is primarily located in the Coral Sea, off the coast of Queensland
* is home to species that are endangered, such as dugongs and large green sea turtles
* ocean acidification has no impact on the coral reefs within the GBR
* biodiversity is comparable to that of tropical rainforests.

**Agree or disagree statements**

**The Great Barrier Reef:**

* plays a vital role in supporting marine biodiversity globally
* is significant only for Australia and not for the rest of the world
* is resilient enough to recover from all environmental pressures without human intervention
* has had a significant decline in global tourist visits due to a loss of the reef
* health is a direct indicator of broader global environmental issues, such as climate change and ocean acidification
* is more than just a natural wonder; it is essential for scientific research and medical discoveries
* is under minimal threat from human activities, such as tourism and coastal development
* protection is solely an Australian responsibility
* coral reefs provide valuable ecosystem services, including fisheries, coastal protection and carbon sequestration
* collapse could lead to significant economic consequences not only for Australia but also for many countries worldwide
* health directly influences global climate regulation due to its vast carbon-storing capacity
* suffers greater damage from natural events, such as cyclones, than from human activity.

## Activity 12 – branching scenario about coral health and the spatial distribution of bleaching events

**Teacher note:** branching scenarios support students to think critically about how environmental factors such as temperature affect coral health and the spatial distribution of bleaching events.

**Scenario 1 – rising ocean temperatures and coral health**

‘In recent decades, ocean temperatures in many tropical regions, including the GBR, have risen due to global climate change. Imagine the average water temperature has increased by 1°C over the past decade. This may not sound like much, but for coral ecosystems, even small changes in water temperature can have significant effects. Knowing this, how do you think coral reefs in these regions will respond?’

* Option A – warmer water will promote coral growth because warmer climates are generally favourable for tropical ecosystems.
* Option B – warmer water can lead to coral stress, causing them to expel the symbiotic algae (zooxanthellae) that provide the coral with food through photosynthesis. This leads to coral bleaching.
* Option C – warmer water will have no noticeable effect on coral reefs, as these ecosystems are adapted to tropical heat.

**Teacher note:** check understanding and provide the correct answer – Option B.

Warmer waters can cause coral stress by disrupting the symbiotic relationship between corals and the algae living in their tissues. The algae, called zooxanthellae, are crucial for coral survival, as they provide most of the energy corals need through photosynthesis. When stressed by heat, corals expel these algae, leading to the white appearance known as coral bleaching. While the corals are not dead immediately, prolonged exposure to higher temperatures without recovery can lead to mass die-offs.

**Scenario 2 – spatial patterns of coral bleaching**

‘Scientists have observed that coral bleaching doesn’t affect all parts of the GBR uniformly. Some areas experience significant bleaching, while others seem relatively healthy. As ocean temperatures rise, this spatial variation in coral health becomes more pronounced. What do you think could explain why some areas of coral are bleached while others are not?’

* Option A – regions closer to the equator experience warmer water temperatures, leading to more bleaching.
* Option B – cooler water currents in some regions prevent coral bleaching by maintaining lower temperatures.
* Option C – coral bleaching is completely random and not influenced by factors such as water temperature or ocean currents.

**Teacher note:** check understanding and provide the correct answer – Option A and B.

Coral bleaching is not random. Water temperature is one of the most critical factors. Regions closer to the equator tend to experience higher sea surface temperatures, making these areas more vulnerable to bleaching. However, ocean currents, such as upwellings of cooler water, can help protect certain areas from bleaching by reducing overall water temperature. Additionally, deeper waters or areas shaded by islands and landforms may be less affected by temperature increases, leading to healthier coral ecosystems in these regions.

**Teacher note:** check understanding and ask the following guiding question: ‘What are some other environmental factors that might contribute to the spatial patterns of coral bleaching?’.

Model response:

* Depth of water – deeper water tends to be cooler, so corals in these areas may be less affected.
* Cloud cover and shading from nearby landforms – this can reduce direct sunlight and thus lower water temperature.
* Nutrient runoff – areas with more agricultural runoff may experience greater stress due to eutrophication, leading to more susceptibility to bleaching.

**Scenario 3 – the long-term impact of repeated coral bleaching events**

‘Coral reefs around the world have been experiencing repeated bleaching events over the last 2 decades. In some places, this has become an annual occurrence. Consider a reef system that has experienced 3 severe coral bleaching events in the last 10 years. What do you think will happen to the coral’s ability to recover over time?’

* Option A – corals will become more resilient and adapt to warmer waters, eventually recovering fully and becoming less susceptible to future bleaching events.
* Option B – repeated bleaching events weaken corals, making them less able to recover each time. Over time, this can lead to the collapse of the coral reef system.
* Option C – corals will recover at the same rate each time, regardless of how many bleaching events have occurred.

**Teacher note:** check understanding and provide the correct answer – Option B.

Repeated coral bleaching events reduce the overall health and resilience of coral reefs. After each bleaching event, corals expend a large amount of energy trying to recover. If the intervals between bleaching events are too short, corals may not have enough time to fully recover before being hit by another event. This leads to reduced growth rates, increased vulnerability to diseases and a higher likelihood of mortality. As coral health declines, the entire reef ecosystem, which depends on the coral structure for habitat, is affected.

**Teacher note:** check understanding and ask the following guiding question: ‘What might happen to marine biodiversity in areas where coral reefs suffer from repeated bleaching events?’.

Model responses:

* Loss of habitat – coral reefs provide shelter for many marine species. As reefs degrade, fish and other marine organisms lose their homes and breeding grounds.
* Decline in biodiversity – a decrease in coral health can lead to a decline in the biodiversity of the reef, affecting everything from small invertebrates to larger predators.
* Shifts in species composition – one species may thrive in degraded environments, leading to changes in the balance of the ecosystem, with more resilient species taking over and others being lost.

**Scenario 4 – the role of climate change in coral bleaching**

‘Many scientists agree that global climate change is the primary driver of rising sea temperatures, which, in turn, is causing coral bleaching events to increase in frequency and intensity. Imagine that you are a marine scientist tasked with explaining to a government body why coral bleaching is becoming more common. How would you explain the link between climate change and coral bleaching?’

* Option A – climate change is increasing global sea surface temperatures, which causes stress to coral reefs. This stress leads to the expulsion of zooxanthellae from the coral, resulting in bleaching.
* Option B – climate change is causing the oceans to become more acidic, which is leading to bleaching.
* Option C – climate change is increasing the amount of sunlight that reaches the oceans, leading to bleaching.

**Teacher note:** check understanding and provide the correct answer – Option A.

Climate change is increasing global sea surface temperatures, especially in tropical regions where coral reefs are most abundant. Even small increases in temperature can stress coral, causing them to expel the zooxanthellae that live within their tissues. Without these algae, corals lose their primary source of energy and their vibrant colours, resulting in bleaching. If the water remains warm for too long, the corals may not recover, leading to widespread mortality.

**Teacher note:** check understanding and ask the following guiding question: ‘How do you think future climate change projections could affect coral reefs in the next 50 years?’.

Model responses:

* Increased frequency and severity of bleaching events – with more frequent heatwaves and rising baseline temperatures, coral reefs may experience near-constant bleaching events.
* Potential for large-scale reef collapse – if coral reefs cannot adapt quickly enough, entire reef systems could collapse, leading to the loss of critical marine habitats.
* Need for urgent action – governments and conservationists may need to take more aggressive measures to reduce carbon emissions and protect coral reefs through mitigation and adaptation strategies.

## Activity 13 – symbiotic relationships and the GBR

Symbiotic relationships in the GBR are essential to maintaining its health and functioning. Below are some key symbiotic interactions.

**Coral and *zooxanthellae* (Algae)**

Relationship type – mutualism

Coral polyps host microscopic algae called zooxanthellae within their tissues. The algae photosynthesise, producing oxygen and organic compounds (such as glucose) that corals use for energy. In return, the coral provides the algae with protection and access to sunlight, as well as the carbon dioxide they need for photosynthesis.

Importance – this relationship is critical for coral survival, as up to 90% of a coral’s energy comes from zooxanthellae. Without this, corals are more susceptible to stress and death, especially under rising temperatures, which can lead to coral bleaching (expulsion of zooxanthellae).

**Cleaner fish (for example, cleaner wrasse) and host fish**

Relationship type: mutualism

Description − cleaner fish, such as the cleaner wrasse, feed on parasites, dead tissue and bacteria found on larger host fish. The host fish benefit from this cleaning service by maintaining better health, while the cleaner fish gain food.

Importance – this relationship helps reduce parasite loads and disease, promoting the health and survival of many fish species in the GBR ecosystem.

**Clownfish and sea anemones**

Relationship type: mutualism

Clownfish live among the tentacles of sea anemones, which provide them with protection from predators due to their stinging cells. In return, clownfish defend the anemone from predators and parasites and help with aeration by moving water around the anemone.

Importance – this relationship helps maintain both species’ populations and contributes to the biodiversity of the reef.

**Giant clams and *zooxanthellae***

Relationship type: mutualism

Like corals, giant clams host zooxanthellae in their mantles. The algae photosynthesise, providing the clams with energy, while the clams provide the algae with a safe environment and access to sunlight.

Importance – this relationship allows giant clams to thrive in nutrient-poor environments, contributing to the diversity of the reef ecosystem.

**Sea cucumbers and reef substrates**

Relationship type: commensalism

Sea cucumbers feed on organic matter in the sediment, cleaning the seafloor by breaking down detritus and other debris. While the sea cucumbers benefit from the nutrient-rich food, the substrate remains relatively unaffected, though it becomes cleaner and more habitable for other organisms.

Importance – this interaction helps maintain the health of the reef by keeping sediments clean and preventing the build-up of detritus that could otherwise harm coral and other benthic organisms.

**Comprehension questions:**

* What is the nature of the symbiotic relationship between coral and zooxanthellae? Explain how both organisms benefit from this relationship.
* How do cleaner fish, like the cleaner wrasse, contribute to the health of the GBR ecosystem? What benefits do both cleaner fish and host fish gain from this interaction?
* Describe the mutualistic relationship between clownfish and sea anemones. How do clownfish and sea anemones protect each other?
* Explain the role of zooxanthellae in the survival of giant clams. What would happen to giant clams if this symbiotic relationship were disrupted?
* How does the relationship between sea cucumbers and reef substrates differ from the mutualistic relationships found in the GBR? Why is this relationship still important for the reef ecosystem?

**Analytical questions:**

* How does the symbiotic relationship between coral and zooxanthellae influence the resilience of coral reefs to environmental stressors such as ocean warming?
* What role do symbiotic relationships play in maintaining biodiversity in the GBR? Provide examples from at least 2 different symbiotic pairs.
* If sea cucumbers were removed from the GBR ecosystem, how might this impact the reef’s health and biodiversity? Discuss potential effects on other organisms and the overall ecosystem.
* Coral bleaching occurs when corals expel their zooxanthellae. How might climate change exacerbate this phenomenon and what could be the long-term consequences for the GBR ecosystem?
* Evaluate the importance of mutualistic relationships, such as those between clownfish and sea anemones, in terms of providing ecological stability and enhancing the resilience of the GBR ecosystem.

**Critical thinking questions:**

* Given the threat of coral bleaching due to rising ocean temperatures, what strategies could be implemented to protect the symbiotic relationship between coral and zooxanthellae?
* How might the loss of one key species, such as the cleaner wrasse, affect the entire food web of the GBR? Discuss the possible chain reaction in terms of symbiotic and predatory relationships.
* How do human-induced changes, such as overfishing and pollution, impact symbiotic relationships in the GBR? Discuss how these disruptions could lead to broader ecological changes.
* In what ways could advances in biotechnology or marine science help to preserve symbiotic relationships like those between coral and zooxanthellae in the face of climate change?
* Reflecting on the importance of symbiotic relationships in the GBR, how would you prioritise conservation efforts for preserving these interactions in the reef ecosystem?

## Activity 14 – research and spatial analysis about the biodiversity and human impacts in TRHS

Students engage in both research and spatial analysis, reinforcing their understanding of biodiversity and human impacts in TRHS. Students use a step-by-step approach.

**Thematic map of biodiversity and human impacts in TRHS**

1. Introduction to biodiversity hotspots

* Begin by providing an overview of biodiversity hotspots and explain why the TRHS is classified as one.
* Highlight key endemic species found in the TRHS, such as the Sumatran Orangutans and Sumatran tigers. Discuss their ecological importance and vulnerability.

1. Research biodiversity hotspots

* Assign students the task of researching different biodiversity hotspots within the TRHS.
* Provide a list of sources or websites where students can find information on endemic species and areas of high biodiversity in Sumatra (for example, IUCN Red List, WWF, Conservation International).
* Have students take notes on the key areas where biodiversity is highest and the species that are most concentrated in these areas.

1. Thematic map of biodiversity

**Part 1 – introduce the concept of a thematic map**

* Explain that a thematic map is used to represent specific data or themes about a geographic area. For example, it can show population density, climate patterns, or in this case, biodiversity concentration.
* Emphasise that the map’s goal is to make it easy to see where biodiversity is most abundant and which areas host endemic species.

**Part 2 – visual representation of biodiversity**

* Colour shading – explain how different colours or shades of a colour can be used to represent varying levels of biodiversity concentration. For example, a dark green shade could represent areas with high biodiversity, while light green could represent areas with lower biodiversity.
* Symbols – explain how symbols like stars, circles or icons can represent specific endemic species, such as orangutans or tigers. Each symbol can have a key or legend explaining what it stands for.

**Part 3 – provide a base map of the TRHS**

* Distribute a pre-drawn base map of Sumatra that includes major geographic features like rivers, mountains and boundaries of the TRHS.
* Ensure the map is large enough for detailed plotting. If digital mapping tools are being used, students can zoom into specific areas.

**Part 4 – plotting areas of high biodiversity**

* Have students refer to their research and identify key areas within TRHS that have high levels of biodiversity.
* Students should use colour shading or other visual methods to highlight these areas on the base map. For instance
* dense biodiversity – dark green
* moderate biodiversity – medium green
* low biodiversity – light green.

**Part 5 – labelling endemic species**

* Students should also label specific areas with significant populations of endemic species, such as
* Sumatran Orangutans – use a specific symbol (for example, a star or animal icon)
* Sumatran tigers – another distinct symbol or label.
* They should also add geographic names for the regions, forests or protected areas that are important biodiversity hotspots (for example, Gunung Leuser National Park).

**Part 6 – create a map legend**

* Ensure students create a legend or key that explains their colour codes and symbols. For example
* dark green – high biodiversity
* light green – low biodiversity
* star symbol – orangutans.

**Dot map of biodiversity and human impacts in TRHS**

1. Introduce the concept of a dot map

* Explain the concept of a dot map and how it visually represents data (in this case, biodiversity concentration).
* Give students a base map of the TRHS. Or alternatively, provide a pre-drawn outline of Sumatra that includes key geographic features.
* Students plot the areas of high biodiversity they researched, using colour shading or symbols to represent these hotspots (for example, darker green for denser biodiversity).
* Students should label areas with significant populations of endemic species.

1. Dot map of human activity and deforestation

* Introduce the concept of a dot map and explain how it can show patterns of specific activities (for example, human activity, deforestation).
* Have students create a dot map overlay on the same base map, marking areas of human activity, such as logging, agriculture or urbanisation.
* Provide data on deforestation rates or human encroachment in Sumatra and ask students to plot dots representing these areas on the map.

1. Comparison and analysis

* Once both maps are completed, guide students through a comparison of the 2 maps. Ask them to identify any overlaps between high biodiversity areas and human activity or deforestation.
* Students should discuss or write about the impacts of human activity on biodiversity hotspots, noting areas where endangered species are at the greatest risk.

## Activity 15 – Tropical Rainforest Heritage of Sumatra endemic species

The TRHS is home to a rich array of endemic species, many of which are unique to the island and its rainforest ecosystems. Some of the key endemic species include:

* Sumatran Orangutan (Pongo abelii) – critically endangered and found only in the rainforests of northern Sumatra
* Sumatran Tiger (Panthera tigris sondaica) – critically endangered, with one of the last remaining tiger populations confined to Sumatra
* Sumatran Rhinoceros (Dicerorhinus sumatrensis) – critically endangered and the smallest living rhinoceros species, found only in Sumatra and Borneo
* Sumatran Elephant (Elephas maximus sumatranus) – critically endangered subspecies of the Asian elephant, known for its smaller size and unique features
* Sumatran Ground-cuckoo (Carpococcyx viridis) – a rare and elusive bird species endemic to the rainforests of Sumatra
* Sumatran Striped Rabbit (Nesolagus netscheri) – a little-known and rarely-seen species, endemic to the montane forests of Sumatra
* Sumatran Serow (Capricornis sumatraensis sumatraensis) – a vulnerable species of goat-antelope, typically found in hilly and mountainous regions
* Sumatran Clouded Leopard (Neofelis diardi diardi) – vulnerable and smaller than other clouded leopards, it is native to Sumatra and Borneo
* Sumatran Laughingthrush (Garrulax bicolor) – endangered and highly sought after in the illegal pet trade, this bird is native to Sumatra’s montane regions
* Sumatran Banded Pitta (Hydrornis schwaneri) – a brightly coloured bird endemic to the lowland and montane forests of Sumatra
* Sumatran Flying Squirrel (Hylopetes winstoni) – a small gliding mammal unique to the forests of Sumatra, known for its ability to glide between trees
* Sumatran Shortwing (Brachypteryx leucophrys) – a species of bird endemic to the montane forests of Sumatra, particularly in higher elevations
* Sumatran Trogon (Harpactes mackloti) – a bird species that inhabits the dense forests of Sumatra, characterised by its colourful plumage
* Sumatran Striped Squirrel (Tamiops maritimus sumatrae) – a subspecies of striped squirrel native to Sumatra, often found in forested areas
* Sumatran Water Shrew (Chimarrogale sumatrana) – a small, elusive mammal that inhabits freshwater ecosystems in Sumatra’s rainforests
* Sumatran Cochoa (Cochoa beccarii) – an endangered bird species found in the highland rainforests, known for its secretive nature
* Sumatran Drongo (Dicrurus sumatranus) – a small, black bird endemic to Sumatra, recognised for its aggressive behaviour and distinct calls
* Sumatran Leafbird (Chloropsis media) – a bright green bird that inhabits lowland forests, known for its melodious song and vibrant appearance.

For more information access the [UNESCO TRHS](https://whc.unesco.org/en/list/1167/) and the [World Heritage in Danger](https://whc.unesco.org/en/danger/) links. These species are an important part of the biodiversity of the TRHS and many are critically endangered due to deforestation, habitat loss and poaching.

## Activity 16 – affinity diagram about the interconnections between different aspects of ecological disturbances

As a class, develop an [affinity diagram](https://app.education.nsw.gov.au/digital-learning-selector/LearningActivity/Card/576?clearCache=86d6dc71-7d45-74a-34d6-3b7453ebeb95) to organise these categories and factors visually, showing the interconnections between different aspects of ecological disturbances. Provided is a step-by-step to help organise ideas around the importance of analysing ecological disturbances like deforestation and climate change and their impact on ecosystem resilience and biodiversity.

**Understand the purpose**

The affinity diagram categorises the reasons why it's crucial to analyse ecological disturbances (deforestation, climate change) and how they affect ecosystem resilience and biodiversity.

**Identify key themes**

Brainstorm a list of themes or categories related to ecological disturbances. For this area, some initial categories could be considered such as:

* causes of ecological disturbances
* effects on ecosystem resilience
* impact on biodiversity
* long-term consequences
* mitigation and adaptation strategies.

**Brainstorm factors**

For each theme, generate specific factors, ideas or examples. Use sticky notes (or digital equivalents) to write one factor per note. Below are examples for each category.

1. Causes of ecological disturbances

* human activities (logging, agriculture)
* climate change (rising temperatures, altered rainfall)
* natural disasters (wildfires, storms)
* pollution (air, water and soil pollution).

1. Effects on ecosystem resilience

* loss of species
* decreased ability to recover from disturbances
* fragmentation of habitats
* alteration of natural cycles (water, carbon).

1. Impact on biodiversity

* extinction of species
* loss of genetic diversity
* disruption of food chains
* reduced ecosystem services (pollination, soil fertility).

1. Long-term consequences

* permanent ecosystem damage
* reduced ecosystem services
* increased vulnerability to further disturbances
* economic impacts on industries (fishing, agriculture).

1. Mitigation and adaptation strategies

* reforestation efforts
* conservation of biodiversity hotspots
* policy changes (international agreements, local laws)
* restoration of degraded ecosystems.

**Group similar factors**

Arrange the sticky notes or digital elements by grouping similar ideas or themes together under their respective categories. This grouping should reflect natural connections between the ideas, such as how a cause leads to an effect or how a mitigation strategy addresses a specific problem.

**Label groups**

Once the related notes have been grouped together, label each group with a descriptive heading. For instance:

* habitat destruction might be a group under ‘Causes of ecological disturbances’
* species loss could be under ‘Impact on biodiversity’
* resilience reduction may group factors under ‘Effects on ecosystem resilience’.

**Review and refine**

Check for any overlapping ideas or themes that need to be reorganised or clarified. Make sure each group clearly reflects an aspect of analysing ecological disturbances and their impact on resilience and biodiversity.

**Visualise the affinity diagram**

Visualise once completed:

* causes of ecological disturbances
* logging, pollution, climate change
* increased human activity
* effects on ecosystem resilience
* reduced capacity to recover
* fragmented habitats
* impact on biodiversity
* species extinction, loss of ecosystem services
* long-term consequences
* permanent damage, economic losses
* mitigation and adaptation strategies
* reforestation, conservation policies, ecosystem restoration.

Check student understanding and ask the following guiding questions:

* How do human activities, such as deforestation and industrial agriculture, disrupt the balance of ecosystems and affect their resilience to further disturbances?
* What role does biodiversity play in maintaining ecosystem resilience and how does climate change and deforestation threaten this balance?
* What are the long-term ecological and economic consequences of failing to address the impacts of climate change on ecosystems and biodiversity?
* What mitigation and adaptation strategies are most effective in promoting ecosystem resilience and conserving biodiversity in the face of increasing ecological disturbances?

## Activity 17 – spatial relationships over time

Students use deforestation maps from different time periods to identify significant land-use changes. Students overlay deforestation maps with biodiversity hotspots, protected areas and human activity maps using spatial technologies like ArcGIS or Google Earth. Students document key observations, such as areas where deforestation is most prominent and the proximity to human settlements, roads or protected areas.

Students analyse and interpret the spatial patterns of deforestation.

Students identify key spatial patterns, such as:

* deforestation occurring near roads or major transport routes
* higher rates of deforestation in lowland areas or near human settlements
* proximity of deforestation to protected areas and the potential spillover effects
* patterns of fragmentation within biodiversity hotspots, leading to loss of habitat connectivity.

Students look for correlations between human activities and deforestation, making notes on areas where conservation efforts appear to be effective or where deforestation is encroaching on protected zones.

Check understanding and ask questions based on the activity description provided.

**Map interpretation**

* What are the major changes in land use observed between the different deforestation maps?
* What areas show the highest rates of deforestation and what possible factors contribute to this trend?

**Spatial patterns**

* How does the proximity of deforestation to human settlements and major roads influence the rate of land clearing?
* Are there noticeable differences in deforestation rates between lowland and upland areas? What factors could explain these differences?

**Deforestation and biodiversity**

* How does deforestation within or near biodiversity hotspots affect habitat connectivity?
* In what ways might deforestation near protected areas lead to spillover effects on conservation efforts?

**Conservation and human activity**

* What patterns or correlations can be identified between human activities and areas of deforestation?
* How effective do conservation zones appear to be in curbing deforestation, based on the proximity of deforestation to these areas?

**Impact and solutions**

* What spatial patterns of deforestation suggest that current conservation efforts are working?
* Based on the spatial data, which areas are most at risk of future deforestation and what recommendations would you suggest for improving conservation strategies in these regions?

Ask students to reflect on the spatial relationships between human activity, biodiversity and deforestation, as well as to reflect on the effectiveness of conservation efforts.

## Activity 18 – relief map and land use map of Sumatra

Show how the relief map and land use map of Sumatra can help us understand the challenges and strategies involved in conserving the TRHS, where human activities, such as agriculture and logging, threaten the ecosystem.

Use a relief and land use map of Sumatra. Provided are links to the [relief map of Indonesia,](https://www.bluegreenatlas.com/maps/relief_map_of_indonesia.html) [Indonesia Sumatra ITMB Map](https://www.mapworld.com.au/products/sumatra-itmb) and ARCGIS. Ensure that the maps are clearly labelled and easy to read. Guide students in orienting themselves with the maps by pointing out major landmarks such as cities, rivers or well-known geographical features.

Direct students to the higher elevation areas of Sumatra, where most of the TRHS sites are located. Explain that the topography (steep, forested mountains) makes these areas less accessible for agriculture and more suitable for conservation. Students look at the lowland areas on the relief map, typically shaded in lighter colours (indicating lower elevation). Explain that these areas are usually more prone to human intervention, such as agriculture or urbanisation, due to their flat terrain and fertile soils. Show that these higher elevation areas are preserved due to the difficulty of human access and their importance for biodiversity.

Students to compare the relief map with the land use map. Can they identify areas on the land use map that show agricultural or urban land use? Guide them in connecting lowland areas from the relief map to regions used for human activity on the land use map.

In groups, students analyse specific TRHS regions (for example, Gunung Leuser, Kerinci Seblat) by comparing the relief and land use maps. They should identify areas where human activities (agriculture, logging) are encroaching upon protected areas and areas where the highland topography supports conservation.

Check understanding and ask: ‘Why are lowland areas more likely to be used for agriculture? What factors make these areas suitable for human intervention?’ Direct students’ attention to the highland areas (darker colours on the relief map) that are less accessible and less suitable for agriculture due to steep slopes and lower soil fertility. These areas are more likely to be designated for conservation. Students find conservation areas or national parks on the land use map. Compare these areas with the highland regions on the relief map. Lead a discussion on why these higher elevation areas are more suitable for conservation. Check understanding and ask: ‘How does the topography influence the decision to conserve these areas? What are the benefits of preserving highland regions?’

Ask students to reflect on how land use and conservation strategies in Sumatra are shaped by the region’s topography. Check understanding and ask class a critical thinking question, ‘How might climate change or deforestation affect these patterns in the future? Could some areas shift from conservation to human use or vice versa?’

## Activity 19 – SWOT analysis of the responses and strategies

Students develop a SWOT analysis of the responses and strategies, including for maintaining ecosystem functioning and actions for sustainability (TRHS). Provide a definition of a SWOT analysis template as a tool to evaluate strategies and responses.

* Strengths – internal factors that are advantageous for the strategy or response.
* Weaknesses – internal challenges or limitations.
* Opportunities – external factors that could be leveraged for future benefits.
* Threats – external risks or challenges that may hinder success.

Using a sample strategy (for example, reforestation initiative), model how to complete a SWOT analysis.

* Strengths – high biodiversity potential, strong government support.
* Weaknesses – limited funding, slow regeneration of key species.
* Opportunities – potential for eco-tourism, carbon credit markets.
* Threats – ongoing illegal logging, climate change impacts.

# Quality assurance alignment

**NSW Syllabus:** [Geography 11–12 Syllabus](https://curriculum.nsw.edu.au/learning-areas/hsie/geography-11-12-2022?tab=course-overview) © NSW Education Standards Authority (NESA) for and on behalf of the Crown in right of the State of New South Wales, 2022.

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**Related resources:**

Geography 11–12, including sample assessment schedules, scope and sequences and assessment tasks:

* [Planning, programming and assessing geography 11–12](https://education.nsw.gov.au/teaching-and-learning/curriculum/hsie/planning-programming-and-assessing-hsie-11-12/planning-programming-assessing-geography-11-12)
* Geography Year 12 – sample scope and sequence
* Geography Year 12 – sample assessment schedule.

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# References

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