THE CLIMATE OF HONG KONG

STUDENT HANDBOOK

Contents

The Climate of Hong Kong
Field Trip Handbook

Field Site: Tai Mo Shan Country Park
Duration: 95 minutes
Related Curriculum: F.1-F.3 Science -- Energy and Change

- **Unit 5: Energy**
- **Unit 7: Living Things and Air**

Learning Objectives:

Knowledge:

1. Investigate the tree carbon storage
2. Explain the relationship between forest carbon and climate change
3. Observe the direct correlation between climate and annual tree growth patterns
4. Examine the direct impact of climate on annual tree growth patterns
5. Identify the impact of climate change on vegetation distribution and biodiversity
6. Explain how past climate patterns can help us understand the changes we are experiencing today

Skills:

1. Locate, access, and compare different kinds of data
2. Apply fieldwork techniques to measure trees
3. Apply scientific inquiry into field study

Attitude:

1. Appreciate the beauty of nature in country parks and special areas
2. Foster students' awareness of resources conservation
3. Recognise the need to act responsibly in daily life

Safety Code and Code of Conduct

A. Bring enough drinking water and outdoor equipment, including organic mosquito repellent and rain gear.
B. Do not leave the group without the permission of teacher/ instructor.
C. When observing plant species, one should pay attention to the insects and animals that inhibit on branches and tree trucks. Avoid touching, disturbing or hurting them.
D. Do not take away anything from nature. The fallen part of the plant can only be picked up for observation and should be put back in its original place.
E. Do not eat or pick any branches, leaves, flowers or fruits of the plants.
F. Do not litter or pollute the natural environment.
G. Care for the environment and take your litter home.
H. Seek teacher/instructor's help if needed.

Overview of Field Activities

Warm-up Activity: Visit to the Climate Change Exhibition Gallery
(20 minutes)

- **Checkpoint 1**

Activity 1: Tree Ring Analysis (30 minutes)

- **Checkpoint 1**

*A 10-minute briefing for activity 2 will be held at the Visitor Centre before going to Checkpoint 2.

Activity 2: Tree Carbon Storage Measurement (45 minutes)

- **Checkpoint 2**

Equipment Checklist

Item	Quantity (per group)	✓
Field Trip Handbook	1-2	
Pen/Pencil	2-3	
Clipboard	1-2	
Measuring tape (2m)	1	
Measuring tape (30m)	1	
Calliper	1	
Clinometer	1	
Magnifying glass (for tree ring observation)	1	
Pairs of gloves (if needed)	1	

Photo of Equipment

Measuring tape (2m)

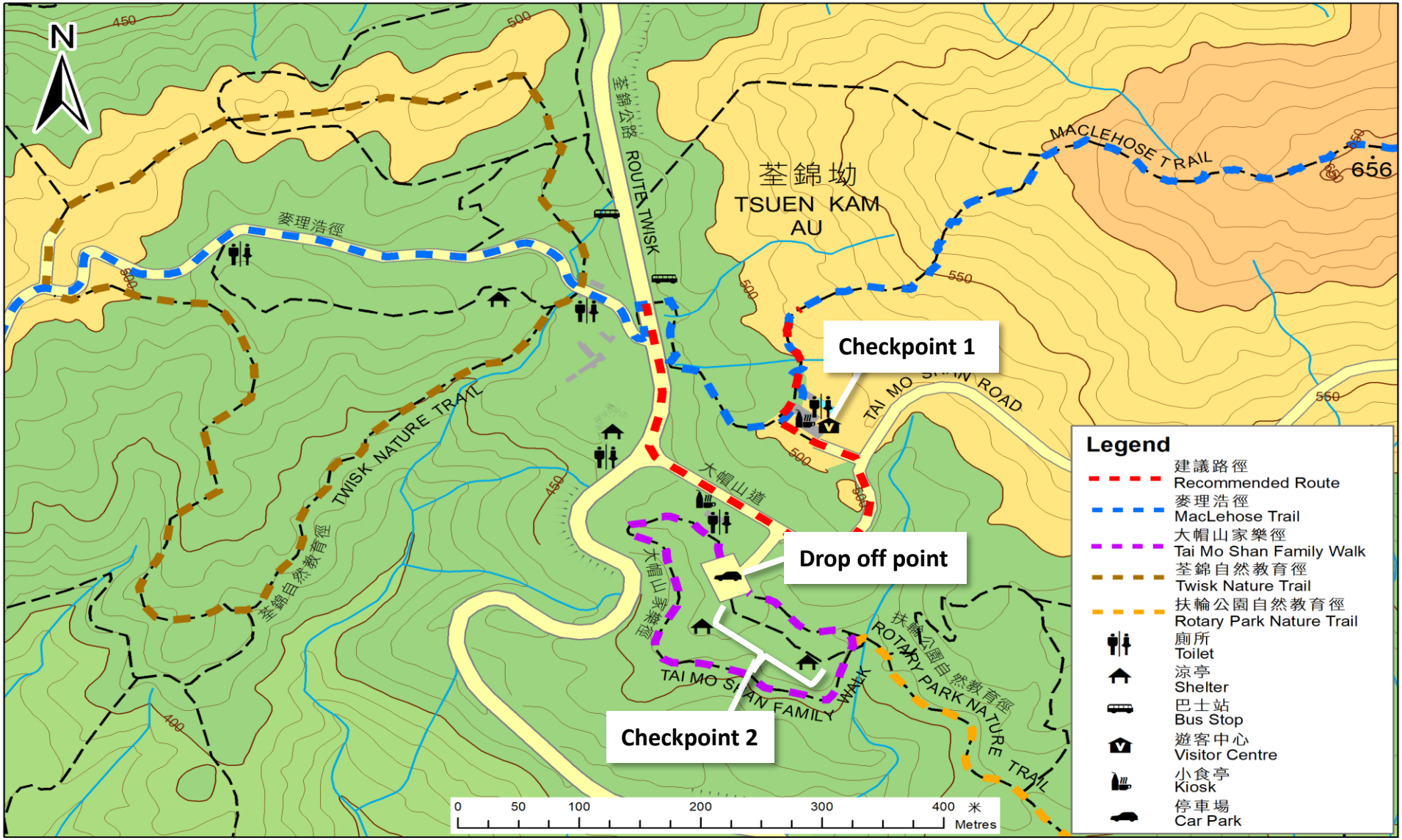
Calliper

Clinometer

Measuring tape (30m)

Magnifying glass

Map of Field Site



Map No. M_R_2021_003_TMS

Visit to the Climate Change Exhibition Gallery

Equipment Checklist	
Items	**Quantity (per group)**
Pen/Pencil	**2-3**
Clipboard	**2**

Time needed: 20 minutes
Venue: Tai Mo Shan Country Park Visitor Centre
Group work: Form a group of 4/5 to complete the following tasks

Task 1: What is Climate Change? (15 minutes)

In order to acquire a basic understanding of climate change issues before the fieldwork, please visit the Climate Change Exhibition Gallery located at Tai Mo Shan Country Park Visitor Centre, and answer the following questions with reference to the information in the gallery. For multiple-choice questions, please circle ONE correct answer in each question.

1. According to IPCC and UNFCCC, which one is not the main cause of climate change?	
A.	Natural climate variability
B.	Deforestation
C.	Spread of viruses
D.	Human activities

2. Which of the following gas is not a greenhouse gas?	
A.	Ozone
B.	Oxygen
C.	Water vapour
D.	Methane

3. Which of the following activities does not contribute to the greenhouse effect?	
A.	Deforestation
B.	Transportation
C.	Energy supply
D.	Communication

4. List two impacts caused by climate change on the global environment.

5. What are the two leading international organisations responsible for driving different countries to cooperate in combating climate change?
1.
2.

6. List four climate change effects in Hong Kong.
1.
2.
3.
4.

7. A higher rate of precipitation increase is recorded in urban areas than in other areas of Hong Kong. What is the reason for this? Please explain your answer.

8. What extreme weather events can be found in Hong Kong? How do extreme weather events affect biodiversity in Hong Kong?

9. How did Agriculture, Fisheries and Conservation Department (AFCD) reconstruct the damaged forest in Tai Mo Shan Country Park? What has been done to enhance the biodiversity in country parks?

10. How many vegetation community types can be found in Tai Mo Shan Country Park? Please write them down.

11. Why are there only frost-tolerant plants on the top of Tai Mo Shan Country Park?

12. Which of the following activities will not help reduce the impact of climate change?	
A.	Recycle paper
B.	Switch off television when you are not watching
C.	Drink plastic bottle beverages
D.	Take public transportation

Task 2: Discussion (5 minutes)

Based on your understanding and own knowledge, discuss the following questions with your groupmates:

1. What are the negative impacts on the environment if AFCD did not reconstruct the damaged forests?
2. What is the role of trees/ vegetation in climate change?
3. Why is biodiversity important to country parks?

Part 1. Introduction of Tree Ring Analysis

Tree Ring Analysis refers as Dendrochronology, the dating and study of annual rings in the trees

Dendrochronology

- **-chronos: time; more specifically, events and processes in the past**
- **Dendros-: using trees; more specifically, the growth rings of trees**
- **-ology: the study of**

Objectives of Tree Ring Analysis:

1. To better understand current environmental processes and conditions
2. To improve understanding of possible future environmental issues

A. Structure of Tree Ring

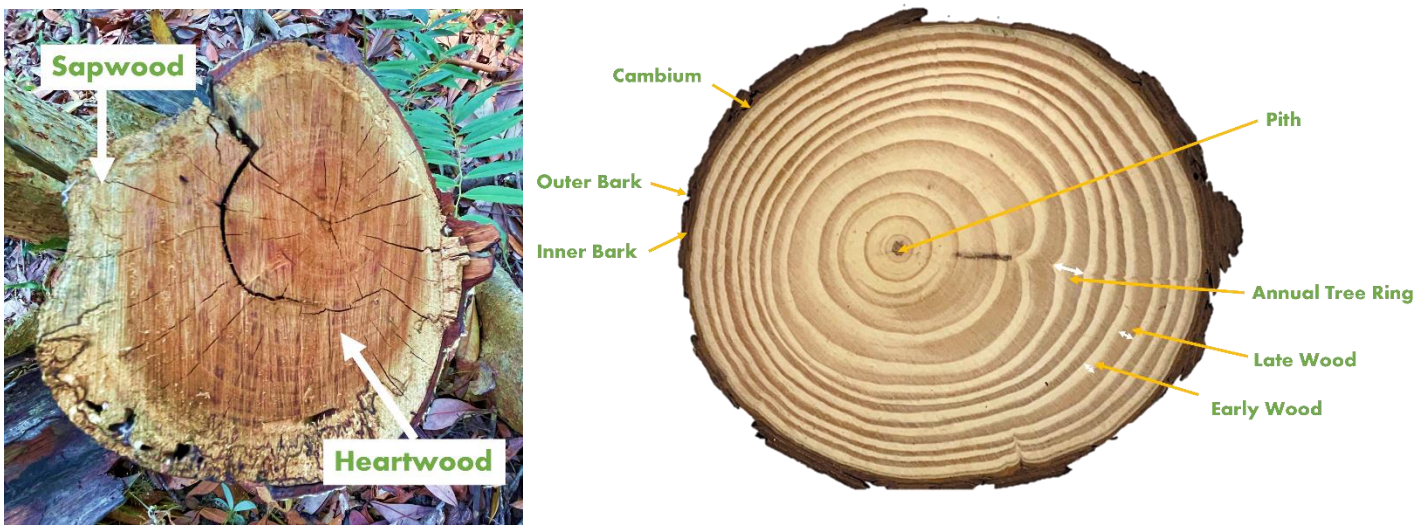
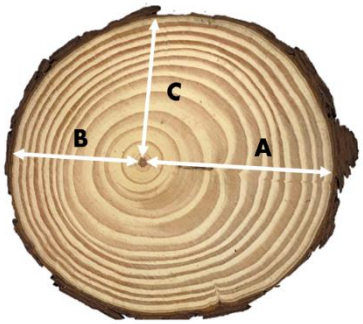


Figure 1. Cross section of a tree stump

B. Ways to Conduct Tree Ring Analysis

- Identify the age of the tree by counting the number of its tree rings from the centre to the outer. The pith and bark should not be counted. It would be better if you know the year that it was cut or was born.
- Observe the tree ring pattern.
- Take three sides from the tree core (shown on the right):
  - Measure and record the width of each tree ring's early and late wood from the three sides with a ruler. Then take the average number.
  - Count the total number of thin rings and compare that with a count of wide rings.
  - Find out the widest and the thinnest rings.



A: The thickest side

B: The thinner side

C: The evenly distributed side

Tree Ring Observation

Equipment Checklist	
Items	**Quantity (per group)**
Pen/Pencil	**2-3**
Clipboard	**2**
Magnifying glass	**2**
Tree ring cookie (displayed at Checkpoint 1)	**1**

Time needed: 30 minutes
Venue: Tai Mo Shan Country Park Visitor Centre
Group work: Form a group of 4/5 to complete the following tasks

Task 1. Observation of Tree Rings (20 minutes)

Observe the tree stump displayed at Checkpoint 1. Can you identify the following tree ring structure provided in Figure 5?

Background information of the tree stump at Checkpoint 1

- Location of where the tree was grown: Hong Kong
- Tree species: *Khaya senegalensis*（非洲桃花心木）

Figure 2. Tree Ring Structure

1a. Tick the tree ring structure that you are able to observe on the tree stump.			
	Sapwood		Pith
	Heartwood		Annual tree ring
	Cambium		Late wood
	Outer bark		Early wood
	Inner Bark		

1b. Roughly sketch the tree ring (with annotations).

2. Why are there variations in the tree-ring width and colour? Suggest what these variations imply.

3. Is there any significant difference between the width of the outermost rings and the width of the rings near the pith? If so, please explain why there is such a difference.

Task 2: Discussion (10 minutes)

1. What factors might influence tree growth?
2. Why is it important to gather information about past climate conditions?
3. If the temperature keeps rising and global warming continues, what would you expect to see in the newly formed tree rings if the tree stump displayed at the Visitor Centre was still alive and continued to grow?

(For more information on tree ring structure, you can refer to the **Supplementary Notes** on p.26-27)

Part 2. Climate Change and Forest Carbon

A. Forest Carbon Cycle

- A critical component of the global carbon cycle.
- **Carbon Sequestration:** the process of absorbing carbon from the atmosphere for use through photosynthesis and transforming it into biomass. This results in the maintenance and growth of plants and trees.
- **Carbon Sinks:** the forest absorbs more carbon from the atmosphere than it releases. Sequestered carbon is then accumulated in forest biomass (trunks, branches, roots, and leaves), dead organic matter (litter and dead wood), and soils.
- **Carbon Source:** the forest releases more carbon than it absorbs. Forest carbon is released when trees burn or decay after dying (as a result of forest fire, insect attack, or other disturbance).
- **Dynamic Carbon Sinks:** The forest carbon sink is dynamic and can gain and lose carbon. The forest carbon sink is quantified by measuring the net annual carbon accumulation (carbon sequestration) by living biomass, soils, and litter in forests.

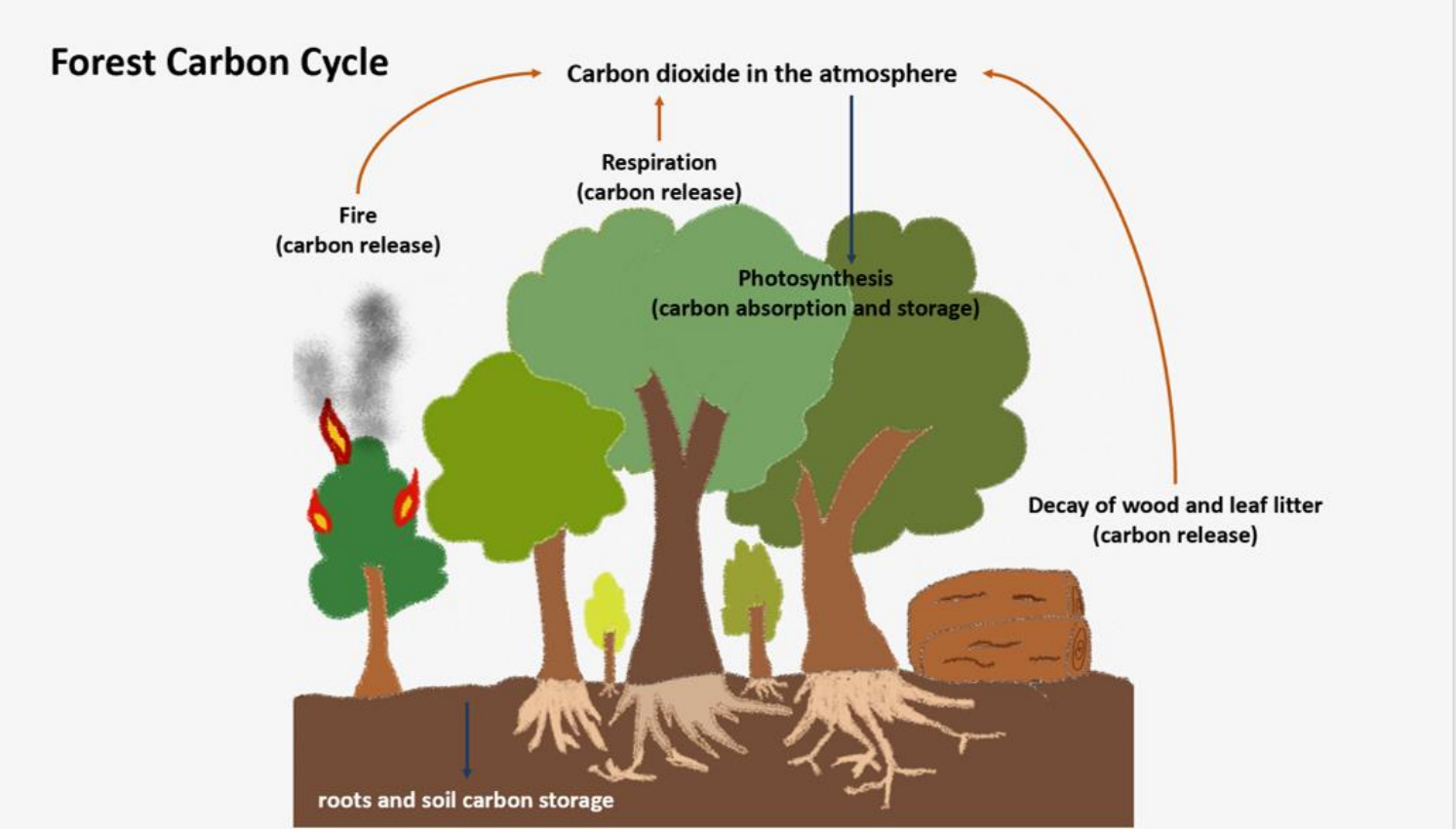


Figure 3. Forest Carbon Cycle

Think Over:

1. What is the relationship between forests, trees, and climate?
2. Besides forests, what other places are important natural carbon pools?

B. Tree Carbon Measurement

This activity aims to allow you to understand the role of forests in mitigating climate change and explore the relationship between forests, carbon dioxide and climate change. This activity requires you to work in groups to conduct tree measurements with field-related techniques. By the end of the field trip, you will be able to understand how forests might help to address the negative impacts brought by climate change.

Instructions

Measure 5 trees and calculate the amount of carbon stored in individual trees with the following steps:

Step 1. Measuring the circumference of the trunk

Step 2. Measuring the tree height

Step 3. Calculating the biomass of the tree

Step 1. Measuring the circumference of the trunk

- Diameter at breast height (DBH) refers to the diameter of a tree trunk measured at breast level (~1.3m). It is a standard and the most common method of measuring tree growth apart from tree height.
- Use a measuring tape to wrap around the tree trunk at 1.3 meters above the ground at the breast height and measure its circumference (Figure 4). Record the data in Table A.
- Below is the equation to calculate the DBH of the tree. Record the data in Table A.
  - **DBH = Circumference / π**
- For young trees or tree seedlings, please use calliper to measure DBH directly (Figure 5).

Figure 4. Using a measuring tape to measure DBH

Figure 5. Using a calliper to measure circumference of the trunk

Step 2. Measuring the tree height

- Choose a point where you can see the top of the tree. The distance between the point and tree should be at least or about the height of tree.
- Measure the distance (D) from the point to the tree with a measuring tape.
- Measure the distance between the top of the tree and the point using the clinometer.
  - Look through the clinometer with one eye. Line up the crosshair of the clinometer with the treetop.
- Read the degree scale on the clinometer (Angle of clinometer).
- Calculate the tree height using the following equation:

Tree height(h) = tanA × distance to tree (D) + eye height (above the ground)

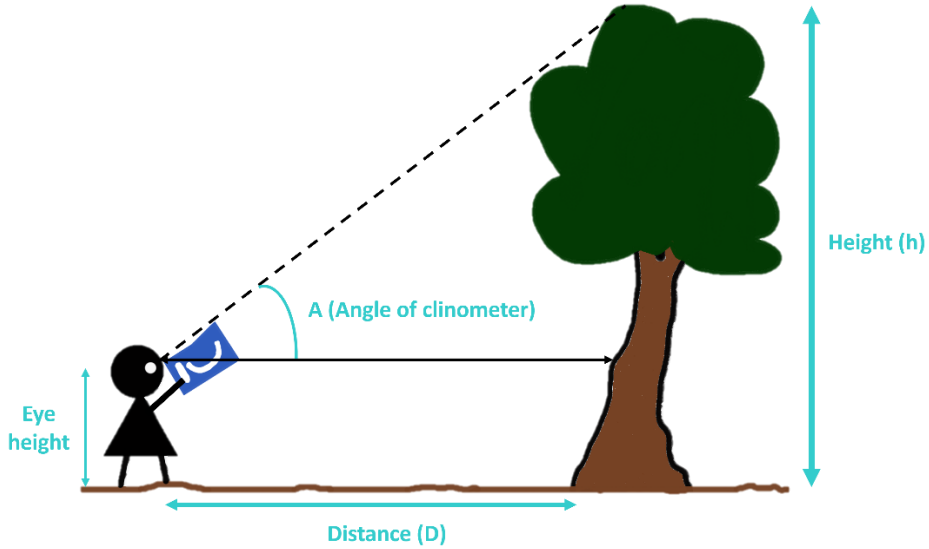


Figure 6. Using a clinometer to measure tree height

Conduct each tree measurement three times

Step 3. Calculation of the biomass of the tree

A. Measuring the total green weight (GW) of the tree

Green weight refers to the estimated weight of an alive tree, containing the wood content and the moisture in the tree.

Formula for calculating the green weight of an above-ground weight:

Trees with diameter <28 cm: $GW = 0.0577 \times (DBH)^2 \times \text{Tree height}$

Trees with diameter >28 cm: $GW = 0.0346 \times (DBH)^2 \times \text{Tree height}$

B. Measuring the dry weight (DW) of the tree

Dry weight refers to the weight of wood mass with the removal of moisture. On average, the dry weight is approximately 50% of its green weight.

Formula for calculating the dry weight of an above-ground weight:

$GW \times 0.5 = DW$

C. Measuring the carbon storage (CS) of the tree

Carbon storage refers to the amount of carbon stored in the wood of a tree through photosynthesis. On average, around 50% of the dry weight is carbon.

Formula for calculating the tree carbon storage:

$DW \times 0.5 = CS$

Tree Carbon Storage Measurement

Equipment Checklist	
Items	**Quantity (per group)**
Pen/Pencil	**2-3**
Clipboard	**2**
Measuring tape (2m)	**1**
Measuring tape (30m)	**1**
Clinometer	**1**
Calliper	**1**
Calculator	**1**

Time needed: 10 minutes (Indoor revision); 35 minutes (Outdoor data collection)
Venue: Checkpoint 2
Group work: Form a group of 4/5 to complete the following tasks

Task 1. Measuring the carbon stored in a tree

Please follow the scientific inquiry process to conduct tree carbon analysis

1. IDENTIFY THE PROBLEMS

Discuss the following questions with your groupmates

- What process is needed for plants to make their own food? What factors are required in this process?
- What is the significance of this process to other living things?
- Where is the carbon stored in trees?
- How much carbon do you think might be stored in a tree?

2. SET THE INQUIRY QUESTIONS

- **Develop an inquiry question based on your research**
- **Set the question(s) with "How, What, When, Who, Which, Why or Where"**

Compulsory: How much carbon is stored in a tree?

Optional: Set your own inquiry question:

3. DATA COLLECTION

- **Record your data in Table A-C (P.20-21)**
- **Present your data in an appropriate format**

Primary Data Collection	
1	Measure tree carbon storage in each group following the steps listed on P.14-16
2	Identify 5 trees at the field site in the measurement
3	Tree Height Measurement – Table A
4	Tree Circumference Measurement – Table B
5	Calculation of Tree Biomass and Tree Carbon Storage – Table C

Primary Data Collection

Record your data collected in the following tables:

Table A. Tree Circumference

Tree Circumference		
Tree no.	**Circumference (cm)**	**DBH (cm)**
1		
2		
3		
4		
5		

Equation to calculate the DBH of tree:

DBH = Circumference / π

Table B. Tree Height

Tree Height							
Tree no.	D Distance to the tree (m)	Clinometer reading (º)		$\tan\theta$ tan [Clinometer reading (º)]	h Eye height above the ground (m)	Tree height (m)	Average tree height (m)
1		1st					
		2nd					
		3rd					
2		1st					
		2nd					
		3rd					
3		1st					
		2nd					
		3rd					
4		1st					
		2nd					
		3rd					
5		1st					
		2nd					
		3rd					

Tree height = tan [Clinometer reading (º)] × Distance to tree + Eye height above the ground

Tree height = $\tan\theta$ × D + h

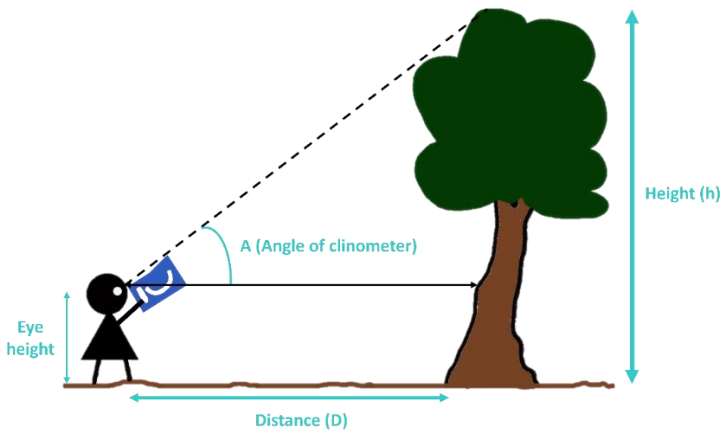


Table C. Tree Carbon Storage

Tree Carbon Storage			
Tree no.	**Green weight (kg)**	**Dry weight (kg)**	**Carbon storage (kg)**
1			
2			
3			
4			
5			

4. DATA ANALYSIS

1. **Based on the data recorded in Tables A and C, what relationship do you observe?**

2. **Discussion:**

Based on the data collected and your own knowledge, answer the following questions:

a. What is the relationship between carbon dioxide and climate change?

b. What is the role of tree carbon storage in climate change?

5. DRAW CONCLUSIONS

Answer the compulsory inquiry question:

How much carbon is stored in a tree?

Optional: Answer your own inquiry question:

Challenge

Plant Identification: Would you be able to find out this low land tree at the field site? Let's try with the help of Plant Identification Card and think about how climate change would influence this tree.

Common name:
Ivy Tree

Tips:
Its palmately compound leaves look like duck or goose webs, which its Chinese common name also indicates this resemblance.

Post-trip Activity: Discussion

Based on the data collected in the field activity and your own knowledge, discuss the following questions with your groupmates:

1. Why are trees/plants important in maintaining the natural balance of oxygen and carbon dioxide in the atmosphere? What are the processes involved in maintaining this balance?

2. In the last hundred years until now, human activities have been disturbing the natural balance of oxygen and carbon dioxide in the atmosphere, contributing to increased carbon dioxides in our atmosphere. Figures 7 & 8 indicate the annual greenhouse gas (GHG) emission trends of Hong Kong and the GHG emission by sector in Hong Kong from 1990-2020. Describe and explain the GHG emission trend of Hong Kong from 2010 to 2020. Select one sector and discuss measures that can be taken to reduce GHG emissions.

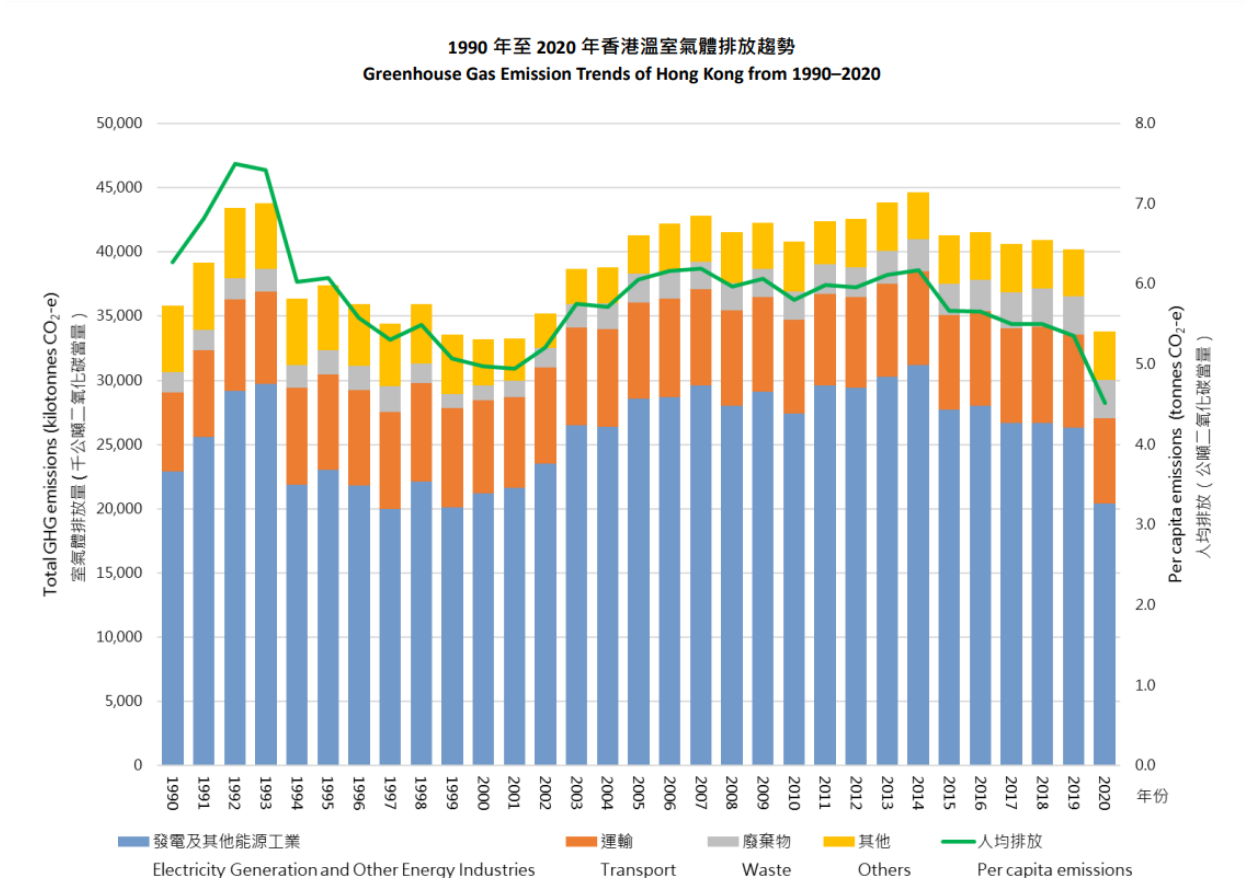


Figure 7. Greenhouse Gas Emission Trends of Hong Kong from 1990-2020 (Environment Bureau, 2022)

香港溫室氣體排放量（按排放源劃分）
Greenhouse Gas Emissions in Hong Kong (by Sector)

單位 Unit：千公噸二氧化碳當量 kilotonnes CO_2-e

年份 Year	能源 Energy			廢棄物 Waste	工業過程及產品使用 Industrial Processes and Product Use	農業、林業及其他土地利用 Agriculture, Forestry and Other Land Use	總數 TOTAL
	發電及其他能源工業 Electricity Generation and Other Energy Industries	運輸 Transport	其它燃料耗用@ Other End Use of Fuel@				
1990	22,900	6,160	4,840	1,550	215	139	35,800
1991	25,600	6,720	4,510	1,600	638	121	39,200
1992	29,200	7,110	4,720	1,660	651	99	43,500
1993	29,700	7,210	4,320	1,750	724	86	43,800
1994	21,900	7,520	4,240	1,770	830	76	36,400
1995	23,000	7,430	4,040	1,940	935	84	37,400
1996	21,800	7,410	3,810	1,900	952	84	35,900
1997	20,000	7,540	3,750	2,000	1,050	74	34,500
1998	22,100	7,670	3,560	1,550	978	68	36,000
1999	20,100	7,710	3,540	1,110	1,020	82	33,500
2000	21,200	7,270	2,530	1,120	978	75	33,200
2001	21,600	7,090	2,340	1,260	862	82	33,200
2002	23,500	7,530	2,100	1,490	503	79	35,100
2003	26,500	7,610	2,140	1,800	540	72	38,700
2004	26,400	7,600	2,110	2,000	634	65	38,800
2005	28,600	7,490	2,070	2,230	857	72	41,300
2006	28,700	7,650	2,250	2,160	1,380	72	42,300
2007	29,600	7,470	2,200	2,180	1,340	50	42,800
2008	28,000	7,450	2,320	2,160	1,560	29	41,500
2009	29,100	7,390	2,210	2,210	1,370	25	42,300
2010	27,400	7,340	2,280	2,200	1,580	32	40,800
2011	29,600	7,150	1,950	2,290	1,350	32	42,300
2012	29,400	7,090	2,090	2,340	1,640	29	42,600
2013	30,300	7,240	2,080	2,530	1,690	31	43,900
2014	31,200	7,290	1,990	2,500	1,630	30	44,700
2015	27,700	7,410	2,020	2,400	1,710	30	41,300
2016	28,000	7,400	2,010	2,450	1,650	30	41,500
2017	26,700	7,360	2,020	2,800	1,720	30	40,600
2018	26,700	7,470	2,090	2,980	1,690	29	41,000
2019	26,300	7,270	1,940	2,950	1,710	28	40,200
2020	20,400 (60.4%)	6,650 (19.7%)	1,970 (5.8%)	2,960 (8.7%)	1,780 (5.3%)	35 (0.1%)	33,800 (100%)

註釋 Notes:

由於四捨五入關係，統計表內個別項目的數字加起來可能與總數略有出入。

There may be a slight discrepancy between the sum of individual items and the total as shown in the table owing to rounding.

數值以三個有效數字表示

Numbers are rounded to three significant figures

@ 「其它燃料耗用」包括在商業、工業及住宅中耗用的燃料

The "Other End Use of Fuel" includes the use of fuel for combustion in commercial, industrial and domestic premises.

Figure 8. Greenhouse Gas Emissions in Hong Kong (by Sector) (HKSAR, 2022)

3. AFCD conducts afforestation work regularly and has implemented Country Parks Plantation Enrichment Programme (PEP) since 2009 (Figure 9-12). What is the significance of these activities in climate change?

Figure 9. AFCD holds Country Parks Hiking and Planting Day for the general public

Figure 10. Notice board introducing Country Parks Plantation Enrichment Project near the PEP site in the country parks

Figure 11. Afforestation work

Figure 12. Planting of native seedlings

Challenge

Refer to the plant identification challenge task, how Ivy Tree will be affected by climate change?

Post-trip Activity: Your Carbon Emissions

Task 1:

Calculate your carbon footprint using the carbon calculator provided below:

https://www.carboncalculator.gov.hk/en

1. **What are your annual carbon emissions? _____ tonnes CO^2 equivalent**
2. **Which category contains the highest amount of your annual carbon emission (circle the option)?**
   - Clothing
   - Food
   - Living
   - Travel

3. **Calculate how many trees would be needed to offset your annual carbon emission** (using the highest tree carbon storage from your primary data collection for the calculation)
   *Tip: 1 ton = 1000 kg

Number of trees needed to offset your annual carbon emission:

Task 2: Discussion

1. How do your daily activities (based on the category that contains the highest amount of your annual carbon emission) affect carbon emissions?

2. What can be done to reduce your carbon emissions?

Part A. Information on Tree Ring Structure:

Structure of Tree Ring

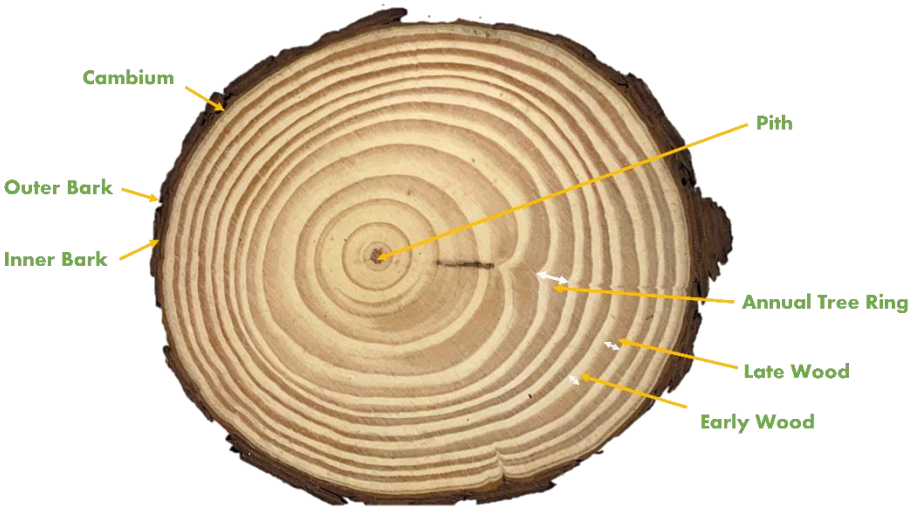


Figure 1. Cross section of a tree stump

COMPONENT	DESCRIPTION
ANNUAL TREE RING 年輪	▪ Distance between 2 rings represents 1 year growth ▪ Annual rings only grow in climates with temperate climates and not tropical climates – where growth occurs all year round ▪ Each year, a tree grows, and a ring is added ▪ Early wood + Late wood = 1 year growth = a ring
EARLY WOOD 早材/春材	▪ During spring and early summer, the growth rate is more rapid, producing large-vessel cells ▪ Appearance: More porous, lightly coloured wood in a wide ring
LATE WOOD 晚材/秋材	▪ During late summer and fall, water becomes more scarce, and the growth rate slows down, producing smaller cells ▪ Appearance: Darker, tighter-grained wood in a narrow ring
PITH 樹心	▪ At the centre of the trunk and is made up of original sapling cells
INNER BARK 內樹皮(韌皮部)	▪ A thin moist layer, also called as phloem ▪ New bark cells are produced as the old cells died ▪ Food is carried down the tree from the leaves
OUTER BARK 外樹皮	▪ A thick layer of cork surrounds the trunk and the branches ▪ Protect against damage from weather, animals, insects and fungus ▪ Prevent evaporation of moisture and minerals from the tree

CAMBIUM 形成層	▪ A layer of cells under the bark ▪ This is where the growth of the tree occurs ▪ Xylem cells are found on the inside of the cambium layer next to the sapwood and this is where water and minerals are transported to the leaves from the roots ▪ Phloem cells are found outside the cambium layer next to the bark. This is where food from the leaves is transported to the tree ▪ This energy causes the phloem cells to split. The outer half becomes new phloem cells and the inner half become the new xylem cells (forms an annual ring) ▪ As new xylem cells are formed the tree grows taller and thicker
SAPWOOD 邊材	▪ As the tree grows layers of cells are added to the sapwood ▪ It is light-coloured wood in the trunk ▪ As the sapwood carries nutrients and moisture to the leaves from the roots it is moist, therefore it is prone to attack from fungi and insects
HEARTWOOD 心材	▪ Darker colour than sapwood ▪ Found beside the pith close to the centre of the tree ▪ Made up of dead mature cells that no longer transport water or nutrients ▪ Provide support for the tree ▪ Heartwood is more durable and resistant to fungal and insect attacks than sapwood

Part B. Explanation of Tree Ring Pattern

- If rings become thicker on one side than the other, the tree leans to one side. Strong winds or big storms can also cause a tree to lean.
- Scars and other marks can be from insect damage, disease, lightning strikes, or forest fire.
- Dry or drought conditions will cause less growth (thinner rings) during the growing season.
- Favorable conditions will result in more growth (thicker rings).
- If the rings are in a consistent width throughout the tree, the climate was the same year after year.

Plants Identification Card

Chinese Name: 鴨腳木/ 鵝掌柴

Common Name: Ivy Tree

Scientific Name: *Schefflera heptaphylla (L.) Frodin*

Shape: Evergreen medium-sized tree or shrub, <10m tall

Stem: Greyish-brown and smooth

Leaf: Alternate and palmately compound

Flower: Aug-Sep, white

Fruit: Dec-Feb, black

Habitats: Shrublands; Low-hill forests; Lowland woodlands

Native species