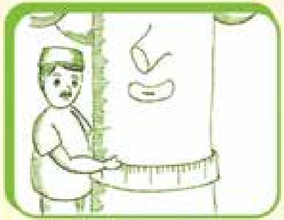
COMMUNITY CARBON ACCOUNTING

Manual for Carbon Accounting in Community Forestry



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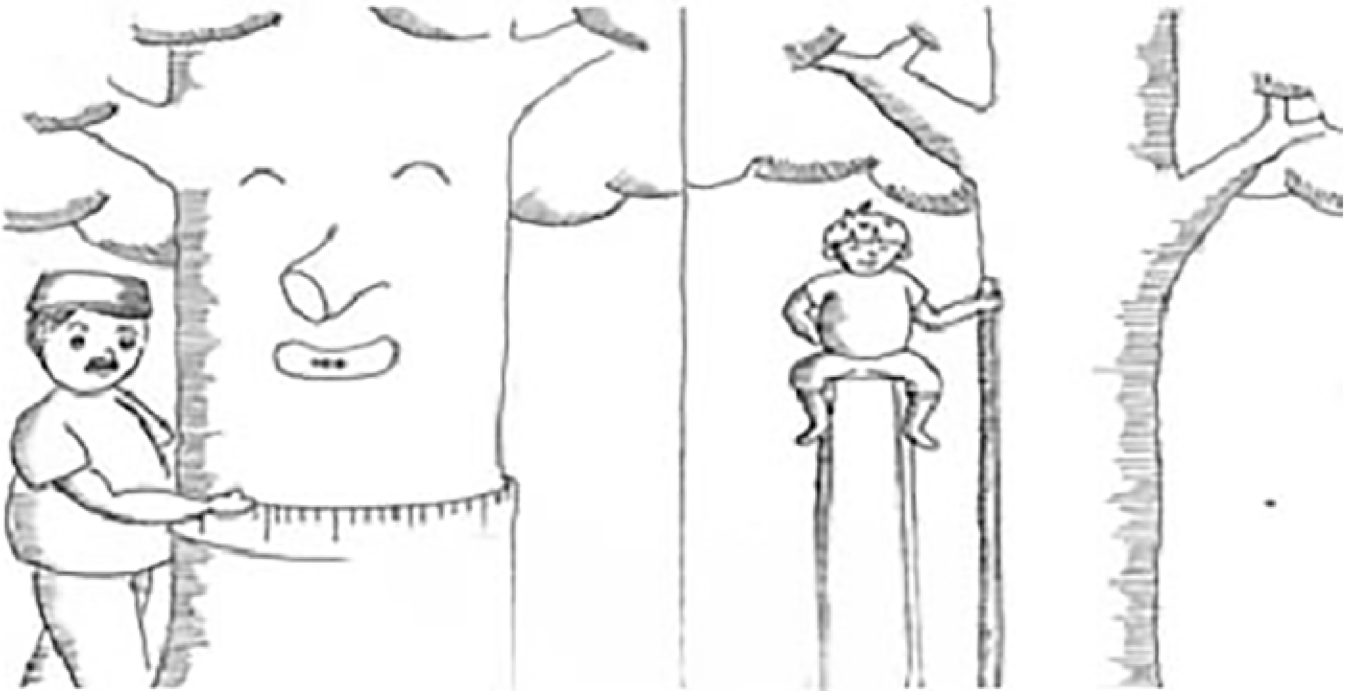
IGES
Institute for Global Environmental Strategies

Ministry of the Environment



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Community Carbon Accounting
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PREFACE

Forest management by local communities provides local benefits and ecosystem services, and can contribute to global climate change mitigation. As an element of community-based forest management, Community Carbon Accounting (CCA) is a unique approach in which local communities measure and monitor the carbon stock of their forests. The knowledge and information generated from this measurement supports the communities in making informed decisions about their forest use and management.

The CCA action research project was launched in 2010 in Indonesia by the Institute for Global Environmental Strategies (IGES), the DKN (Dewan Kehutanan Nasional - National Forestry Council) and ARuPA (Aliansi Relawan Untuk Penyelamatan Alam) with funding from the Ministry of Environment of Japan and the Asia-Pacific Network for Global Change Research (APN). The action research has been implemented in Semoyo Village, Gunung Kidul Regency and Terong Village, Bantul Regency, Yogyakarta Province. Working closely with the communities, approaches and methods have been developed and tested, and farmers from the two villages have built their institutions and capacity to monitor carbon within their forests.

This “Manual for Carbon Accounting in Community Forestry” is designed to support local communities and farmers in learning to monitor carbon for community forestry. The manual has been developed by ARuPA with support from IGES and DKN. It reflects the knowledge acquired during the action research and activities in Semoyo Village and Terong Village. The CCA community leaders in Semoyo Village have also participated in the process to develop the manual. We hope that this manual provides useful and clear guidance for trainers and local communities to engage actively with sustainable forest management and actions for climate change mitigation.

Yogyakarta, February, 2016
ARuPA

Table of Contents

Introducing the manual: What is this manual about?

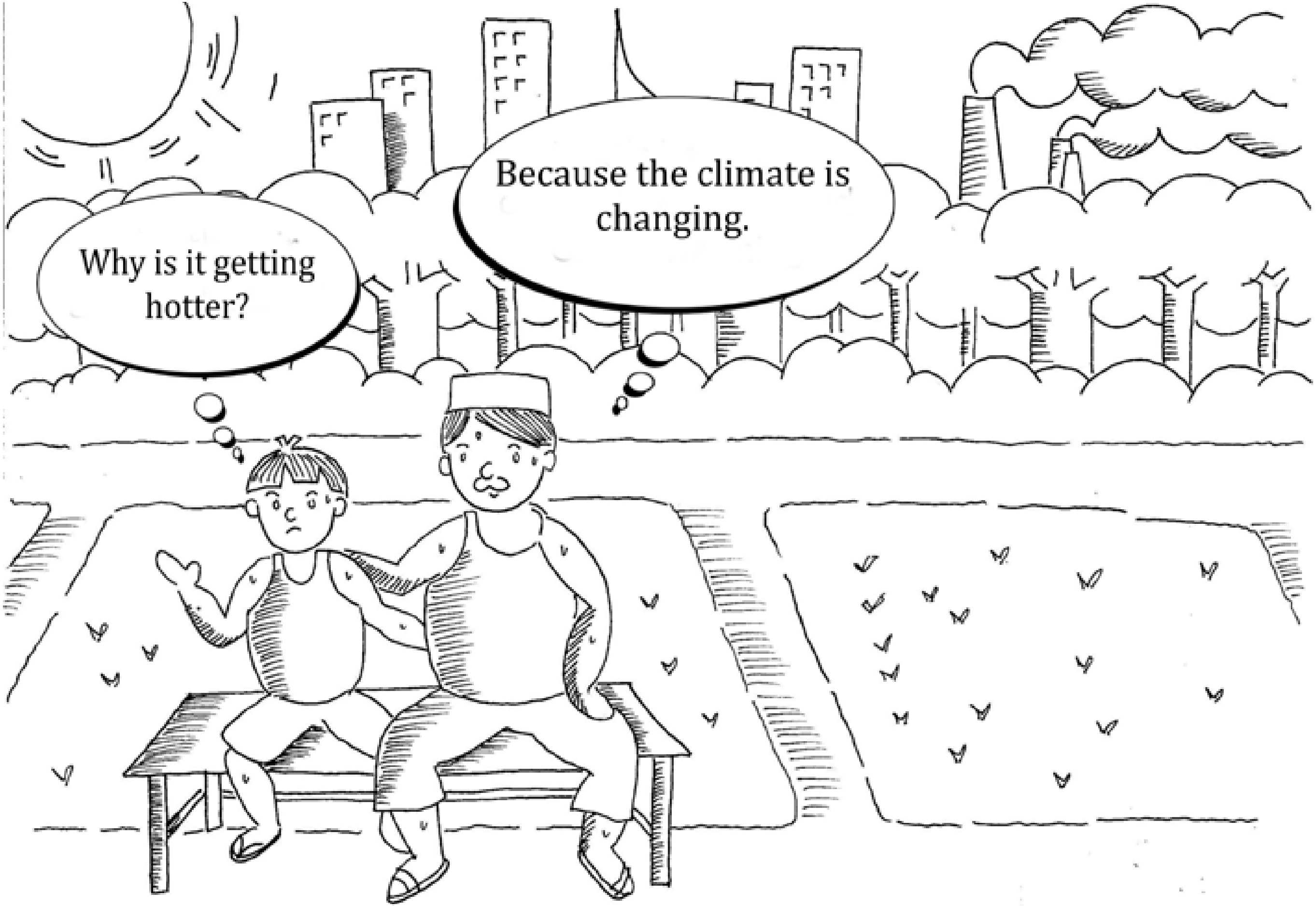
This “Manual for Carbon Accounting in Community Forestry” is designed to support local communities and farmers in learning to monitor carbon for community forestry. Also the manual can be used by trainers and facilitators as a reference material to assist local communities to measure and monitor the carbon stock of their forests.

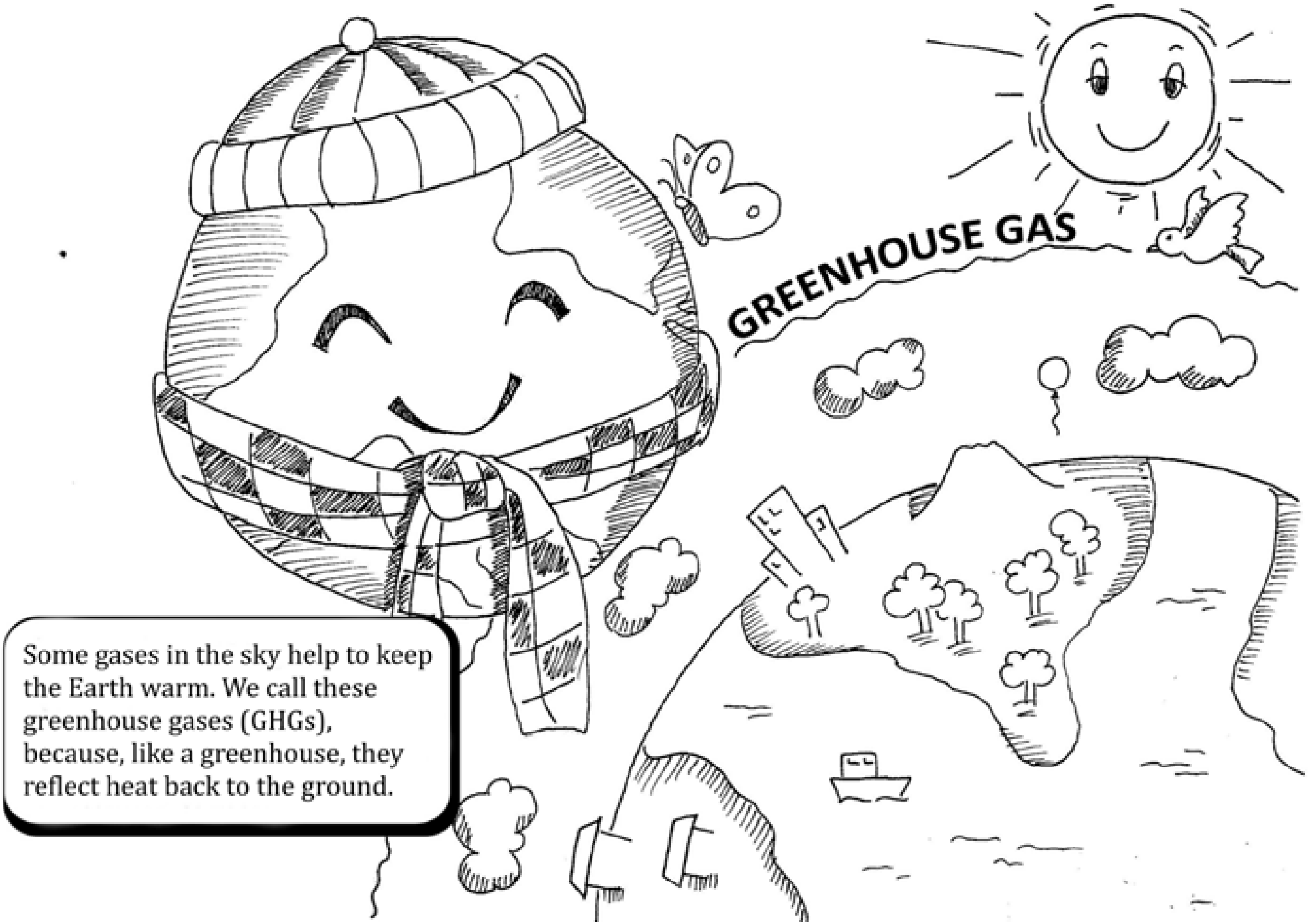
The manual is divided into three parts, are: Part 1 introduces what climate change is and explains the roles of forests to mitigate climate change impacts. Part 2 explains field measurement to estimate the carbon stock in the community forest. Part 3 describes steps to calculate the carbon stock using Microsoft Excel examples.

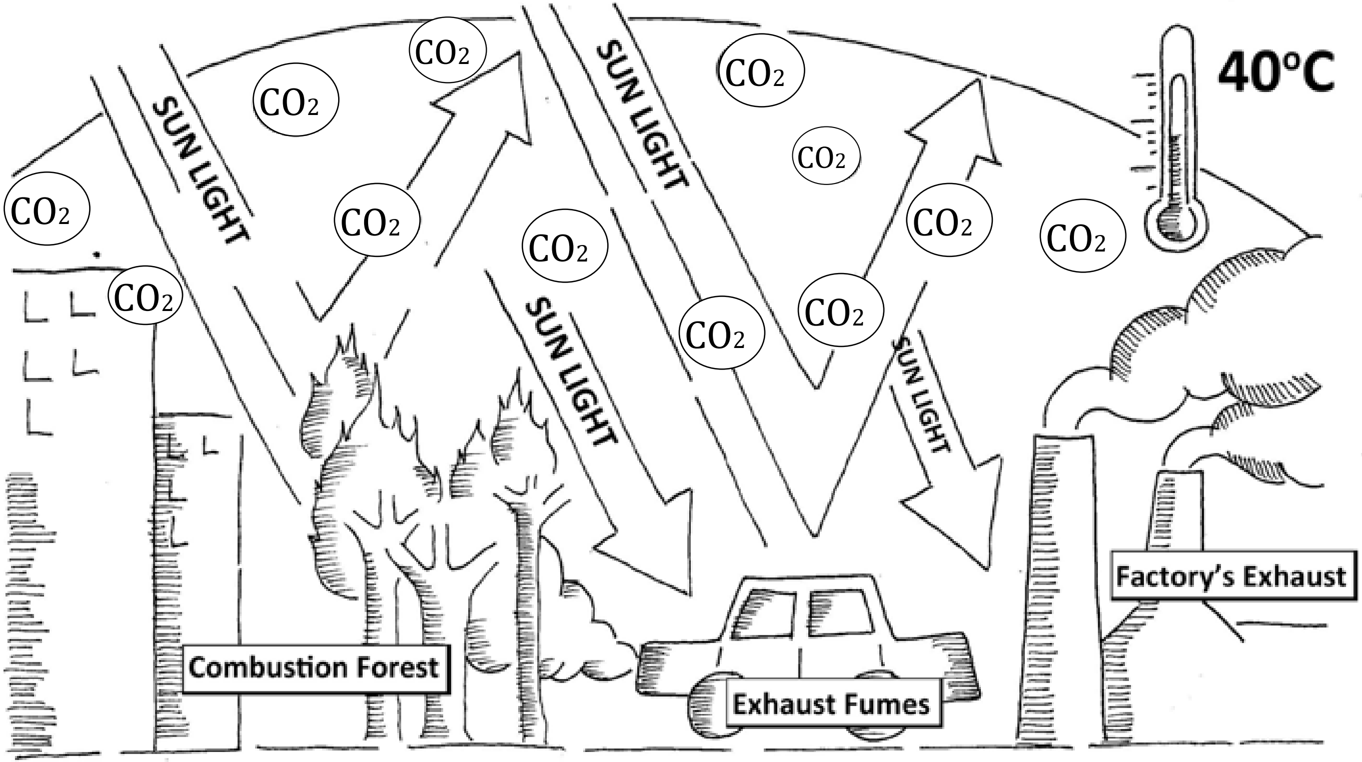
Please do not forget to carry this manual with you into the forest!

Part 1

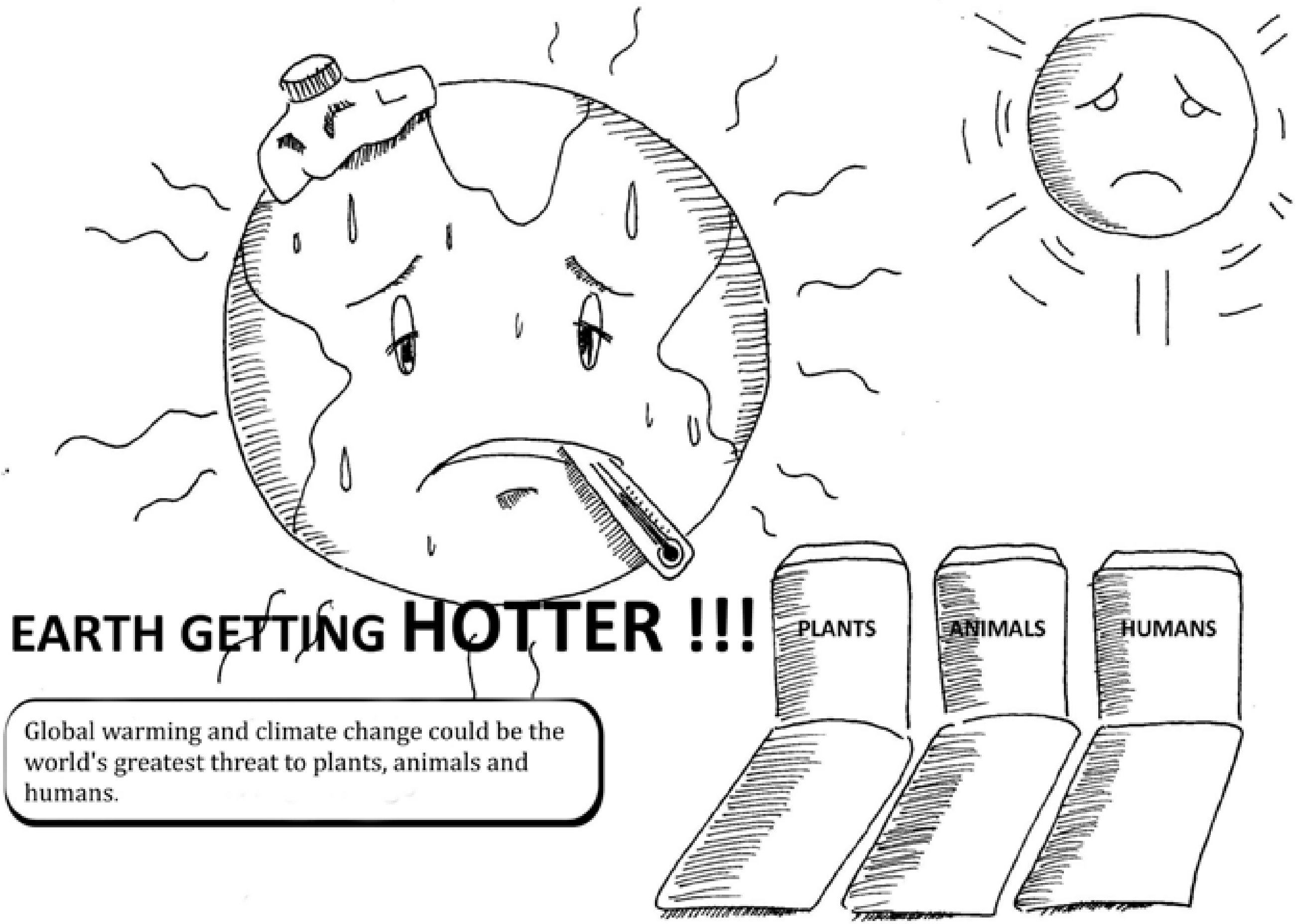
Climate Change and Carbon

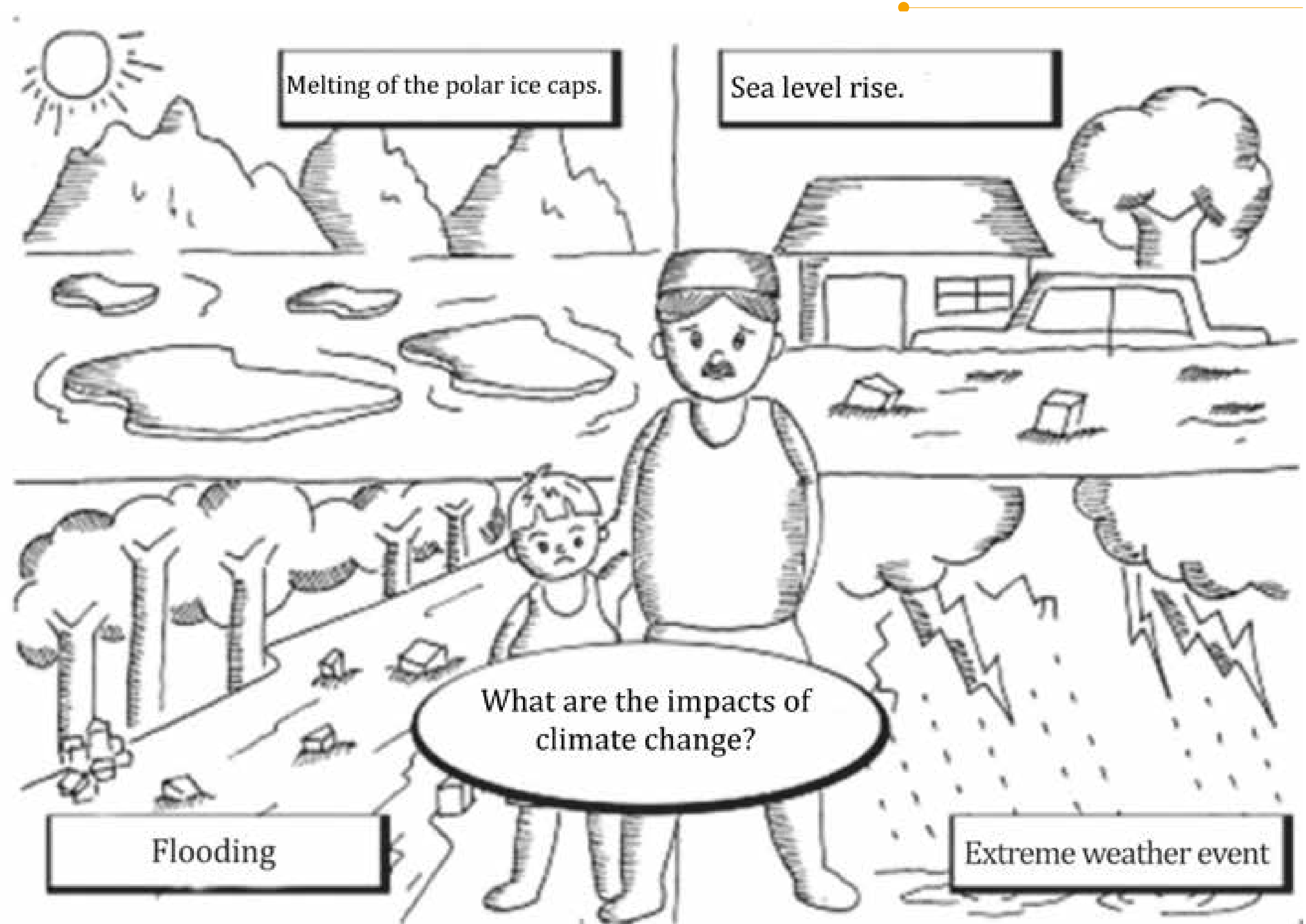

Why is it getting hotter?
Because the climate is changing.

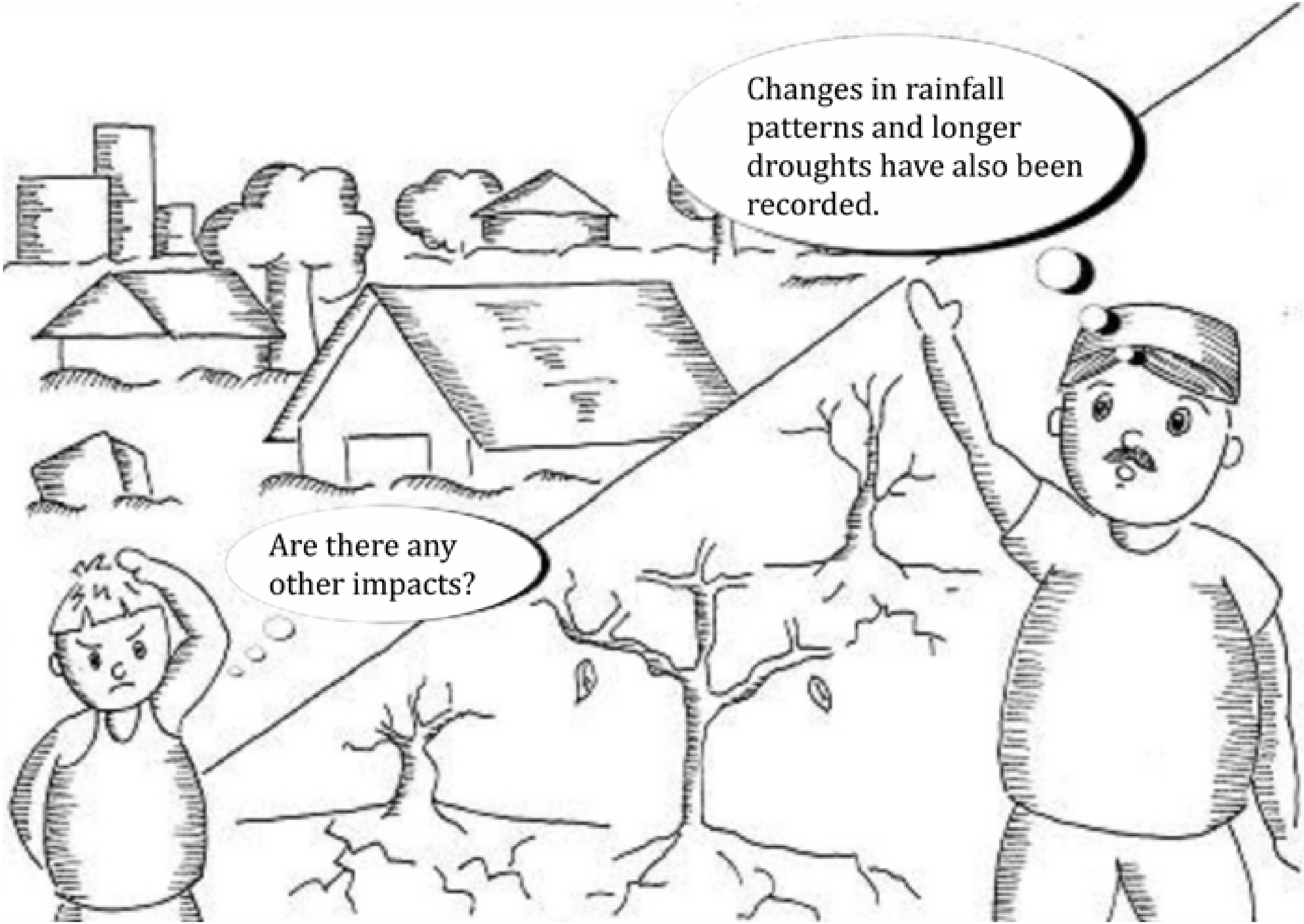

GREENHOUSE GAS
Some gases in the sky help to keep the Earth warm. We call these greenhouse gases (GHGs), because, like a greenhouse, they reflect heat back to the ground.

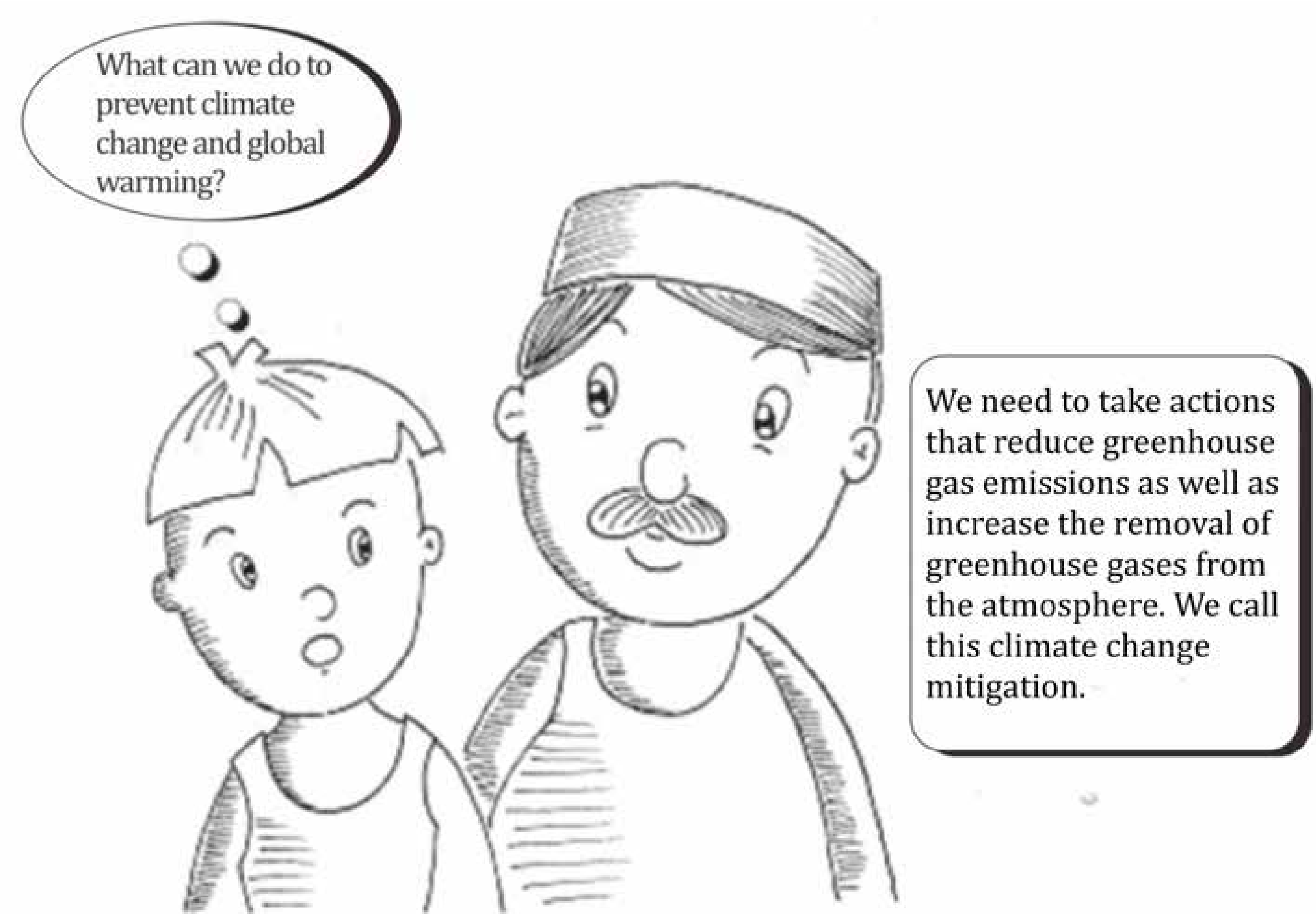


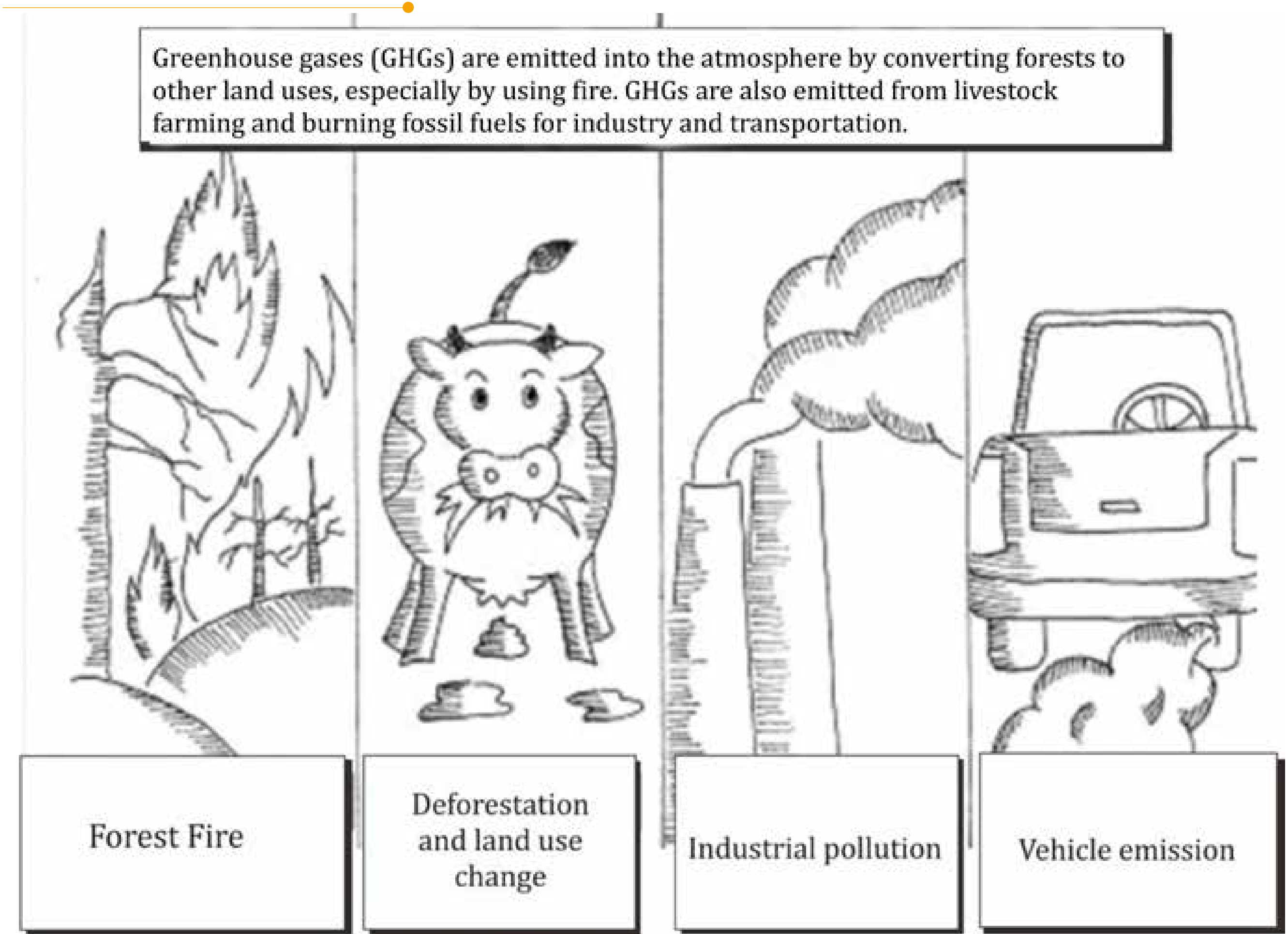
Due to the human activities, CO_2, and other greenhouse gasses have been increasingly emitted to atmosphere. Consequently average of the Earth's surface is getting warmer. This is what we call global warming and climate change.

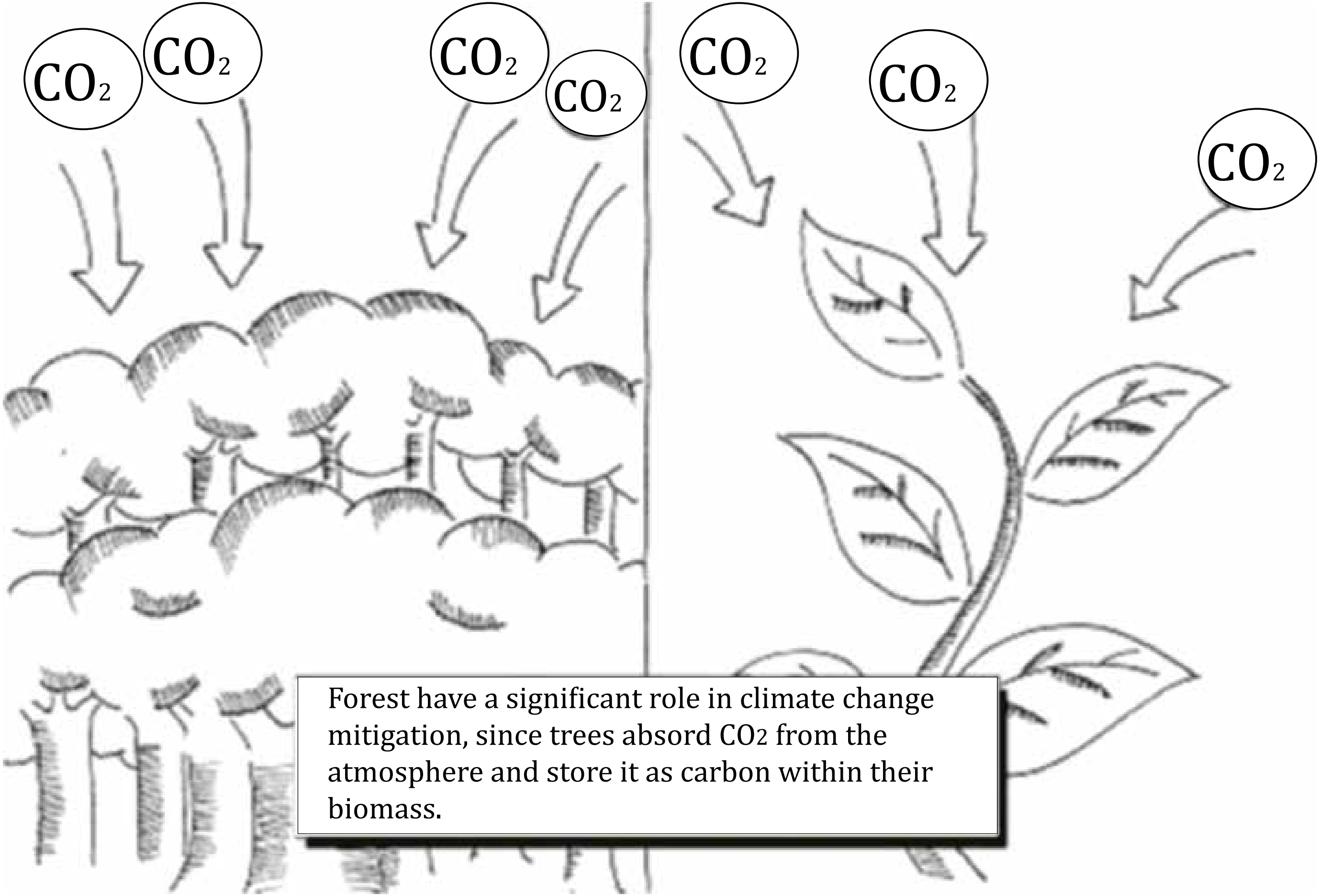

EARTH GETTING HOTTER !!!
Global warming and climate change could be the world's greatest threat to plants, animals and humans.
PLANTS
ANIMALS
HUMANS


Melting of the polar ice caps.
Sea level rise.
What are the impacts of climate change?
Flooding
Extreme weather event

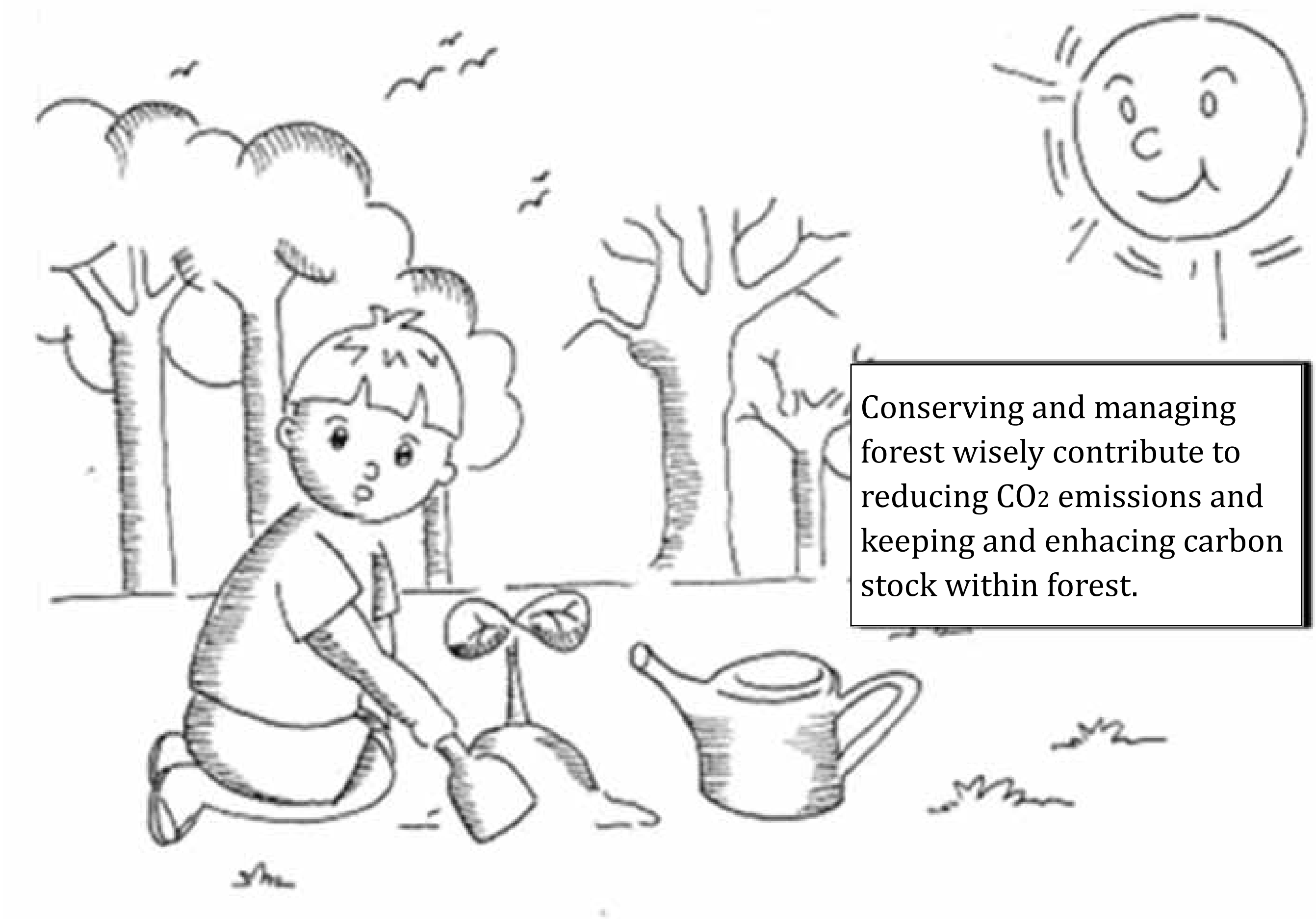

Changes in rainfall patterns and longer droughts have also been recorded.
Are there any other impacts?

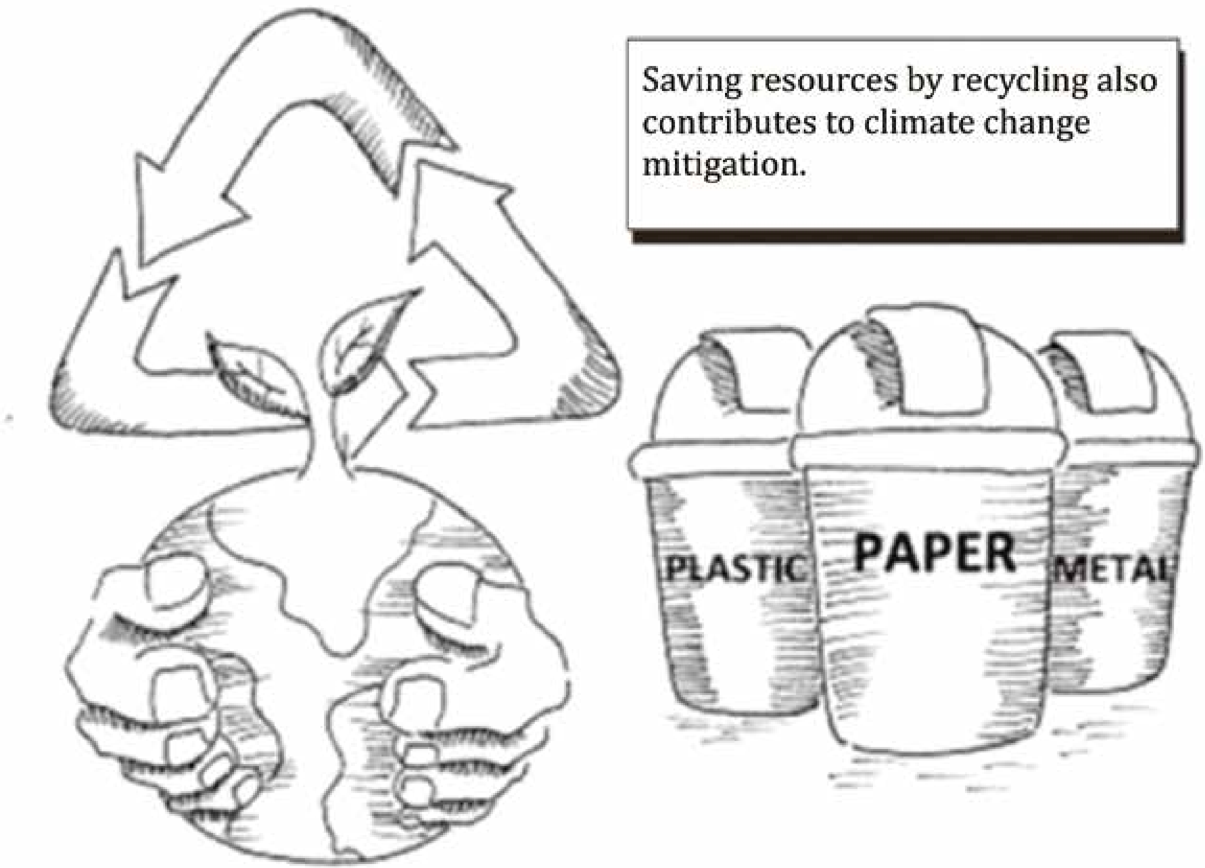

What can we do to prevent climate change and global warming?
We need to take actions that reduce greenhouse gas emissions as well as increase the removal of greenhouse gases from the atmosphere. We call this climate change mitigation.

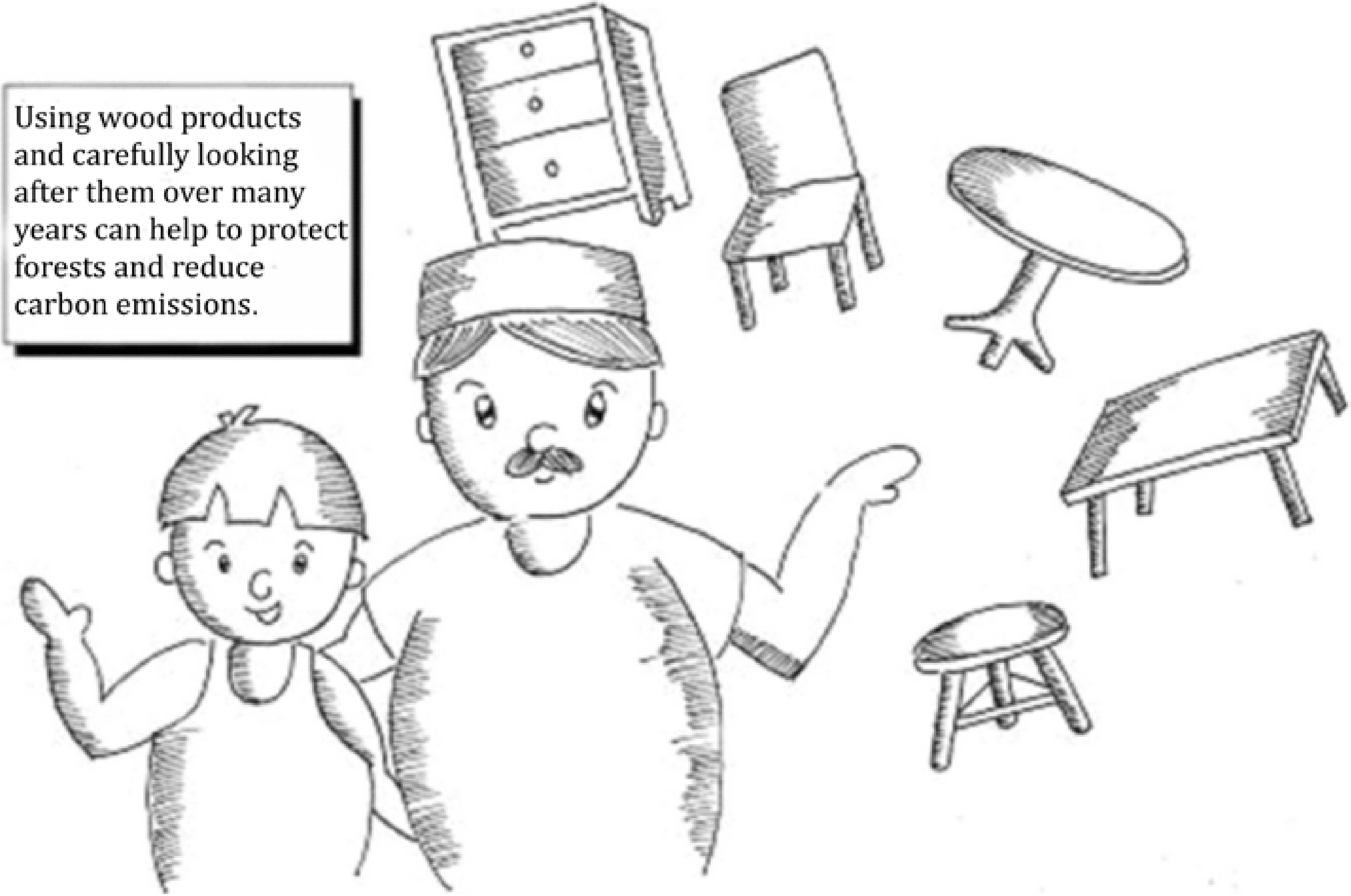

Greenhouse gases (GHGs) are emitted into the atmosphere by converting forests to other land uses, especially by using fire. GHGs are also emitted from livestock farming and burning fossil fuels for industry and transportation.
Forest Fire
Deforestation and land use change
Industrial pollution
Vehicle emission

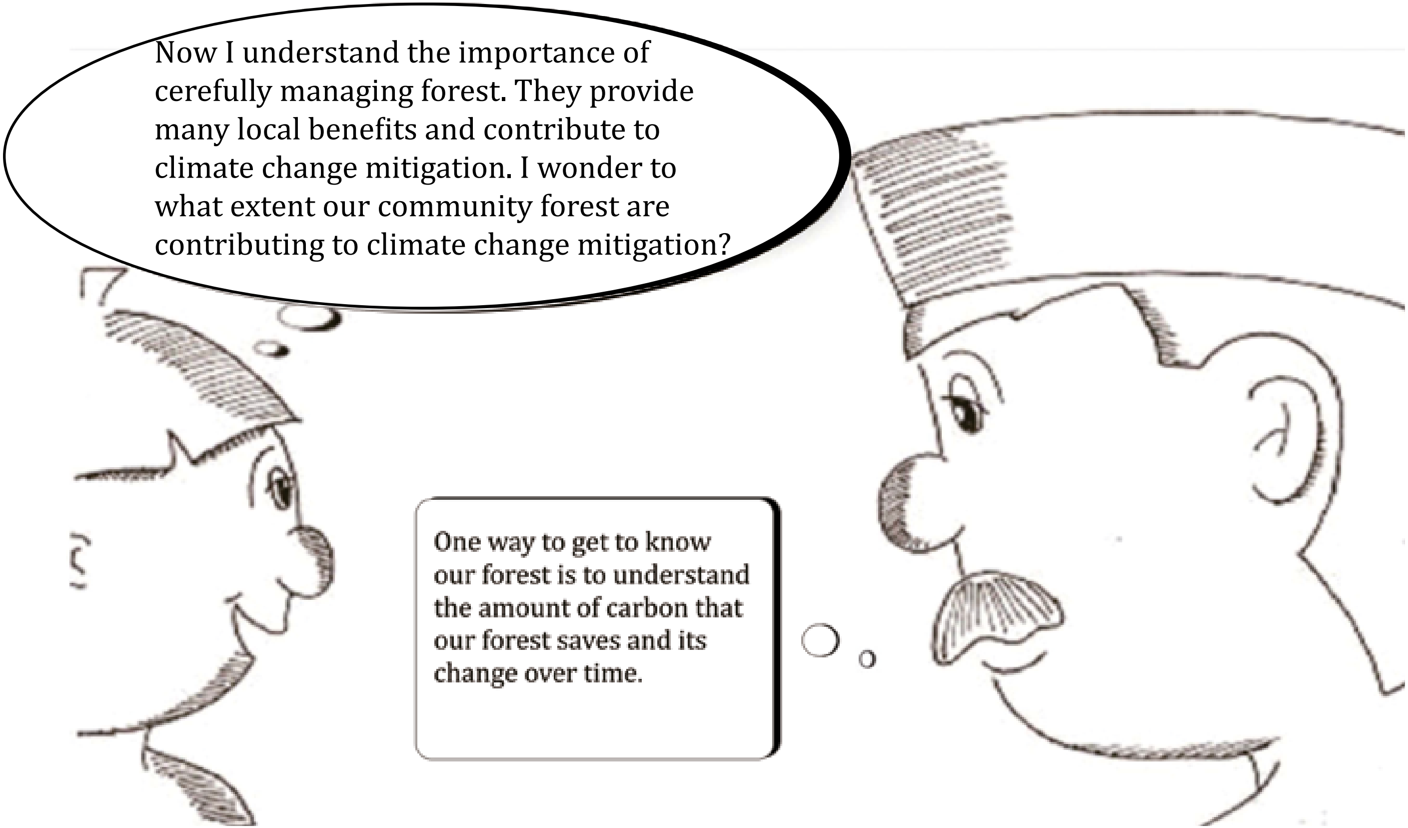


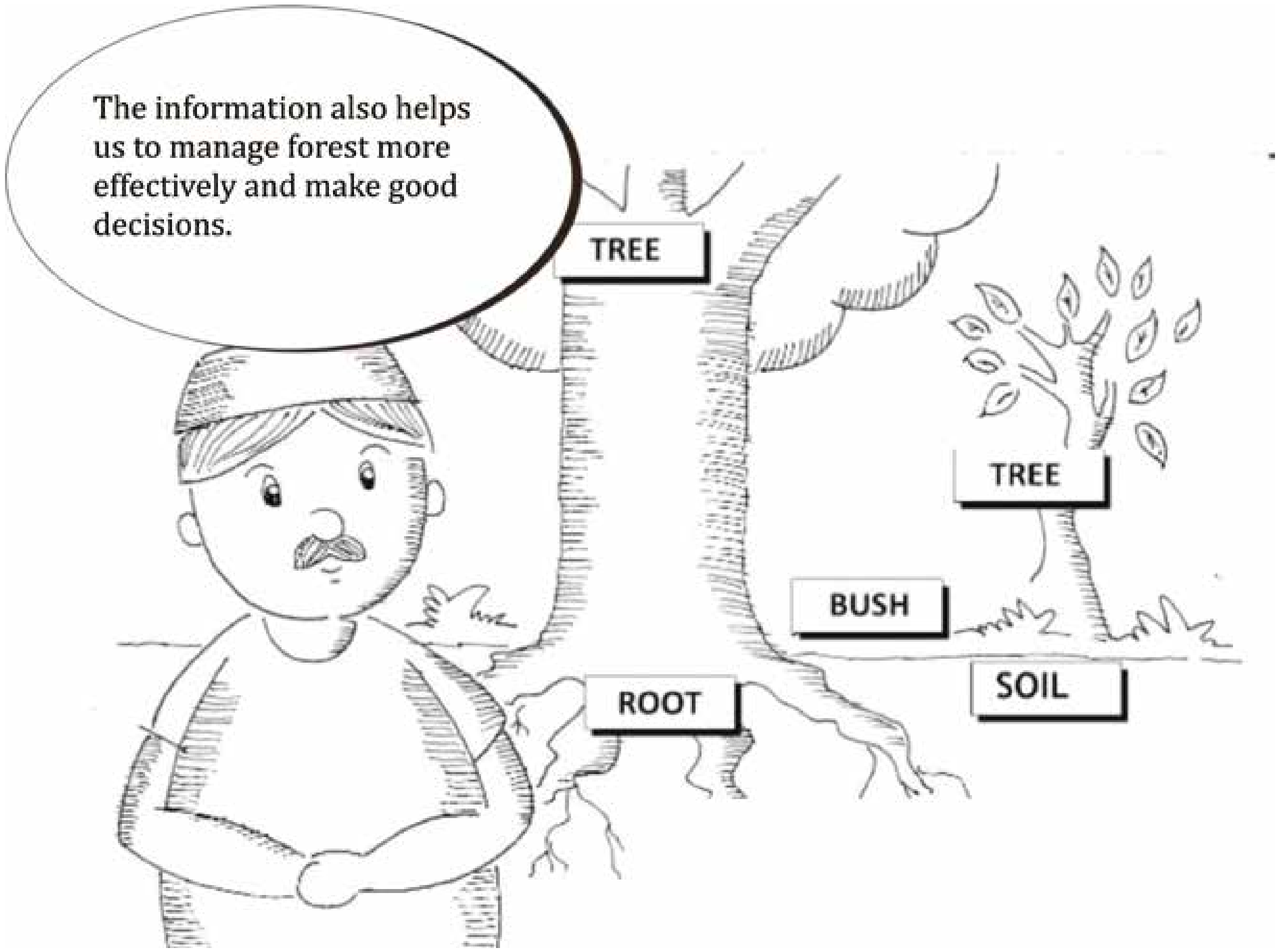
Forest have a significant role in climate change mitigation, since trees absord CO_2 from the atmosphere and store it as carbon within their biomass.

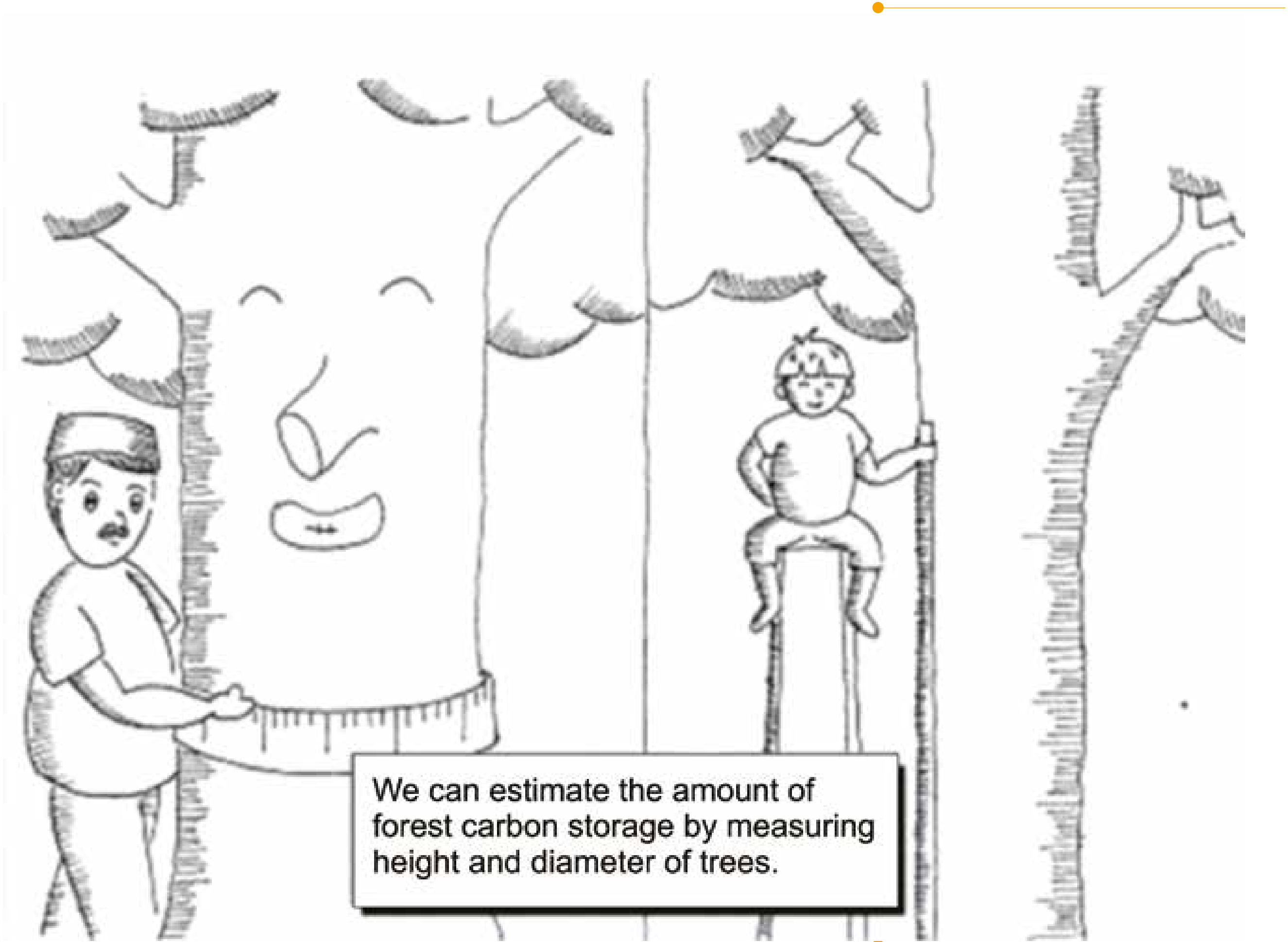

Conserving and managing forest wisely contribute to reducing CO_2 emissions and keeping and enhacing carbon stock within forest.


Saving resources by recycling also contributes to climate change mitigation.
PLASTIC
PAPER
METAL


Using wood products and carefully looking after them over many years can help to protect forests and reduce carbon emissions.

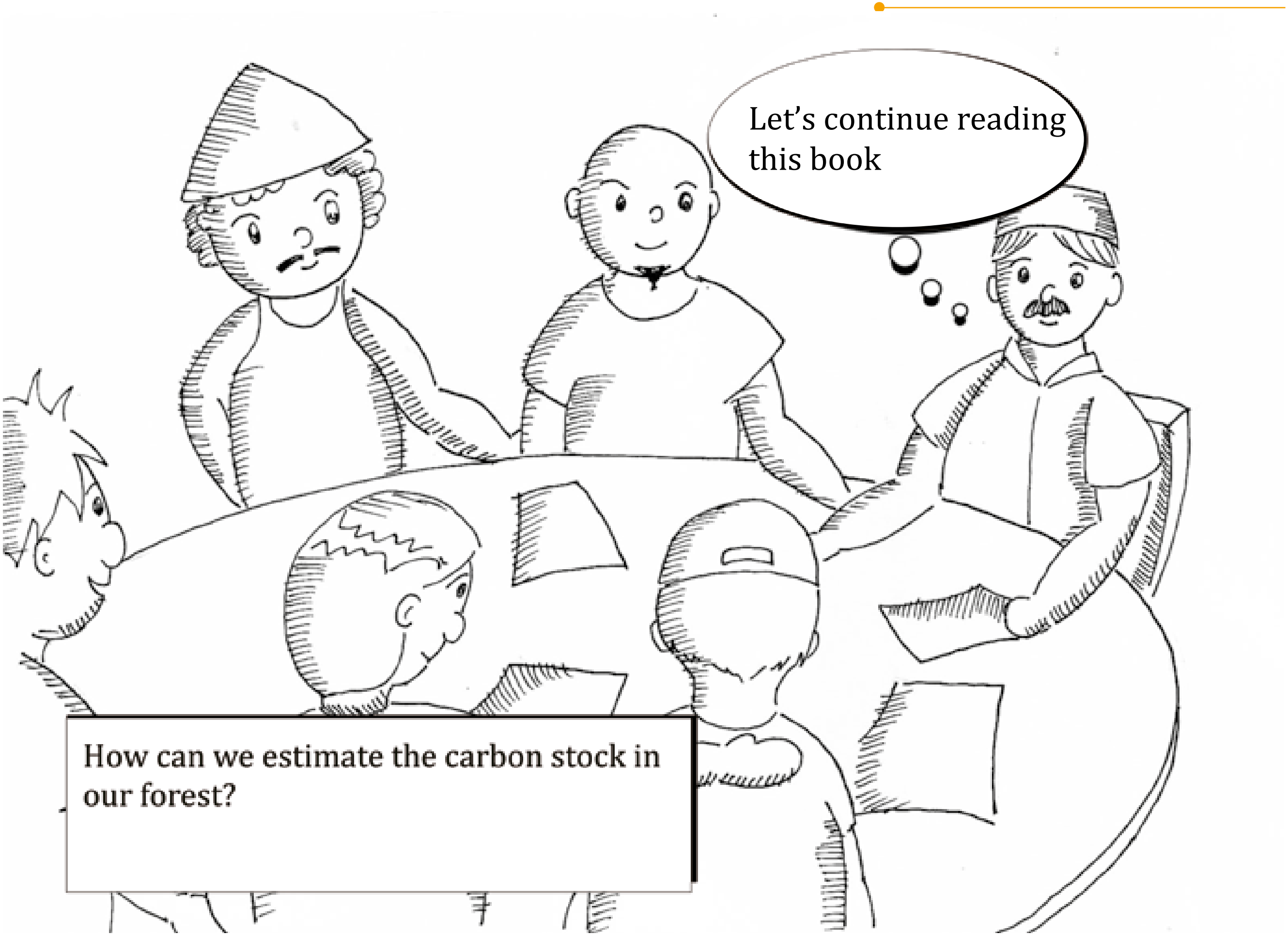

Now I understand the importance of cerefully managing forest. They provide many local benefits and contribute to climate change mitigation. I wonder to what extent our community forest are contributing to climate change mitigation?
One way to get to know our forest is to understand the amount of carbon that our forest saves and its change over time.


The information also helps us to manage forest more effectively and make good decisions.
TREE
TREE
BUSH
SOIL
ROOT


We can estimate the amount of forest carbon storage by measuring height and diameter of trees.

Part 2

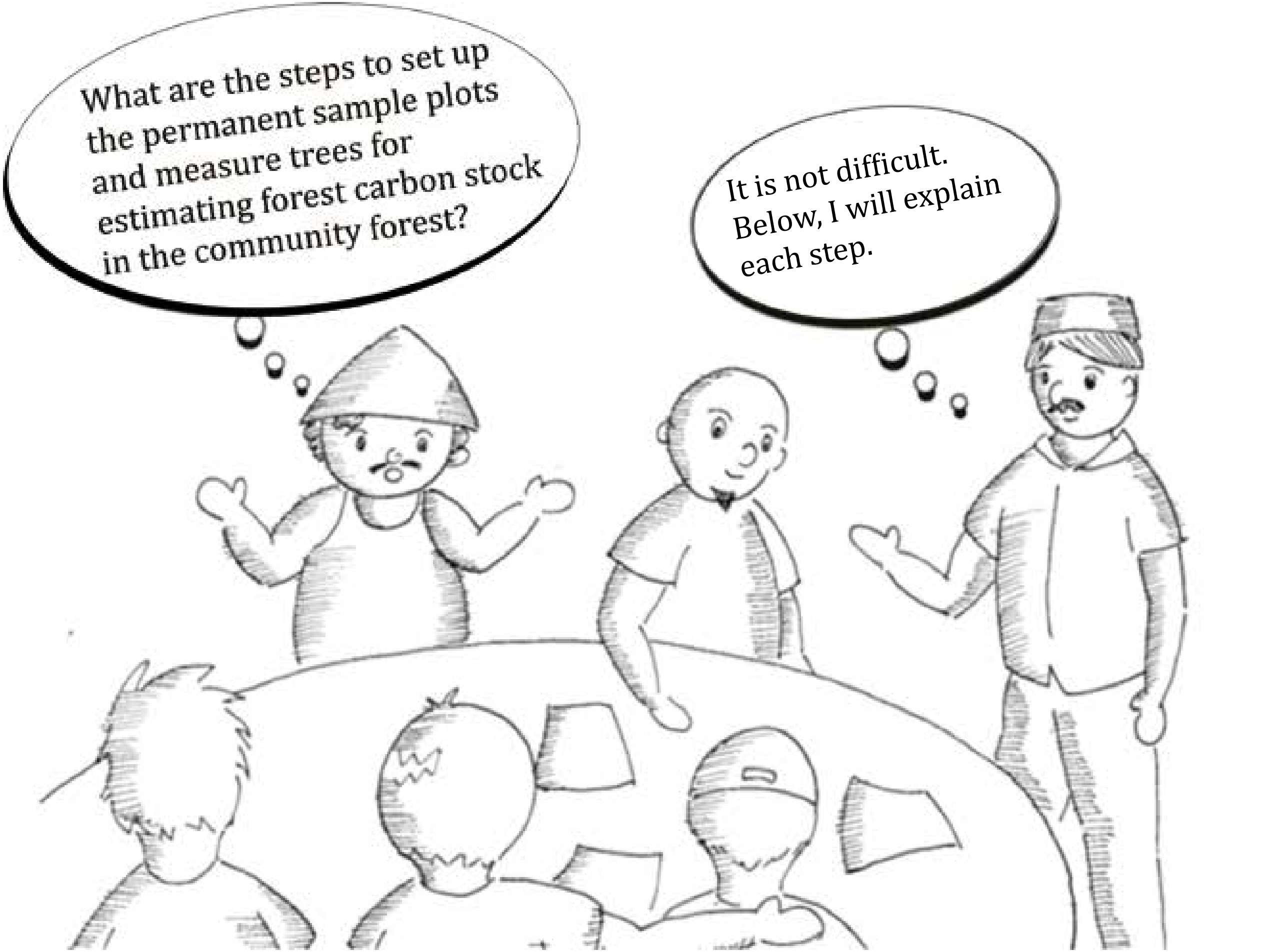
Community Carbon Accounting


Let's continue reading this book
How can we estimate the carbon stock in our forest?

Community Forest Carbon Accounting

How can we estimate the amount of carbon stock in the community forest? In this part, we are going to learn how to measure the carbon stock in the community forest.

Because there are a great number of trees in a forest, we cannot measure every tree. One effective way to measure and monitor forest carbon stock is to use sample plots and measure the trees in the plots. We call these plots permanent sample plots, because we will re-measure them in the future to monitor changes in the carbon stock. It is important to set up enough plots so that we can get an idea of the condition of the whole community forest. Within a plot, we first observe the site condition, then identify and measure living trees. Key information and data to be collected are location of the plots, tree species name, tree diameter and height. We will use the information and data collected to estimate the forest carbon stock.


What are the steps to set up the permanent sample plots and measure trees for estimating forest carbon stock in the community forest?
It is not difficult. Below, I will explain each step.

The major steps for measuring the trees in the permanent sample plot:

1. Preparing tools and equipment
2. Organising the field measuring team
3. Setting up the permanent sample plot
4. Field measurement
    1) Recording site conditions
    2) Numbering trees and identifying tree species
    3) Measuring the circumference of the trees
    4) Measuring the height of the trees
    5) Sketching the permanent sample plot
    6) Checking the field sheets
5. Preparation to leave the permanent sample plot

1. Preparing tools and equipment

Before going to the forest, we need to prepare and check the tools and equipment. Figure 1 shows the tools and equipment that we need for the measurement in the forests.

Figure1.Tools and equipment for forest carbon accounting

- Map of the community forest area

  We use the map which shows the area of community forest to decide the locations of the permanent sample plots (Figure 2).

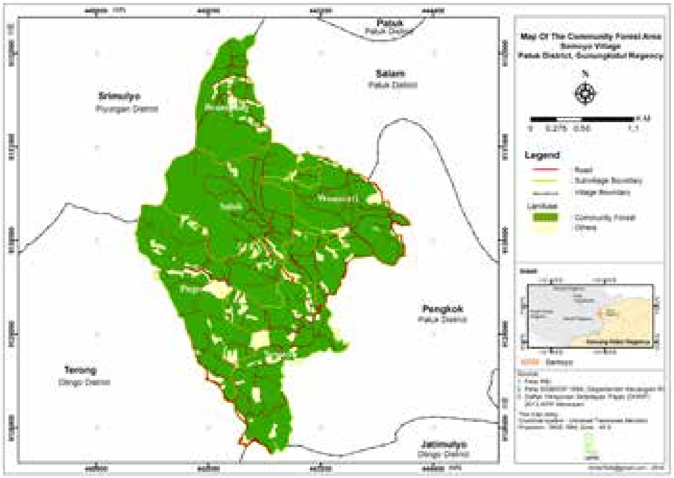


Figure 2. Example of Community Forest map

- Measurement tape (plastic or nylon)

  We will use measurement tape to measure the circumference of the tree's trunk.

- Christen hypsometer and a 2 metre pole

  A Christen hypsometer is an instrument to estimate the tree height. This instrument is used with a pole (the use of the Christen hypsometer is illustrated in Figure 13).

- Nylon or plastic rope (80 m) and 4 stakes
  These tools will be used to make a square sample plot. The plot size is 400 m2 (20m x 20 m).

- Compass
  A compass shows the direction that you are facing and helps to make a square plot by confirming that each corner has a right angle (90 degrees).

- Field sheet, board, and pens
  The field sheets are for recording the data in the field. An example of the field sheet is shown in Figure 11 and 14. The field sheet can be adjusted according to the information and data needed. The board helps when writing on the field sheet. You will also need pens; waterproof ballpoint pens are the best.

- Paint and brush
  These will be used for numbering the trees. Bright paint colors like red, yellow, or orange are highly recommended because they will be visible in the forest.

- Handheld GPS receiver
  GPS (Global Positioning System) is a satellite-based system that can be used to locate positions anywhere on the Earth. With a handheld GPS receiver, you can know information on the plot location (latitude, longitude and altitude), which is a useful reference of the permanent sample plot. With the GPS data, anyone can easily find the plot (the use of the GPS is illustrated below).

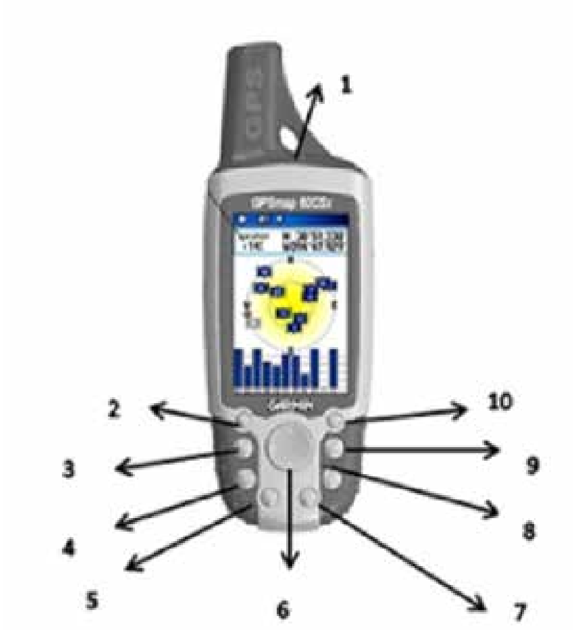
What is a handheld GPS receiver?

A GPS receiver shows geographic information of our current location (north-south and east-west) by giving a set of numbers (so called GPS coordinates). GPS coordinates are most commonly expressed as latitude and longitude. It is also shows the elevation of our location.

- Latitude indicates the north-south position of a point, which means how far north or south of the equator a location is.
- Longitude indicates the east-west position of a point, which means how far east or west of the prime meridian your location is.

Figure 3. A handheld GPS receiver

Figure 4. Satellite Page



1. Power button: to turn on the GPS receiver
2. Zoom in: to make the display appear nearer/larger
3. Find: to see the record of spots that have been marked
4. Mark: to mark (record) a current location
5. Quit: to quit
6. Cursor: to move up-down and left-right
7. Enter: OK
8. Page: to move between pages on home display
9. Zoom-out: to make the display appear smaller/ further away

Figure 5. Example of a handheld GPS receiver

How to mark your current location in the GPS receiver (creating waypoints)?

1. Turn on the GPS receiver at the sample plot by pressing button 1 (see Figure 5).
2. Push the Page button until the Satellites Page is displayed (see Figure 5).
3. Check the accuracy at the Satellites Page, and wait until the accuracy is about 5 meters or less. If you are in dense forest, it may be difficult to get the accuracy of 5 meters. In such case, wait for 10 minutes and take the reading.
4. Read the accuracy from the Satellite Page (see Figure 4)
5. Press the Mark button (see Figure 5) for recording the location of the plot. The Mark Location Page will be displayed (see Figure 6)
6. Use the Cursor bottom to highlight the top box on the Mark Location Page and press the Enter Key
7. Enter the plot name using the Cursor bottom

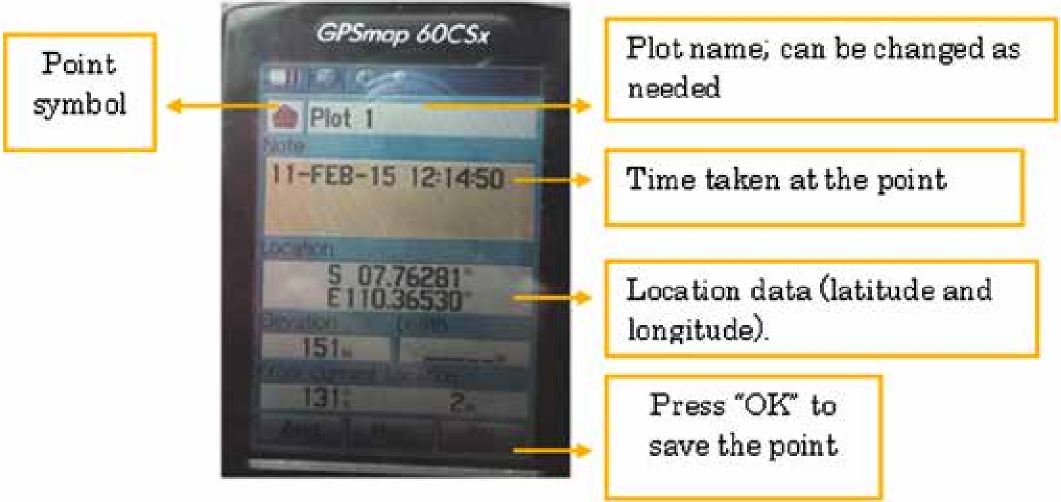


Figure 6. Mark location page

2. Organizing a field team

Generally, a field team should have at least 4-5 members for measuring trees in the plot. Table 1 describes the work and responsibility of each member.

Tabel 1. Field team for forest carbon measuring

Position	Roles	Note
Leader	• Assign tasks to each member before going to the forest • Takes a decision on the plot location and leads the team to set up the plot • Guides the team and ensures the quality of filed work • Checks the field sheet after all information and data are recorded	Should understand all the process for measuring forest carbon and have a good knowledge on the overall community forest area
Data recorder	• Responsible for recording information and data in the field sheet	Should fill the field sheet clearly so that the data is easy to read
Tree marker	• Identify tree species and number trees • Call out information (tree number and specie name) to the data recorder	Should have good knowledge of the tree species
Tree circumference measurer	• Measures the tree circumference • Call out the tree numbers and tree circumference to the data recorder	Should follow the rules of the measurement (see Figure12)
Tree height measurer	• Measures tree height using the Christen hypsometer • Call out the tree numbers and height to the data recorder	This task requires a supporter, who holds the pole of 2 meters along the targeted tree

3. Setting up the Permanent Sample Plots

3.1. What is a permanent sample plot?

We use permanent sample plots to estimate carbon stocks in forests, because there are a great number of trees in a forest and we cannot measure every tree. The permanent sample plots are permanently demarcated areas of forest to understand the average conditions. We will set up plots and only measure trees within the plots to estimate the forest carbon stocks of the entire community forest area. It is very important to keep the trees within the plots intact once established, so that we can monitor the changes in forest volume and carbon stocks over time.

3.2. How many permanent sample plots do we need?

It is important to set up enough plots so that we can make a good estimate of the total amount of wood and carbon. When the forest includes diverse conditions (e.g. different tree species in different areas, or different ages of trees in different areas), we may need more sample plots to cover different parts of the forest. A map is helpful to identify the locations of the sample plots.

If the conditions in the forest are relatively similar though the whole area (for example, same land use and planting pattern, same tree species and similar size, and similar geographic condition such as slope), the number of sample plots may be determined based on the random selection of forest units owned by community members. Also we can consider the sub-village unit to determine the locations of plots to distribute the plots evenly. That means, a certain number of the sample plots are distributed randomly at each sub-village unit (see Figure 7). This is found effective since the sample plots can be easily located and be distributed covering the whole village area using the list of members of the community forest.

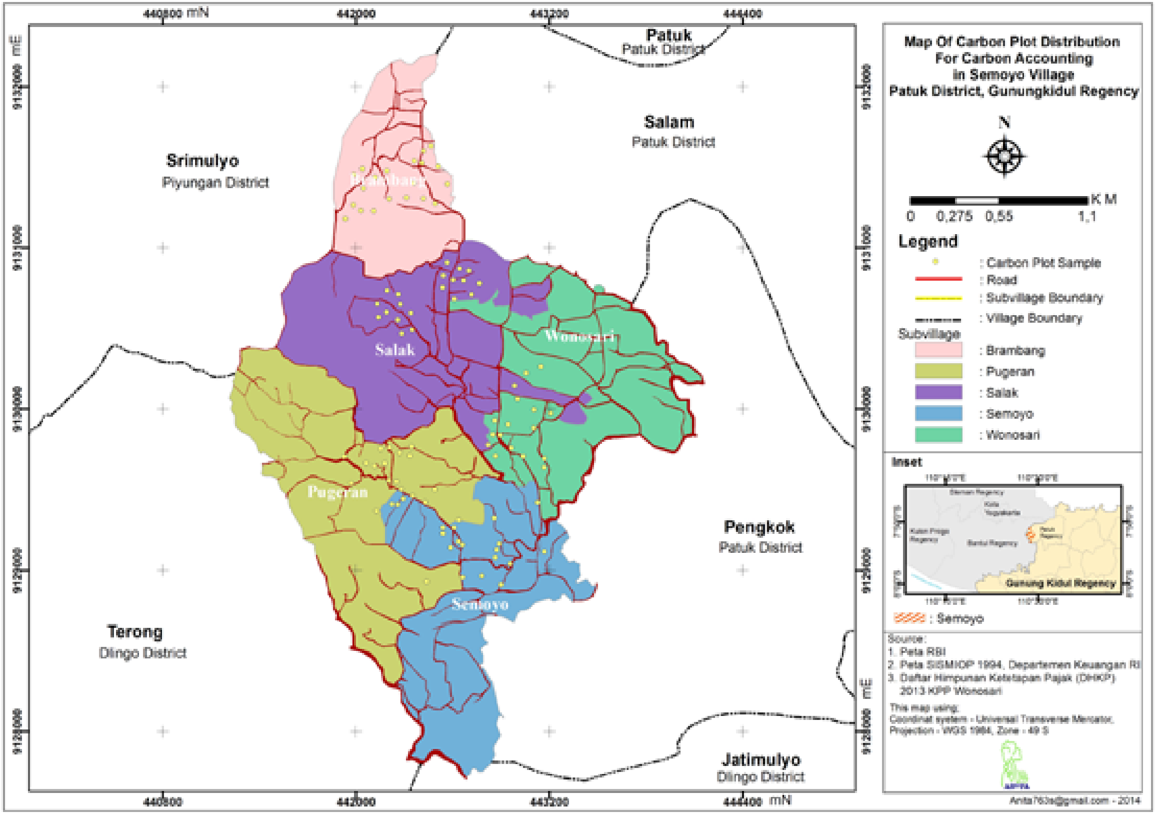


Figure 7. Example of distribution of the sample plots

3.3. What are size and shape of the permanent sample plots?

The size and shape of plots are determined by the tree planting patterns. Usually, the planting patterns vary depending on the management objectives. For example, in Central Java, there are mainly 2 spatial tree planting patterns found in the community forests: which are the trees planted in clusters (Picture 1) and trees planted at boundaries (Picture 2).

Picture 1. Trees in clusters

Picture 2. Trees at boundaries

1). How to make a sample plot for the trees in clusters

For the clustered tree distribution type, the plot is square with dimensions of 20 x 20 meters (Figure 8). It is important to choose the locations of the plots to show the average forest condition. Once we decide the location of a plot, we need to mark its location with handheld GPS. The point is called the reference point. From the reference point, we set up a square plot towards the west and south.

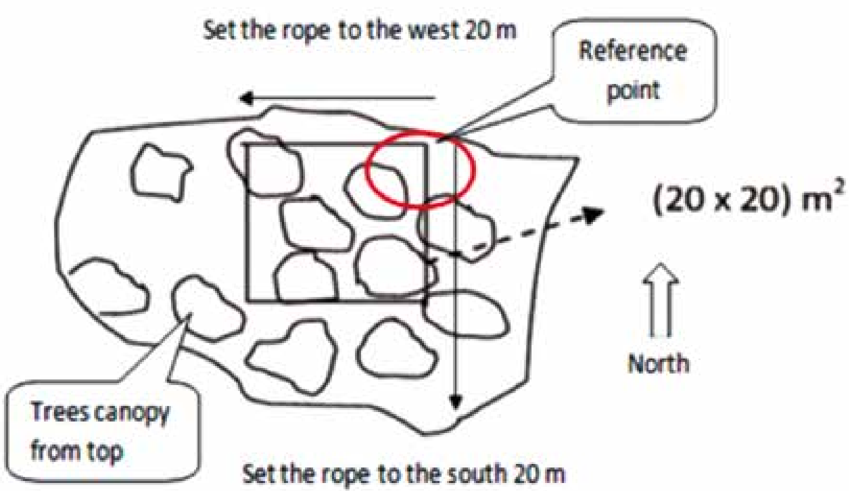


Figure 8. Plot shape for trees in clusters

To make a square plot, each corner should be a 90-degree angle (Figure 9):

1. Measure 30 cm along one side of the plot from a corner (Point A)
2. Measure 40 cm meters along the other side of the plot from the Reference point (Point B)
3. Measure across Points A and B. If your measurement is 50 cm, the corner is square. Try to adjust the corner to make the measurement 50 cm. This is known as the 3-4-5 method.

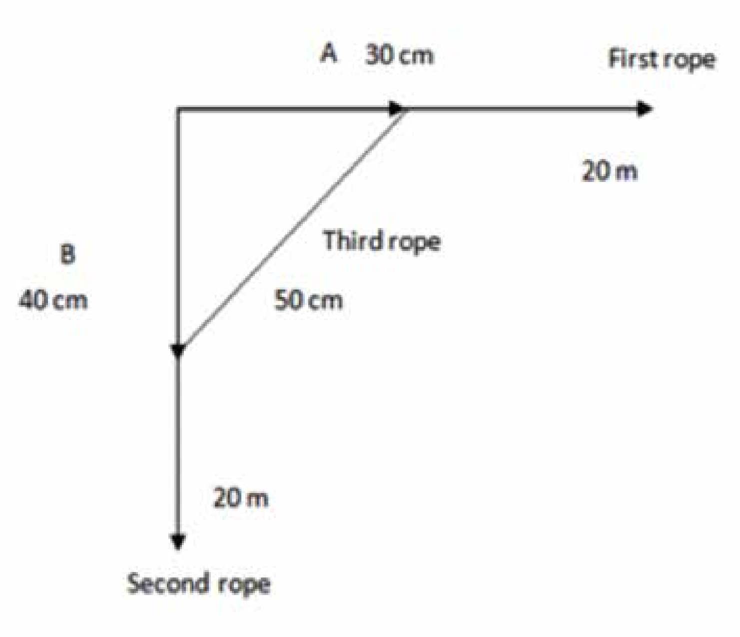


Figure 9. 3-4-5 method to make a square corner

Steps to set up a square plot:

1. Identify the reference point and record the location using the handheld GPS receiver
2. Put a stake into the ground where you took the GPS reading
3. Use a compass to identify the boundaries of the plot (go toward south and west from the reference point)
4. Demarcate the boundaries using the nylon tape and stakes
5. Check each corner has a right angle

Picture 3. Set up a square plot

2). How to make sample plot for trees at borders

For trees that are planted along the border of land units, trees are selected and measured at each 10 metre interval along the border of the area (Figure 10). We can choose any tree for the starting point. It is important to note the location of this starting point as a reference point of the plot.

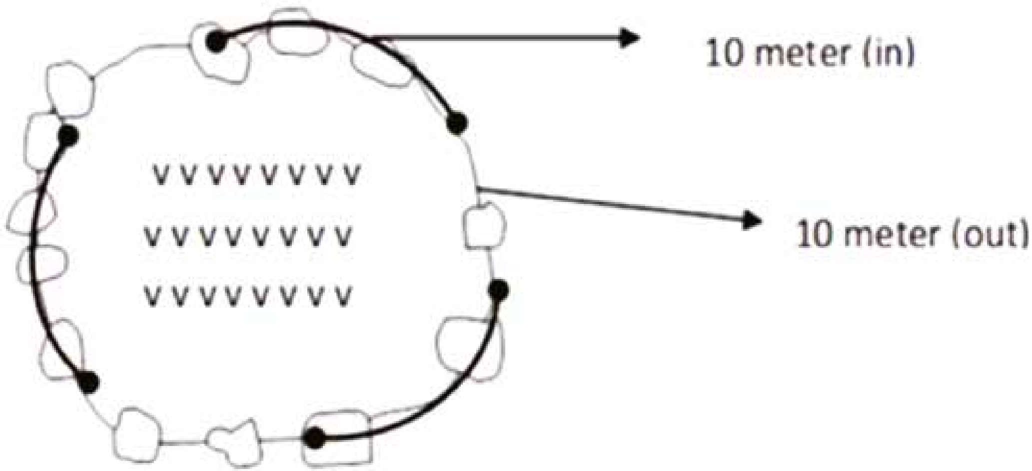


Figure 10. Plot shape for trees on the border

4. Field Measurement

4.1. Recording the general information of the permanent sample plot

Before measuring trees in the plot, we need to gather the general information of the plot and fill in the field sheet (Figure 11).

The information includes name of land owner, sub-village and village name, land address, land size, plot size, forest litter, canopy cover, competition, name of data recorder, date, and location (latitude and longitude) and altitude of the reference point of the plot.

Field Sheet
Community Carbon Accounting

Plot No.	**1**

Land use type	Homegarden
Planting pattern	Clusters

Name of the land owner	Yono	Forest litter	0.5 cm
Village name	Makmur	Canopy cover (%)	30%
Sub-village name	Rejo Makmur	Competition	Moderate
Land address	Rejo Makmur/RT 01	Location	S:070.xx.xxx/E.110.xx.xxx
Land size	600 m2	Data recorder	Brambang Team
Plot size	20*20m	Date	16.07.2014

Figure 11. Example of the field sheet for general information

4.2. Numbering trees and identifying tree species

After we collect the general information of the plot, we start to number all living trees that will be measured in the sample plot. We only measure trees bigger than 10 cm in circumference.

Steps to number trees:

1. Paint the numbers on the trees (from 1, 2, 3, 4 and so on)
2. Identify the species name of each tree
3. Call out the name of trees clearly to the data recorder

Picture 4. Numbering trees

4.3. Measuring the circumference of the tree

We measure the circumference of the trees to calculate the diameter of the tree at 1.3 meters above the ground. The point at 1.3 meters is known as breast height. By measuring the circumference at breast height, we can calculate tree diameter at breast height (DBH), and this is used to estimate the carbon stock. However, there are some trees that we need to be careful to identify the point to measure the circumference. The rules for the measurement are illustrated in Figure 12.

Picture 5. Measuring tree circumference

Steps to measure the tree circumference

1. Prepare a 1.3 metre stick and indicate the point for measurement following the rules.
2. Use the measuring tape. The tape should be held level (or on perpendicular plane to the stem axis) and firmly, but not stretched.
3. Call out the tree number and the measurement reading (tree circumference).

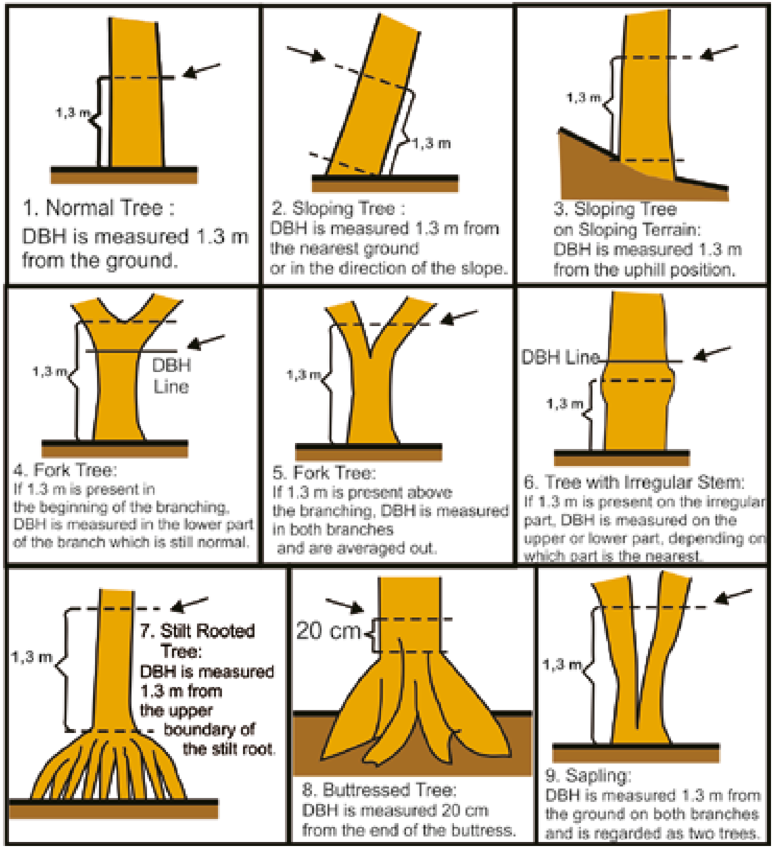


Figure 12. Rules for measuring the tree diameter (Tim AR^{u}PA, 2014)

4.4. Measuring the tree height

Tree height is an important tree parameter. Tree height can be measured using a variety of instruments. In this book, we use the Christen hypsometer (Figure 13), as it can be manufactured locally. Measuring the tree height requires at least 2 people; one uses the Christen hypsometer, and another holds a 2 metre pole upright against the base of the tree.

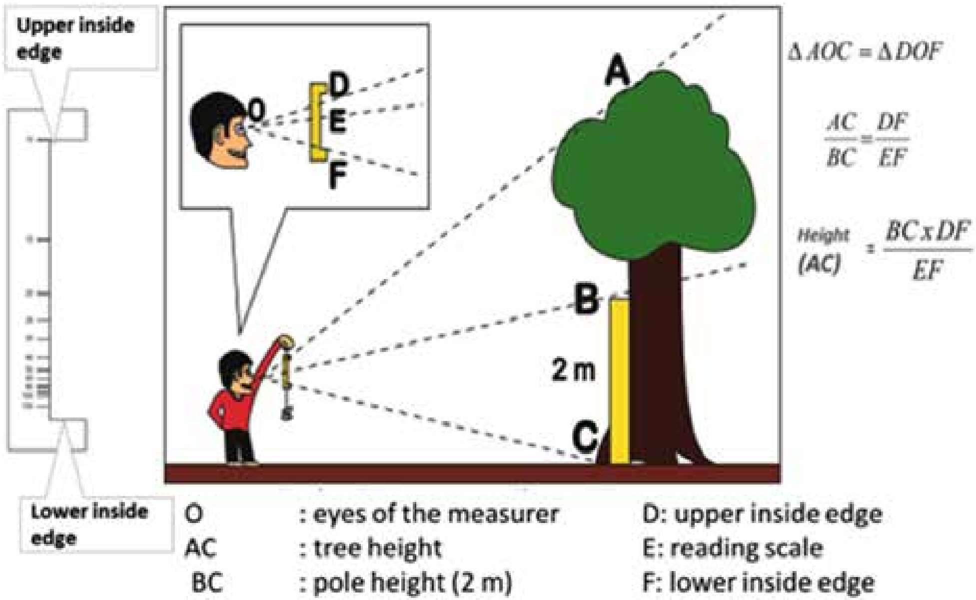


Figure 13. Christen hypsometer (left) and its use to measure tree height (right) (Tim ARuPA, 2014)

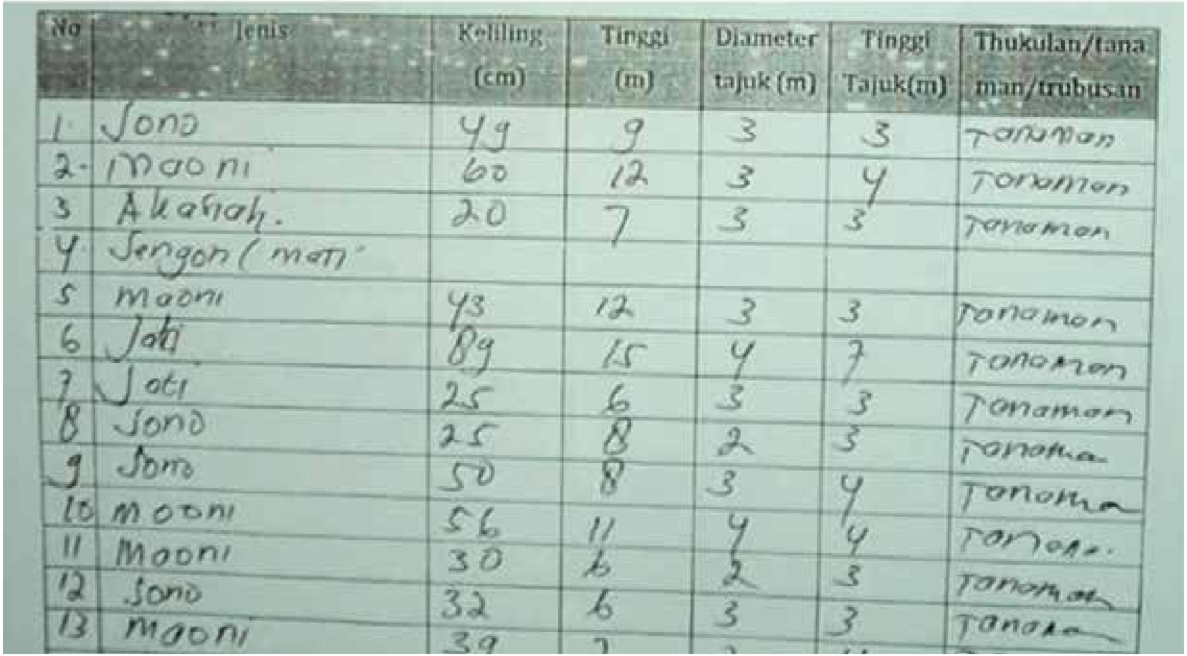
Steps to measure the tree height

1. Hold a 2 metre pole upright against the base of the tree.
2. Hold the hypsometer at a distance from the eye such that the two inside edges of the flanges are in line with the top and base of the tree.
3. Move closer or further from the tree as necessary to achieve this.
4. Read the graduation on the scale that is in line with the top of the pole to obtain the tree height.
5. Call out the tree number and your reading (tree height) to the data recorder

Picture 6. Using the Christen hypsometer

4.5. Filling in the field sheet

The field sheet should be filled neatly and carefully. Figure 14 shows the field sheet for living trees, where we have to record the tree number, species name, tree circumference, tree height, canopy height, and canopy diameter. We must fill in the sheet for each sample plot.



No	Jenis	Keliling (cm)	Tinggi (m)	Diameter tajuk (m)	Tinggi Tajuk(m)	Thukulan/tanaman/trubusan
1	Sono	49	9	3	3	Tanaman
2	Mooni	60	12	3	4	Tanaman
3	Akasiah.	20	7	3	3	Tanaman
4	Sengon (mati)					
5	Maoni	43	12	3	3	Tanaman
6	Jati	89	15	4	7	Tanaman
7	Jati	25	6	3	3	Tanaman
8	Sono	25	8	2	3	Tanaman
9	Sono	50	8	3	4	Tanama
10	Mooni	56	11	4	4	Tanama
11	Mooni	30	6	2	3	Tanoma..
12	Sono	32	6	3	3	Tanaman
13	Maoni	39	[illegible]	[illegible]	[illegible]	Tana..

Figure 14. Example of the field sheet for living trees

4.6. Sketching the sample plot

Sketching the sample plots help us to understand and record the conditions of the plots. Figure 15 shows the distribution of the trees measured with the tree numbers. Figure 16 shows the projection map of the tree canopy of the plot. Figure 17 is another example of the sketch, which shows vertical layers of trees of the plot.

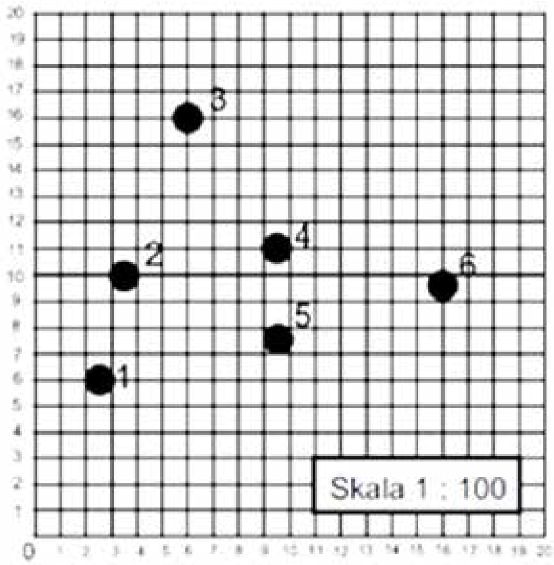


Figure 15. Sketch of the distribution of the measured trees

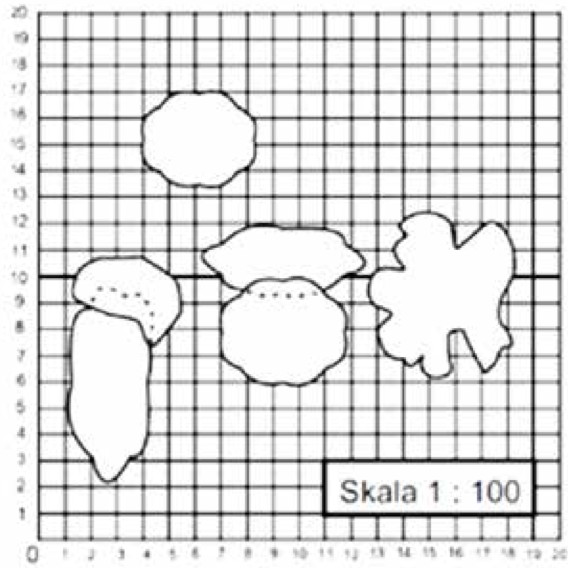


Figure 16. Sketch of the tree canopy projection

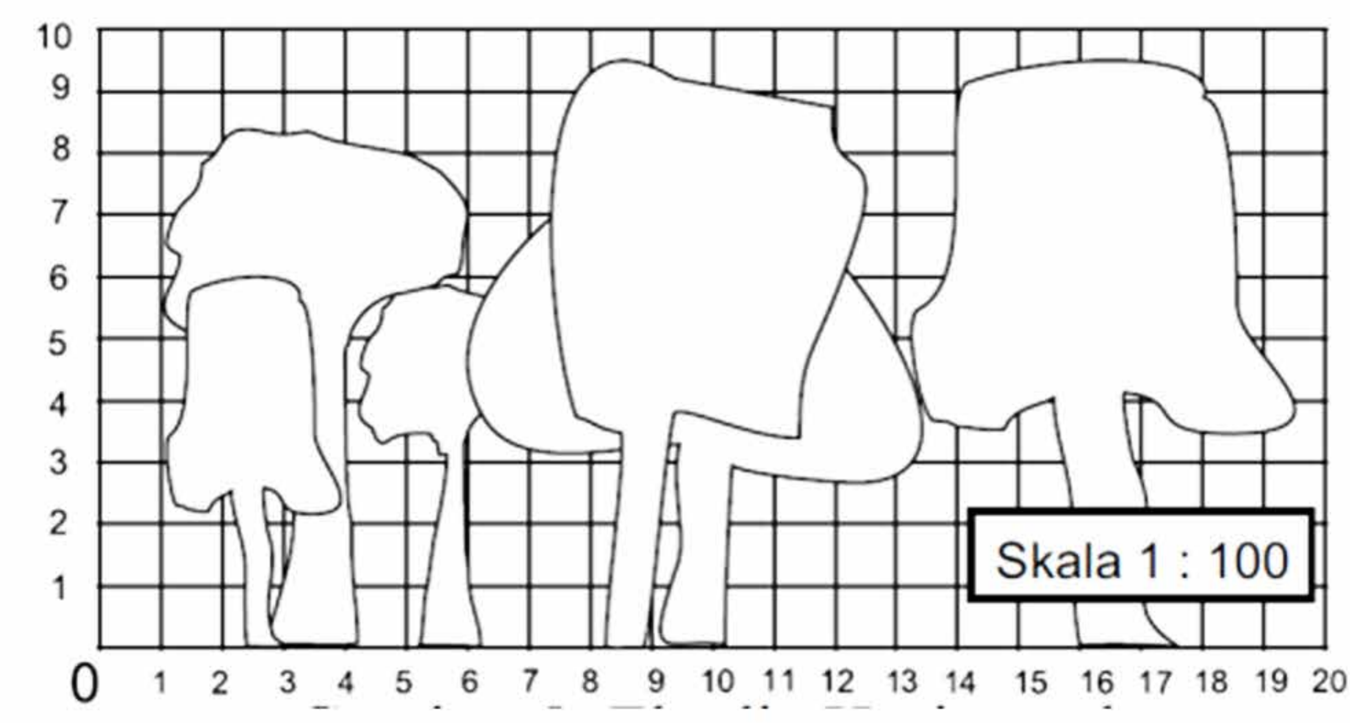


Figure17. Sketch of the vertical spatial structure of the plot

4.7. Other information

1) Forest litter:

Knowing the depth of the forest litter, i.e. the organic matter on the forest floor, can be useful as it can be used to estimate the amount of carbon in the litter and it can help us understand the forest conditions. The way to measure the thickness of forest litter is by plugging a ruler into the litter layer until touching the soil layer. To estimate the average thickness of the litter in the area, we need to measure 10 different points in the plot. In this manual, the estimation of forest carbon stock does not include carbon in forest litter.

2) Canopy cover:

Observing the canopy cover tells us the density of forest stands, which is a key for understanding the condition of the forests. In plantations, the density is determined by how the trees are planted (distance between plants) and managed (harvesting and thinning). The way to evaluate the canopy cover is to estimate the percentage of the canopy cover area in a plot.

3) Competition:

We evaluate the competition of trees, based on the tree density and canopy cover observed. To do this, we use three categories of competition, which are “high”, “moderate”, and “low” competition. If you observe that the competition between trees is high and the plantation is very dark, you can remove some trees (thinning), so that conditions of the plantation can be improved to increase timber production.

Useful reference materials

There are reference materials relevant to the above topics that you can find on the internet web.

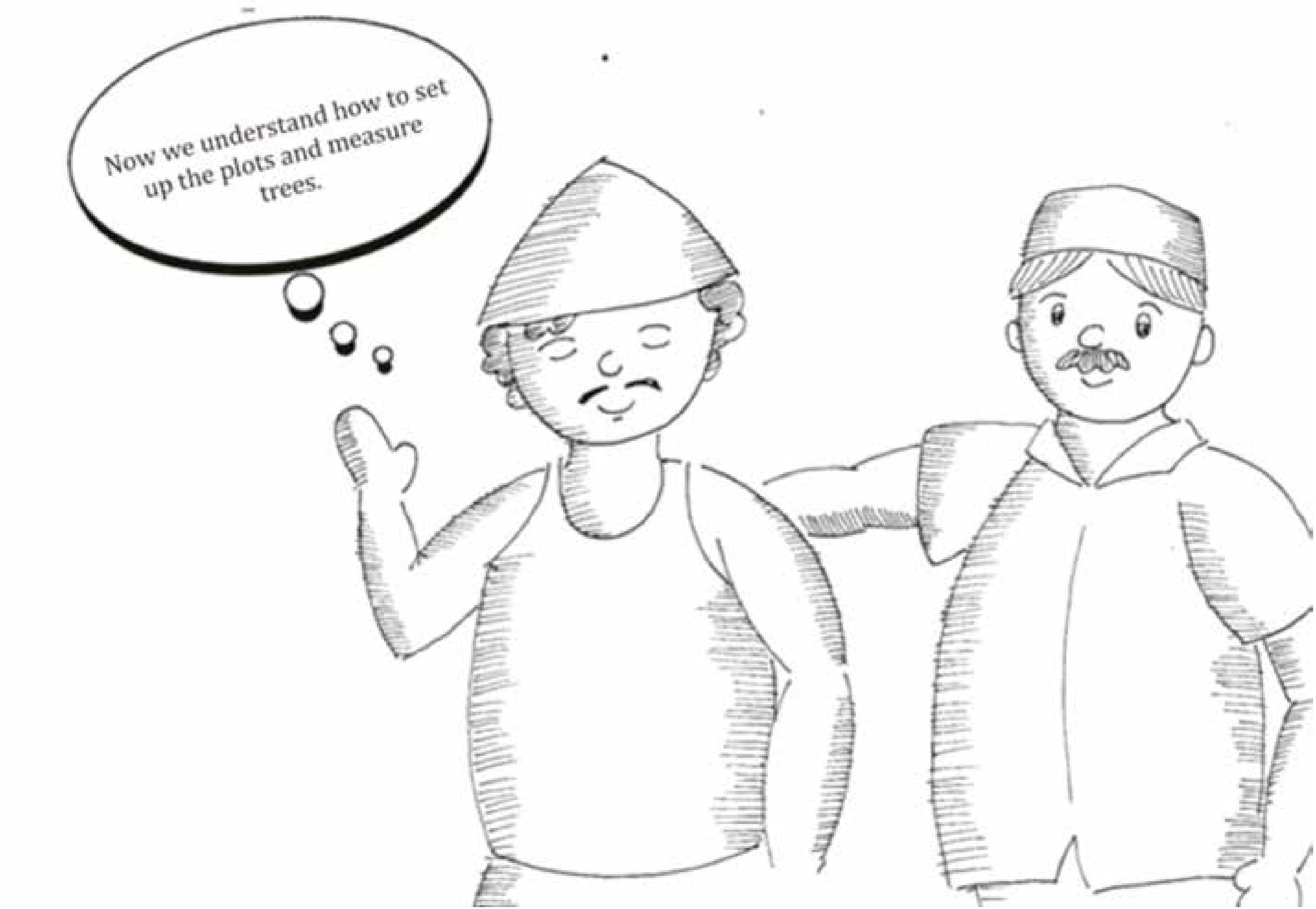
- Measuring forest litter: Guidelines for Measuring Carbon Stocks in Community-Managed Forests (Bhishma et al. 2011) (http://www.ansab.org/wp-content/uploads/2010/08/Carbon-Measurement-Guideline-REDD-final1.pdf)

- Assessing canopy cover condition: Crown-Condition Classification: A Guide to Data Collection and Analysis (Schomaker et al., 2007) (http://www.srs.fs.usda.gov/pubs/gtr/gtr_srs102.pdf)

4.8. Checking the field sheets

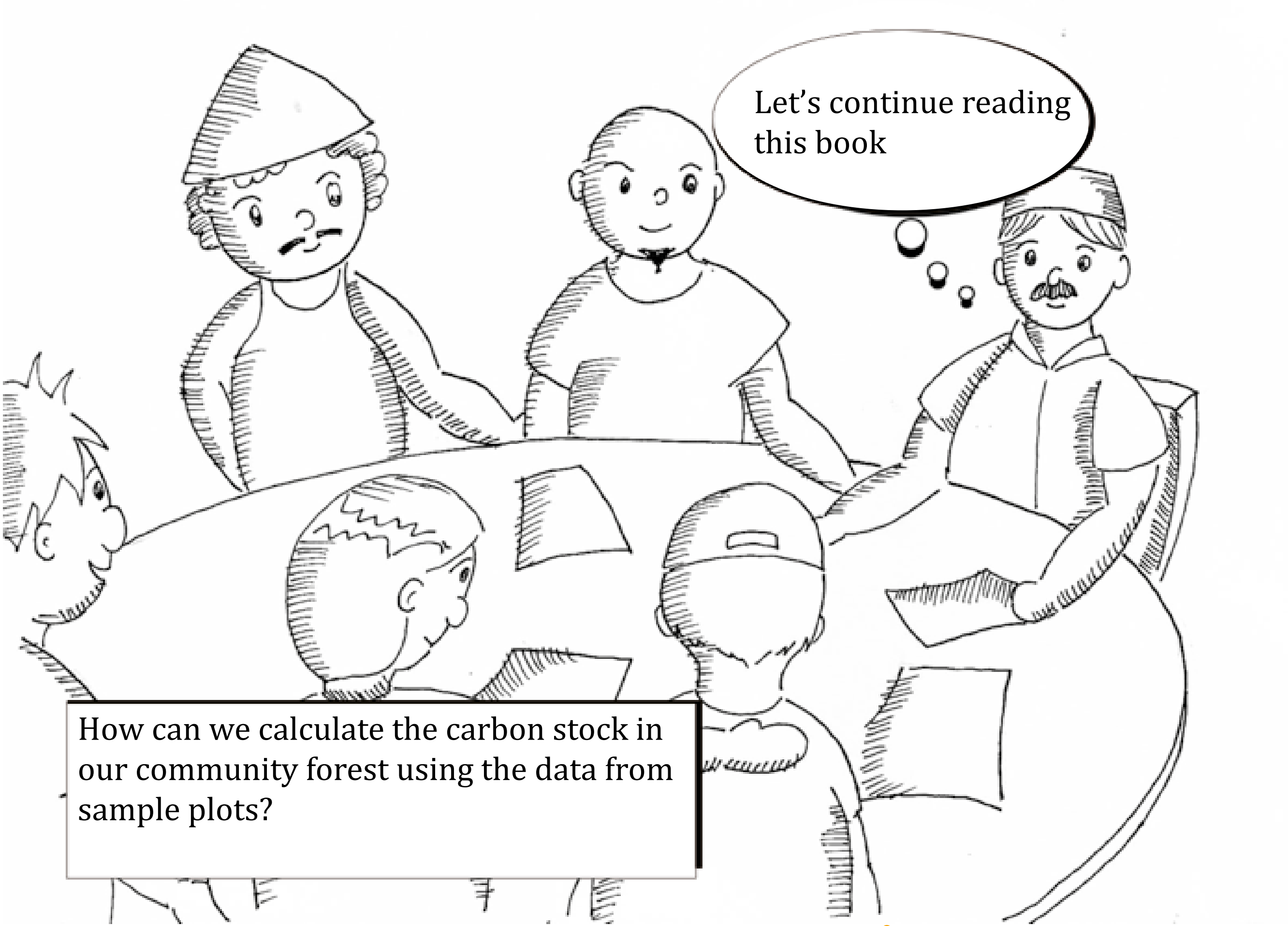
Before leaving the sample plot, it is very important to review the field sheets to check whether information and data are correctly and neatly filled in. This is the task of the team leader.
In Part 3, we will learn how to calculate the carbon stocks using the data collected in the sample plots.

Picture 7. Checking the field sheets


Now we understand how to set up the plots and measure trees.

Part 3

Data Entry and Analysis


Let's continue reading this book
How can we calculate the carbon stock in our community forest using the data from sample plots?

Analysis of Forest Carbon Stock

How can we know the amount of carbon stock in the community forests? Part 3 explains how to calculate the carbon stock using Microsoft Excel, examples, and the following step-by-step process:

1. Open Microsoft Excel program
2. Create a table form on the Excel worksheet
3. Enter the data collected from the permanent sample plots into the table
4. Calculate the tree diameter at breast height (DBH) from the tree circumference
5. Calculate the above ground tree biomass
6. Calculate the above ground forest carbon stock

**In this manual we calculate the biomass and carbon stock in the above ground living trees only. This includes the trunks, branches, and leaves of the trees. We do not calculate the carbon stock in the below ground tree biomass (i.e. the roots), leaf litter and deadwood (which can be standing and lying dead trees). It should be also noted that we calculate the biomass and carbon stock according to the land use type (i.e. carbon stock in home gardens and in dry land).*

We will learn these steps using an example of the community forest of Makmur village, Yogyakarta Province, Indonesia. The Makmur Village has 3 sub-villages (Rejo Makmur, Ngudi Makmur, and Jati Makmur). Their community forest is laid out in both home gardens and dry land areas. Each sub-village has 10 sample plots in home gardens and 10 sample plots in dry land. Therefore, the total number of the sample plots is 60, consisting of 30 plots located in home gardens and 30 plots located in dry land. The sample plot used in all cases is square with dimensions of 20 x 20 meters.

In Part 3, we use the data of the 30 plots located in home gardens and determine the forest carbon stock in the community forest in home gardens of Makmur village.

1. Open Microsoft Excel program

As a first step, we open the Microsoft Excel Programme (see Figure 18)

1. Turn on the computer.
2. Click "Start" menu
3. Select and click *"Microsoft Office Excel"*
4. When we open Excel, "Worksheet" (right-lower display in Figure 18) appears automatically

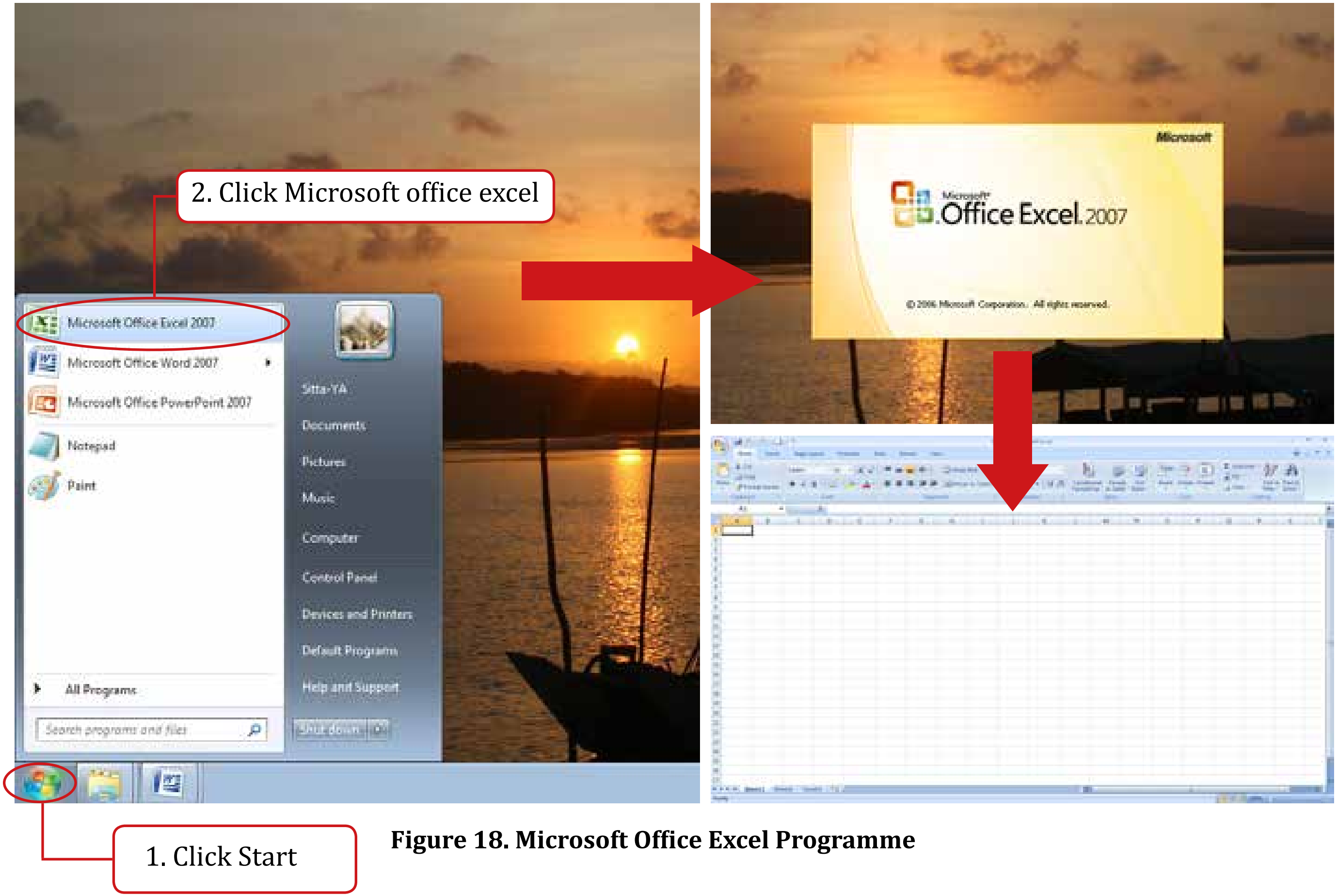


Figure 18. Microsoft Office Excel Programme

2. Create a table form on the Excel worksheet

When you open Excel worksheet, rename your file in this format: village name, land use type and year.xls (e.g.Makmur_homegarden_2014.xls). Then create a datatable form for each of the sample plots as shown in Figure 19. We will calculate the forest biomass and carbon stock at the plot scale. So rename the worksheet for each sample plot as follows: the plot number (e.g. Plot 1).

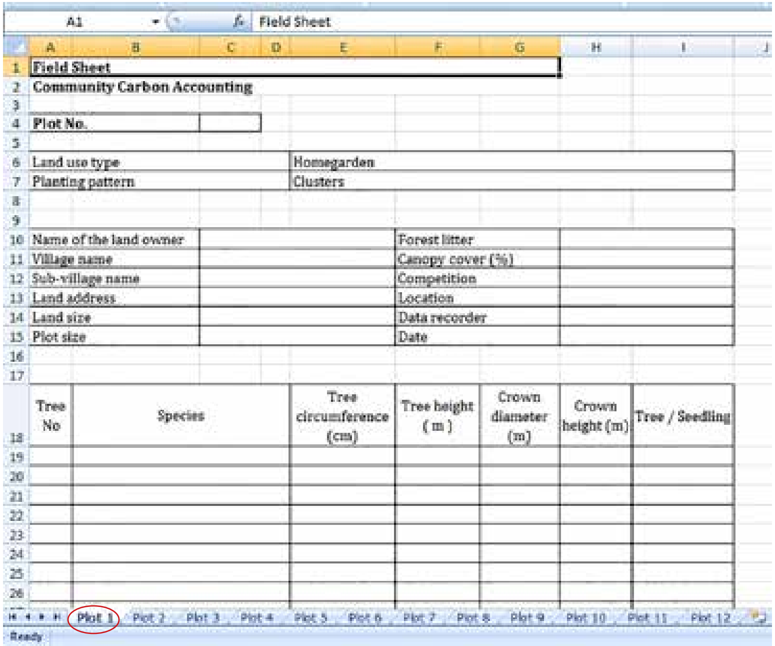
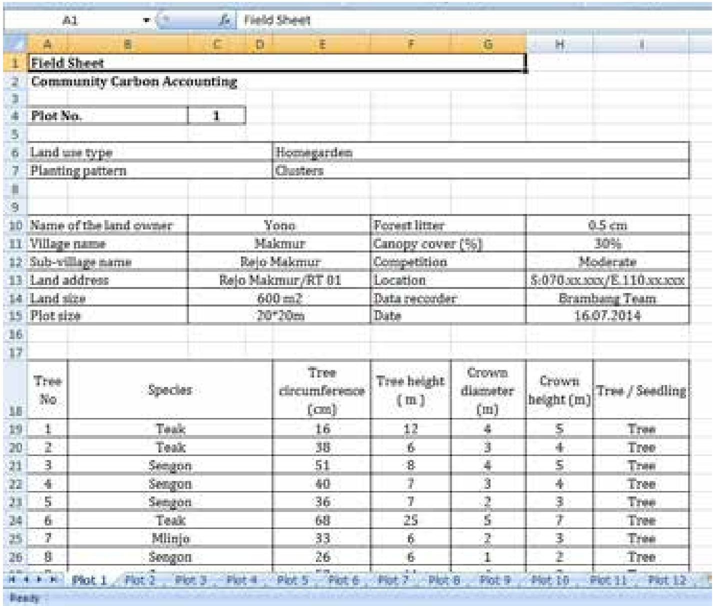


Figure 19. Data table to enter the field data

**We need to have 30 worksheets, as there are 30 sample plots located in home garden in Makmur Village*

3. Enter the data collected from the permanent sample plots into the table

Next, we will enter the field data from the sample plots into the Excel worksheets. As explained, we will calculate tree biomass and carbon stock for each sample plot according to the land use type (i.e. home garden and dry land respectively). Here we use the data of one sample plot (Plot No.1) of the community forest located in home gardens in Makmur Village (Figure 20).



Field Sheet

Community Carbon Accounting

Plot No. 1

Land use type	Homegarden
Planting pattern	Clusters

Name of the land owner	Yono	Forest litter	0.5 cm
Village name	Makmur	Canopy cover (%)	30%
Sub-village name	Rejo Makmur	Competition	Moderate
Land address	Rejo Makmur/RT 01	Location	S.070.xx.xxx/E.110.xx.xxx
Land size	600 m2	Data recorder	Brambang Team
Plot size	20*20m	Date	16.07.2014

Tree No	Species	Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling
1	Teak	16	12	4	5	Tree
2	Teak	38	6	3	4	Tree
3	Sengon	51	8	4	5	Tree
4	Sengon	40	7	3	4	Tree
5	Sengon	36	7	2	3	Tree
6	Teak	68	25	5	7	Tree
7	Mlinjo	33	6	2	3	Tree
8	Sengon	26	6	1	2	Tree

Figure 20. Input the field data of Plot 1

4. Calculate the tree diameter at breast height (DBH) from tree circumference

The tree diameter at breast height (DBH) is a key parameter to estimate the tree biomass and carbon stock. Here, we calculate the DBH of each tree from its circumference data. The formula to calculate the DBH is "Diameter = tree circumference / 3.14". Follow the steps below to calculate the DBH of each tree (see Figure 21 and 22).

1). Add a column at the right end of the table
2). Select the cell J18 (column J- row 18) and type "DBH (cm)" to name the new column
3). Select the cell J19 (column J- row 19) for the tree diameter of the tree No.1 and type the following formula

=E19/3.14

Tips to understand the formula

- = : the formula starts with an =
- E19 : the cell that has data of the tree circumference of the tree No.1
- / : symbol for division
- 3.14: the ratio of a circle's circumference to its diameter (we also call it Pi)

4). Press “Enter” key. You will get the DBH of the tree (Tree No. 1) in the cell J19
5). We need to calculate the DBH of every tree in the plot. For the tree No.2, select the cell J20 and type the same formula (but type E20, instead of E19). You will get the DBH of the tree No 2 in the cell J20.
6). Repeat this for all the trees

Example:

- For the tree No. 3, select the cell J21 and type =E21/3.14
- For the tree No. 4, select the cell J22 and type =E22/3.14

Note: copy and paste the formula to calculate the diameter of other trees

After the calculation of Tree No. 1, copy the cell that contains the formula (cell J19) and paste to all cells (from J20 to J33), the formula will automatically reference the values in the cells that you selected, and you will get the DBH of all trees. But check and make sure that the formula is using the correct cell.

	A	B	C	D	E	F	G	H	I	J
3										
4	Plot No.		1							
5										
6	Land use type				Homegarden					
7	Planting pattern				Clusters					
8										
9										
10	Name of the land owner		Yono			Forest litter		0.5 cm		
11	Village name		Makmur			Canopy cover (%)		30%		
12	Sub-village name		Rejo Makmur			Competition		Moderate		
13	Land address		Rejo Makmur/RT 01			Location		S:070.xx.xxx/E.110.xx.xxx		
14	Land size		600 m2			Data recorder		Brambang Team		
15	Plot size		20*20m			Date		16.07.2014		
16										
17										
18	Tree No	Species			Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling	DBH (cm)
19	1	Teak			16	12	4	5	Tree	=E19/3.14
20	2	Teak			38	6	3	4	Tree	
21	3	Sengon			51	8	4	5	Tree	
22	4	Sengon			40	7	3	4	Tree	
23	5	Sengon			36	7	2	3	Tree	
24	6	Teak			68	25	5	7	Tree	
25	7	Mlinjo			33	6	2	3	Tree	
26	8	Sengon			26	6	1	2	Tree	
27	9	Sengon			52	11	4	3	Tree	
28	10	Sengon			34	7	2	3	Tree	

=E19/3.14

Plot 1 | Plot 2 | Plot 3 | Plot 4 | Plot 5 | Plot 6 | Plot 7 | Plot 8 | Plot 9 | Plot 10 | Plot 11 | Plot 12

Edit

Figure 21. Calculation of the DBH of Tree No.1

E	F	G	H	I	J
Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling	DBH (cm)
16	12	4	5	Tree	5.10
38	6	3	4	Tree	12.10
51	8	4	5	Tree	16.24
40	7	3	4	Tree	12.74
36	7	2	3	Tree	11.46
68	25	5	7	Tree	21.66
33	6	2	3	Tree	10.51
26	6	1	2	Tree	8.28
52	11	4	3	Tree	16.56
34	7	2	3	Tree	10.83
25	7	1	1	Tree	7.96
20	6	1	2	Tree	6.37
16	4	1	2	Tree	5.10
28	7	2	3	Tree	8.92
19	5	1	2	Tree	6.05

Figure 22. DBH of all the trees in Plot No.1

5. Calculate the above ground tree biomass

Now we have the DBH of all the trees. Next, we will calculate above ground tree biomass and then determine total above ground tree biomass per unit of area.

5.1. Filter the data by tree species

We estimate the above ground biomass of each tree from its DBH and height, using specific formulas that are called "allometric equations". Because different tree species have different characteristic (mathematical relationship between DBH, tree height and biomass), we calculate tree biomass by species, using different allometric equations. To do so, we first arrange the data set using ***"Filtering"*** function of MS Excel, which allows us to focus on particular species among the all trees of a plot (see Figure 23).

1). Select the range A18:K18 (the first row of the table (highlighted in yellow)

2). Click ***"Data"*** on the toolbar

3). Click ***"Filter"***

4). The "filter icon (triangle)" will appear at the lower-right corner of each cell.

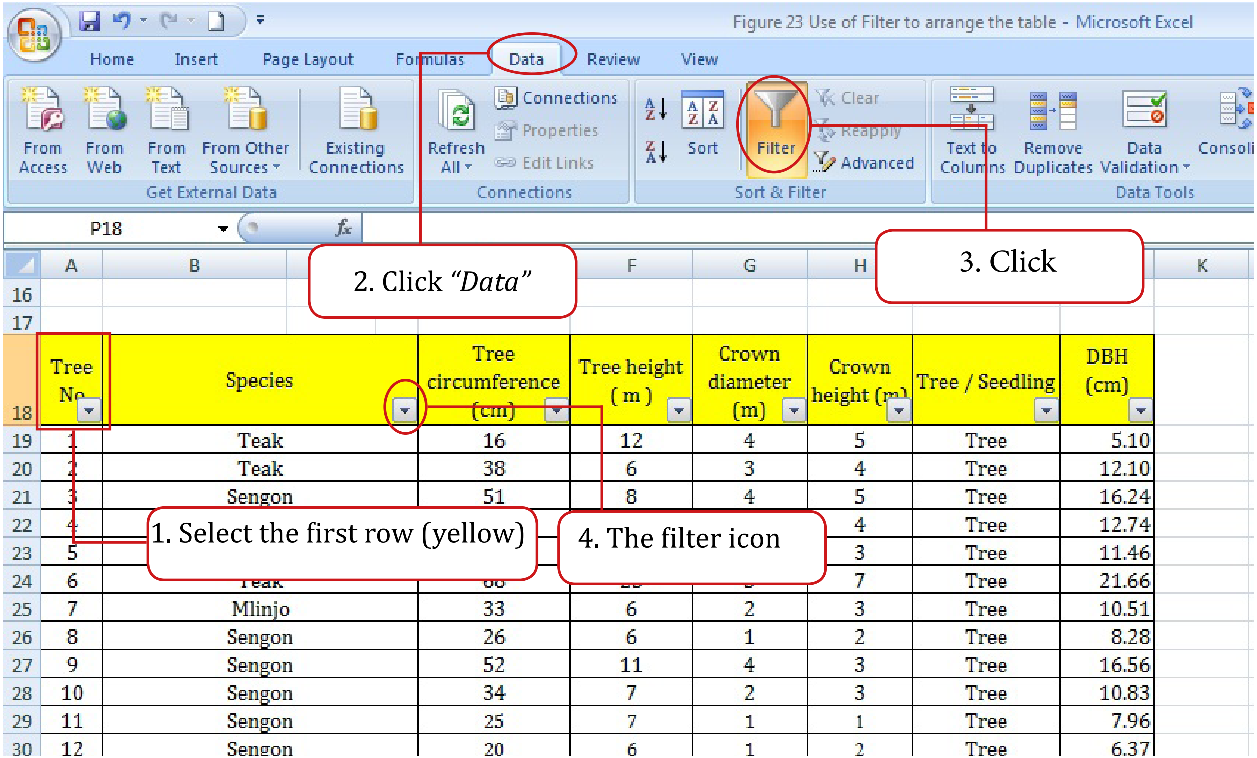


Figure 23. Use of "Filter" to arrange the table as an example, we select the data of Sengon trees (see Figure 24 and 25).

1) Click the "filter icon (triangle)" on column Species (highlighted in yellow)
2) Select Sengon by putting a tick (√) on the box (☐)
3) Click "OK"
4) Only the data of Sengon trees appears on the table, while the data of other species are temporarily hiding.

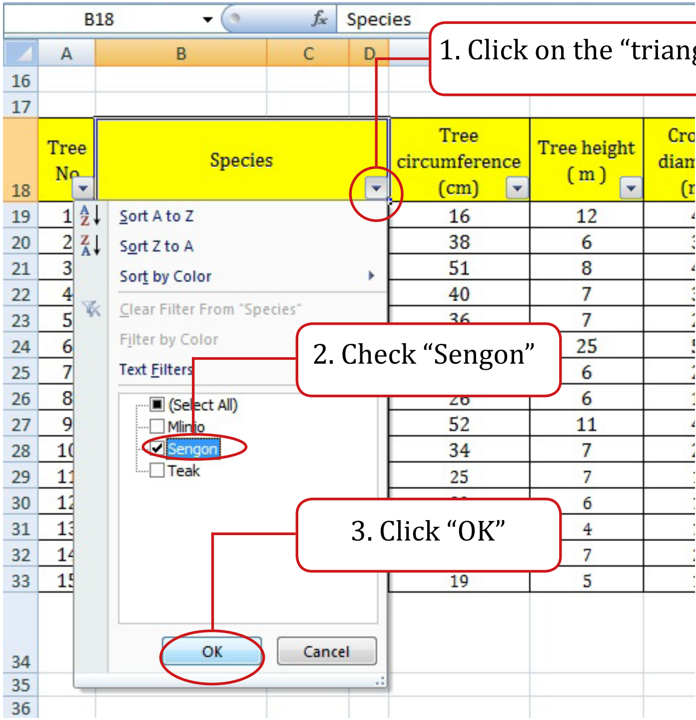


Figure 24. Filtering the plot data

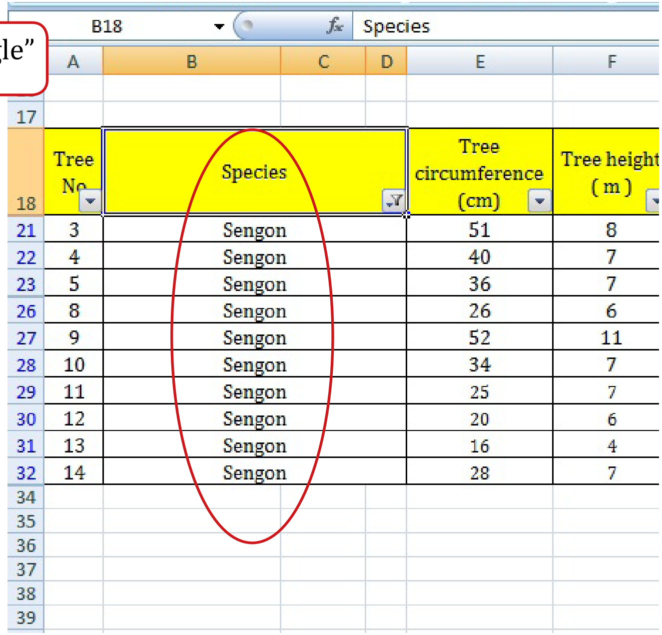


Figure 25. Excel only displays Sengon trees

5.2. Calculating above ground tree biomass of the plot

Allometric equations are formulas to calculate tree biomass using field data. In this manual, we use the allometric equations for Mahogany, Rosewood, Teak, Sengon, Acacia and other species (see Table 2). These formulas were developed based on the research in community forests in Central Java by Ministry of Forestry (Indonesia) and the Forestry Faculty of Gadjah Mada University.

Note: selection of the allometric equations

Various allometric equations have been developed based on field survey according to species and different conditions such as forest types, ecological zones and countries. Therefore, the allometric equation should be carefully selected, by considering these conditions, in order to improve the accuracy of biomass and carbon stock assessment.

Tabel 2. Allometric equations used for forest carbon estimation

Tree Species *(botanical name)*	Total above ground biomass (trunks, branches and leaves)
Mahoni *(Swietenia mahagony)*	$Bt = 0{,}9029(D^2H)^{0{,}6840}$
Rose wood *(Dalbergia latifolia)*	$Bt = 0{,}7458(D^2H)^{0{,}6394}$
Teak *(Tectona grandis)*	$Bt = 0{,}0149(D^2H)^{1{,}0835}$
Sengon *(Paraserianthers falcataria)*	$Bt = 0{,}0199(D^2H)^{0{,}9296}$
Akasia auri *(Acacia auriculiformis)*	$Bt = 0{,}0775(D^2H)^{0{,}9018}$
Others	$Bt = 0{,}0219(D^2H)^{1{,}0102}$

**Bt is above ground tree biomass (kg), D is the DBH (cm), and H is the tree height (m)*

After filtering the data of a particular species, we calculate their biomass.
Here, we calculate the biomass of Sengon trees, using the allometric equation as follows:

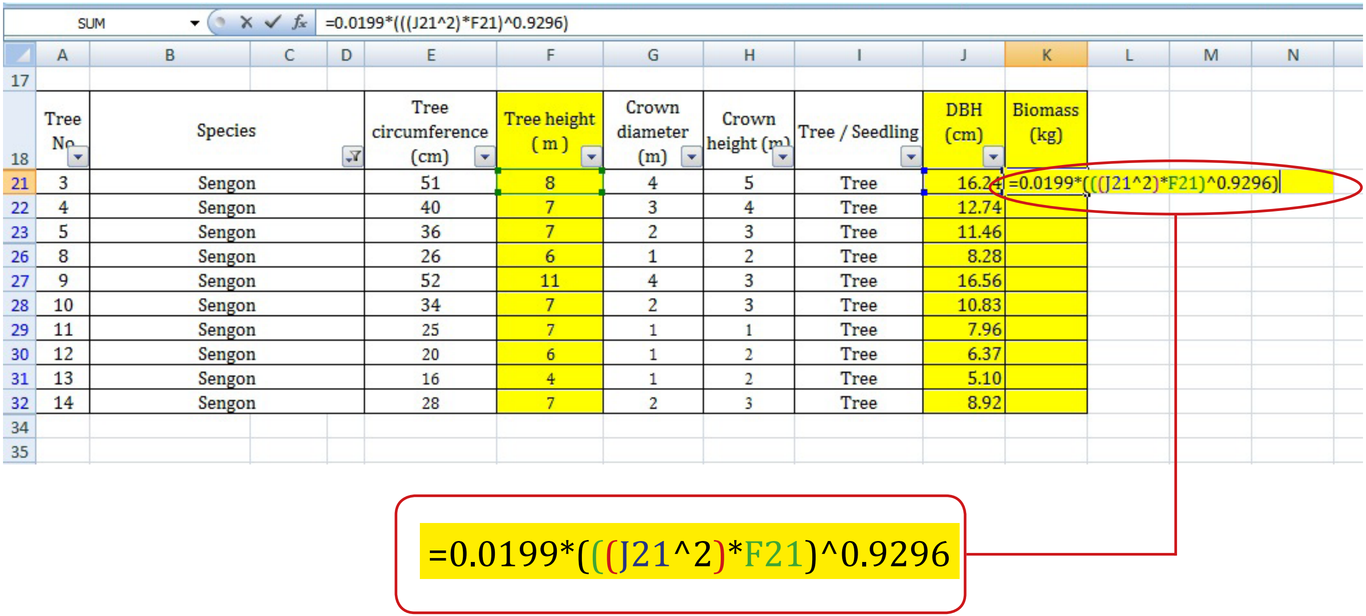
$Bt = 0.0199(D2H)^{0.9296}$ (see Figure 26)

1) Add a new column at the right end of the table, select the cell K18 and type “Biomass (kg)”
2) Select the cell K21 (column K- row21) and type the following formula and push “Enter” key

```
=0.0199*(((J21^2)*F21) ^0.9296)
```

Tips to understand the formula

- : symbol for multiplication (x)
- ^ : symbol for powers (or exponents) of numbers
- J21 : column J-row 21 is the data of the DBH (of Tree No.3)
- F21 : column F-row 21 is the data of the tree height (of Tree No.3)



SUM | =0.0199*(((J21^2)*F21)^0.9296)

Tree No	Species	Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling	DBH (cm)	Biomass (kg)
3	Sengon	51	8	4	5	Tree	16.24	=0.0199*(((J21^2)*F21)^0.9296)
4	Sengon	40	7	3	4	Tree	12.74	
5	Sengon	36	7	2	3	Tree	11.46	
8	Sengon	26	6	1	2	Tree	8.28	
9	Sengon	52	11	4	3	Tree	16.56	
10	Sengon	34	7	2	3	Tree	10.83	
11	Sengon	25	7	1	1	Tree	7.96	
12	Sengon	20	6	1	2	Tree	6.37	
13	Sengon	16	4	1	2	Tree	5.10	
14	Sengon	28	7	2	3	Tree	8.92	

=0.0199*(((J21^2)*F21)^0.9296

Figure 26. Calculation of above ground biomass of Tree No.3 (Sengon)

3). Calculate the all Sengon trees of Plot1 (Figure 27)

Example:

- For the tree No. 4, select the cell K22 and type the formula as follows:
  = 0.0199*(((J22^2)*F22)^0.9296)
- For the tree No. 5, select the cell K23 and type the formula as follows:
  = 0.0199*(((J23^2)*F23)^0.9296)

Note: copy and paste the formula to calculate other trees

After the calculation of the first Sengon tree, you can simply copy this formula to all cells for other Sengon biomass (from **K22** to **K32**) to calculate their biomass, but make sure that the formula is using the correct cell for Height and Diameter values

Tree No	Species	Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling	DBH (cm)	Biomass (kg)
3	Sengon	51	8	4	5	Tree	16.24	24.50
4	Sengon	40	7	3	4	Tree	12.74	13.78
5	Sengon	36	7	2	3	Tree	11.46	11.33
8	Sengon	26	6	1	2	Tree	8.28	5.36
9	Sengon	52	11	4	3	Tree	16.56	34.15
10	Sengon	34	7	2	3	Tree	10.83	10.18
11	Sengon	25	7	1	1	Tree	7.96	5.75
12	Sengon	20	6	1	2	Tree	6.37	3.29
13	Sengon	16	4	1	2	Tree	5.10	1.49
14	Sengon	28	7	2	3	Tree	8.92	7.10

Figure 27. Calculation of the above ground biomass of all Sengon trees of Plot 1

4). Calculate the above ground biomass of all tree species of the sample plot:

Sengon is not the only species in Plot 1(there are Teak and other species), and we need to calculate their above ground biomass. So we will “Filter” these species (i.e. teak and other species), and calculate the tree biomass of each species, using their specific allometric equations, which are listed in Table 2. Each tree biomass (kg) is shown in Figure 28.

K18 fx Biomass

Tree No	Species	Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling	DBH (cm)	Biomass (kg)
1	Teak	16	12	4	5	Tree	5.10	7.50
2	Teak	38	6	3	4	Tree	12.10	23.06
3	Sengon	51	8	4	5	Tree	16.24	24.50
4	Sengon	40	7	3	4	Tree	12.74	13.78
5	Sengon	36	7	2	3	Tree	11.46	11.33
6	Teak	68	25	5	7	Tree	21.66	381.99
7	Mlinjo	33	6	2	3	Tree	10.51	15.51
8	Sengon	26	6	1	2	Tree	8.28	5.36
9	Sengon	52	11	4	3	Tree	16.56	34.15
10	Sengon	34	7	2	3	Tree	10.83	10.18
11	Sengon	25	7	1	1	Tree	7.96	5.75
12	Sengon	20	6	1	2	Tree	6.37	3.29
13	Sengon	16	4	1	2	Tree	5.10	1.49
14	Sengon	28	7	2	3	Tree	8.92	7.10
15	Teak	19	5	1	2	Tree	6.05	4.21

Figure 28. Calculation of all species trees of Plot 1

5). Calculate the total above ground tree biomass of the sample plot

After the biomass of every tree of the plot is calculated, we will sum them up to determine the total above ground tree biomass of the sample plot (Plot 1). We add up the biomass of Tree No.1 (the cell K19) to the biomass of Tree No. 15 (the cell K39) (see Figure 29 and 30).

①. Select the cell J34 and name “Plot Total Biomass”

②. Select the cell K34 and type the formula as follows

=SUM (K19:K39)

Tips to understand the formula

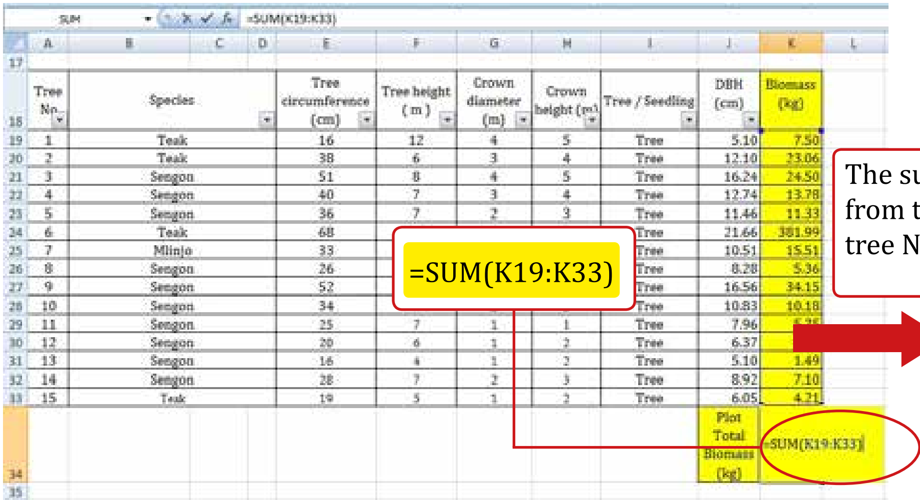
- SUM : function of Excel to sum numbers in a range of cells that you specify
- (K19:K39) : a range of cells that numbers will be added. In this formula, we specify the range from the cell K19 until the cell K39

③. Push “Enter” key. We will get the total biomass of the plot in the cell K34, which is 549.20 kg

6). Calculate the total biomass of all the sample plots according to the land use type

Repeat the calculation for all the sample plots of home garden.

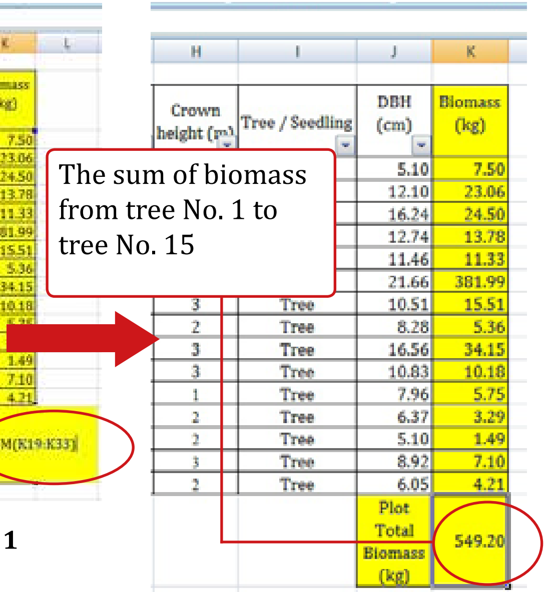
**We calculate biomass and carbon stock according to the land use type (i.e. home garden and dry land). In this manual, we use the sample plots in home gardens as an example.*



=SUM(K19:K33)

Tree No.	Species	Tree circumference (cm)	Tree height (m)	Crown diameter (m)	Crown height (m)	Tree / Seedling	DBH (cm)	Biomass (kg)
1	Teak	16	12	4	5	Tree	5.10	7.50
2	Teak	38	6	3	4	Tree	12.10	23.06
3	Sengon	51	8	4	5	Tree	16.24	24.50
4	Sengon	40	7	3	4	Tree	12.74	13.78
5	Sengon	36	7	2	3	Tree	11.46	11.33
6	Teak	68				Tree	21.66	381.99
7	Mlinjo	33				Tree	10.51	15.51
8	Sengon	26				Tree	8.28	5.36
9	Sengon	52				Tree	16.56	34.15
10	Sengon	34				Tree	10.83	10.18
11	Sengon	25	7	1	1	Tree	7.96	[illegible]
12	Sengon	20	6	1	2	Tree	6.37	
13	Sengon	16	4	1	2	Tree	5.10	1.49
14	Sengon	28	7	2	3	Tree	8.92	7.10
15	Teak	19	5	1	2	Tree	6.05	4.21
							Plot Total Biomass (kg)	=SUM(K19:K33)

Figure 29. Calculation of total above ground tree biomass of Plot 1



Crown height (m)	Tree / Seedling	DBH (cm)	Biomass (kg)
		5.10	7.50
		12.10	23.06
		16.24	24.50
		12.74	13.78
		11.46	11.33
		21.66	381.99
3	Tree	10.51	15.51
2	Tree	8.28	5.36
3	Tree	16.56	34.15
3	Tree	10.83	10.18
1	Tree	7.96	5.75
2	Tree	6.37	3.29
2	Tree	5.10	1.49
3	Tree	8.92	7.10
2	Tree	6.05	4.21
		Plot Total Biomass (kg)	549.20

Figure 30. Total biomass of Plot 1

5.3. Calculate total above ground biomass according to the land use type

Now we have the above ground biomass of every sample plot located in home gardens.

** To calculate the above ground biomass of every sample plot located in dry land, we would repeat the above steps.*

1). Create a table as Figure 31 on a new a worksheet, and name it "Total". It is important to name the type of land use in the tile of the table (i.e. home garden).

2). Enter the total biomass data of each sample plot of home gardens.

Community Carbon Accounting

Total Biomass and Forest Carbon Calculation

Land use type (Home garden)

Plot number	Biomass (kg)	Carbon stock (kg)
Plot 1	549.20	
Plot 2	328.45	
Plot 3	640.98	
Plot 4	563.23	
Plot 5	449.12	
Plot 6	582.40	
Plot 7	763.20	
Plot 8	828.53	
Plot 9	725.34	
Plot 27	668.22	
Plot 28	831.23	
Plot 29	665.46	
Plot 30	557.02	

Figure 31. Biomass of all sample plots of home garden

** There are 30 sample plots in home garden in Makmur Village. However, Figure 31 does not show all of the plots (from Plot 10 to Plot 26 are hidden), due to the limited display space.*

3). Sum the biomass data of the 30 sample plots (from the cell C6 till the cell C35) (see Figure 32 and 33)

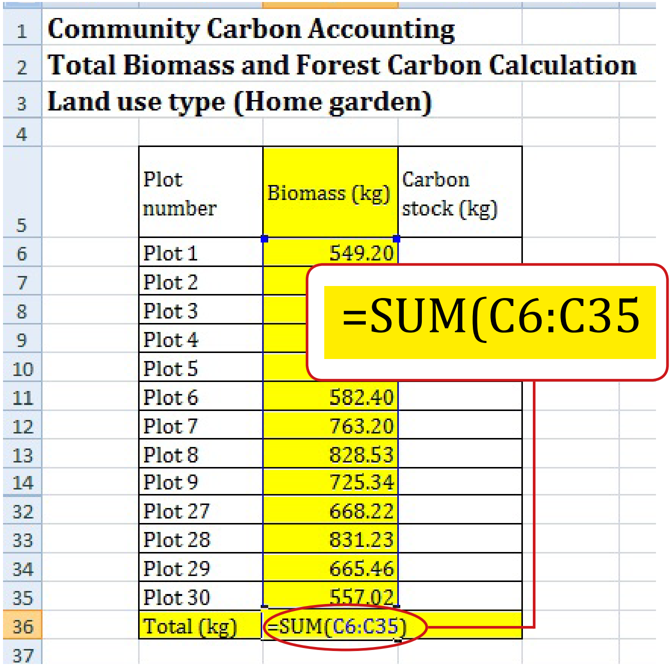
①. Add a new row below the table. Select the cell B36 and name "Total (kg)"
②. Select the cell C36, and type the formula as follows

=SUM (C6:C35)

Tips to understand the formula

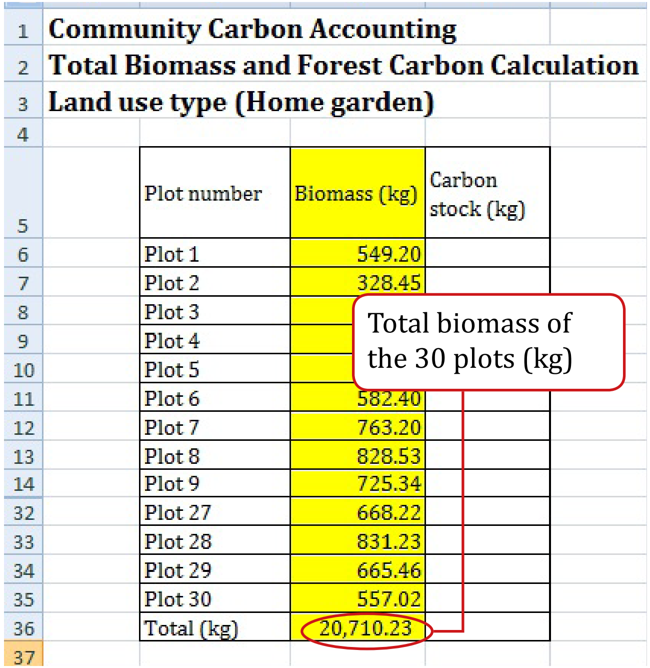
- (C6:C35): a range of cells that numbers will be added. In this formula, we specify the range from the cell C6 till the cell C35 (from Plot 1 to Plot 30)

③. Press "Enter" key. We will get the total biomass of 30 sample plots in home garden, which is 20,710.23 kg



1	**Community Carbon Accounting**		
2	**Total Biomass and Forest Carbon Calculation**		
3	**Land use type (Home garden)**		
4			
5	Plot number	Biomass (kg)	Carbon stock (kg)
6	Plot 1	549.20	
7	Plot 2		
8	Plot 3		
9	Plot 4		
10	Plot 5		
11	Plot 6	582.40	
12	Plot 7	763.20	
13	Plot 8	828.53	
14	Plot 9	725.34	
32	Plot 27	668.22	
33	Plot 28	831.23	
34	Plot 29	665.46	
35	Plot 30	557.02	
36	Total (kg)	=SUM(C6:C35)	
37			

Figure 32. Adding the biomass of the 30 sample plots in home garden



1	**Community Carbon Accounting**		
2	**Total Biomass and Forest Carbon Calculation**		
3	**Land use type (Home garden)**		
4			
5	Plot number	Biomass (kg)	Carbon stock (kg)
6	Plot 1	549.20	
7	Plot 2	328.45	
8	Plot 3		
9	Plot 4		
10	Plot 5		
11	Plot 6	582.40	
12	Plot 7	763.20	
13	Plot 8	828.53	
14	Plot 9	725.34	
32	Plot 27	668.22	
33	Plot 28	831.23	
34	Plot 29	665.46	
35	Plot 30	557.02	
36	Total (kg)	20,710.23	
37			

Figure 33. Total biomass of the 30 plots in home garden

4). Convert the total biomass from kg in tons per hectare (ton/ha)

Now we have calculated the total biomass of all the sample plots in home garden (20,713.23kg) (Figure 33). This biomass is the sum of the 30 sample plots, each of which is 400 m2 (20m x 20m) in size. We need to calculate this total biomass on a per-area basis (the biomass density), so we can compare with other forests. The formula below explains how to convert our result to "Biomass in tons per hectare (ton/ha)".

$$\text{Biomass (ton/ha)} = \frac{\frac{total\ biomassa\ (kg)}{1.000\ kg} \times \frac{10.000\ m^2}{plot\ size}}{\text{Number of plots}}$$

Tips to understand the formula:

- The hectare (ha) is a unit of land area (1ha = 10,000 m2)
- The ton is a unit of weight (1 ton = 1,000 kg)
- Conversion from Biomass (kg) to Biomass (ton): Biomass (kg) divided by 1,000 (kg)
- Conversion from m2 to ha: Biomass multiplied by 10,000 (m2) divided by plot size
- The plot size: 400 m2
- The number of plot: in this example, there are 30 sample plots in home gardens

①. Add a new row below the table. Select the cell B37 and name "Total (ton/ha)" (Figure 34)

②. Select the cell C37, and type the formula as follows (Figure 34)

=(C36/1000)*(10000/400)/30

Tips to understand the formula:

- C36: total biomass (kg) of the 30 sample plots

③. Press "Enter" key. We will get the total biomass in tons per hectare (17.26 ton/ha) (Figure 35).

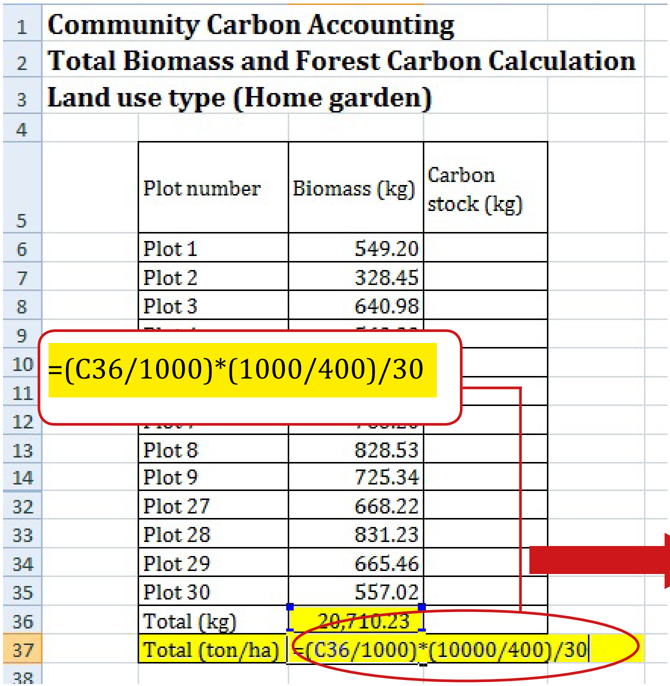


Figure 34. Conversion of the total biomass in tons per hectare (ton/ha)

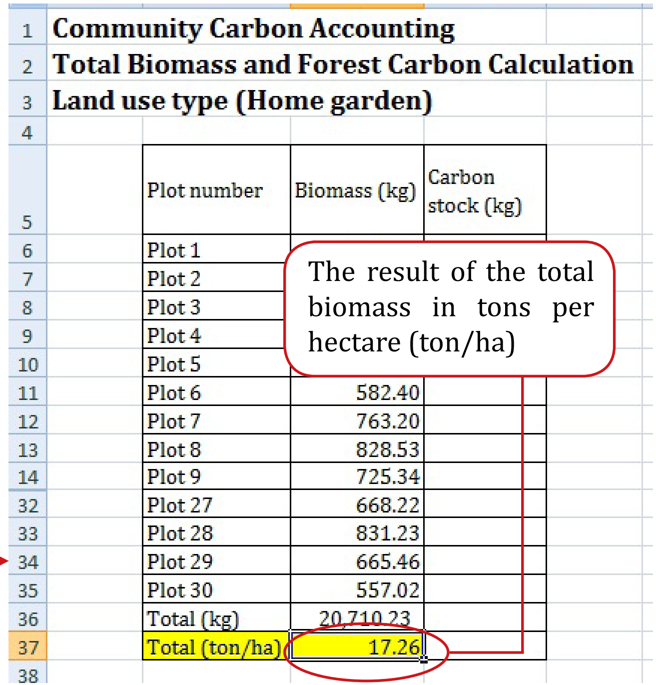


Figure 35. Result of the total biomass in tons per hectare (ton/ha)

6. Calculate the above ground forest carbon stock

We have calculated the above ground biomass of each sample plot in home gardens and determined the total biomass (ton/ha) of all the plots. As the last step, we will calculate the forest carbon stock of each plot and determine the total forest carbon stock in home garden.

6.1. Calculate the above ground forest carbon stock of each sample plot (see Figure 36)

1). Carbon in living trees approximately accounts for one-half (50%) of its biomass. Therefore, we use the following formula to convert the biomass value of living trees into carbon stock: Carbon stock = 0.5 x biomass

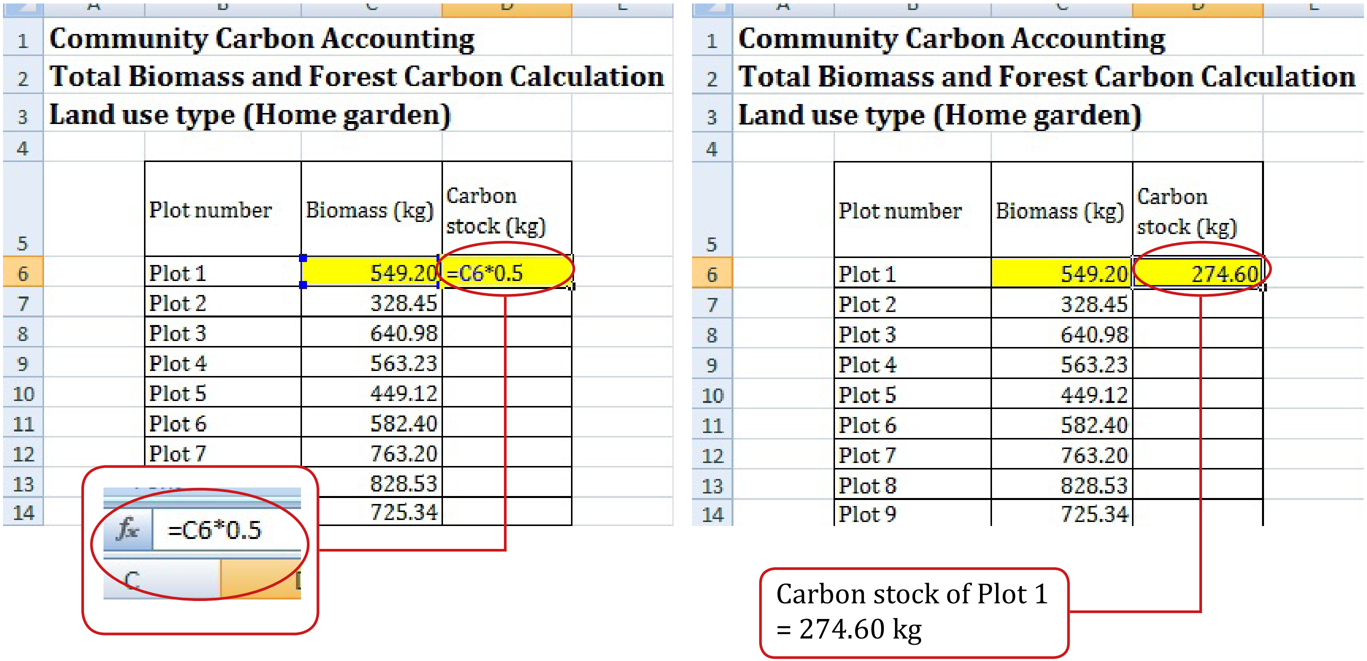
2). Select the cell D6 and type the formula as follows

=0.5*C6

Tip to understand the formula:

- C6: total biomass of Plot 1

3). Press the "Enter" key. We will get the carbon stock of Plot 1 (274.60 kg)



Community Carbon Accounting
Total Biomass and Forest Carbon Calculation
Land use type (Home garden)

Plot number	Biomass (kg)	Carbon stock (kg)
Plot 1	549.20	=C6*0.5
Plot 2	328.45	
Plot 3	640.98	
Plot 4	563.23	
Plot 5	449.12	
Plot 6	582.40	
Plot 7	763.20	
Plot 8	828.53	
Plot 9	725.34	

Figure 36. Calculataion of forest carbon stock of Plot 1

6.2. Calculate the forest carbon stock of all the sample plots (from Plot 2 to Plot 30) (see Figure 37)

Examples:

- For the Plot 2 (at row 7), select the cell D7 and type the formula as follows: =0.5*C7
- For the Plot 3 (at row 8), select the cell D8 and type the formula as follows: =0.5*C8

Note: copy and paste the formula to calculate the carbon stock of other plots

After the calculation of Plot 1, copy the cell D6 that contains the formula to all cells (from D7 to D35). You will get the forest carbon stock of each plot. But check and make sure that the formula is using the correct cell.

	A	B	C	D	E
1	**Community Carbon Accounting**				
2	**Total Biomass and Forest Carbon Calculation**				
3	**Land use type (Home garden)**				
4					
5		Plot number	Biomass (kg)	Carbon stock (kg)	
6		Plot 1	549.20	274.60	
7		Plot 2	328.45	164.23	
8		Plot 3	640.98	320.49	
9		Plot 4	563.23	281.62	
10		Plot 5	449.12	224.56	
11		Plot 6	582.40	291.20	
12		Plot 7	763.20	381.60	
13		Plot 8	828.53	414.27	
14		Plot 9	725.34	362.67	
32		Plot 27	668.22	334.11	
33		Plot 28	831.23	415.62	
34		Plot 29	665.46	332.73	
35		Plot 30	557.02	278.51	
36		Total (kg)	20,710.23		
37		Total (ton/ha)	17.26		
38					

Figure 37. Calculation of forest carbon stock of each plot

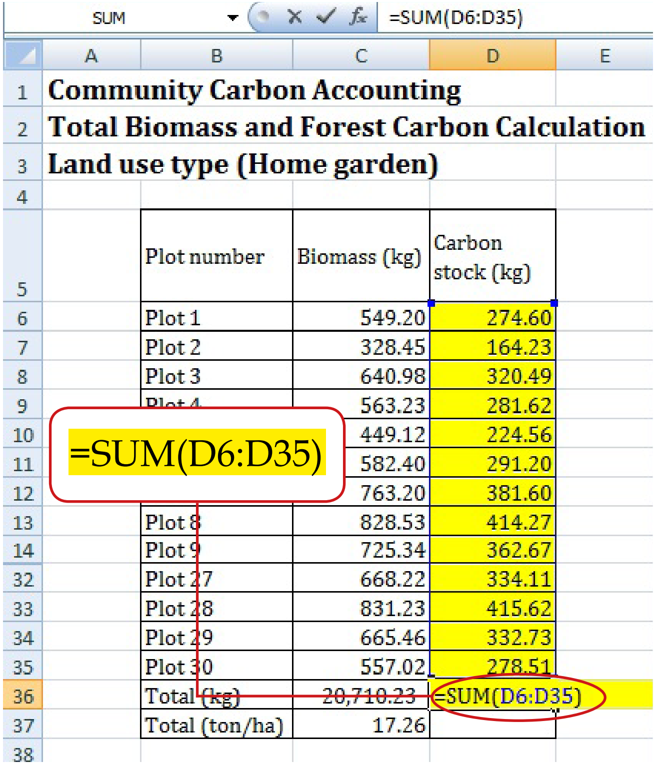
6.3. Sum the forest carbon stock of all the sample plots according to land use type

Here, we sum the forest carbon stocks of all the sample plots in home gardens (see Figures 38 and 39)

1) Select the cell D36 and type the formula as follows:

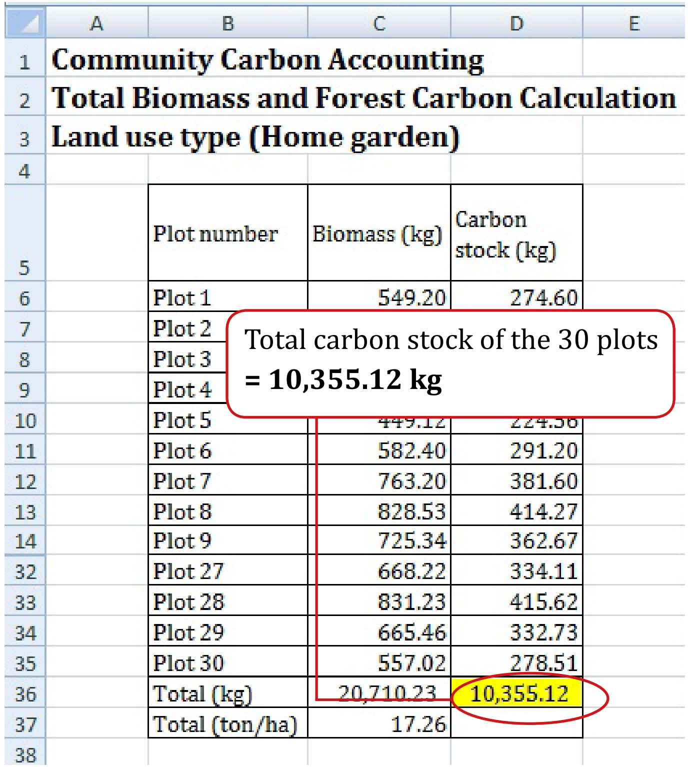
```
=SUM(D6:D35)
```

2) Press the “Enter” key. We will then get the total forest carbon stock of all sample plots in home gardens (10,355.12 kg)



Plot number	Biomass (kg)	Carbon stock (kg)
Plot 1	549.20	274.60
Plot 2	328.45	164.23
Plot 3	640.98	320.49
Plot 4	563.23	281.62
	449.12	224.56
	582.40	291.20
	763.20	381.60
Plot 8	828.53	414.27
Plot 9	725.34	362.67
Plot 27	668.22	334.11
Plot 28	831.23	415.62
Plot 29	665.46	332.73
Plot 30	557.02	278.51
Total (kg)	20,710.23	=SUM(D6:D35)
Total (ton/ha)	17.26	

Figure 38. Adding the carbon stocks of the 30 plots in home garden



Plot number	Biomass (kg)	Carbon stock (kg)
Plot 1	549.20	274.60
Plot 2		
Plot 3		
Plot 4		
Plot 5	449.12	224.56
Plot 6	582.40	291.20
Plot 7	763.20	381.60
Plot 8	828.53	414.27
Plot 9	725.34	362.67
Plot 27	668.22	334.11
Plot 28	831.23	415.62
Plot 29	665.46	332.73
Plot 30	557.02	278.51
Total (kg)	20,710.23	10,355.12
Total (ton/ha)	17.26	

Figure 39. Sum of carbon stocks of the 30 plots in home garden

6.4. Convert the forest carbon stock in tons per hectare (ton/ha)

Now we have calculated the forest carbon stock of all the sample plots in home gardens (10,355.12 kg) (Figure 39). As we did for biomass, we need to convert this total forest carbon stock on a per-area basis (forest carbon density), so that we can compare with other forests. The formula below explains how to convert our result to "Carbon stock in tons per hectare (ton/ha)" (same formula for converting biomass in tons per hectare).

$$\text{Carbon stock (ton/ha)} = \frac{\frac{total\ biomass\ (kg)}{1.000\ kg} \times \frac{10.000\ m^2}{plot\ size}}{\text{Number of plots}}$$

1). Select the cell D37, and type the formula as follows (see Figure 40).

=(D36/1000)*(10000/400)/30

Tips to understand the formula:

- D36: sum of the forest carbon stocks (kg) of the 30 sample plots

2). Press “Enter” key. We will get the total forest carbon stock in tons per hectare (8.63 ton/ha) (see Figure 41).

**The result of 8.63 (ton/ha) is the forest carbon stock of community forest in home garden. As explained, the forest carbon stock is estimated for each land use type (home garden and dry land). Forest carbon stock of community forest in dry land is calculated following the same process.*

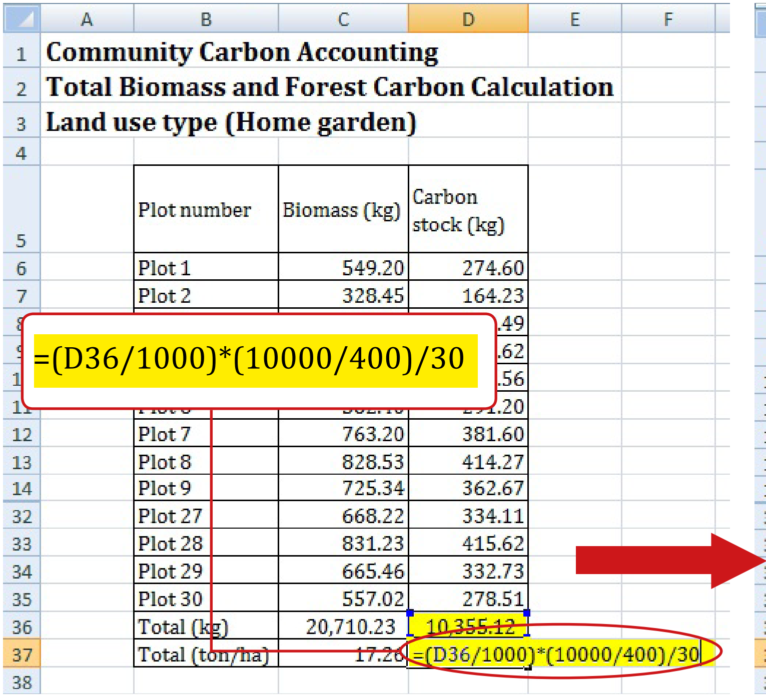


Figure 40. Conversion of total carbon stock in tons per hectare (ton/ha)

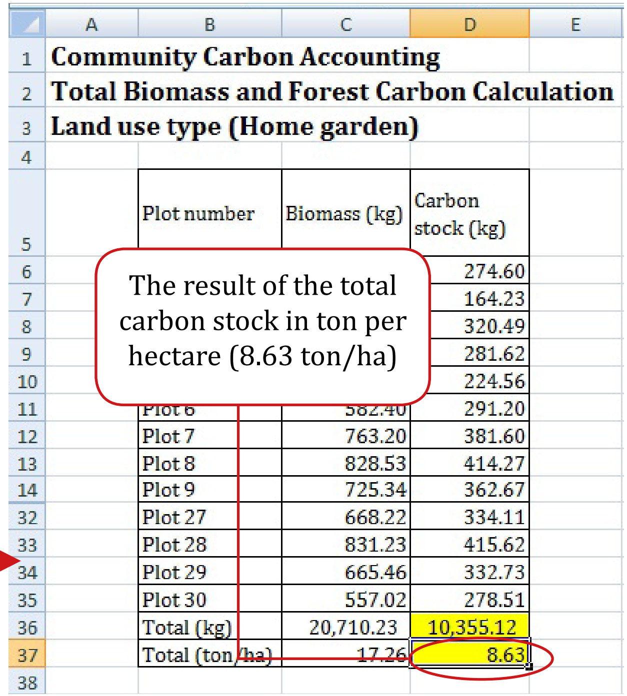


Figure 41. Result of total carbon stock in tons per hectare (ton/ha)

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ARuPA (*Aliansi Relawan untuk Penyelamat Alam* / Volunteer Alliance for Nature Rescue) is a NGO (non-government organization engaged in the preservation of natural resources and environment. ARuPA was founded on May 16, 1998 in Yogyakarta as an action to encourage people to do reformation. ARuPA has a spirit to make critical corrections on the issues of natural resource management in general; and forest resources in particular, due to errors in the paradigm, policy, institution, and management systems.

ARuPA's vision is to make civil society have a power on economic, social and political; to create a management of natural resources and environment that is fair, everlasting, democratic, and sustainable; and to achieve social welfare. More information about ARuPA can be found in the following website: www.arupa.or.id

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