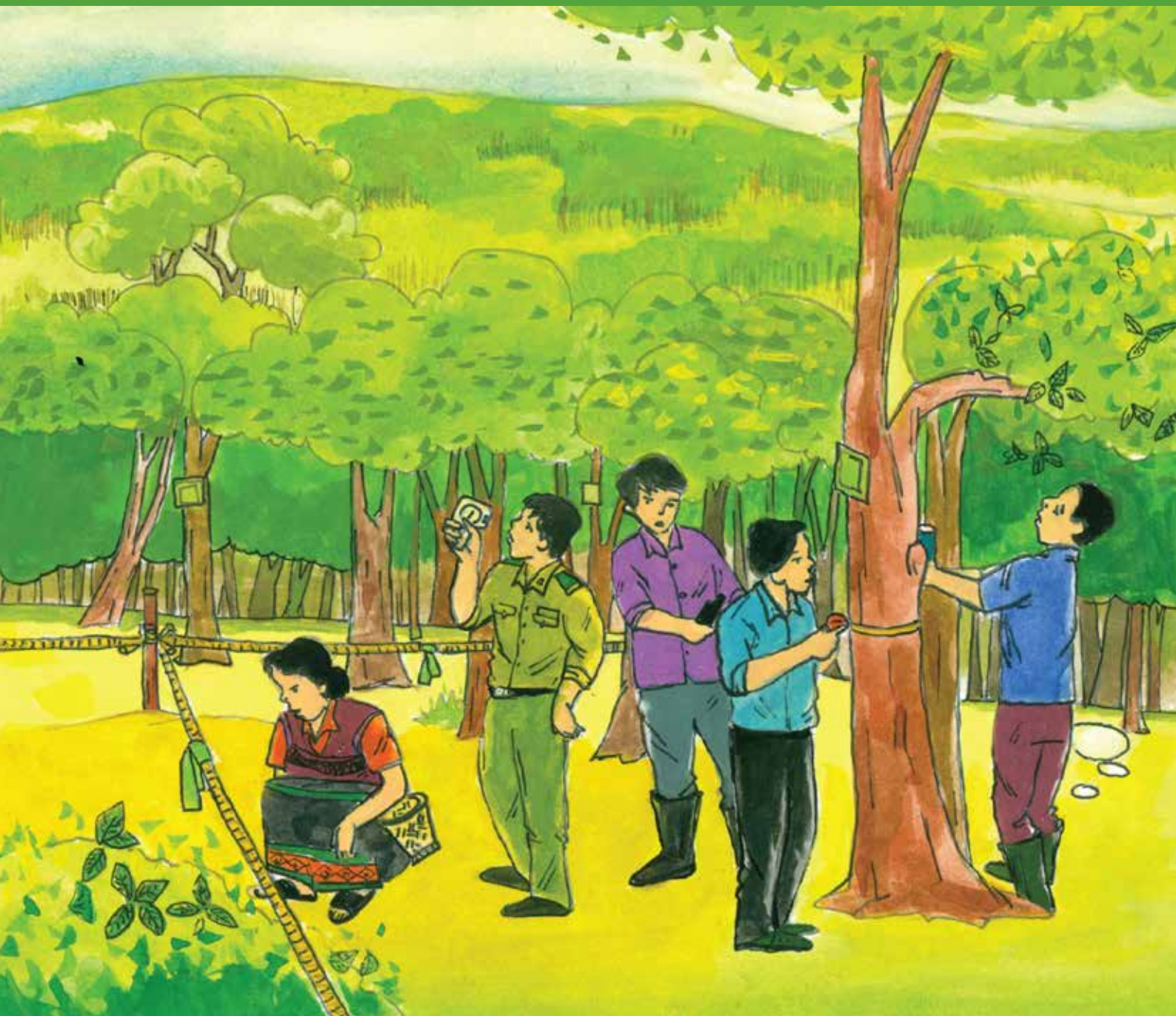


Participatory Carbon Monitoring: Manual for Local People

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Introduction to participatory carbon monitoring (PCM)

1

The implementation of incentive based forestry programs such as Payment for Ecosystem Services (PES); Reducing Emissions from Deforestation and Forest Degradation (REDD+); and forestland allocation, management and protection under commitment contract with households, communities and forest owners needs a monitoring system to quantify the change in forest biomass and carbon for allocating incentives based on performance.

The monitoring system must involve local households and forest owners to ensure that local stakeholders actively participate in forest management and assist in gathering or providing qualitative and quantitative information on the forests allocated to them or managed under the contract with the forest owner. The participating households may receive a direct payment for labour invested during monitoring as well as other benefits such as payment, goods or services that accrue from the emissions reductions or emission removals achieved through the incentive based forestry activities such as from REDD+. A monitoring system that involves stakeholders in various steps of monitoring of forest carbon is called participatory carbon monitoring (PCM).

In order for local households and communities to undertake monitoring activities, the monitoring method must be simple and suitable for community and forest owner alike. Local stakeholders must be able to implement the monitoring activities with support of forestry staff to produce reliable data that meets the national and international expectations as well as quality standards.



This PCM manual, **Manual for Local People**, is one of the three individual manuals designed to facilitate stakeholders' participation in carbon monitoring and is designed for use by local households and communities for collecting and monitoring field data. In this manual, a quick review of forest parameters, i.e. carbon pools measured in the field using PCM, is covered.

This manual provides detailed step-wise procedures to measure changes in the forest area, forest status and forest carbon in the field using existing forest maps, the GPS and predetermined plot locations. The **Manual for Local Technical Staff** is for use by local forestry staff for designing and implementing PCM activities in the field and analysing PCM data. A third in the series, the **Manual for Field Reference**, is to be used in the field for quick reference.

Parameters measured in participatory carbon monitoring (PCM)

2

- Five forest carbon¹ pools can be measured using PCM (Figure 1). These are:
 - i. above-ground
 - ii. below-ground
 - iii. litter
 - iv. dead wood
 - v. soil.

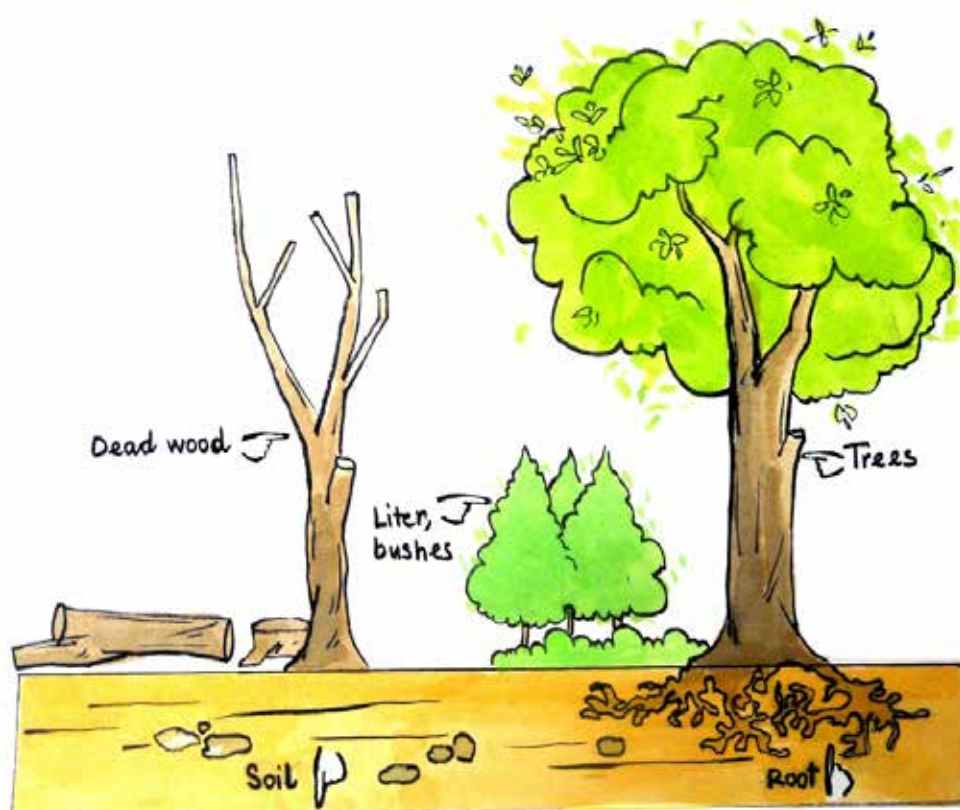


Figure 1. Carbon sinks in the forest

- PCM based monitoring of change in forest carbon includes the following two primary activities:
 - Measuring changes in the forest area and forest status
 - Measuring forest carbon pools and other attributes in sample plots,

This manual provides guidelines for measuring changes in forest area and forest status as well as for measuring forest attributes and carbon pools in forest. However, the scope of this manual is limited to the measurement of above-ground pools i.e. manual does not include guidelines for measuring below-ground, dead wood, litter and soil pools.

¹ An additional carbon pool, wood product (HWP), is not measured in the forest and therefore related procedures are not included in this manual.



Figure 2. Necessary tools and materials for PCM activity

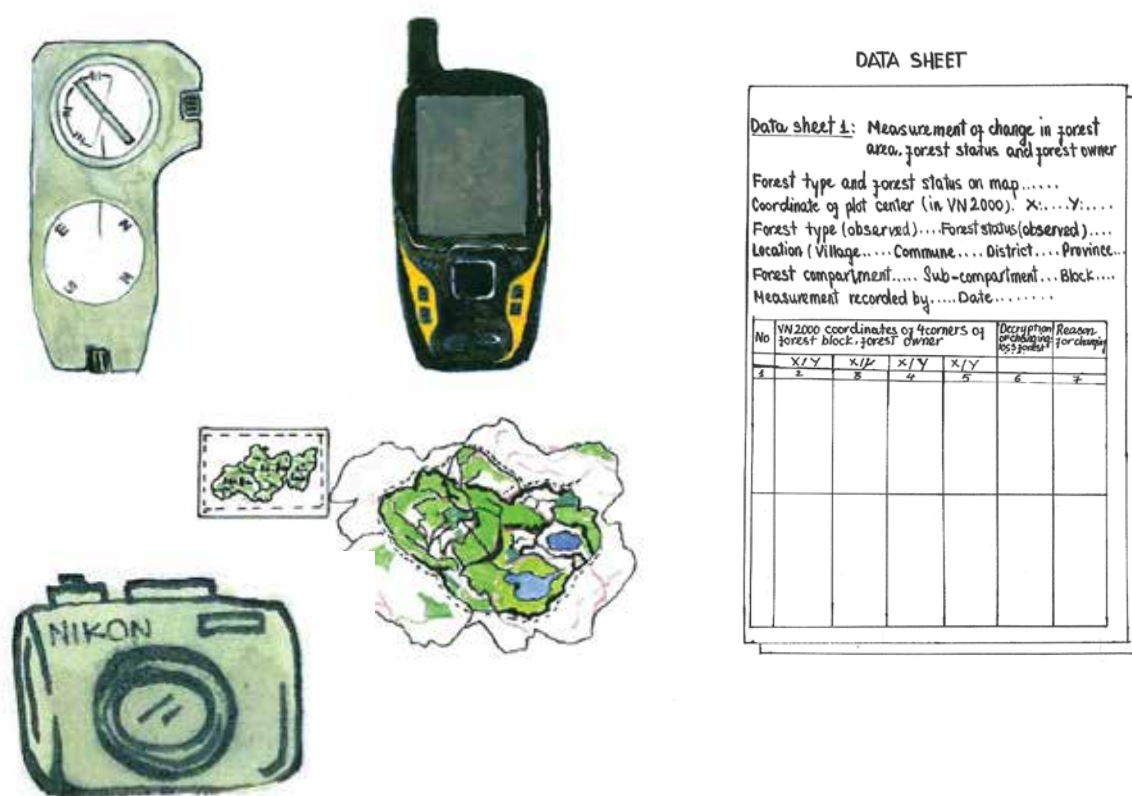
If the forest boundary or forest status is found to be different from that which is indicated on the forest map, the forest boundary must be delineated using the GPS tracking function. Upon delineating the boundary, update the boundary and forest status information.

Expected outcome:

- Forest boundaries demarcated, changed area quantified and map prepared
- Status of forest change (e.g. past forest exploitation resulted in change of status from average to poor) indicated and deforestation rate in the forest management unit quantified
- Any change in area, boundary or status over a period (annual to period) recorded.

Materials required:

- Forest map showing the boundaries of forest owners
- GPS² for delineating forest boundary of forest owners and estimating forest area
- Suunto clinometer and compass
- Digital or other camera (optional)
- Data sheets to record forest area and status change (Form 1)



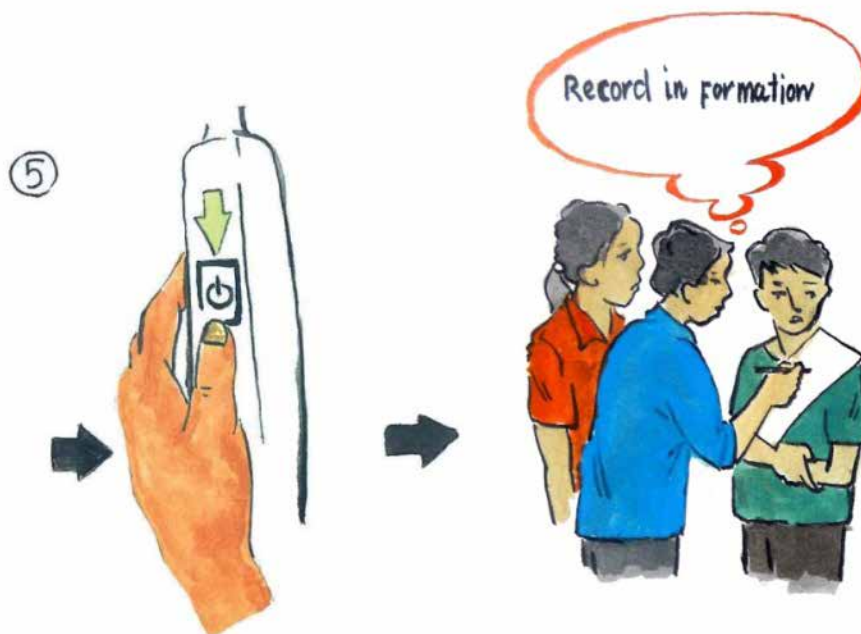
2 The illustration contained in this manual is based on GPS 60CSx. For other model of GPS, refer to user's manual.

Procedure:

Step 1: Boundary delineation using GPS 60CSx

- Power on and press Menu twice to access Tracks, then press Enter
- Press Clear button to delete all old tracks
- Press Menu and select Area Calculation; press Enter two times to start track function
- Walk around the area while the GPS is still on
- When measurement is complete, press Enter twice to end the tracking
- Save and name the result, then press OK to finish the area delineation
- If a digital camera is available, take few pictures of the area. The name of the picture files must be similar to the name of the track for easy identification.





Make sure that the GPS is turned on while track function is active. Turn off the GPS upon completion of delineation of one area or forest parcel. If the GPS is on and track mode is active while moving to next forest parcel, the delineated areas could get connected together in the map, making the editing process time consuming and cumbersome.

Technical staff must lead the team and instruct local people about using the GPS. When local people feel comfortable about using the GPS, local people can lead this task.

Step 2: Record forest area change

Use Form 1 (see Appendix) to record the following information on forest area change in the field:

- Location, forest owners, date, time and person or team leader recording data leader
- VN2000 coordinates (X/Y) in four corners of the forest
- Description of changes and underlying causes.

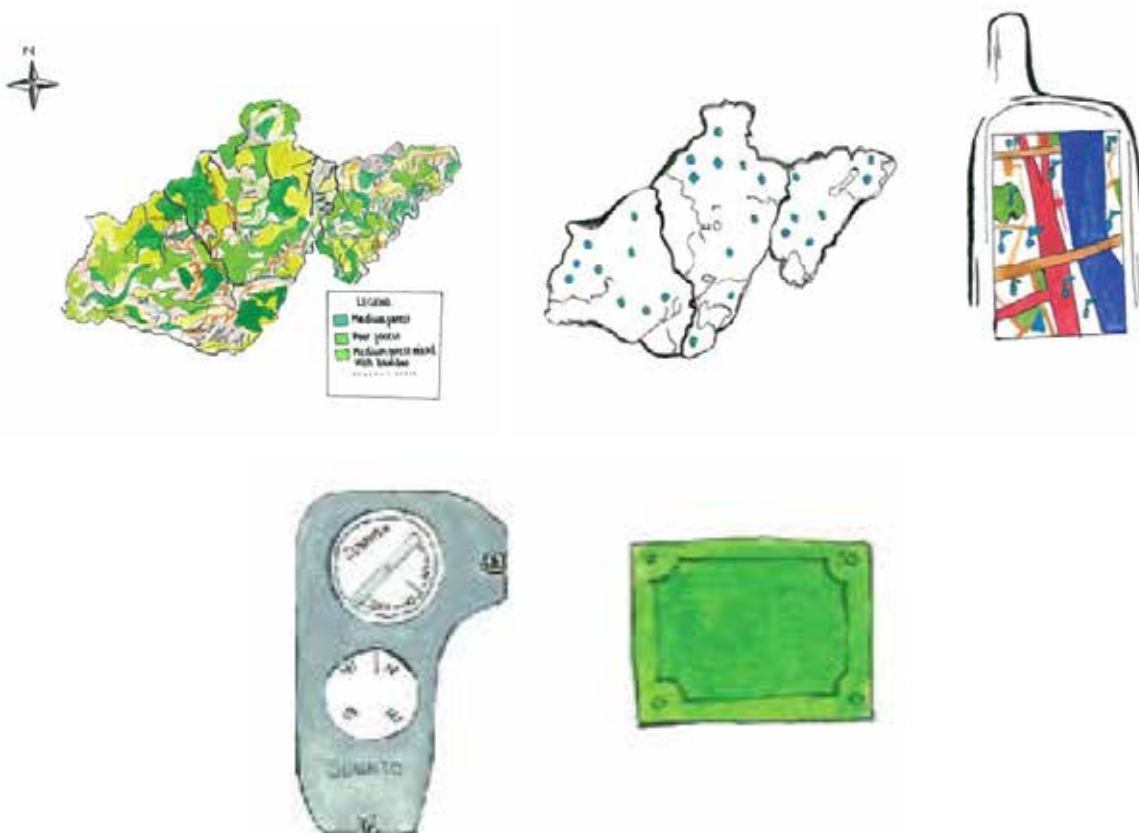
The random sample plots are shown on the map. The location of plots is pre-installed in the GPS by a technician. The locations of plots are identified in the forest.

Expected outcome:

- The random permanent plots for collecting data on forest biomass and carbon are located in the forest and the centre of the plot is marked.

Materials required:

- Map of location of random sample plots
- Suunto clinometer and compass
- GPS with coordinates of random sample plots
- Sheet with recorded code and coordinates of sample plots
- Iron board for placing identification tags for plot and coordinates of sample plots
- Hammer and nails for affixing tree tags
- Permanent paint to mark identification tags on sample plots
- Digital camera (optional).





Procedure:

- Press Find, then press Enter to access Waypoint
- From the list of plots, select the correct plot to be sampled
- Press Goto and select Off road
- Walk to the destination shown on the GPS. The GPS will sound an alarm when the destination plot is reached
- The coordinates of the centre of the defined plot should be checked on the GPS and on the map
- If a camera is available, take a picture of the GPS while the GPS is showing the coordinate position
- End Goto function by pressing Menu and then selecting Stop Navigation
- At the centre of permanent sample plots, place the plot marker i.e. concrete or wooden pillar, and affix an iron board
- Write the identification number of sample plots and coordinates (i.e. VN2000 coordinates) directly on the iron board with permanent paint or marker
- The permanent marker on the field will be useful for locating plots for repeated measurements
- Take a picture of the plot centre with plot marker and iron board with plot information clearly visible.

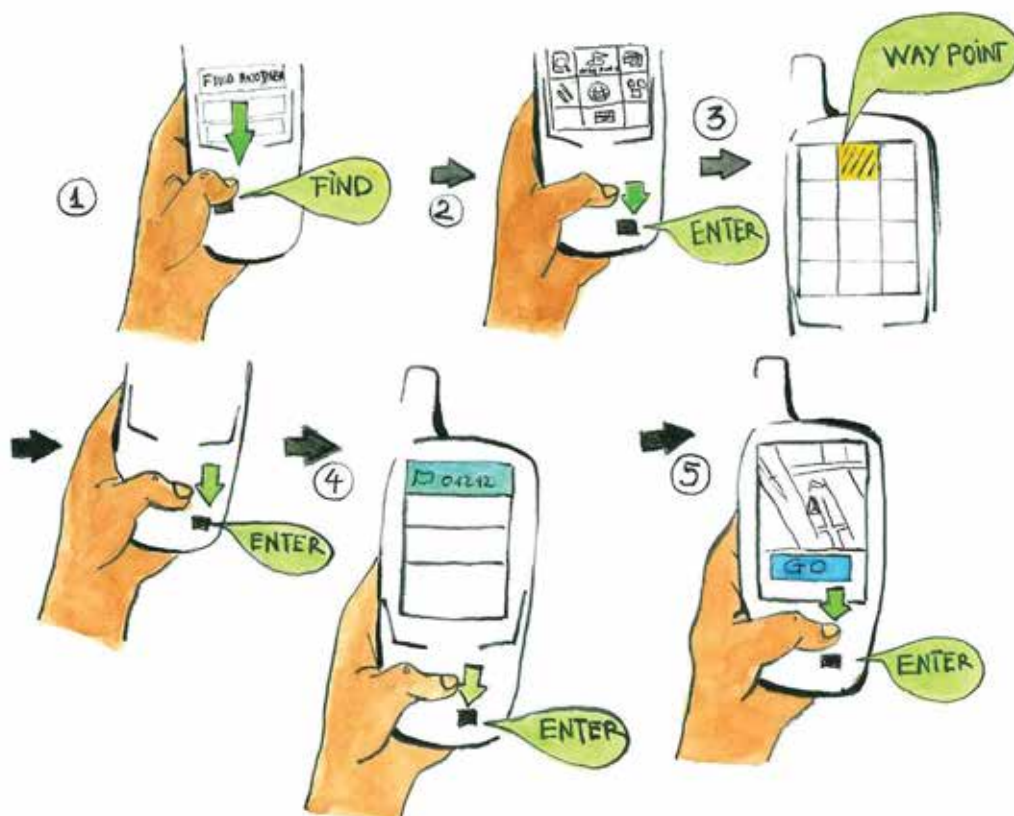


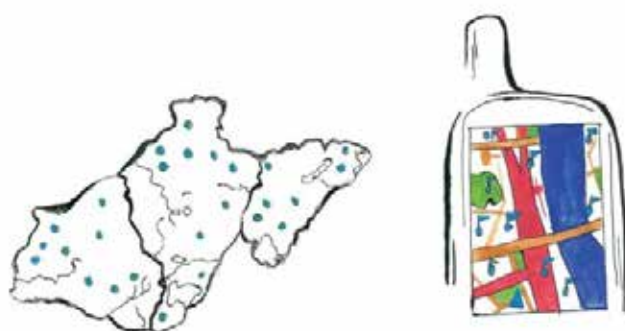


Figure 3. Locating position of a random plot by using GPS

The shape of the plots can be rectangular, square or circular. In this document, circular sample plots are recommended for use, as they are relatively easy to establish in the field. Additionally, a plot is convenient for household and the community in locating plots in the field. Within the sample plot, trees of different sizes are measured in different sized sub-plots: larger trees are measured in larger sub-plots and smaller trees are measured in smaller sub-plots.

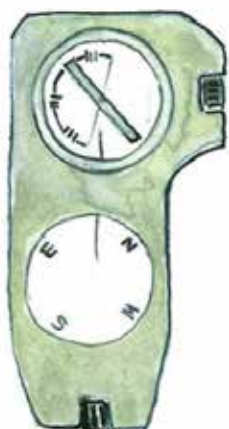
Expected outcome:

- Nested circular plots are established in the field.

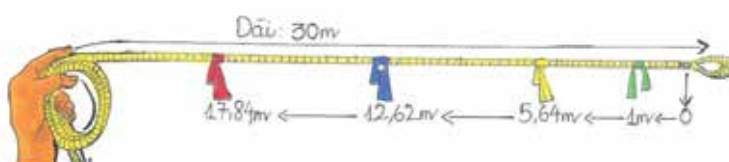


Materials required:

- Suunto clinometer
- Four ropes with a range of coloured knots at specified intervals equivalent to the radius of the sub-plots
- Form for additional distances at different radius for plots located on slope
- Digital camera (optional).



Slope Level (degree)	SLOPE CORRECTION FACTOR SHEET			
	RADIUS OF CIRCLE PLOT			
	1m	5,64m	12,62m	17,84m
0	0.00	0.00	0.00	0.00
2	0.00	0.00	0.01	0.01
4	0.00	0.01	0.03	0.04
6	0.01	0.03	0.07	0.10
8	0.01	0.06	0.12	0.18
10	0.02	0.09	0.19	0.28
12	0.02	0.13	0.28	0.40
14	0.03	0.17	0.39	0.55
16	0.04	0.23	0.51	0.72
18	0.05	0.29	0.65	0.92

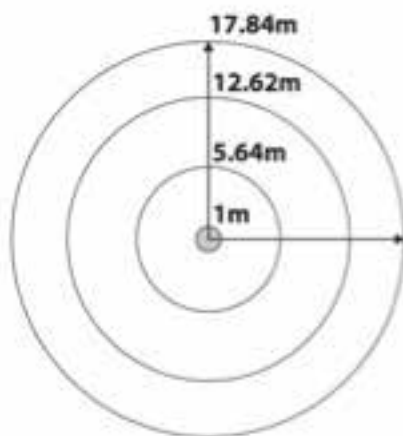


Procedure:

5.1 Design circular sample and sub-plot for different forest types:

Nested circular plot consisting of four concentric circles or sub-plots are used. Large trees are measured in larger circular plots while small trees are measured in smaller circular plots. The plot design also varies by forest types.

- For **evergreen, semi-deciduous, dipterocarp, and pine forest:**



- Sub-plot 1: radius 1 m, area 3.64 m², measure regeneration with DBH < 6 cm and H > 1.3 m
- Sub-plot 2: radius 5.64 m, area 100 m², measure tree 6 cm ≤ DBH < 22 cm or bamboo
- Sub-plot 3: radius 12.62 m, area 500 m², measure tree 22 cm ≤ DBH < 42 cm
- Sub-plot 4: Radius 17.84 m, area 1000 m² to measure tree ≥ 42 cm DBH

Figure 4. Layout of circular nested plot with four concentric sub-plots

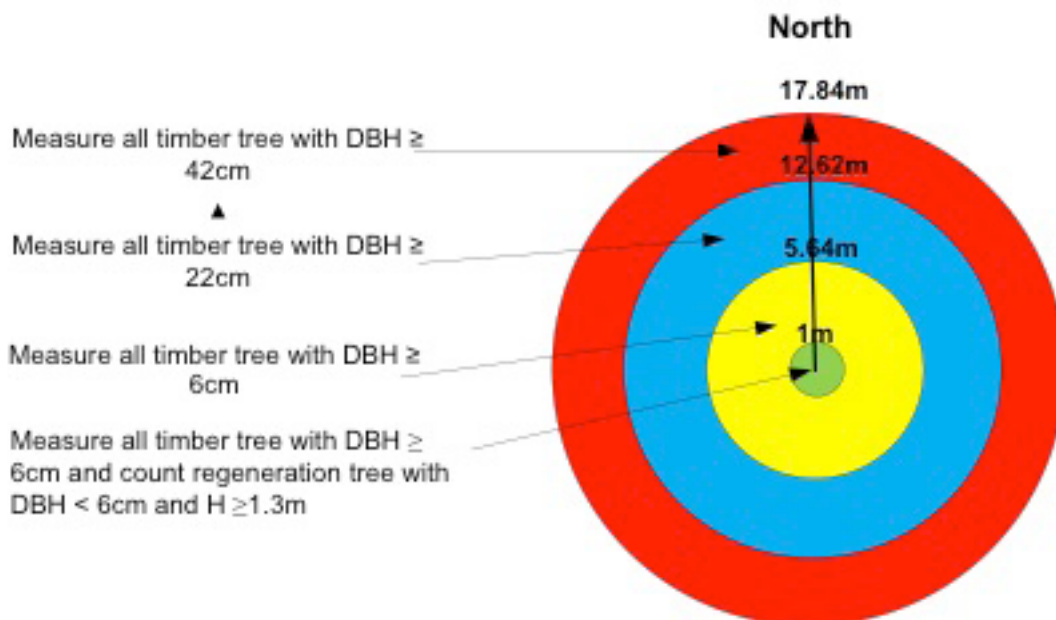
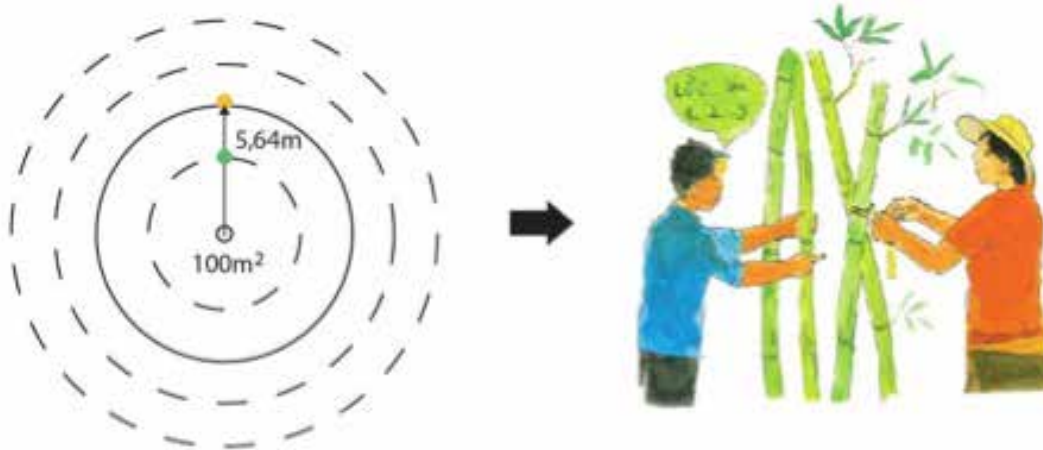
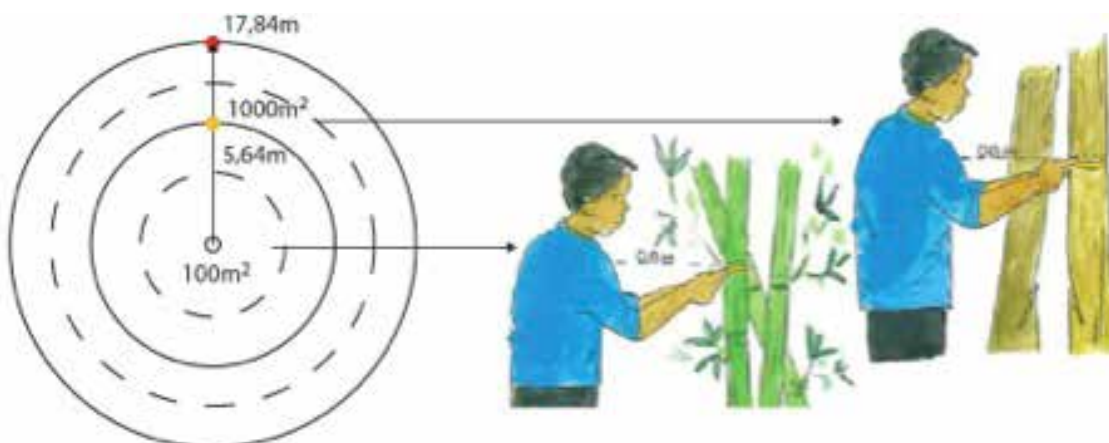


Figure 5. Measure diameter class according to radius of sample plot

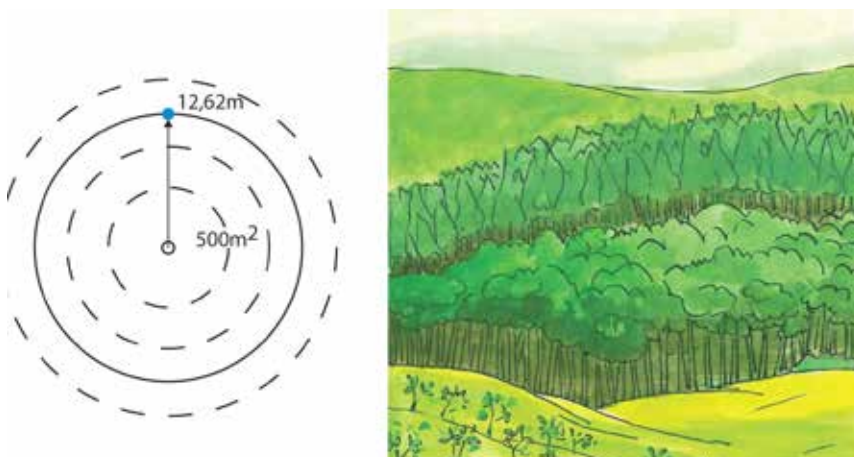
- For **bamboo forest**, the size of sample plot is 100 m²



- For **mixed woody – bamboo forest**, measure trees as in the case of evergreen forest in four concentric sub-plots and measure bamboo only in sub-plot 2



- For **plantation forest**, the maximum diameter in plantation forest rarely exceeds 42 cm. Therefore, the measurement of the tree is conducted in sub-plot 3 i.e. in 500 m² circular plot with a radius of 12.62 m.



Within 1m radius sub-plot (green), measure all trees with DBH \geq 6 cm and count

regeneration trees with $DBH < 6$ cm and $H \geq 1.3$ m; within 1 m - 5.54 m radius sub-plot (yellow), measure all trees with $DBH \geq 6$ cm; within 5.64 m - 12.62 m radius sub-plot (blue), measure trees with $DBH \geq 22$ cm; and within 12.62 m - 17.84 m radius sub-plot (red), measure trees $DBH \geq 42$ cm (Figure 5).

5.2 Establish circular plot and sub-plots in the forest:

Prepare a rope with several knots. Use different colours for individual knots. Put knots at intervals equivalent to the radius of the sub-plots. For example, make a green knot at 1 m, a yellow knot 5.64 m, blue knot at 12.62 m and a red knot at 17.84 m (**Error! Reference source not found.** Figure). An additional rope may be needed for plots located on slopes. The length of rope should be about 30 m. Four ropes with colour knots need to be prepared. On each rope, at each colour knot add another same coloured knot that is movable along the rope to adjust for the radius of sub-plots on slope.

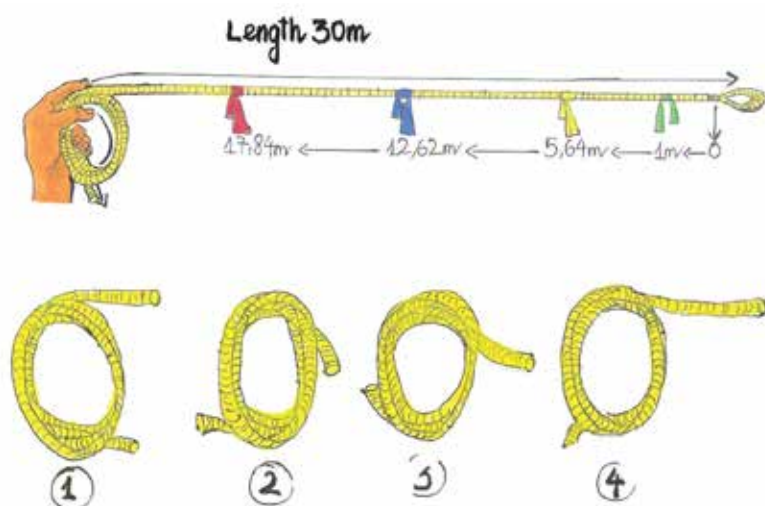


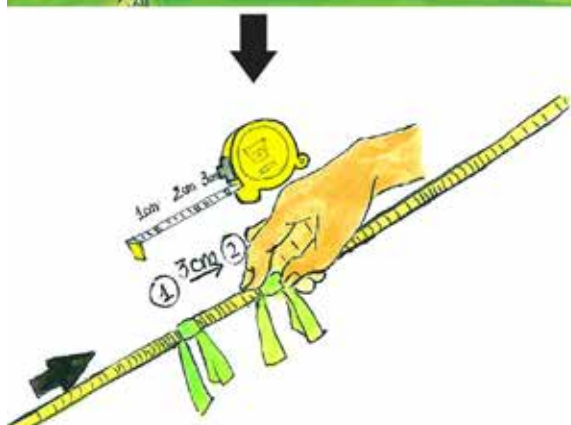
Figure 6. Making knots of different colours corresponding to radius of concentric sub-plot

- Measure slope of the ground every time the rope is laid out on the ground along the plot radius (eight times) using the clinometer (Figure).
- Ask one field crew member to stand on the slope. With the clinometer, aim at the head of the person standing above or below the slope to create the line of sight (Figure). The line of sight must be parallel to the slope surface. The indicator on the left of the clinometer shows the slope angle, which must be recorded.
- A table with slope corrected horizontal distances can be taken to the field (see Appendix). The knots representing the radius for the plot must be corrected. For example, if a plot is located at slope of 20 degrees, then using the slope corrected distance the green knot should be placed at 1.06 m, yellow knot at 6 m, blue knot at 13.43 m and red knot at 18.98 m. Use linear tape to adjust the position of the knots in the field.



Figure 7. Compass and Clinometer

Figure 8. Obtaining slope using clinometer



Sheet of slope correction factors:

Slope level (degree)	Radius of cycle plot (m)			
	1.00 Green	5.64 Yellow	12.62 Blue	17.84 Red
0	0.00	0.00	0.00	0.00
2	0.00	0.00	0.01	0.01
4	0.00	0.01	0.03	0.04
6	0.01	0.03	0.07	0.10
8	0.01	0.06	0.12	0.18
10	0.02	0.09	0.19	0.28
12	0.02	0.13	0.28	0.40
14	0.03	0.17	0.39	0.55
16	0.04	0.23	0.51	0.72
18	0.05	0.29	0.65	0.92
20	0.06	0.36	0.81	1.14
22	0.08	0.44	0.99	1.40
24	0.09	0.53	1.19	1.69
26	0.11	0.64	1.42	2.01
28	0.13	0.75	1.67	2.37
30	0.15	0.87	1.95	2.76
32	0.18	1.01	2.26	3.20
34	0.21	1.16	2.60	3.68
36	0.24	1.33	2.98	4.21
38	0.27	1.52	3.40	4.80
40	0.31	1.72	3.85	5.45
42	0.35	1.95	4.36	6.17
44	0.39	2.20	4.92	6.96
46	0.44	2.48	5.55	7.84
48	0.49	2.79	6.24	8.82
50	0.56	3.13	7.01	9.91

- First, stretch one rope from the centre towards the north. Stretch another rope to the east. Stretch a third rope at 45° N between the first and second ropes. As a result, two segments are established from north to east. Measurement is carried out from the left to the right segment (i.e. clock-wise) and from the centre towards the sub-plot radius indicated by the coloured knots.

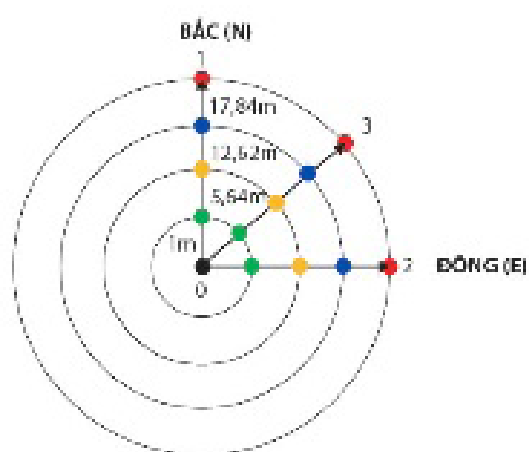


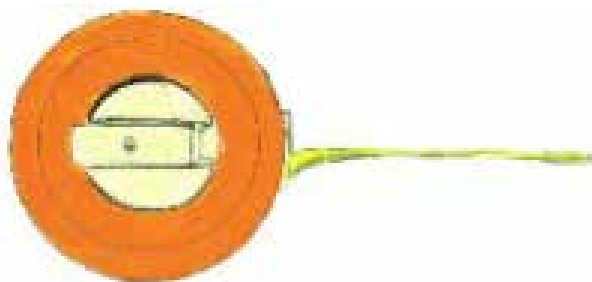
Figure 9. North-east section of plot

In each sample plot, measure tree and other information.

Expected outcome: Validated data about trees and bamboo and forest resources.

Materials required:

- Diameter measurement tape (i.e. D tape)



- Chalk, marker, or paint for making on the tree



- Iron board or tree tag for marking trees



- Hammer and nails to affix tree tag



- Paint to mark sign of sample plots



- Spreadsheet for recording inventory factor

DATA SHEET

DATA SHEET 1: Measurement of change in forest area, forest stakes and forest cover

Forest type and forest status on map.....

Coordinates of plot center (in UTM 2000): N.....E.....

Forest type (observed).....Forest status (observed).....

Location (Village.....Community.....District.....Province.....)

Forest compartment.....Sub-compartment.....Block.....

Measurement recorded by.....Date.....

No.	Observed forest area (ha)	Observed forest area (ha)	Observed forest area (ha)	Observed forest area (ha)	Observed forest area (ha)	Observed forest area (ha)
1	2	3	4	5	6	7

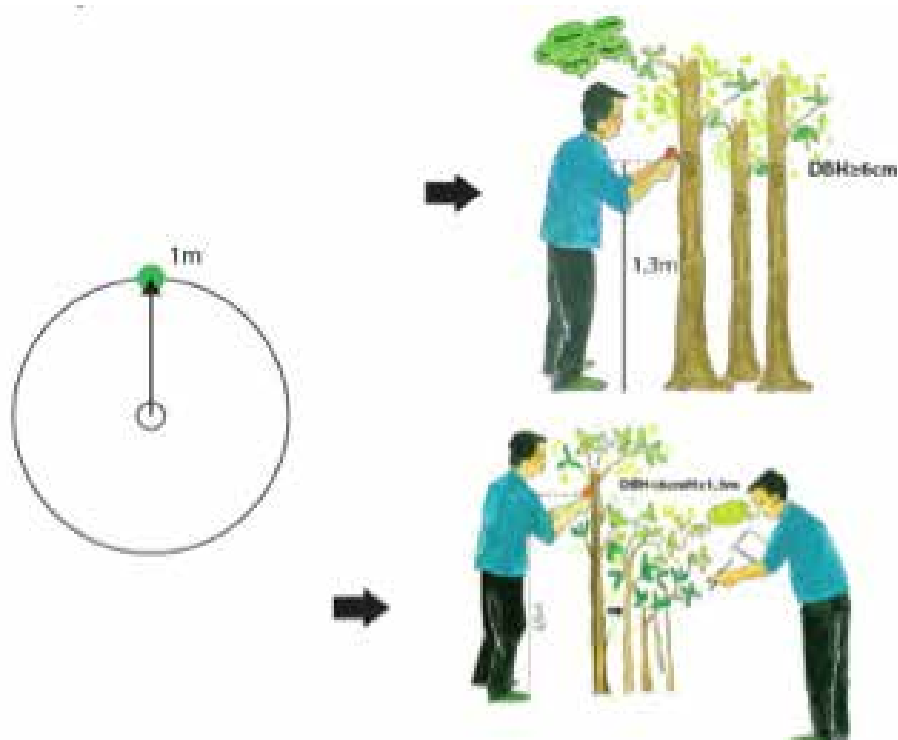
- Digital camera for taking picture (optional).



Procedure:

Measurement in sample plot to estimate forest biomass and carbon:

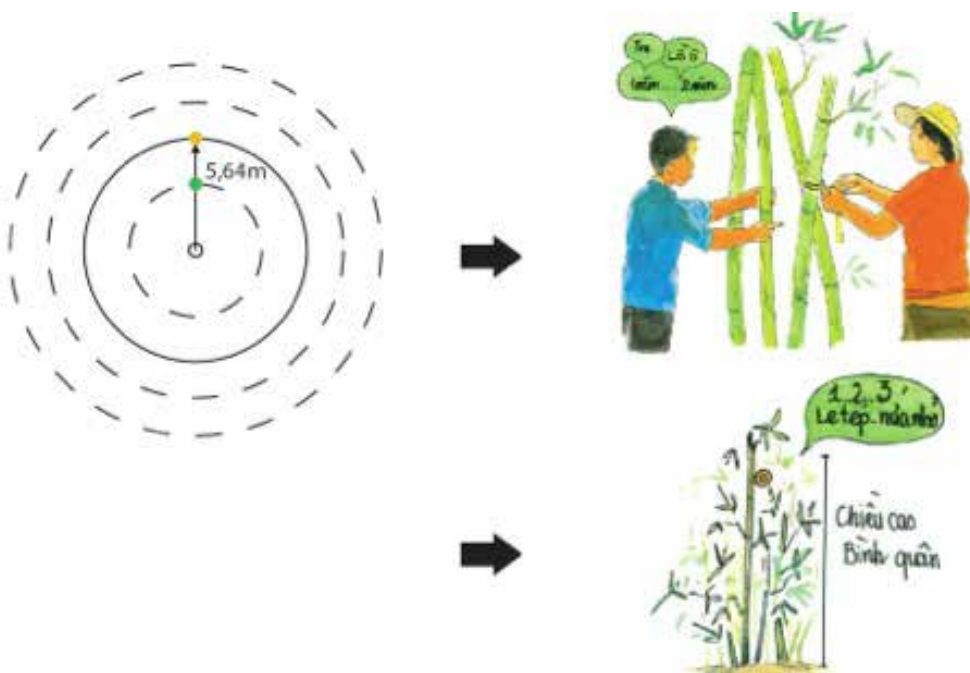
- For woody tree, identify species, measure DHB if trees DBH is greater than 6 cm. For trees with DBH < 6 cm and height > 1.3 m, count the number within the sub-plot 1



- Use tree tags to mark the trees



- **Bamboo** is measured in a 5.64 m radius plot. Age and individual DBH are measured. In the case of certain species of bamboo, such as neohouzeaua, the number of trees, average DBH and average height must also be estimated



- Use Figure 13 to determine the position of DBH on tree during DBH measurement for **irregular stems or for trees standing on slopes**
- If a tree falls on **the plot boundary** and over 50% of the stem is inside the plot, consider that tree to fall inside the plot. Otherwise, exclude boundary tree
- **Take pictures** of trees and crews measuring trees. Name picture files beginning with the plot name. For example, if plot id is 104, then name of picture can be "104_NorthWest".

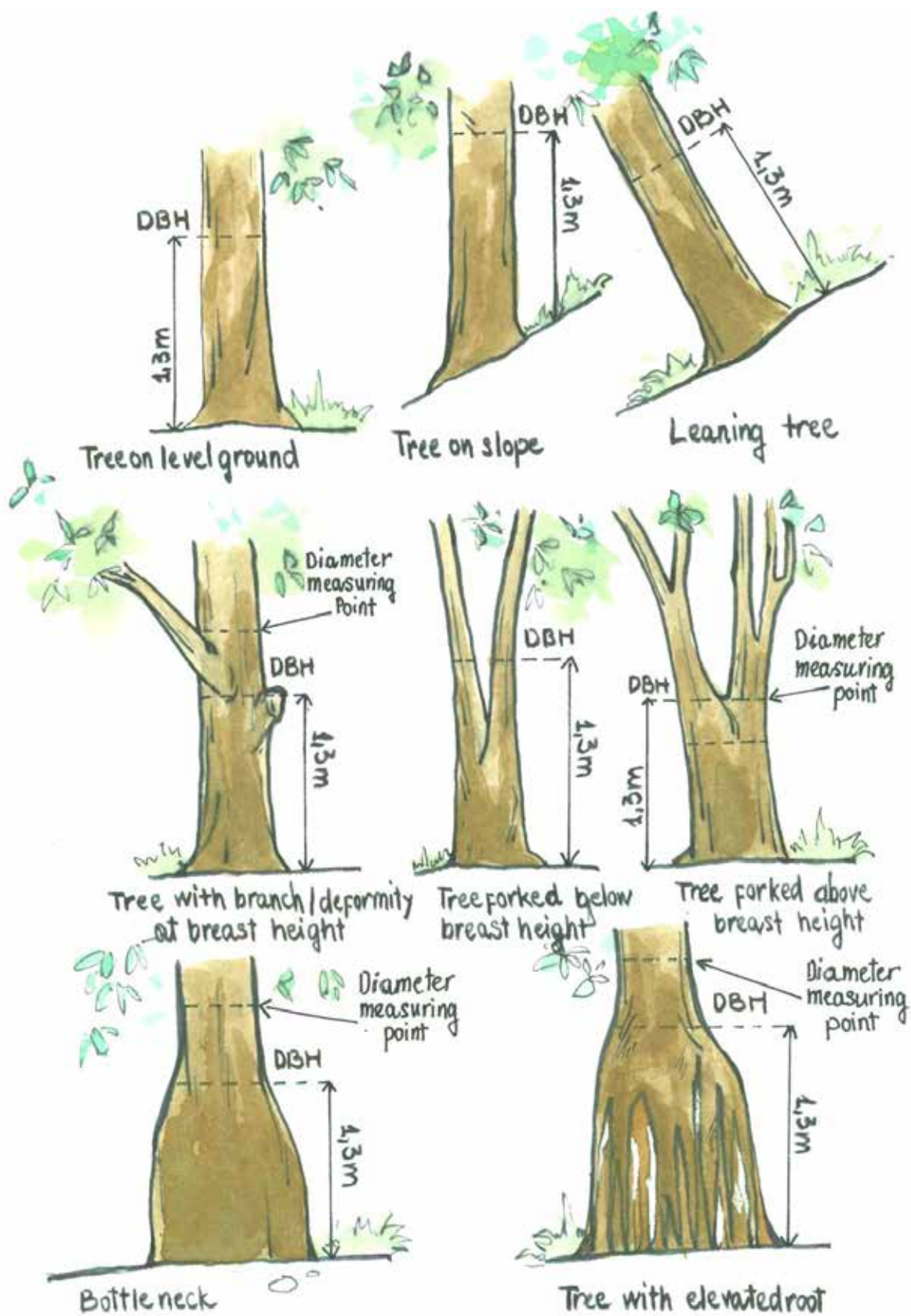


Figure 13. Measuring DBH tree of irregular stems or trees on slope

Appendix I: Field Form

Form 1: Measuring change in forest area, forest status, and forest owner

Forest type and forest status on map:

Coordinate of plot centre (in VN2000): X:

Y:

Forest type (observed):

Forest status (Observed):

Forest owner:

Contractor:

Location (village, commune, district, province):

Forest compartment:

Sub-compartment:

Block:

Measurement recorded by:

Date:

Time:

Picture: Yes/No (Circle Yes if pictures were taken. Circle No if pictures were not taken.)

No	VN2000 coordinates of four corners of forest block, forest owner				Description of change, (i) Loss of forest cover, (ii) Change in forest type	Underlying causes or reasons for change
	X/Y	X/Y	X/Y	X/Y		
1	2	3	4	5	6	7

Note: Information on change in area and status are stored as tracks in the GPS and are named to follow the identification number of delineated area.

Column 1: Identification number of delineated area. Numbers in serial order such as 1, 2, 3 can be used. Use separate form for each forest boundary. This identification number must be used to name the track in the GPS.

Column 2, 3, 4 and 5: Record X, Y coordinates of the four corners from the GPS. On the GPS coordinates page the value for the x-coordinate is located at the top and the y-coordinate is at the bottom.

Column 6: Description of change, either i) Forest loss, or ii) Reduced quality of forest, e.g. selected logging/exploitation.

Column 7: Underlying causes or reason for change, e.g. logging forest for cropping, exploited as planned in 2013 etc.

Form 2: Data Sheet form for forest inventory

Plot No.: Forest status on map:

Coordinates: X Y

Forest type: Forest stratum/status:

Forest owner: Contractor:

Location (Village, Commune, District, Province):

Forest compartment: Altitude (m):

Forest sub-compartment: Canopy cover (%):

Forest block: Slope (degree):

Recorded by: Date:

Picture: Yes/No (Circle Yes if pictures were taken. Circle No if pictures were not taken.)

Measuring trees with DBH ≥ 6 cm in all sub-plots

No.	Species		DBH (cm)	Comment	No.	Species		DBH (cm)	Comment
	Local name	Common name				Local name	Common name		
1					26				
2					27				
3					28				
4					29				
5					30				
6					31				
7					32				
8					33				
9					34				
10					35				
11					36				
12					37				
13					38				
14					39				
15					40				
16					41				
17					42				
18					43				
19					44				
20					45				
21					46				
22					47				
23					48				
24					49				
25					50				

Form 3: Data Sheet for measuring DBH<6 cm and H>1.3 m in 1 m radius sub-plot

Plot no.:

No.	Species		Number of tree	Comment	No.	Species		Number of tree	Comment
	Local name	Common name				Local name	Common name		
1					26				
2					27				
3					28				
4					29				
5					30				
6					31				
7					32				
8					33				
9					34				
10					35				
11					36				
12					37				
13					38				
14					39				
15					40				
16					41				
17					42				
18					43				
19					44				
20					45				
21					46				
22					47				
23					48				
24					49				
25					50				

Form 4: Data Sheet form for bamboo inventory

Plot No.:

Forest status on map:

VN2000 Coordinates: X Y

Location (Village, Commune, District, Province):

Forest type:

Forest stratum/status:

Forest owner:

Contractor:

Forest compartment:

Altitude (m):

Forest sub-compartment:

Canopy cover (%):

Forest block:

Slope (degree):

Recorded by:

Date:

Picture: Yes/No (Circle Yes if pictures were taken. Circle No if pictures were not taken.)

For special bamboo:

Species:

Average height(m)

Number of tree:

Average DBH (cm):

No.	DBH (cm)	Age	Comment	No.	DBH (cm)	Age	Comment
1				26			
2				27			
3				28			
4				29			
5				30			
6				31			
7				32			
8				33			
9				34			
10				35			
11				36			
12				37			
13				38			
14				39			
15				40			
16				41			
17				42			
18				43			
19				44			
20				45			
21				46			
22				47			
23				48			
24				49			
25				50			

Appendix II. Tools and equipment needed for PCM/PFM for a technical group

No.	Item	Unit	Quantity	Purpose
	Actual forest map with demarcation of boundaries of forest owner, household contracted to protect forest	Map	1	Monitor area of forest plot, forest owner
	Map with location of random sample plots	Map	1	Position sample plots on the field
	GPS	Unit	1	Define boundaries, change area, location of sample plots
	Battery for GPS	Unit	10	
	Digital camera	Unit	1	Take pictures
	Data sheet for measuring forest area (Form 1)	Form	50	Record of area change
	Rope for sub-plot with coloured knots for different sub-plot radii	Rope	4	Establish circular sample plot
	Compass, Sunnto clinometer	Equipment	1	Orientation, measuring tree height and slope angles
	Diameter	Equipment	2	Measure tree diameter
	Iron board to write plot number sign	Table	20	Record and fix plot number sign
	Paint	Box	5	To write plot number sign
	Paintbrush	Paintbrush	5	To write plot number sign
	Hammer	Hammer	1	Fix metal tags on tree
	Nail	kg	5	Place the tags
	Data sheet form for measuring timber forest, bamboo forest (Form 2, 3, 4)	Form	50	Record data of sample plot

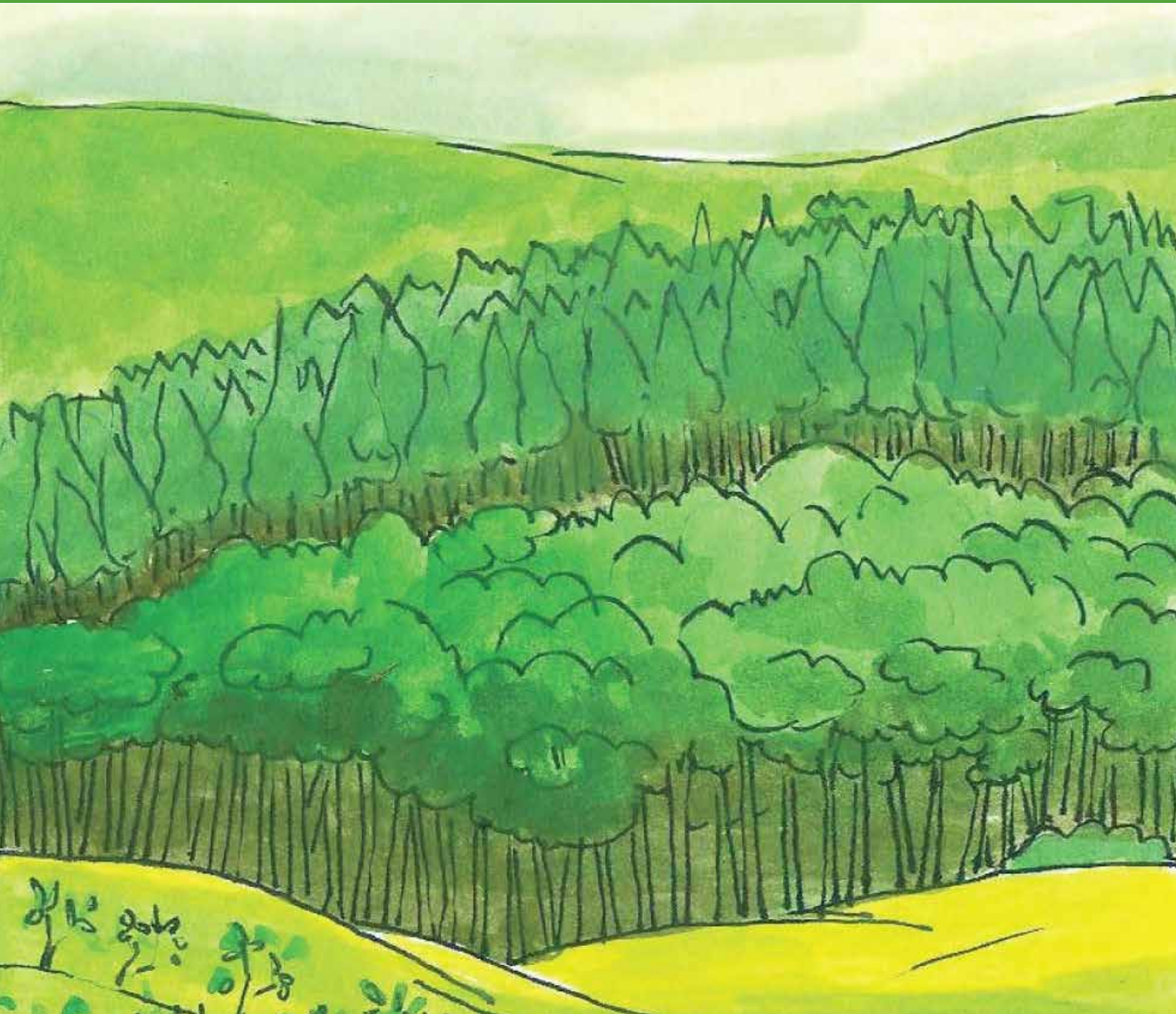
Appendix III. Slope correction factors

No.	Item	Unit	Qual-ity	Purpose
	Actual forest map with demarcation of boundaries of forest owner, household contracted to protect forest	Map	1	Monitor area of forest plot, forest owner
	Map with location of random sample plots	Map	1	Position sample plots on the field
	GPS	Unit	1	Define boundaries, change area, location of sample plots
	Battery for GPS	Unit	10	
	Digital camera	Unit	1	Take pictures
	Data sheet for measuring forest area (Form 1)	Form	50	Record of area change
	Rope for sub-plot with coloured knots for different sub-plot radii	Rope	4	Establish circular sample plot
	Compass, Sunnto clinometer	Equipment	1	Orientation, measuring tree height and slope angles
	Diameter	Equipment	2	Measure tree diameter
	Iron board to write plot number sign	Table	20	Record and fix plot number sign
	Paint	Box		To write plot number sign
	Paintbrush	Paintbrush		To write plot number sign
	Hammer	Hammer		Fix metal tags on tree
	Nail	Kg		Place the tags
	Data sheet form for measuring timber forest, bamboo forest (Form 2, 3, 4)	Form		Record data of sample plot

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