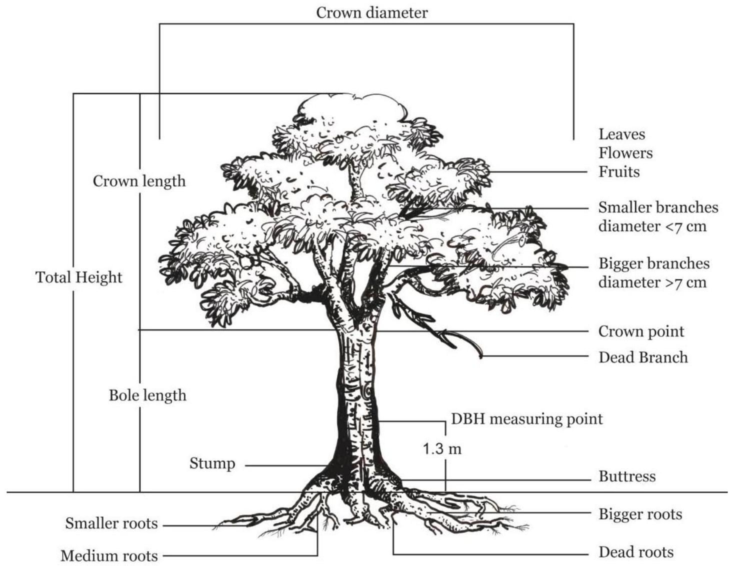
Field measurement protocol on tree allometric equation for estimating above-ground biomass and volume in Bangladesh

Dhaka



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Field measurement protocol on tree allometric equations for estimating above-ground biomass and volume in Bangladesh

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The manual is designed to develop the Allometric Equation in Bangladesh to support the National Forest Inventory process. The designations employed and the presentation of material in this information product do not imply the expression of any opinion what so ever on the part of the Food and Agriculture Organization of the United Nations (FAO), or University of Khulna, or Forest Department. Should readers find any errors in the documents or would like to provide comments for improving their quality they are encouraged to contact the authors.

Photo credit: Mahmood Hossain (Figure 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 16, 17 and 18), Picard et al 2012 (Figure 15), http://www. treeremoval.com/tree-cutting/#. Vr3j5E1unmI (Figure 12)

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List of Acronyms

AGB	Above Ground Biomass	kg
AICc	Akaike's information criterion corrected	
AR	Above-ground Roots	kg
BA	Basal Area: Stem cross-sectional area at DBH point	cm
Ba	Bark	kg
BaBg	Bark of Bigger Branch	kg
Bd	Dead Branches	kg
BFD	Bangladesh Forest Department	
BFRI	Bangladesh Forest Research Institute	
Bg	Bigger Branches (diameter > 7 cm)	kg
BIC	Bayesian Information Criterion	m
Bt	Thin Branches (diameter < 7 cm)	kg
CC	Carbon Concentration	%
CD	Crown Diameter	m
CF	Crown Form	
CH	Crown Height or Thickness or Crown Length	m
CR	Conversion Ratio	
CS	Carbon Stock	kg
CSh	Crown Shape	
D03	Diameter at 0.3 m (cm)	cm
D1	Diameter (m) at Thicker end of Log	m
D2	Diameter (m) at Thinner end of Log	m
DBB	Base Diameter of Branch	cm
DBH	Diameter at 1.3 m (cm)	cm
Dm	Diameter (m) at Midpoint of Log	m
DMP	Diameter Measuring Point	cm
F	Fruit	kg
FB	Fresh Biomass	kg
Fi	Furnival index	m
Fl	Flower	kg
GBH	Girth at Breast Height	cm
GCH	Girth at Collar height	cm
H	Total Height	m
Hb	Height of Buttress	m
HL	Total Length (Liana)	m
Hme	Merchantable Bole Length	m
Ht	Bole Length	m
L	Leaf	kg
lb	Width of Buttress at the Base	m
Lb	Length of Buttress	m
Lg	Log Length	m
Ll	Leaf let	kg
LL	Total Length of Leaf (Nypa)	m

LUL	Total Usable Length of Leaf (Nypa)	m
ODB	Oven-dried Biomass	kg
P	Petiole	kg
R	Rachis	kg
R^2	Coefficient of determination	
S	Stump	kg
Sub	Sub-samples	
T	Bole or Stem	kg
V	Volume	m^3
WD	Wood Density	Kg/m^3
Yr	Age	Year

List of Annexes

1. Introduction

Sustainable forest management requires measurements of forest biomass and volume for estimating forest stocking and productivity, nutrient cycling and budgeting, amount of carbon stock and prediction of future status of forest resources (Golley et al., 1975; Mahmood, 2014). Tree biomass and volume can be measured from both destructive (clear-cut) and non-destructive (allometric equation) methods (Ketterings et al., 2001; Golley et al., 1975). Allometric equations are the most powerful tool of measurement which is frequently used for estimating biomass and volume of forest plant species (Mahmood et al., 2004, 2012; Akhter et al., 2013; Komiyama et al., 2005, 2008). The use of appropriate equations for biomass and volume estimation will contribute towards improving the accuracy of forest resource assessment and also guide the forest policies and the management initiative.

Development of allometric models for biomass and volume requires extensive planning, field works (sampling of forest within each forest stratum, sampling of plots within each forest, sampling of plants within each plot; measurement of standing tree dimensions; felling of sampled plant; separating and weighing of different plant parts; sub-sampling of different plant parts for further assessment and data recording), sample analysis in the laboratory, and data analysis. These activities are mostly destructive, difficult and expensive to repeat. Measurements of some variables are mandatory for the development of allometric equations, which are linked with the national forest inventory and other variables may be considered as additional information for future forest monitoring. This protocol aims to provide guidance to technicians, professionals, and students for developing biomass and volume allometric equations involving the destructive and semi-destructive activities. It is believed that this manual will be helpful at present and in the future to ensure proper measurement of plant variables and recording of field data for the development allometric equation.

2. Calculation procedure

2.1 Steps involved in development of biomass and volume allometric equation

Development of biomass and volume allometric equations consists of seven important steps. The following flow chart will assist to organize the related activities to develop allometric equations. This manual provides necessary information for step 1 to 6 (Figure 1).

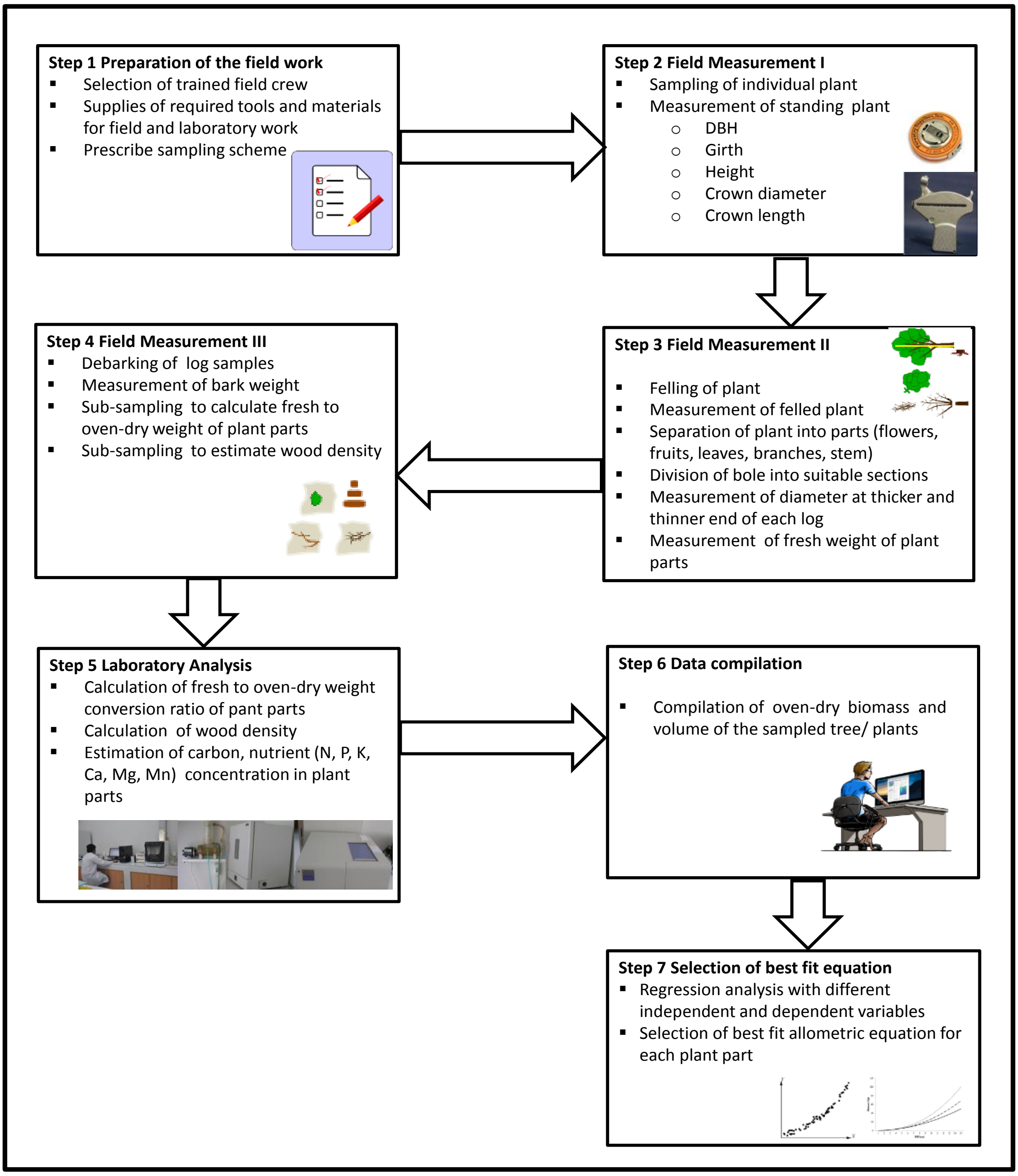


Figure 1: Steps involve in the development of allometric equation

2.2 Required formulas for field and laboratory work

Some important formulas related to field measurement and laboratory analysis are as follows:

Equation 1

DBH measurement by Tree caliper

$$\text{Mean DBH (cm)} = \frac{\text{DBH reading 1} + \text{DBH reading 2}}{2}$$

Equation 2

Tree height measurement using Haga altimeter

$$\text{Height (m)} = \frac{\text{(Top reading} - \text{Base reading) x Distance}}{\text{Scale}}$$

Equation 3

Fresh weight of bark of a log

Fresh weight (kg) = Fresh weight of a log (kg) x ratio of bark

Equation 4

Ratio of fresh weight of bark and fresh weight of log with bark

$$\text{Ratio of bark} = \frac{\text{Bark weight (kg)}}{\text{Log weight with bark (kg)}}$$

Equation 5

Oven dry weight of plant samples

Oven dry weight (kg) = Fresh weight (kg) x Fresh to oven dry weight conversion ratio

Equation 6

Fresh to dry weight conversion ratio of plant samples

$$\text{Conversion ratio} = \frac{\text{Ovendry weight (kg)}}{\text{Fresh weight (kg)}}$$

Equation 7

Wood density

$$\text{Wood density (Kg/m}^3\text{)} = \frac{\text{Sample weight (kg)}}{\text{Sample volume (m3)}}$$

Equation 8

Loss of ignition

$$\text{LOI (\%)} = \frac{\text{Loss of weight after ignition}}{\text{Oven dry weight}} \text{ x } 100$$

Equation 9

Organic carbon concentration in plant parts

$$\text{Organic arbon (\%)} = \text{loss of ignition x } \frac{50}{100}$$

Equation 10

Organic carbon content in plant part

$$\text{Organic carbon (kg)} = \text{Oven dry weight of plant parts (kg) x } \frac{\text{Concentration of organic carbon in respective part (\%)}}{100}$$

Equation 11

Huber's volume formula

$$\text{Volume (m}^3\text{)} = \frac{\pi L D_m^2}{4}$$

Equation 12

Smalian's volume formula

$$\text{Volume (m}^3\text{)} = \frac{\pi L (D_1^2 + D_2^2)}{8}$$

Equation 13

Newton's volume formula

$$\text{Volume (m}^3\text{)} = \frac{\pi L (D_1^2 + 4D_m^2 + D_2^2)}{24}$$

Equation 14

Buttress volume formula

$$\text{Volume (m}^3\text{)} = \left(1 - \frac{\pi}{4}\right) \times \frac{lb \times Hb \times Lb}{3}$$

Equation 15

Cone volume formula

$$\text{Volume (m}^3\text{)} = \frac{1}{3}\left(\frac{\pi L D_1^2}{4}\right)$$

Equation 16

Crown volume

Volume (m^3)
= (CF) x (crown length (m)) x (crown diameter (m))^2

3. Step 1: Preparation of the field measurement

3.1 Field crews

The field measurement activities include intensive works (felling of plants, delimbing, sectioning of logs and separation of plant parts), careful measurements (total height, merchantable height, DBH, girth, collar diameter and girth, crown length and diameter, estimation of volume and biomass of logs) and proper recording of data. Therefore, well trained field crews are essential for the accuracy and smoothing of these activities.

3.2 Tools and materials

Some of the tools and materials are required for the measurement of volume and fresh biomass of plants. These tools and materials can be categorized as mandatory and non-mandatory.

Mandatory tools and materials	
• Hand compass • GPS • Measuring tape (1 cm precision) • Tree caliper • Finnish parabolic caliper • Diameter measuring tape (1 mm precision) • Haga altimeter • Criterion DR 1000 • Chain saw • Crosscut saw • Pruning saw • Axe • Debarking knife or bark spud • Ladder	• Rope • Digital hanging measuring scale 200-500 kg (0.1 kg precision) • Digital measuring scale 50 kg (0.05 kg precision) • Digital laboratory balance 2200 g (0.01 g precision) • Zip poly bag • Woven polypropylene bag • Permanent marker • Pen and pencil • Paint • Field and laboratory data collection tables/ sheets
Non-mandatory tools and materials	
• Digital camera • Measuring rod • 1.3 m long stick (to reduce human error during DBH measurement) • Knives • Gloves	• Large tarpaulins • Pruning scissor • Paper • Gasoline powered portable winch • Open foris collect software (may be used for data entry and analysis)

3.3 Sampling of plants

Sampling of tree, shrub, palm, liana and bamboo from different ecosystem, ecological zone, forest structure, soil type, natural forest, and plantation should be done with great care and well defined strategy. Different dimensions (DBH, Girth, Collar diameter and girth, Total Height, and Merchantable Height etc.) of the targeted species can be known from previous literature and forest inventory. Sampling can be performed following different options depending on the information available and the final objective.

Option 1:
Consider DBH as sufficient to stratify the population. Additional information such as the plant functional types, the families, and the architecture can be considered as additional information to explain the biomass and volume variability within each diameter classes.

Option 2:
DBH^2 and Height can also stratify the population. DBH^2*H would provide an information regarding volume.

Option 3:
Wood density also stratifies the population biomass within each class.

Option 4:
Basal area range of the desired tree species can be the best way to stratify the population.

The number of sample is the tradeoff among precision, time and budget. However, a minimum of three sample trees should be selected from each class of DBH, DBH^2*H, and basal area, but it should give a minimum of 30 samples in total for a given forest area. Trees/ plants with broken top, hollow, damaged by natural calamities and animals, suppressed and disease affected should be avoided as sample tree.

4. Step 2: Field measurement I

4.1 Season of measurement

Season of measurement is an important consideration for field work as well as measurement of biomass and volume. Early monsoon (March to April) and late monsoon (September to October) can be the appropriate time for the field work considering the weather condition and phenology of plant species. Most of the plant species flush new leaves, flowers and fruits during that time, which will be the opportunity to get maximum biomass.

4.2 Geographical coordinate

Take geographical coordinate (longitude and latitude) of each sample tree, shrub, palm, bamboo and liana with a GPS following the GPS Manual (FD, 2015).

4.3 Measurement of standing tree

4.3.1 Components of a tree

A tree consists of different parts or components. The major components are bole, crown and roots. These major components can also be sub-divided into followings:

Crown	Leaves
	Flowers
	Fruits
	Smaller branches (diameter < 7 cm)
	Bigger branches (diameter > 7 cm),
	Dead branches
Bole	Bole with bark
	Bole without bark
	Bark
	Buttresses
	Stump
Root	Fine roots
	Medium roots
	Bigger roots
	Dead roots

A tree have different dimensions of measurement like total height, merchantable height, bole height, stump height, crown length, crown diameter, DBH, and girth at 1.3 m height and 0.3 m height (Figure 2).

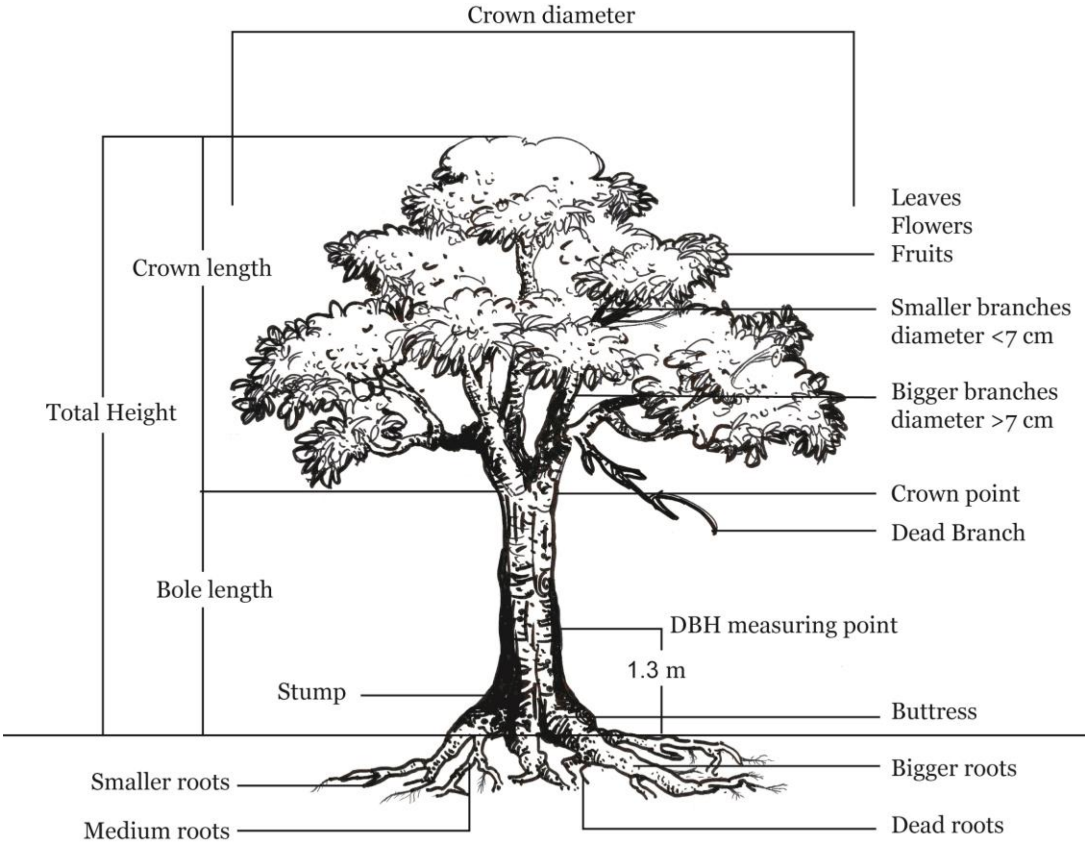


Figure 2: Illustration of different parts or components of a tree

4.3.2 Bole diameter and DBH

- Measure diameter at 0.3 cm and 1.3 m (DBH) from the ground level using diameter tape or tree caliper and record in data form (Annex 1).
- Option 1: Using a diameter tape

Figure 3: Diameter measurement procedure using diameter tape

- Option 2: Using a diameter tape

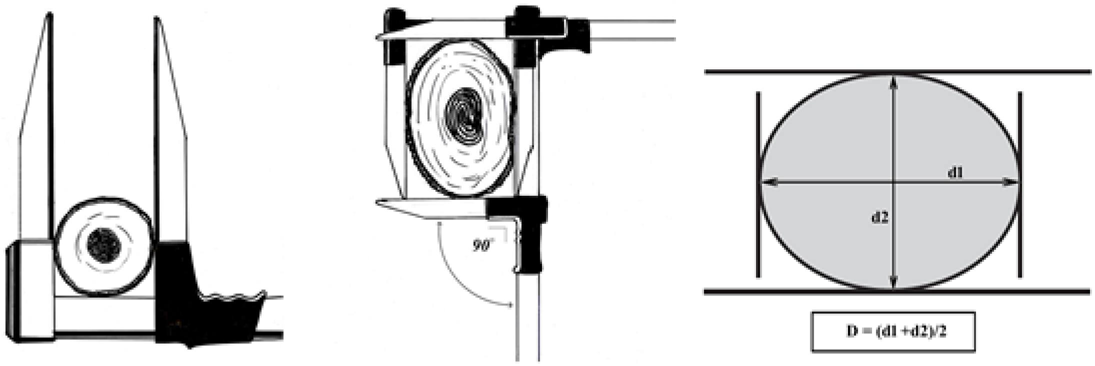


Figure 4: Diameter measurement procedure using tree caliper

- Measure DBH of trees with abnormalities at 1.3 m height following the instruction as given in Figure 5.

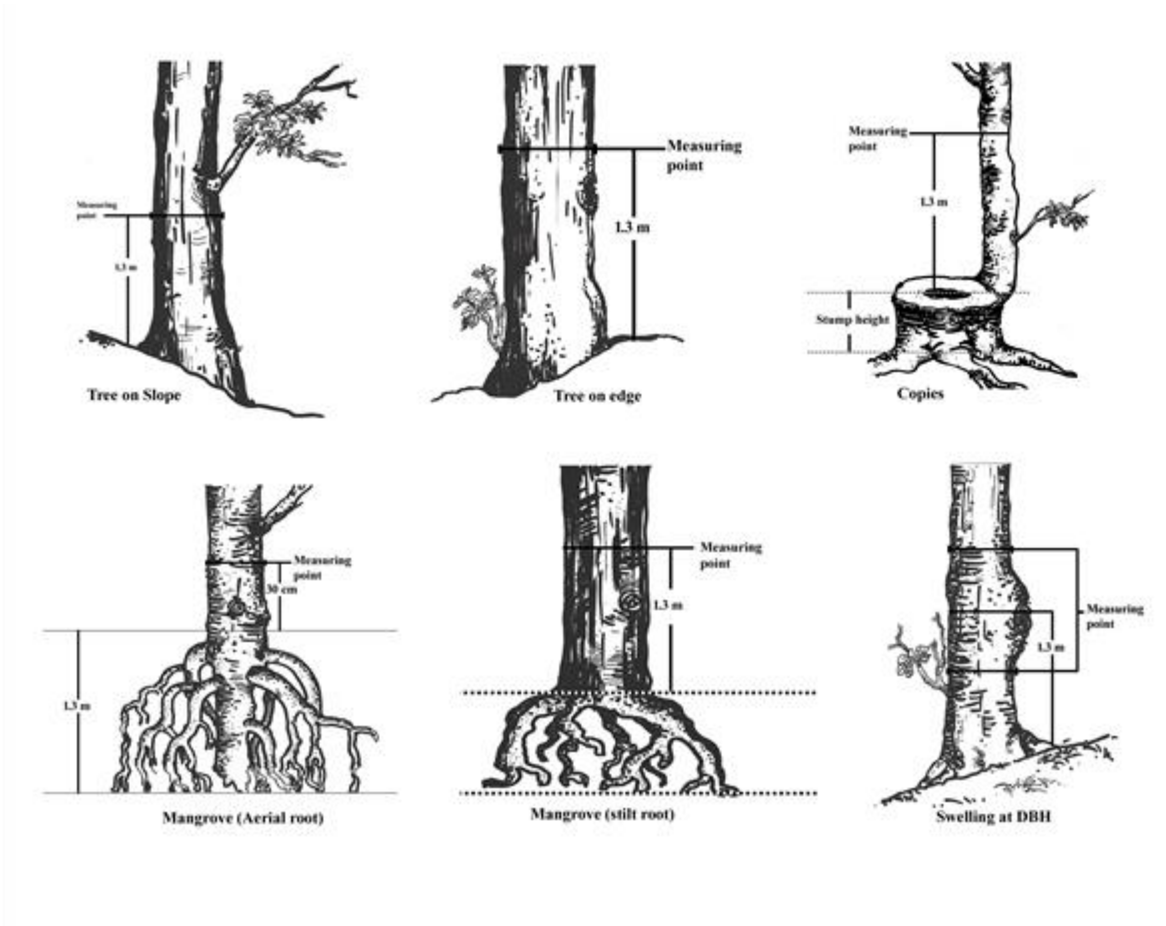


Figure 5: DBH measurement for trees with abnormalities at 1.3 m height and ground level

4.3.3 Height

- Measure total height, bole height and merchantable height of the sample tree using any scale (15 m, 20 m, 25 m and 30 m) of Haga altimeter (Figure 6) and the following formula as well as record in data form (Annex 1).

$$\text{Height (m)} = \frac{(\text{Top reading} - \text{Base reading})}{\text{Scale}} \text{ x Distance} \text{......Equation 2}$$

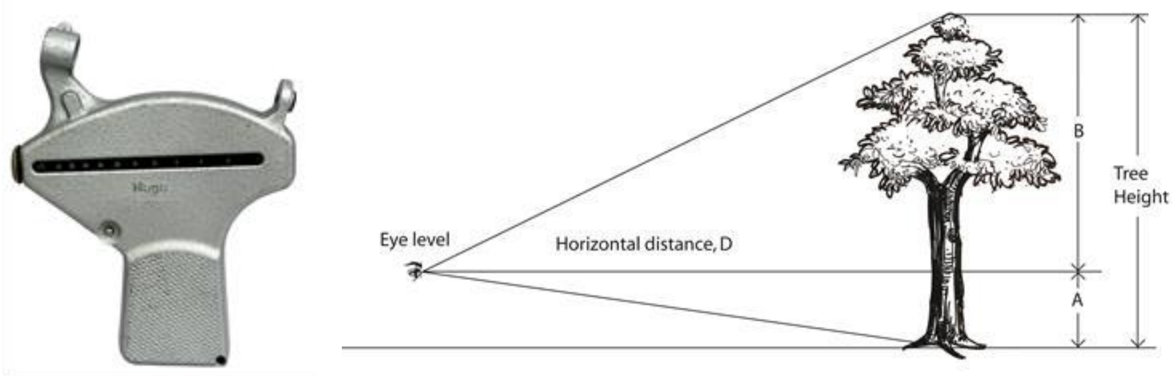


Figure 6: Height measurement using Haga altimeter

4.3.4 Buttress

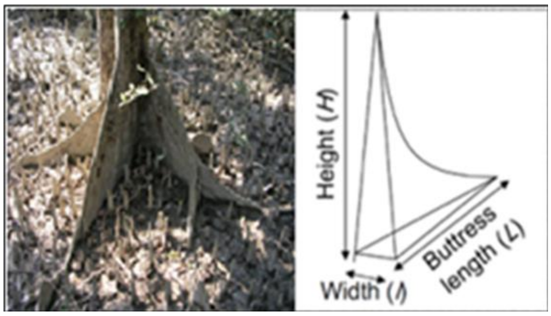


Figure 7: Dimension of tree buttress

- Count the buttress
- Measure buttress height
- Measure buttress width.
- Measure buttress length (Picard et al., 2012)
- Record in data form (Annex 1)

4.3.5 Crown diameter

- Find out the widest side of the crown by moving around the tree (Figure 8 and 9).
- Measure diameter of the crown projection from one side to another of the widest crown (Figure 9).
- Move 90 degree of the first measurement line and measure the length between two projections of crown (Figure 9).
- Average these two reading to get the diameter of the crown or average maximum crown spread and record in data form (Annex 1).

- When measuring crown diameter on steep slopes (>15 degrees), it is important to correct the slope distance to horizontal distance to avoid exaggeration. This can easily be accomplished by taking the COSINE function of the angle of the slope in degrees and multiplying it by the slope distance.

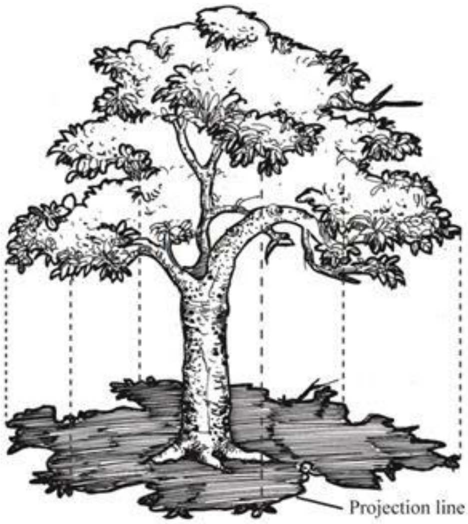
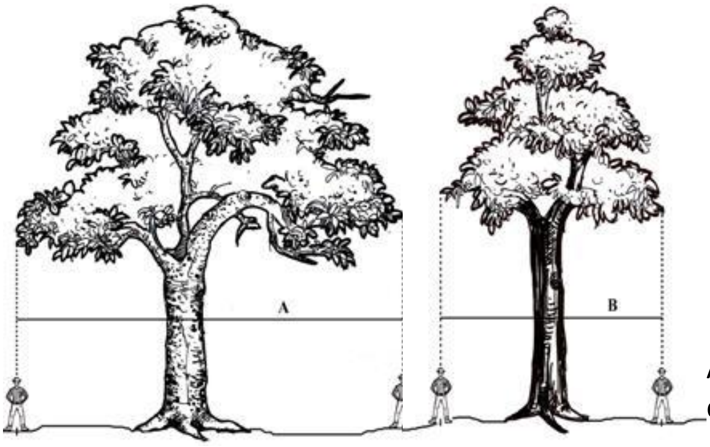
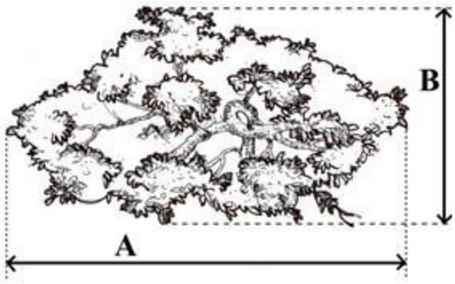


Figure 8: Crown projection on ground





A + B = C/2 = Average crown diameter ………………… Equation 1

Figure 9: Measurement of crown diameter of a tree

4.3.6 Crown length

- Crown length is the vertical distance from crown forming point to the top of the tree (Figure 2).
- Measure crown length of the sample tree using Haga altimeter as mentioned in section 4.3.3 and record in data form (Annex 1).

4.3.7 Crown shape and form

- Visually assess the crown shape (Frank, 2010) of the sampled tree by comparing with the chart of basic crown shape in Annex 2.
- Get the crown form value from the respective crown shape (Frank, 2010) using the chart of basic crown shape and form (Annex 2) and record in data form (Annex 1).

4.3.8 Age

- Get the age of plantation and trees in agroforestry system from the plantation journals or land owner and record in data form (Annex 1) (If available).

4.4 Measurement of standing shrub

4.4.1 Diameter and height measurement

- Select the shrub having collar girth ≥3 cm.
- Measure DBH and girth at Collar height.
- Measure total height using height measuring rod and measuring tape.
- Count the number of ramifications emerging from the root collar.
- Record the above information in data form (Annex 3).

4.5 Measurement of standing palm

4.5.1 DBH and height measurement

- Measure DBH and total height of the selected palm following the sections 4.3.2 and 4.3.3 and record in data form (Annex 4).

4.5.2 Crown diameter and length

- Measure crown diameter and length of the selected palm following the sections 4.3.5 and 4.3.6 and record in data form (Annex 4).

4.6 Measurement of standing liana

4.6.1 Diameter measurement

- Measurement of diameter should follow the following conditions (Figure 16)
    - **A.** Diameter Measuring Point (DMP) should be 130 cm from the main rooting position.
    - **B.** For twining lianas, DMP should be 130 cm from the rooting point, along the stem.
    - **C.** Lianas having branch below 130 cm but above 40 cm, DMP should be 20 cm below the branching point.
    - **D.** For lianas having looped and roots before climbing into the canopy, ignore the loop and measure 130 cm from the last considerable rooting point.
    - **E.** If lianas loop to the ground and root (as in D), but the loops have branches having minimum diameter, consider it as multi-stemmed liana and care for it.
    - **F.** Lianas containing aerial roots (roots >80 cm from ultimate rooting point), DMP should be 50 cm form the last aerial root.
    - **G.** If the distance between branching point and rooting is <40 cm, measure each branch of the individual separately at 130 cm above the main rooting point and consider it as multi-stemmed liana and care for it.
- Record the diameter in data form (Annex 5).

Figure 10: Diameter measurement points for liana (Gerwing et al., 2006)

4.7 Measurement of standing bamboo

4.7.1 DBH and height measurement

- Measure DBH and total height of the sampled bamboo and record in data form (Annex 6).

5. Step 3: Field measurement II

5.1 Felling, processing and measurement of tree

5.1.1 Felling of tree

- Fell the selected trees at the stump height to a suitable direction using chain saw or crosscut saw following the standard method of cuts (Figure 10).

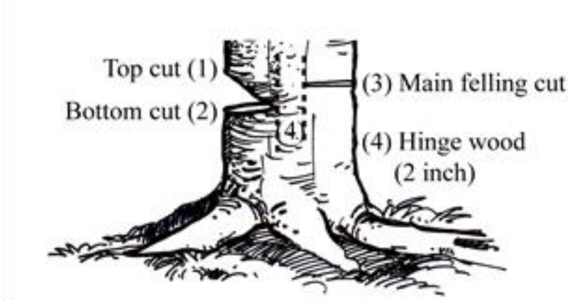


Figure 11: Different cuts and felling direction of the sample tree

5.1.2 Processing of felled tree

- Separate the above-ground parts of the individual felled tree into followings:
  - Leaves
  - Flowers
  - Fruits
  - Smaller branches (diameter < 7 cm)
  - Bigger branches (diameter > 7 cm)
  - Dead branches
  - Bole
  - Stump

5.1.3 Measurement of felled tree

- Measure the stump height (height from ground level to the felling cut).
- Measure the total height (height from cutting end of stump to pot green point of the tree).
- Measure bole length (height from cutting end of stump to crown forming live and dead branches).
- Measure merchantable bole length (height from stump to the point of 10 cm diameter)

- Delimb the felled tree using axe and pruning saws.
- Divide the bole and bigger branches (diameter > 7 cm) into suitable section for easy handling (Figure 11).
- Give ID number by paint on stump, each section of bole and bigger branch as described in Annex 7.

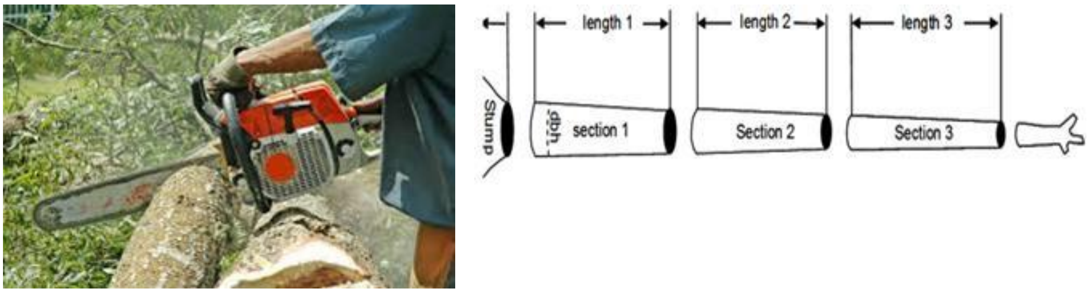
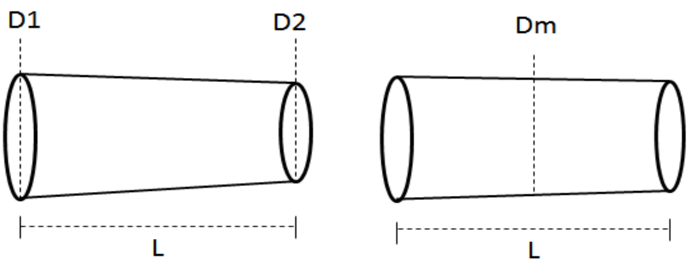


Figure 12: Sectioning of the bole (Source of illustration: http://www.treeremoval.com/tree-cutting/#.Vr3j5E1unmI)

- Measure fresh weight of individual part of sampled tree in the field and record in data form (Annex 1).
- Measure length and diameter with bark at thicker and thinner end of each log section (Figure 12) and record in data form (Annex 1).
    - Consider 10 cm is the lowest diameter at the thinner end of log to calculate the merchantable volume of the sampled tree.



L = Length of the log
D1 = Diameter at thicker end
D2 = Diameter at thinner end
Dm = Diameter at the midpoint of the log

Figure 13: Diameter measurement point on logs

- Measure diameter under bark at thicker and thinner end of each log section by removing bark from the measurement points or deducting the 2 times thickness of bark from the diameter with bark and record in data form (Annex 1) (Bark thickness can be measured from bark chips).

- Take fresh weight of representative sub-sample of tree parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 8).
- Estimate oven-dry biomass of tree parts and compile the biomass data of the sampled shrubs as described in section 8.

5.2 Felling, processing and measurement of shrub

5.2.1 Felling and processing of shrub

- Fell the shrub at the ground level
- Delimbing the felled shrub
- Separate the above-ground parts into leaves/ leaflets, flowers, fruits and stem

5.2.2 Measurement of felled shrub

- Measure the fresh biomass of each part in the field and record in data form (Annex 3).
- Take fresh weight of representative sub-sample of plant parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 9).
- Estimate oven-dry biomass of plant parts and compile the biomass data of the sampled shrubs as described in section 8

5.3 Felling, processing and measurement of palm

5.3.1 Felling and processing of palm

- Fell the sampled palm at stump height.
- Count the number of leaves and record in data form (Annex 4)
- Separate the above-ground parts into petiole, rachis and leaflets, flowers, fruits and bole.
- Divide the bole into suitable section for easy handling.

5.3.2 Measurement of felled palm

- Measure fresh biomass of all parts in the field and record in data form (Annex 4)
- Measure diameter of each log at the thicker and thinner end and record in data form (Annex 4).
- Take fresh weight of representative sub-sample of palm parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 10).
- Estimate oven-dry biomass of palm parts and compile biomass of the sampled palms as described in section 8.
- Estimate the volume of logs and compile volume of the sampled palms as describe in section 8.

5.4 Felling, processing and measurement of *Nypa fruticans*

5.4.1 Felling and processing of *Nypa fruticans*

- Fell leaf of *Nypa fruticans* at the base.
- Separate the leaf into petiole, rachis and leaflets.

5.4.2 Measurement of *Nypa fruticans*

- Measure the total length of leaf (from the base of petiole to the tip of the leaf) (Figure 15).
- Measure the useable length of Nypa leaf (From tip of the leaf to the end of last pair of leaflet and additional 20 cm of rachis) (Figure 15).
- Measure fresh biomass of all parts in the field and record in data form (Annex 11).
- Take fresh weight of representative sub-sample of palm parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 12).
- Estimate oven-dry biomass of Nypa palm parts and compile biomass of the sampled Nypa palms as described in section 8.

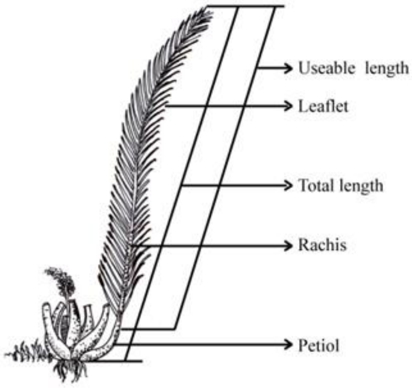
 

Figure 14: Dimension of *Nypa fruticans* leaves

5.5 Felling, processing and measurement of liana

5.5.1 Felling and processing of liana

- Fell the selected liana at the ground level
- Measure the length of the stem and separate into different parts (leaves, flowers, fruits, branches, stem and above-ground roots.

5.5.2 Measurement of felled liana

- Immediately measure fresh biomass of plant parts and record in data form (Annex 5).
- Take fresh weight of representative sub-sample of liana parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 13).
- Estimate oven-dry biomass of liana parts and compile biomass of the sampled liana as described in section 8.

5.6 Felling, processing and measurement of bamboo

5.6.1 Felling and processing of biomass

- Fell the sampled bamboo at the base level.
- Separate the bamboo into stem, branches and leaves.
- Divide the stem into suitable size.

5.6.2 Measurement of felled bamboo

- Measure the fresh biomass of each part of the bamboo in the field and record in data form (Annex 6).
- Take fresh weight of representative sub-sample of bamboo parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 14).
- Estimate oven-dry biomass of bamboo parts and compile biomass data of the sampled bamboos as described in section 8.

5.7 Semi-destructive measurement of biomass and volume of larger (DBH > 50 cm) trees

Development of biomass and volume allometric equation requires massive labour and time involvement that appear almost impossible of felling trees with larger DBH (DBH >50 cm). Semi-destructive measurement method found to be appropriate for these larger sized trees. This method involves direct measurement of certain parts (smaller branches diameter < 7 cm, leaves, flowers, fruits etc.) and volume and wood density measurement of other parts (bole and bigger branches diameter > 7 cm). This measurement technique is as follows:

- Biomass measurement from trimmed parts of trees.
    - Select the representative numbers of branches from the tree and measure the diameter at the base or each selected branch and record in data form (Annex 15).
    - Trim the selected branches and separate them into leaves, flowers and fruits (Figure 14) and measure their fresh biomass in the field and record in data form (Annex 15).
    - Take the fresh weight of representative sub-sample of trimmed parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 16).
    - Estimate oven-dry biomass of the trimmed parts as described in section 8.

- Measurement from untrimmed parts of trees
    - Give ID number as recommended (Annex 7) to the all untrimmed branches and measure their base diameter and record in data form (Annex 15)
    - Derive relationship among base diameter of trimmed branches and their biomass.
    - Smaller untrimmed branches consider separately than the bigger one.
    - Get the fresh biomass of untrimmed smaller branches from the derived relationship among base diameter of trimmed branches and biomass of respective branches.
    - Divide the bigger branches and bole into suitable sections using paint marking and give ID number for each section as shown in Figure 14
    - Measure diameter at thicker and thinner end of each bole section and bigger branches and record in data form (Annex 15).
    - Measure the bark thickness from bark chip
    - Measure the volume of all the log section of bole and bigger branches as described in section 8.
    - Measure biomass of the log section from the measured volume and the wood density as described in section 8.
- Compile the biomass data of selected sample tree as described in section 8.

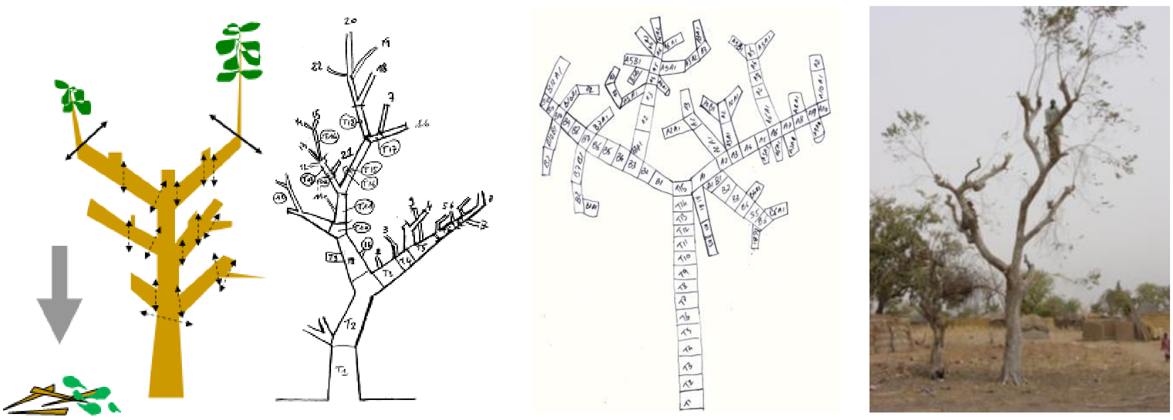


Figure 15: Measurement of biomass and volume of bigger sized trees using semi-destructive method. (Source of illustration: Picard et al. 2012)

6. Step 4: Field measurement III

6.1 Conversion ratio of Fresh weight of log with bark to bark fresh weight

- Bole:

  Collect 0.5 m long bole section for smaller individuals and 1 m long bole section for larger trees from the base, middle and upper portion of the bole of each individual sampled tree.

  - Measure the fresh weight of bole section with bark and recorded in data form (Annex 17)
  - Debark the bole sections in the field (Figure 13).
  - Measure the fresh weight of the same bole section without bark in the field.
  - Record in data form (Annex 17).

- Bigger branches

  Collect 0.5 m long section of bigger branch from the base, middle and upper portion of each individual sampled tree

  - Measure the fresh weight of bigger branch section with bark and record in data form (Annex 17).
  - Debark the bigger branch sections in the field.
  - Measure the fresh weight of the same section of the bigger branch without bark in the field and record in data form (Annex 17).

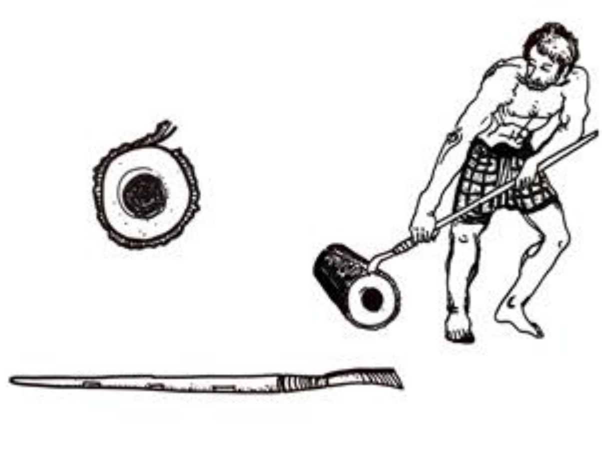


Figure 16: Debarking of sampled logs

- Take fresh weight of representative sub-sample of tree parts to calculate fresh to oven-dry weight conversion ratio as described in Section 6.2 and record in data form (Annex 8).
- Estimate oven-dry biomass of tree parts and compile the biomass of sampled tree as described in section 8.
- Estimate volume of logs, stump and buttress of sampled tree and compile the volume of the sampled trees as described in section 8.

6.2 Sub-sampling of plant parts for fresh to oven-dried weight conversion ratio

Sub-sampling for estimating fresh to oven-dry (60 to 80 ^{o}C) weight conversion ratio should be done immediately in the field to avoid rapid moisture loss. The sub-sampling and sample processing of different parts of sampled plants should be as follows:

6.2.1 Leaves or leaflets

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias
- Take fresh weight of sub-samples in the field using high precision portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

• Annex 8 (Trees)	• Annex 14 (Bamboo)
• Annex 9 (Shrubs)	• Annex 16 (Trimmed part of bigger sized tree)
• Annex 13 (Liana)	

6.2.2 Rachis

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias

- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

• Annex 10 (Palm)	• Annex 12 (Nypa Palm)

6.2.3 Petiole

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

• Annex 10 (Palm)	• Annex 12 (Nypa Palm)

6.2.4 Flowers

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

• Annex 8 (Trees)	• Annex 13 (Liana)
• Annex 9 (Shrubs)	• Annex 14 (Bamboo)
• Annex 10 (Palm)	• Annex 16 (Trimmed part of bigger sized tree)

6.2.5 Fruits

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

• Annex 8 (Trees)	• Annex 13 (Liana)
• Annex 9 (Shrubs)	• Annex 14 (Bamboo)
• Annex 10 (Palm)	• Annex 16 (Trimmed part of bigger sized tree)

6.2.6 Smaller branches (diameter < 7 cm)

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

• Annex 8 (Trees)	• Annex 14 (Bamboo)
• Annex 9 (Shrubs)	• Annex 16 (Trimmed part of bigger sized tree)
• Annex 13 (Liana)	

6.2.7 Bigger branches (diameter > 7 cm)

- Collect 20 disks of 2 to 4 cm without bark without any bias
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample

- Record the ID number and fresh weight of each sub-sample in data form of following annex

- Annex 8 (Trees)

6.2.8 Dead branches

- Collect 20 homogenous sub-samples (about 0.25 kg or more) without any bias
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample
- Record the ID number and fresh weight of each sub-sample in data form of following annex

- Annex 8 (Trees)
- Annex 9 (Shrubs)
- Annex 14 (Bamboo)
- Annex 16 (Trimmed part of bigger sized tree)

6.2.9 Bark

- Collect each of 20 homogenous sub-samples (about 0.25 kg or more) for bole bark and bigger branches without any bias.
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance.
- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample.
- Record the ID number and fresh weight of each sub-sample in data form of following annex

- Annex 8 (Trees)

6.2.10 Bole or stem

- Collect 20 disks of 2 to 4 cm without bark at the base of each log.
- Take fresh weight of sub-samples in the field using high precision of portable digital laboratory balance.

- Put the sub-samples in zip poly bag and give ID number as recommended in Annex 7 for each sub-sample.
- Record the ID number and fresh weight of each sub-sample in data form of following annex

- Annex 8 (Trees)
- Annex 9 (Shrubs)
- Annex 10 (Palm)
- Annex 13 (Liana)
- Annex 14 (Bamboo)

6.3 Sampling for wood density

- Take one disk of 10 cm thick stem from stump level, middle and top portion of sampled trees
- Give ID number as recommended in Annex 7 with code of sampling position on the disk using permanent marker and record in field data form (Annex 18).

7. Step 5: Laboratory analysis

7.1 Oven-dry weight of sub-samples

- Transfer the sub-samples immediately (collected from the field) to the laboratory for further processing.
- Measure the weight of each sub-sample to check the loss of moisture during sample transportation.
- Oven-dry the sub-samples of leaves, leaflets, flowers, fruits, petiole, rachis, smaller branches and bark at 60 to 80 ^{o}C until constant weight.
- Oven-dry the sub-samples (disks) of bigger branches and bole at 105 ^{o}C until constant weight.
- Take the weight of samples using high precision digital laboratory balance and record in data form of following annex

- Annex 8 (Trees)
- Annex 9 (Shrubs)
- Annex 10 (Palm)
- Annex 12 (Nypa palm)
- Annex 13 (Liana)
- Annex 14 (Bamboo)
- Annex 16 (Trimmed part of bigger sized tree)

7.2 Organic carbon concentration in different parts of sample trees

Concentration of organic carbon in plant sample can be determined by ignition method (Allen, 1989). The procedure is as follows:

- Crash the oven-dried sub-samples and sieved through 2 mm mesh
- Take 1 g of that processed sample at 105 ^{o}C into a porcelain cup and placed in the muffle furnace at 450 ^{o}C for four hours.
- After ignition, put the sample in a desiccator to allow it to room temperature
- Take the weight of the ignited sample
- Calculate the loss on ignition from the following formula

$$\text{Loss on ignition (\%)} = \frac{\text{Loss of weight (g)}}{\text{Oven dry weight (g)}} \times 100 \text{............ .... .Equation 8}$$

- Estimate the organic carbon from the 50% of loss of ignition or ash free dry weight of the sample
- Record the data in data form (Annex 19).

7.3 Wood density

Wood density of the collected samples can be estimated as follows:

- Take 6 sub-samples (2.5 cm x 2.5 cm x 7.5 cm) from each disk at 2.5 cm interval (from periphery to the center of disk).
- Record ID number of the sample.
- Oven-dry the sub-samples at 105 ^{o}C until constant weight.
- Take weight of the sub-samples using high precision digital laboratory balance and record in data form (Annex 20).
- Measure the sub-sample volume using water displacement method (Figure 17) or estimate from the dimension of the sub-samples after re-saturation of water and record in data form (Annex 20).
- Calculate the wood density using the following formula

  Wood density (kg/m^3) = $\frac{\text{Sample weight}}{\text{Sample volume}}$ .... Equation 7

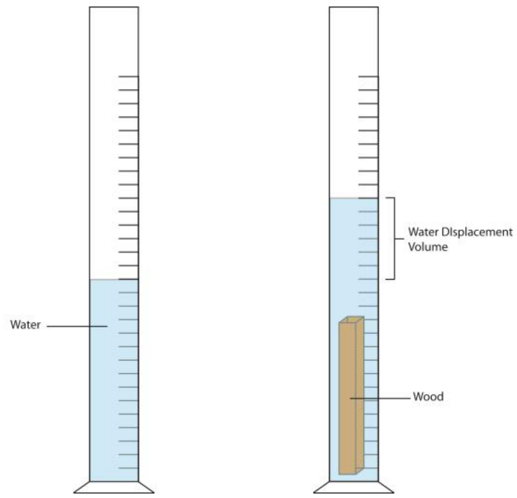


Figure 17: Measurement of wood volume using water displacement method

7.4 Nutrients (N, P, K, Ca, Mg and Mn) in different part of sampled plant

- Nutrients (N, P, K, Ca, Mg and Mn) concentration in plant parts can be estimated from the same sample that was collected from the fresh to oven dry weight conversion weight.
- Crushed and sieved the oven-dried subsamples of plant parts through 2 mm mesh
- Kjeldahl digestion should be given for Nitrogen determination (Allen 1989).
- Tri-acid (H_2SO_4, $HClO_4$ and HNO_3) digestion should be given for Phosphorus and Potassium, Calcium, Magnesium and Manganese (Allen 1989).
- Nitrogen and Phosphorus in the sample extract can be measured colorimetrically according to Baethgen and Alley (1989) and Timothy et al. (1984) respectively using UV-visible Recording Spectrophotometer
- Potassium concentration in the sample extract can be measured by Atomic Absorption Spectrophotometer.
- The amount of nutrients in each part of individual tree is estimated from their concentration and the oven-dried biomass of respective plant parts.

8. Step 6: Data compilation

8.1 Crown volume

- Measure the crown volume using following formula

Crown volume (m^3) = (CF) x (crown length (m)) x (crown diameter (m)) ^{2} .. Equation 16

8.2 Log biomass calculation from volume data

- Multiply the log volume with wood density using the following formula

Log biomass (kg) = Log volume (m^3) X Wood density (kg/m^3) …… Equation 17

8.3 Oven-dry biomass of sampled plants

- Estimate the oven-dry biomass of each part (leaves, smaller branches, bigger branches, bark and bole without bark) of sampled plants from the derived fresh to oven-dry weight conversion ratio (Section 6.2) and the fresh weight of the respective part of plant. Record the data in the following annex

- Annex 21 (Trees)
- Annex 22 (Shrubs)
- Annex 23 (Palms)
- Annex 24 (Nypa Palm)
- Annex 25 (Liana)
- Annex 26 (Bamboo)
- Annex 27 (Trimmed part of bigger sized tree)

- Sum up the oven-dry biomass of all parts of a plant to get total oven-dry biomass of that plant.
- Compile the biomass data of the sampled plants in data form of respective annex

- Annex 28 (Trees)
- Annex 29 (Shrubs)
- Annex 30 (Palms)
- Annex 31 (Nypa Palm)
- Annex 32 (Lana)
- Annex 33 (Bamboo)
- Annex 34 (Bigger sized trees)

8.4 Estimation of log volume

- Use Huber's, and Smalian's formula of volume to calculate volume of stump and log.
- Use cone formula to estimate the volume of last log section of bigger branches

Smalian's formula: V = $\frac{\pi L(D_1^2 + D_2^2)}{8}$.....Equation12

Huber's formula: V = $\frac{\pi L D_m^2}{4}$.......... ....Eq uation11

Volume of cone: V = $\frac{1}{3}\left(\frac{\pi L D_1{}^2}{4}\right)$........... .Equation15

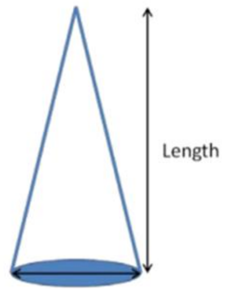


Figure 18: Dimension of a cone

- Calculate the volume of buttress using following equation

Volume = $\left(1 - \frac{\pi}{4}\right) \times \frac{lb \times Hb \times Lb}{3}$.......... .Equation14

- Record the volume of buttress, stump and log of the sampled plants in data form of the following annex

- Annex 35(Trees)
- Annex 36(For Palms)
- Annex 37 (Bigger sized trees)

- Arrange the sampled plant volume data in data form of the following annex

- Annex 38 (Trees)
- Annex 39 (Palms)
- Annex 40 (Bigger sized trees)

8.5 Carbon stock in sampled plant

- Multiply the carbon concentration of individual plant part with their oven-dry biomass to get carbon stock in that respective plant part using following formula and record in data form "Carbon stock in plant biomass"

Example: Leaf biomass is 10 kg and carbon concentration is 46%.

Carbon stock (kg) = $\text{Ovendried biomass of leaves} \times \frac{46}{100}$ .... Equation 18

- Sum up the carbon stock in all parts of a plant to get total carbon stock in that plant
- Compile the carbon stock data in the plants in data form of the following annex

- Annex 41 (Trees)
- Annex 42 (Shrubs)
- Annex 43 (Palms)
- Annex 44 (Nypa Palm)
- Annex 45 (Lana)
- Annex 46 (Bamboo)
- Annex 47 (Bigger sized trees)

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Annex 1: Field data form for fresh biomass and diameter measurement of logs of individual tree

Survey date:	
Name of team leader:	
Tree no:	
Scientific name:	
Local name:	
Administrative location:	
Coordinates of the sample tree:	

Longitude:		Latitude:	
Altitude:		Average slope:	

Forest types:	

A. Measurement of tree dimension

Diameter at 0.3 m (cm)						
DBH (cm)						
Total height (m)	Standing tree				Felled tree	
Bole length (m)	Standing tree				Felled tree	
Merchantable bole length (m)	Standing tree				Felled tree	
Crown diameter (m)	A =		B =		(A + B)/2 =	
Crown thickness or crown length (m)						
Crown shape (Annex 2)						
Crown form (Annex 2)						
Buttress no (if any)						
Buttress height (m)						
Buttress width (m)						
Buttress length (m)						
Age (year)						

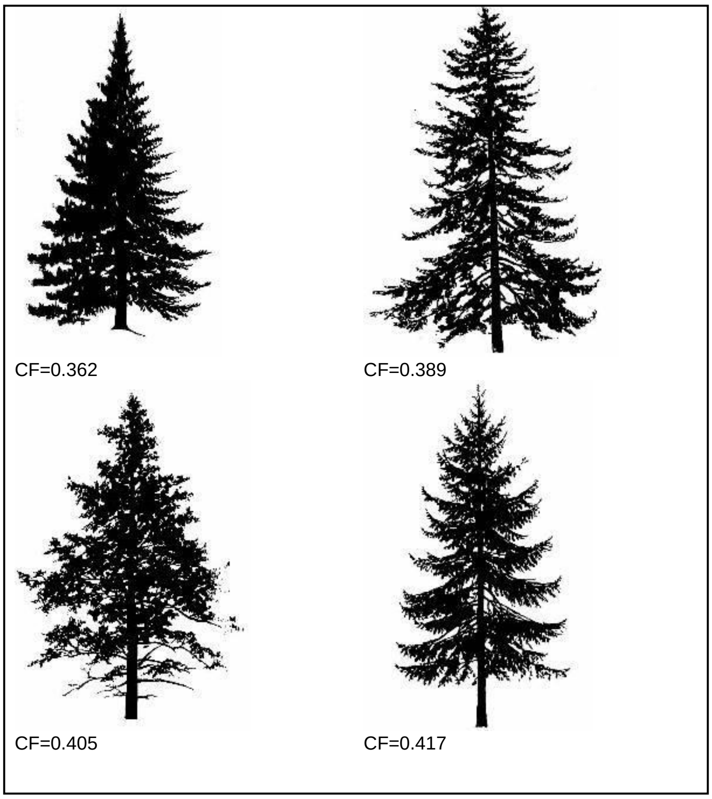
B. Fresh biomass measurement of the sample tree

SL no	Fresh weight of tree parts (kg)						Weight (kg) of buttress (if any)
	Bole	Leaves	Flowers	Fruits	Smaller branches (<7 cm diameter)	Bigger branches (> 7 cm diameter)	

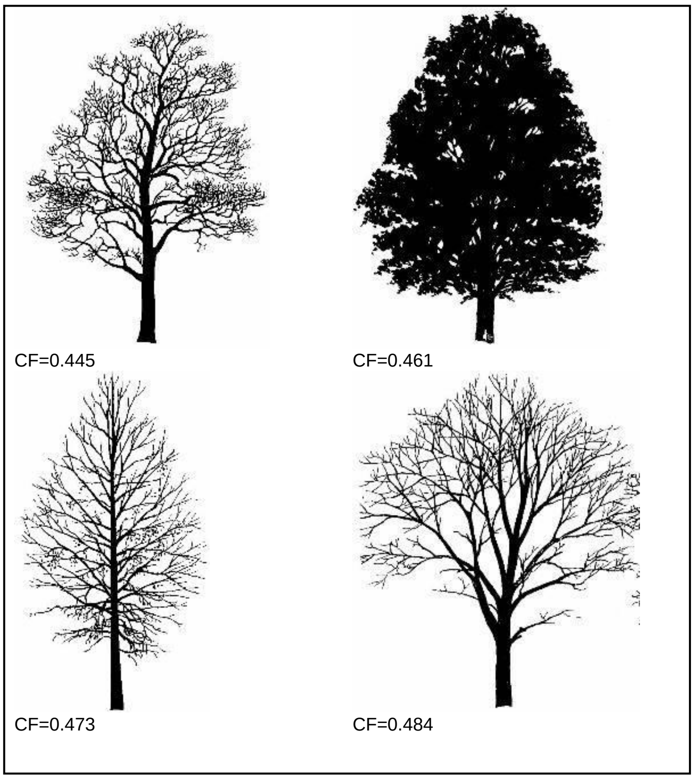
C. Length and diameter measurement of logs

Log ID	Log length (m)	Diameter with bark (cm)		Diameter without bark (cm)	
		Thicker end	Thinner end	Thicker end	Thinner end

Annex 2: Crown shape and crown form (Frank 2010)

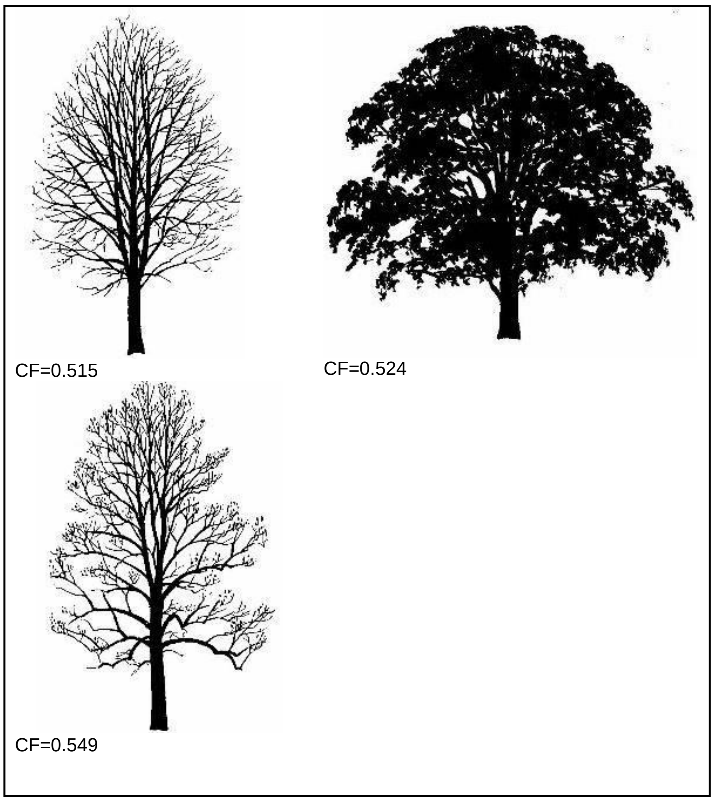


Conical to Pyramidal Forms: CF values range from 0.362 to 0.417

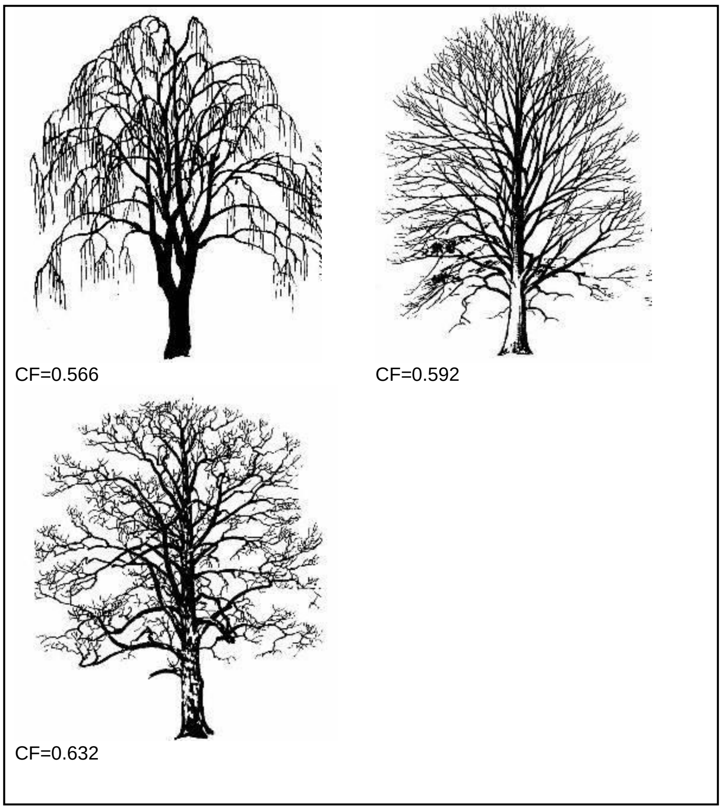


Spade Shaped Forms: CF values range from 0.445 to 0.484

Annex 2: (Cont..)

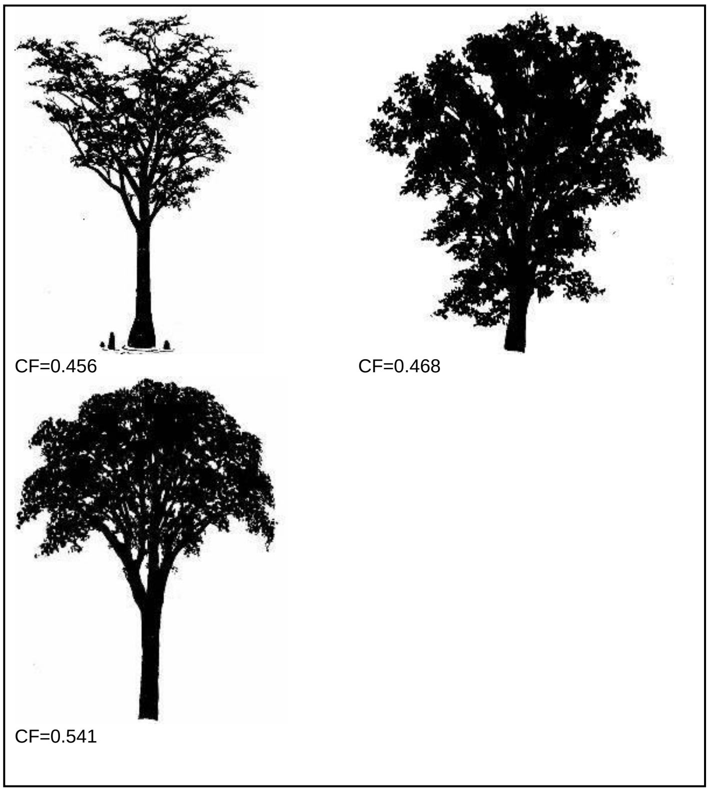


Elongate Spade to Rounded to Oval Shapes: CF values range from 0.508 to 0.549

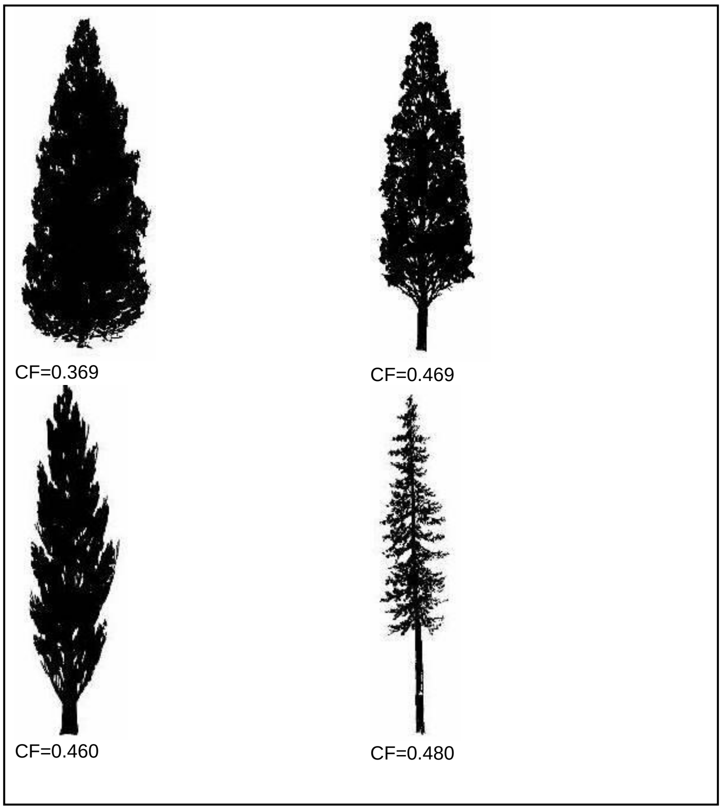


Spreading to Cylindrical Forms: CF values range from 0.565 to 0.632

Annex 2: (Cont..)



Upswept and Vase Shapes: CF ranges from 0.456 to 0.468. The American Elm in the third example has an upswept branch form but the crown itself is rounded in form.



Columnar Forms: CF factors range from 0.369 to 0.480

Annex 3: Field data form for fresh biomass of individual shrub

Survey date:	
Name of team leader:	
Shrub no:	
Scientific name:	
Local name:	
Administrative location:	

Coordinates of the sample shrub:

Longitude:		Latitude:	
Altitude:		Average slope:	

Forest types:	

A. Measurement of shrub dimension

Collar girth (cm)	
DBH (cm)	
Total height (m)	
Number of ramification	
Age (year)	

B. Fresh biomass measurement of the sample shrub

SL no	Fresh weight of shrub parts (kg)				
	Stem	Leaves	Flowers	Fruits	Branches

Annex 4: Field data form for fresh biomass and volume of individual palm

Survey date:	
Name of team leader:	
Palm no:	
Scientific name:	
Local name:	
Administrative location:	

Coordinates of the sample palm:

Longitude:		Latitude:	
Altitude:		Average slope:	

Forest types:

A. Measurement of palm dimension

Diameter at 0.3 m (cm)				
DBH (cm)				
Total height (m)	Standing tree		Felled tree	
Bole length (m)	Standing tree		Felled tree	
Crown diameter (m)				
Crown thickness or crown length (m)				
Number of leaves				
Age (year)				

B. Fresh biomass measurement of the sampled palm

SL no	Fresh weight of palm parts (kg)					
	Petiole	Rachis	Leaflets	Flowers	Fruits	Bole

C. Length and diameter measurement of logs section

Log ID	Log length (m)	Diameter with bark (cm)	
		Thicker end	Thinner end

Annex 5: Field data form for fresh biomass of individual liana

Survey date:	
Name of team leader:	
Liana no:	
Scientific name:	
Local name:	
Administrative location:	

Coordinates of the sample liana:

Longitude:		Latitude:	
Altitude:		Average slope:	

Forest types:	

A. Measurement of liana dimension

Diameter at DMP (Diameter Measurement Point) (cm)	
Total Length (m)	
Age (year)	

B. Fresh biomass measurement of the sample liana

SL no	Fresh weight of liana parts (kg)					
	leaves	Flowers	Fruits	Branches	Stem	Above-ground roots

Annex 6: Field data form for fresh biomass of individual bamboo

Survey date:

Name of team leader:

Bamboo no:

Scientific name:

Local name:

Administrative location:

Coordinates of the sample bamboo:

Longitude: Latitude:

Altitude: Average slope:

Forest types:

A. Measurement of bamboo dimension

DBH (cm)	
Total height (m)	
Age (year)	

B. Fresh biomass of the bamboo

SL no	Fresh weight of bamboo parts (kg)		
	Leaves	Branches	Stem

Annex 7: Recommended Identification number for plant parts

Level 1 (Plant life form)	Code	Example for code of trees	Level 2 (Plant parts)	Code for plant parts	Example of Code for fresh weight	Level 3 (Sub-sample)	Code for sub-samples	Example of code for sub-samples of plat parts
Tree	Tr	Tr1, Tr2 ..Trn	Leaf	L	Tr1L1, Tr1L2…….TrnLn	Leaf	SubL	Tr1SubL1 ….TrnSubLn
			Flower	Fl	Tr1Fl1, Tr1Fl2…..TrnFln	Flower	SubFl	Tr1SubFl1.. TrnSubFln
			Fruit	F	Tr1F1, Tr1F2…….TrnFn	Fruits	SubF	Tr1SubF1.. TrnSubFn
			Smaller branch	Bt	Tr1Bt1, Tr1Bt2...TrnBtn	Smaller branches	SubBt	Tr1SubBt1.. TrnSubBtn
			Bigger branch	Bg	Tr1Bg1, Tr1Bg2 ..TrnBgn	Bigger branches	SubBg	Tr1SubBg1.. TrnSubBgn
			Dead Branch	Bd	Tr1Bd1, Tr1Bd2..TrnBdn	Dead Branch	SubBd	Tr1SubBd1.. TrnSubBdn
			Bole or stem	T	Tr1T1, Tr1T2…….TrnTn	Bole or stem	SubT	Tr1SubT1 ... TrnSubTn
			Bark of bole	Ba	Tr1Ba1, Tr1Ba2..TrnBan	Bark of Bole or stem	SubBa	Tr1SubBa1.. TrnSubBan
			Bark of bigger branch	BaBg	Tr1BaBg1…………TrnBaBg	Bark of bigger branch	SubBaBg	Tr1SubBaBg1. TrnSubBaBgn
			Wood Density	WD	Tr1T1WD1……….TrnTnWDn	Wood Density	SubWD	Tr1T1SubWD1…TrnTnSubWDn
Shrub	Sh	Sh1, Sh2..Shn	Leaf	L	Sh1L1, Sh1L2……. ShnLn	Leaf	SubL	Sh1SubL1 ….ShnSubLn
			Flower	Fl	Sh1Fl1, Sh1Fl2…..ShnFln	Flower	SubFl	Sh1SubFl1.. ShnSubFln
			Fruit	F	Sh1F1, Sh1F2…….ShnFn	Fruits	SubF	Sh1SubF1.. ShnSubFn
			Smaller branch	Bt	Sh1Bt1, Sh1Bt2...ShnBtn	Smaller branches	SubBt	Sh1SubBt1.. ShnSubBtn
			Bole or stem	T	Sh1T1, Sh1T2…….ShnTn	Bole	SubT	Sh1SubT1 ... ShnSubTn
			Bark of bole	Ba	Sh1Ba1, Sh1Ba2..ShnBan	Bark of Bole or stem	SubBa	Sh1SubBa1.. ShnSubBan
Palm	Pa	Pa1, Pa2..Pan	Petiole	P	Pa1P1, Pa1P2……. Panpn	Petiole	SubP	Pa1SubL1 ….PanSubLn
			Rachis	R	Pa1R1, Pa1R1…….PanRn	Rachis	SuR	Pa1SubL1 ….PanSubLn
			Leaflets	Ll	Pa1L1, Pa1L2……. PanLn	Leaflets	SubL	Pa1SubL1 ….PanSubLn
			Flower	Fl	Pa1Fl1, Pa1Fl2…..PanFln	Flower	SubFl	Pa1SubFl1.. PanSubFln
			Fruits	F	Pa1F1, Pa1F2…….PanFn	Fruits	SubF	Pa1SubF1.. PanSubFn
			Bole or stem	T	Pa1T1, Pa1T2…….PanTn	Bole or stem	SubT	Pa1SubT1 ... PanSubTn
Nypa palm	Ny	Ny1, Ny2, .. Nyn	Petiole	P	Ny1P1, Ny1P2……. Nynpn	Petiole	SubP	Ny1SubL1 ….NynSubLn
			Rachis	R	Ny1R1, Ny1R1…….NynRn	Rachis	SuR	Ny1SubL1 ….NynSubLn
			Leaflets	Ll	Ny1L1, Ny1L2……. NynLn	Leaflets	SubL	Ny1SubL1 ….NynSubLn
Liana	Li	Li1, Li2, ..Lin	Leaf	L	Li1L1, Li1L2…….LinLn	Leaf	SubL	Li1SubL1 ….LinSubLn
			Flower	Fl	Li1Fl1, Li1Fl2…..LinFln	Flower	SubFl	Li1SubFl1.. LinSubFln
			Fruits	F	Li1F1, Li1F2…….LinFn	Fruits	SubF	Li1SubF1.. LinSubFn
			Bole or stem	T	Li1T1, Li1T2…….LinTn	Bole or stem	SubT	Li1SubT1 ... LinSubTn
			Above-ground Root	AR	Li1AR1, Li1AR2…….LinARn	Bole	SubAR	Li1SubAR1 ... LinSubTn
Bamboo	Bo	Bo1, Bo2 ..Bon	Leaf	L	Bo1L1, Bo1L2…….BonLn	Leaf	SubL	Bo1SubL1 ….BonSubLn
			Smaller branch	Bt	Bo1Bt1, Bo1Bt2...BonBtn	Smaller branches	SubBt	Bo1SubBt1.. BonSubBtn
			Bole or stem	T	Bo1T1, Bo1T2…….BonTn	Bole	SubT	Bo1SubT1 ... BonSubTn

Annex 7: (Cont..)

Generation and description of ID number

- Plant life forms like Tree, Shrub, Palma, Nypa palm, Liana, and Bamboo coded as Tr, Sh, Pa, Ny, Li and Bo respectively
- 1st, 2nd, 3rd and nth tree coded as Tr1, Tr2, Tr3 ……….. Trn; 1st, 2nd, 3rd and nth Shrub coded as Sh1, Sh2, Sh3 ……….Shn; 1st, 2nd, 3rd and nth Palm coded as Pa1, Pa2, Pa3 ……….. Pan respectively
- Plant parts like Leaf, Flower, Fruit, Smaller branch, Bigger branch, Dead Branch, Bole or stem, Bark of bole, Bark of bigger branch, Wood Density coded as L, Fl, F, Bt, Bg, Bd, T, Ba, BaBg, WD respectively
- The code of 1st log of 1st Tree and 4th log of 5th tree will be codes as Tr1T1 and Tr5T4 respectively
- Use "Sub" as code for sub-sample of plant parts
- The code of 1st, 2nd and 3rd sub-samples of leaf from 1st tree and 10th shrub will be Tr1Subl1, Tr1SubL2, Tr1SubL3 and Sh10SubL1, Sh10SubL2, Sh10SubL3 respectively

Tagging of sub-samples

- Put each sub-sample inside the zip poly bag except bigger sized stem disk
- Write the ID number on the polybag using permanent marker
- Write the same ID number on hard paper using ball point pane and pencil and put them inside the zip polybag for double protection of the ID number
- Write the ID number on stem disk using permanent marker, ball point pen and pencil on both the surface

Annex 8: Fresh to oven-dry weight conversion ratio for sub-samples of tree parts

Survey date:	
Name of researcher:	
Scientific name:	
Local name:	

A. Leaves

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Flowers

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Fruits

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

D. Smaller branches (Diameter < 7 cm)

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

E. Bigger branches (Diameter > 7 cm) without bark

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 8 (Cont…)

F. Bark of bigger branches

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

G. Dead branches

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

H. Bole without bark

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

I. Bark of bole

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 9: Fresh to oven-dry weight conversion ratio for sub-samples of shrub parts

Survey date:	
Name of team leader:	
Name of researcher:	
Scientific name:	
Local name:	

A. leaves

Sample shrub no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Flowers

Sample shrub no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Fruits

Sample shrub no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

D. Branches

Sample shrub no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

E. Dead branches

Sample shrub no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

F. Stem

Sample shrub no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 10: Fresh to oven-dry weight conversion ratio for sub-samples of palm parts

Survey date:	
Name of team leader:	
Name of researcher:	
Scientific name:	
Local name:	

A. Petiole

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Rachis

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Leaflets

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

D. Flowers

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

E. Fruits

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

F. Bole

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 11: Field data form for fresh biomass of individual *Nypa fruticans*

Survey date:	
Name of team leader:	
Nypa palm no:	
Scientific name:	
Local name:	
Administrative location:	

Coordinates of the sample palm:

Longitude:		Latitude:	
Altitude:		Average slope:	

Forest types:	

A. Measurement of *Nypa fruticans*

SL no	Total length of leaf (m)	Usable length of leaf (m)	Fresh weight of parts (kg)		
			Petiole	Rachis	Leaflets

Annex 12: Fresh to oven-dry weight conversion ratio for sub-samples of *Nypa fruticans*

Survey date:	
Name of team leader:	
Name of researcher:	
Scientific name:	
Local name:	

A. Petiole

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Rachis

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Leaflets

Sample palm no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 13: Fresh to oven-dry weight conversion ratio for sub-samples of liana

Survey date:	
Name of team leader:	
Name of researcher:	
Scientific name:	
Local name:	

A. leaves

Sample liana no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Flowers

Sample liana no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Fruits

Sample liana no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

D. Stem

Sample liana no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

E. Above-ground root

Sample liana no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 14: Fresh to oven-dry weight conversion ratio for sub-samples of bamboo parts

Survey date:	
Name of team leader:	
Name of researcher:	
Scientific name:	
Local name:	

A. Leaves

Sample bamboo no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Branches

Sample bamboo no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Stem

Sample bamboo no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 15: Field data form for fresh biomass and diameter measurement of logs of individual bigger sized (DBH >50 cm) tree

Survey date:			
Name of team leader:			
Tree no:			
Scientific name:			
Local name:			
Administrative location:			
Coordinates of the sample tree:			
Longitude:		Latitude:	
Altitude:		Average slope:	
Forest types:			

A. **Measurement of tree dimension**

Diameter at 0.3 m (cm)						
DBH (cm)						
Total height (m)						
Bole length (m)						
Merchantable bole length (m)						
Crown diameter (m)	A =		B =		(A + B)/2 =	
Crown thickness or crown length (m)						
Crown shape (Annex 2)						
Crown form (Annex 2)						
Buttress no (if any)						
Buttress height (m)						
Buttress width (m)						
Buttress length (m)						
Age (year)						

B. **Measurement of selected trimmed branched**

SL no	Base diameter (cm)	Fresh weight of tree parts (kg)			
		Leaves	Flowers	Fruits	Total

C. **Base diameter of untrimmed branches**

SL no	Diameter (cm)

D. **Length and diameter measurement of untrimmed bole and bigger branch section**

Log ID	Log length (m)	Diameter with bark (cm)		Diameter without bark (cm)	
		Thicker end	Thinner end	Thicker end	Thinner end

Annex 16: Fresh to oven-dry weight conversion ratio for sub-samples of bigger sized (DBH >50 cm) tree

Survey date:	
Name of team leader:	
Name of researcher:	
Scientific name:	
Local name:	

A. Leaves

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

A. Flowers

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

B. Fruits

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

C. Smaller branches (Diameter < 7 cm)

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

D. Bigger branches (Diameter > 7 cm)

Sample tree no	Sample ID no	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)	Conversion ratio = $\frac{\text{Oven dry weight (kg)}}{\text{Fresh weight (kg)}}$
Average					

Annex 17: Field data form for estimating ratio of fresh weight of bark and log with bark

Survey date:	
Name of team leader:	
Scientific name:	
Local name:	

A. Fresh weight ratio of bark and bole wood

Sample tree no	Log length (m)	Log weight with bark (kg)	Log weight without bark (kg)	Weight of bark (kg)	Ratio of bark = $\frac{\text{Bark weiht of log (kg)}}{\text{Log weight with bark (kg)}}$

B. Fresh weight ratio of bark and bigger branch with bark

Sample tree no	Log length (m)	Log weight with bark (kg)	Log weight without bark (kg)	Weight of bark (kg)	Ratio of bark = $\frac{\text{Bark weiht of log (kg)}}{\text{Log weight with bark (kg)}}$

Annex 18: Field data form for wood density sample collection and oven-dry weight of samples

Survey date:	
Name of team leader:	
Scientific name:	
Local name:	

A. Wood density sample origin and position

Sampled tree no	Sample ID and code	Sample position

B. Wood density sample weight

Sample ID and code	Sub-sample ID and code	Sub-sample fresh weight (kg)	Sub-sample weight at laboratory (kg)	Sub-sample oven-dry weight (kg)

Annex 19: Organic carbon concentration in plant parts

Date of measurement:	
Name of researcher:	
Scientific name:	
Local name:	

Plant parts	Sample weight at 105 °C	Sample weight at 450 °C	Loss on ignition (%) = $\frac{\text{Loss of weight (g)}}{\text{Oven dry weight (g)}} \times 100$	Organic carbon (%) = loss of ignition x $\frac{50}{100}$

Annex 20: Wood density calculation

Date of measurement:	
Name of researcher:	
Scientific name:	
Local name:	

Sample ID and code	Sub-sample ID and code	Oven-dry weight of sub-sample (kg)	Volume of sub-sample (m^3)	Wood density (kg/m^3) = $\frac{Oven\ dry\ biomass\ (kg)}{Volume\ (m3)}$

Annex 21: Oven-dry biomass of individual tree

Date of calculation:	
Tree no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Biomass of fresh bark

Tree parts	Fresh weight with bark (kg)	Ratio of bark from Annex 4	Fresh weight of bark (kg) = Fresh weight with bark (kg) x ratio of bark	Fresh weight without bark (kg) = Fresh weight with bark (kg) - Fresh weight of bark (kg)
Bole				
Bigger branch				
Total fresh weight of bark (kg)				

B. Oven-dry biomass of individual sampled tree

Tree parts	Fresh weight (kg)	Fresh weight to oven-dry weight Conversion ratio	Oven-dry biomass (kg) = Fresh weight x conversion ratio
Leaves			
Flowers			
Fruits			
Smaller branches (<7 cm diameter)			
Bigger branches (> 7 cm diameter) with bark			
Bigger branches (> 7 cm diameter) without bark			
Bark of bigger branches			
Bole and buttress (if any) with bark			
Bole and buttress (if any) without bark			
Bark of bole			
Total oven-dry biomass (kg)			

Annex 22: Oven-dry biomass of individual shrub

Date of calculation:	
Shrub no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Oven-dry biomass of individual sampled shrub

Tree parts	Fresh weight (kg)	Fresh weight to oven-dry weight Conversion ratio	Oven-dry biomass (kg) = Fresh weight x conversion ratio
Leaves			
Flowers			
Fruits			
Smaller branches			
Stem with bark			
Total oven-dry biomass (kg)			

Annex 23: Oven-dry biomass of individual palm

Date of calculation:	
palm no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Oven-dry biomass measurement of the sample palm

Parts	Fresh weight (kg)	Fresh weight to oven-dry weight Conversion ratio	Oven-dried biomass (kg) = Fresh weight x conversion ratio
Petiole			
Rachis			
Leaflets			
Bole			
Total oven-dry biomass (kg)			

Annex 24: Oven-dry biomass of *Nypa fruticans* leaves

Date of calculation:	
palm no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Oven-dry biomass measurement of *Nypa fruticans*

Parts	Fresh weight of tree parts (kg)	Fresh weight to oven-dry weight Conversion ratio	Oven-dried biomass (kg) = Fresh weight x conversion ratio
Petiole			
Rachis			
Leaflets			
Total oven-dry biomass (kg)			

Annex 25: Oven-dry biomass of individual liana

Date of calculation:	
Liana no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Oven-dry biomass measurement of the liana

Parts	Fresh weight (kg)	Fresh weight to oven-dry weight Conversion ratio	Oven-dried biomass (kg) = Fresh weight x conversion ratio
Leaves			
Flowers			
Fruits			
Stem			
Above-ground roots			
Total oven-dry biomass (kg)			

Annex 26: Oven-dry biomass of individual bamboo

Date of calculation:	
palm no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Oven-dry biomass of the bamboo

Parts	Fresh weight (kg)	Fresh weight to oven -dry weight Conversion ratio	Oven-dried biomass (kg) = Fresh weight x conversion ratio
Leaves			
Branches			
Stem			
Total oven-dry biomass (kg)			

Annex 27: Oven-dry biomass of individual bigger sized (DBH > 50 cm) tree

Date of calculation:	
Tree no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Biomass of trimmed parts

Tree parts	Fresh weight (kg)	Fresh weight to oven-dry weight Conversion ratio	Oven-dry biomass (kg) = Fresh weight x conversion ratio
Leaves			
Flowers			
Fruits			
Branches (Diameter < 7 cm)			

B. Biomass of untrimmed parts

Log ID	Volume without bark (m^3)	Wood density (kg/m^3)	Biomass (kg) = Volume of log (m^3) x Wood density (kg/m^3)
Total			

Annex 28: Compilation of tree biomass data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample tree no	DBH (cm)	Total height (m)	Merchantable bole length (m)	Oven-dried biomass of tree parts (kg)											
				1	2	3	4	5	6	7	8	9	10	11	12
				Leaves	Flowers	Fruits	Smaller branches	Bigger branches with bark	Bigger branches without bark	Bark of bigger branch	Bole with bark	Bole without bark	Bark of bole	Total bark	Total AGB = (1+2+3+4+6+9+11)

Annex 29: Compilation of shrub biomass data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample shrub no	Collar girth (cm)	DBH (cm)	Total height (m)	Oven-dried biomass of tree parts (kg)					
				1	2	3	4	5	6
				Leaves	Flowers	Fruits	Branches	Stem with bark	Total AGB = (1+2+3+4+5)

Annex 30: Compilation of palm biomass data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample palm no	DBH (cm)	Total height (m)	Oven-dried biomass of palm parts (kg)						7
			1	2	3	4	5	6	
			Petiole	Rachis	leaflets	Flowers	Fruits	Bole	Total AGB = (1+2+3+4+5 +6)

Annex 31: Compilation of *Nypa fruticans* leaf biomass data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample Nypa palm no	Total length (m)	Usable length (m)	Oven-dried biomass of Nypa palm parts (kg)			
			1	2	3	4
			Petiole	Rachis	Leaflets	Total Biomass = (1 + 2 + 3)

Annex 32: Compilation of liana biomass data

Date of compilation:

Name of researcher:

Scientific name:

Local name:

Administrative location:

Forest types:

Sampled liana no	Diameter (cm)	length (m)	Oven-dried biomass of tree parts (kg)					6
			1	2	3	4	5	
			Leaves	Flowers	Fruits	Stem	Above-ground roots	Total AGB = (1+2+3+4+5)

Annex 33: Compilation of bamboo biomass data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sampled bamboo no	DBH (cm)	Total height (m)	Oven-dried biomass of bamboo parts (kg)			4
			1	2	3	
			Leaves	Branches	Stem	Total AGB = (1+2+3)

Annex 34: Compilation of bigger sized (DBH > 50 cm) tree biomass data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample tree no	DBH (cm)	Total height (m)	Merchantable bole length (m)	Oven-dried biomass of bigger sized (DBH > 50 cm) tree parts (kg)						
				1	2	3	4	5	6	7
				Leaves	Flowers	Fruits	Smaller branches	Bigger branches with bark	Bole without bark	Total AGB = (1+2+3+4+6)

Annex 35: Volume calculation of log sections of individual tree

Date of calculation:	
Tree no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Length and diameter measurement of logs

Log ID	Log length (m)	Diameter with bark (cm)		Volume with bark (m^3)	Diameter without bark (cm)		Volume without Bark (m^3)
		Thicker end	Thinner end		Thicker end	Thinner end	
Volume (m^3) of stump					Volume (m^3) of stump		
Volume (m^3) of buttress (if any)					Volume (m^3) of buttress (if any)		
Total volume with bark (m^3)					Total volume without bark (m^3)		

Annex 36: Volume calculation of log sections of individual palm

Date of calculation:	
Palm no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Length and diameter measurement of logs

Log ID	Log length (m)	Diameter with bark (cm)		Volume with bark (m^3)	Diameter without bark (cm)		Volume without Bark (m^3)
		Thicker end	Thinner end		Thicker end	Thinner end	
Volume (m^3) of buttress (if any)					Volume (m^3) of buttress (if any)		
Total volume with bark (m^3)					Total volume without bark (m^3)		

Annex 37: Volume calculation of log sections of individual bigger sized (DBH > 50 cm) tree

Date of calculation:	
Tree no:	
Name of researcher:	
Scientific name:	
Local name:	

A. Length and diameter measurement of logs

Log ID	Log length (m)	Diameter with bark (cm)		Volume with bark (m^3)	Diameter without bark (cm)		Volume without Bark (m^3)
		Thicker end	Thinner end		Thicker end	Thinner end	
Volume (m^3) of buttress (if any)					Volume (m^3) of buttress (if any)		
Total volume with bark (m^3)					Total volume without bark (m^3)		

Annex 38: Compilation of tree volume data

Date of compilation:

Name of researcher:

Scientific name:

Local name:

Administrative location:

Forest types:

Sample tree no	DBH (cm)	Total height (m)	Merchantable bole length (m)	Merchantable Volume (m^3)	Total volume (m^3)	Crown Volume (m^3)

Annex 39: Compilation of palm volume data

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sampled palm no	DBH (cm)	Total height (m)	Volume (m^3)

Annex 40: Compilation of bigger sized (DBH > 50 cm) tree volume data

Date of compilation:

Name of researcher:

Scientific name:

Local name:

Administrative location:

Forest types:

Sample tree no	DBH (cm)	Total height (m)	Merchantable bole length (m)	Merchantable Volume (m^3)	Total volume (m^3)	Crown Volume (m^3)

Annex 41: Carbon stock in tree

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample tree no	DBH (cm)	Total height (m)	Merchantable bole length (m)	Oven-dried biomass of tree parts (kg)											
				1	2	3	4	5	6	7	8	9	10	11	12
				ODB of Leaves X CC	ODB of Flowers X CC	ODB of Fruits X CC	ODB of Smaller branches X CC	ODB of Bigger branches with bark X CC	ODB of Bigger branches without bark X CC	ODB of Bark of bigger branch X CC	ODB of Bole with bark X CC	ODB of Bole without bark X CC	ODB of Bark of bole X CC	CC in Total bark (7+10)	Total carbon in AGB = (1+2+3+4+6+9+11)

Annex 42: Carbon stock in shrubs

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample shrub no	DBH (cm)	Total height (m)	Carbon stock in palm parts (kg)					
			1	2	3	4	5	6
			ODB of leaves x CC	ODB of flowers x CC	ODB of fruits x CC	ODB of branches x CC	ODB of stem x CC	CS in total AGB = (1+2+3+4+5)

Annex 43: Carbon stock in palm

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample palm no	DBH (cm)	Total height (m)	Carbon stock in palm parts (kg)						
			1	2	3	4	5	6	7
			ODB of Petiole x CC	ODB of rachis x CC	ODB of leaflet x CC	ODB of flowers x CC	ODB of fruits x CC	ODB of bole x CC	CS in total AGB = (1+2+3+4+5+6)

Annex 44: Carbon stock in *Nypa fruticans* leaves

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample palm no	Total length (m)	Usable length (m)	Carbon stock in plant parts (kg)			4
			1	2	3	
			ODB of Petiole x CC	ODB of rachis x CC	ODB of leaflet x CC	CS in total biomass = (1+2+3)

Annex 45: Carbon stock in liana

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample liana no	Diameter (cm)	length (m)	Carbon stock in liana parts (kg)					
			1	2	3	4	5	6
			ODB of leaves x CC	ODB of flowers x CC	ODB of fruits x CC	ODB of stem x CC	ODB of above-ground biomass x CC	CS in total AGB = (1+2+3+4+5)

Annex 46: Carbon stock in bamboo

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample bamboo no	DBH (cm)	Total height (m)	Carbon stock in bamboo parts (kg)			
			1	2	3	7
			ODB of Leaves x CC	ODB of Branches x CC	ODB of Stem x CC	CS in total AGB = (1+2+3)

Annex 47: Carbon in stock bigger sized (DBH > 50 cm) tree

Date of compilation:	
Name of researcher:	
Scientific name:	
Local name:	
Administrative location:	
Forest types:	

Sample tree no	DBH (cm)	Total height (m)	Merchantable bole length (m)	Oven-dried biomass of bigger sized (DBH > 50 cm) tree parts (kg)						
				1	2	3	4	5	6	7
				ODB of Leaves X CC	ODB of Flowers X CC	ODB of Fruits X CC	ODB of Smaller branches X CC	ODB of Bigger branches X CC	ODB of Bole without bark X CC	Total AGB = (1+2+3+4+6)