EASTERN PROVINCE-JURISDICTIONAL SUSTAINABLE LANDSCAPE PROJECT

STANDARD OPERATING PROCEDURES FOR FORESTRY

AUGUST, 2022

BioCarbon Fund
Initiative for Sustainable Forest Landscapes

About the Standard Operating Procedure (SOP)

<table>
<tr><th colspan="4">Standard Operating Procedure</th></tr>
<tr><td>Version</td><td>Final Version</td><td>Date of Issue</td><td>August 2023</td></tr>
<tr><td>Purpose</td><td colspan="3">This SOP details how to set up and execute data collection for forest measurement and inventory approaches to assist in quantifying the amount of carbon within the various organic pools found within the eastern province landscape</td></tr>
<tr><td>Responsibilities</td><td colspan="3">MRV Coordinator
a) In coordination with the PIU, the role will entail working with forest sector lead officers to deliver high-quality MRV outputs.
b) Will serve as a focal point for enquiries regarding national MRV systems.
c) Will work closely with forest sector leads person, traditional leaders, community leaders, and private sector partners in developing and maintaining the MRV systems.
d) Oversee data collection according to indicators and metrices provided for in the standard operating procedures for Forestry.
e) Provide guidance in the development of the sampling framework for Energy, Forestry, and Agriculture.
f) Supervise data collection at district and chiefdom level for Forestry.</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Sampling design are provided in the MRV management plan</td></tr>
<tr><td>Related documents</td><td colspan="3">The following are the related documents to be used alongside the SOP:
a) MRV management plan
b) ZIFLP-MRV mobile application software
c) Integrated Land Use Assessment Phase II Zambia Biophysical Field Manual
d) Forest Biophysical Field Data Entry Booklet Integrated Land Use Assessment Phase II Zambia</td></tr>
</table>

CONTENTS

ACRONYMNS

EP-JSLP	Eastern Province Jurisdictional Sustainable Landscape Programme
GHG	Green House Gases
GPS	Global Positioning System
ID	Identification
ILUA II	Integrated Land use Assessment Phase Two
IPCC	Intergovernmental Panel on Climate Change
MRV	Monitoring Reporting and Verification
PIU	Project Implementation Unit
PVC	Polyvinyl Chloride
SOP	Standard Operating Procedure
UTM	Universal Transverse Mercator
ZEMA	Zambia Environmental Management Agency
ZIFLP	Zambia Integrated Forest Programme

1.0 INTRODUCTION-BIOPHYSICAL ASSESSMENTS

The Zambia Integrated Forest Landscape Project (ZIFLP) in Eastern province is supported by the World Bank and its objective is to improve landscape management and increase environmental and economic benefits for targeted rural communities in Eastern Province and to improve Zambia's capacity to respond promptly and effectively to an Eligible Crisis or Emergency.

The project provides support to rural communities in the Eastern Province to allow them to better manage the resources of their landscapes so as to reduce deforestation and unsustainable agricultural expansion; enhance benefits they receive from forestry, agriculture and wildlife; and reduce their vulnerability to climate change. Simultaneously, the project is supporting the creation of the enabling environment for subsequent carbon emission reduction purchases. The ZIFLP's key beneficiaries are the rural poor communities of the Eastern province.

The Zambia Environmental Management Agency (ZEMA) with support from ZIFLP have been mandated to develop national and subnational (EP-JSLP) Measurement, Reporting and Verification System (MRV) and other Green House Gas (GHG) emission-related processes and systems under subcomponent 1.2: Emissions Reduction Framework. With this support, ZEMA will have one integrated and robust MRV that will be used to monitor emissions for the EP-JSLP and at national level.

The aim of this document is to provide standard field measurement approaches to assist in quantifying the amount of carbon within the various organic pools found within the eastern province landscape. The methods presented in Standard Operating Procedure (SOP) is based on the Integrated Land Use Assessment (ILUA II) and good practices and lessons from drawn from regional and international experiences.

This SOP will be used in collaboration with the following:

a) MRV management plan
b) ZIFLP-MRV mobile application software
c) Integrated Land Use Assessment Phase II Zambia Biophysical Field Manual
d) Forest Biophysical Field Data Entry Booklet Integrated Land Use Assessment Phase II Zambia

The SOPs are grouped by purpose. The first set of SOPs are general and can be used for many field measurement goals. A set of SOPs are also presented on the measurement of all the carbon pools. These can be used to estimate the standing stock of a carbon pool within a stratum. Another set of SOPs are presented to estimate the emissions resulting from selective logging. Various SOPs are also presented on estimating canopy cover. These SOPs should only be used when the purpose of data collection is known. This SOP along with the above mentioned documents should be used after receiving extensive field training in the measurement methods performed by a qualified forester or ecologist.

2.0 SOP FIELD SAFETY

Safety is foremost priority and precautions must be taken and strictly adhered to. Planned field activities must remain flexible and allow for adjustments in response to on-the-ground assessments of hazards and safety conditions. Field personnel must be well prepared, vigilant and always avoid unnecessary risks. It is recommended that personnel engaging in field activities hold general first aid training[1]. The following guidelines will apply to all field-

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[1] Sarah M. W et.al, 2012: Standard Operating Procedures for Terrestrial Carbon Measurement

based activities:

a) Field crews will include no less than three people who must be directly accompanying each other for the entire duration of field work. Ideally field crews should include a minimum of three people; in case of an accident resulting in injury one person may leave to seek help while another person stays with the injured crew member.
b) For each day in the field, specific location and scheduling information must be logged in advance with a field team leader who can be reached at any time during the anticipated duration of field work. While in the field, crews should check in with their designated field team leader once per day.
c) Each independent crew must carry a radio with wider coverage, satellite phone or cell phone and any other necessary field equipment provided by the project. Crews should make sure to check batteries each time before entering the field.
d) Trip planning will include identification of the nearest medical facility and specific directions to reach that facility. When in areas with poisonous snakes, advance communication should be made to verify that appropriate antivenins' are available.
e) Personnel will carry personal identification and, if possible, project name tags at all times.
f) Field crews will carry a first aid kit with them at all times. First aid kits should contain Epinephrin/Adrenalin or an antihistamine for allergic reactions (e.g. bee/wasp stings). insect repellent should be carried in the field and other relevant medical supplies.
g) Where poisonous snakes are common, snake chaps are recommended. In the event of snake bite, the victim should be taken immediately to a medical facility.
h) Basic field clothing should be appropriate for the range of field conditions likely to be encountered. This will include: sturdy boots with good ankle support or rubber boots, long sleeves and pants, rain gear, and gloves. Blaze orange (vest or hat) is recommended when and where hunting may be taking place. Where necessary, to avoid extended contact with plant oils, ticks, and a change of clothes should be made at the end of each day in the field and field clothes should not be re-worn without first laundering.
i) Ensure personnel stay sufficiently hydrated and carry enough clean water for the intended activity. Carry iodine tablets or other water purification tablets in case there is a need to use water from unpurified sources.
j) Some plots may be too hazardous to sample. Situations include: plot center on a slope too steep to safely collect data (i.e., >100% slope or on a cliff); presence of bees; illegal activities; etc. When hazardous situations arise, a discussion should be conducted among the team members to assess the situation.

3.0 SOP LABELING PLOTS

The following provides recommendations on how plots should be labeled. However, this SOP must be altered and provide explicit instructions on how each plot will be labeled for a given field measurement campaign.

Proper plot labeling is important because it provides a unique signature to sampled plots as well as information about the sampling conducted. Experience has shown that plots should be named with multiple characters defining the type of sampling conducted, the area, the number of the plot and any other relevant information.

All plots must be numbered with a unique name and number. The labeling system must be finalized prior to data collection. The character denoting the number of the plot should include at least as many digits as total numbers of plots expected to be sampled. In other words, if the number of plots is expected to be greater than 100 but less than 1000, the number characters must be at least three integers e.g. 001 to 999.

The following is an example of a recommended plot labeling format: The coordinates of plot marker position are determined with the help of GPS receiver (as averaging positions of several measurements). Then, an identification code will be assigned to identify each points measured by the GPS as follows:

[Cluster number] + "P" + [Plot number] + "_M" (="Marker"), e.g. for cluster 113, plot 3 => 113P3_M

- A photo of the marker point may be taken, and it should show the same code;
- A steel marker pin should be positioned in the ground at the starting point of all plots.

Reference objects for starting point:

- Three prominent and preferably permanent reference objects (rock, non-abundant tree species or largest tree, house etc.) as fixed points must be identified for a marker.
- These objects should be 80-130 degrees apart to help with triangulation.
  The following information is recorded about the reference point: object ID, type of object,
  bearing (compass reading in degrees) to the plot marker, distance to the plot marker, tree diameter (if object is a tree), and photo ID.
- Reference point coordinates are only recorded if these cannot be measured at the plot marker point.
- A photo should be taken for each reference objects, and coded as follows:
  [Cluster number] + "P"+ [plot number] + "_R" + [running photo number within plot] (e.g. Photo of the 3rd reference taken in the 2nd plot on the cluster number 28
  => 28P2_R3

4.0 SOP DATA COLLECTION

This SOP will consider measurement and data collection in forestland, cropland, grassland, wetland, and other lands for the following:

a) Measurement of trees
b) Measurement of bamboos
c) Non-tree woody vegetation measurements
d) Herbaceous vegetation
e) Measurement of litter
f) Sampling soil carbon
g) Measurement of standing dead wood
h) Measurement of lying dead wood
i) Measurement and estimation of dead wood density classes
j) Measurement of canopy cover
k) Area of canopy opening
l) Forest fires
m) Tree crown area from the ground
n) Stump data
o) Regeneration

The data collected will be assembled and analyzed and this is considered under SOP for data analysis. Details of the SOP for data collection are provided in the table 4.1.

Table 4.1 Standard Operating Procedure for Forestry

<table>
<tr><th>Steps</th><th>Description</th></tr>
<tr><td>Step 1: Planning the data collection</td><td>
Step 1a Identify data to be collected. Provided below is the sampling framework and number of persons to be involved in data collection.

Sampling Design
<table>
<tr><th>Sample details</th><th>Clusters</th><th>Plots</th><th>Sample size</th></tr>
<tr><td>• Total number of sample plots in Forest Land</td><td>116[2]</td><td>464</td><td>51.7%</td></tr>
<tr><td>• Total Number of sample plots in cropland</td><td>63</td><td>252</td><td>27.4%</td></tr>
<tr><td>• Total Number of Sample Plots in Grassland</td><td>27</td><td>108</td><td>11.7%</td></tr>
<tr><td>• Total Number of Sample Plots in Settlements</td><td>13</td><td>52</td><td>5.7%</td></tr>
<tr><td>• Total Number of Sample Plots in Wetlands</td><td>8</td><td>32</td><td>3.5%</td></tr>
<tr><td>• Total clusters and samples</td><td>233</td><td>932</td><td>-</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="3">Confidence level</td><td>95%</td></tr>
<tr><td colspan="3">Margin of Error (%)</td><td>5%</td></tr>
</table>
The baseline data categories will be collected through the following methods;
• Biophysical measurements-Biomass carbon stock, soil carbon and deadwood and litter
• Fuel removals data-Survey
• Wood removals for timber-Records(database)

This data will be collated to generate the forestry inventory database for Eastern Province in Zambia. The surveys and tests will take place in indigenous forests and forest plantations. Respondents will be asked to provide information on the amount of wood removals for timber and fuel wood used from the forests over a specified period.

Step 1 b. The MRV Coordinator estimates the necessary level of effort for the data collection

Step 1c. The MRV Coordinator identifies the persons who may be involved in the data collection in line with the records in the MRV Management Plan.

Step 1d. The data collection timeline to be followed is as stipulated in the MRV management plan.
</td></tr>
</table>

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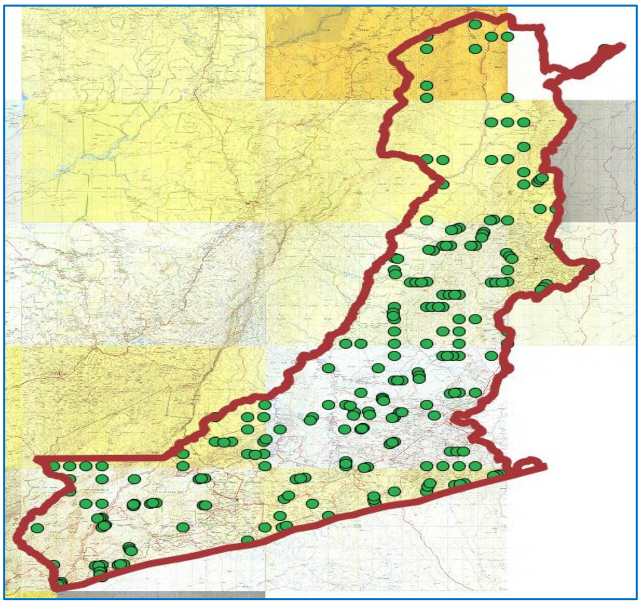
[2] **Each cluster has 4 rectangular sample plots:** the sample plots are spaced at 500m apart. And each sample plot has 2 sub plots: a 10 x 20m rectangular sub-plot for saplings, and 4.99m circular sub-plot for smaller seedlings

Steps	Description
	Step 1 e. The PIU will arrange logistics, including safety kit, field clothing, tablets, GPS, weighing scales, note books, sufficient time for data collection, remunerations arrangements.
Step 2: Identification of sampling units/design	**Step 2a. Forestry Biophysical Assessment, the Permanent Observation Units Framework for Eastern Province.** The MRV Coordinator will compile a list of areas in each district where the survey should be conducted. The areas should be identified and marked geographically on the Map as shown below.  There are 233 Clusters 932 Sample Plots displayed Figure 4.1 Clusters and sample plots The sampling design will include the following elements: 1. Forestry regeneration data 2. Forestry sapling data 3. Forestry data collected on trees, shrubs, deadwood, bamboo, litter, soil, carbon content, biomass density, forest fires, biodiversity, carbon and none carbon credit benefits. 4. Forest land areas (indigenous forests and forest plantations) 5. IPCC land use category and Land conversions (i.e. forestland, settlements, cropland, grassland, wetlands and other)

Steps	Description

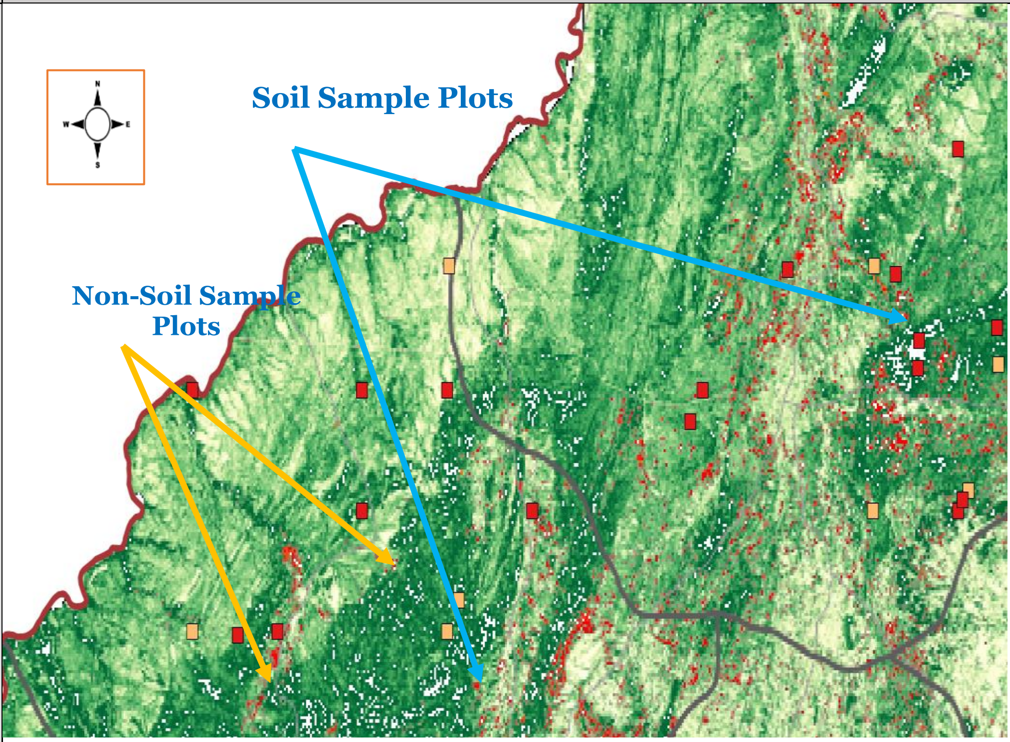


Figure 4.2 sample plots for soil sampling against non-soil sample plots

The ideal sample frame is identified by estimating the total natural forest area, reduction in deforestation, emissions reduction, and land reforested/afforested, land users who have adopted sustainable land management practices.

Provided in the table below is the harmonized classification scheme based on land cover data.

Harmonized classification scheme based on land cover data	
Targeted datasets	**Descriptions**
1. Settlements	Land covered mainly by densely populated and organized or irregular settlement patterns surrounding cities, towns, chiefdoms and rural centers commonly referred to as urban and rural built-up areas.
2. Cropland	Land actively used to grow agriculture (annual and perennial) crops which may be irrigated or rain feed for commercial, peasant and small scale farms around urban and rural settlements
3. Grasslands	Land that includes wooded rangeland that may be covered mainly by grasslands, plains, ambos, pans found along major river basins and water channels.
4. Forest land	This is land covered both by natural and planted forest meeting the threshold of 10% canopy cover growing over a minimum area of 0.5 ha with trees growing

Steps	Description

	above 5m height.
5. Wetlands	Land which is waterlogged, may be wooded such as marshland, perennial flooded plains and swampy areas (surface water bodies included).
6. Other land	Barren land covered by natural bare earth / soil such as sandy dunes, beach sand, rocky outcrops and may include old open quarry sites for mines and related infrastructure outside settlements.

Land use classification system

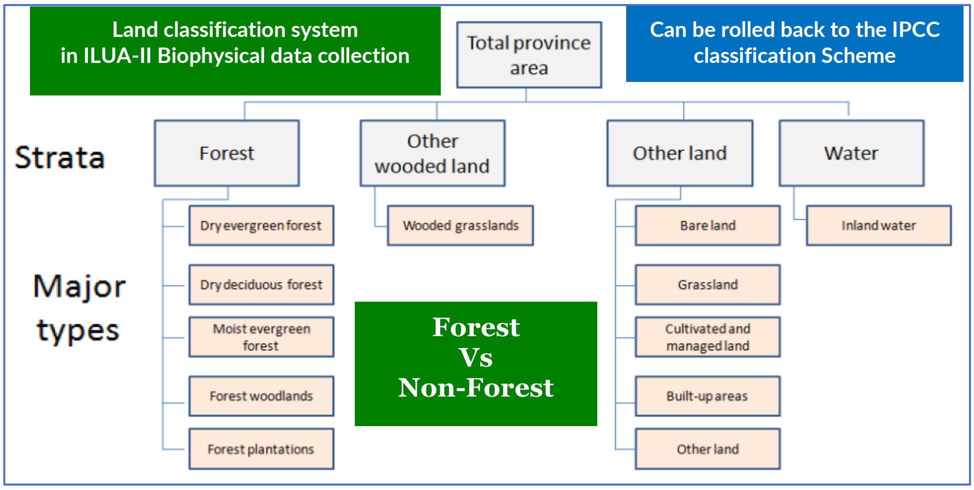


Figure 4.3 Land use Classification System

Step 3: Sampling Frame For The Biophysical Assessment

Provided below is the detailed sampling framework.

Observation points, and sample plots by site

Observation Points	# of Plots By Site	# of Subsets / units
1 OBSERVED POINT on a MAP is for the FIRST PLOT in a cluster and represents a SAMPLING CLUSTER		
1 Sampling Cluster	Has 4 Woody Plots	12 Observation Units
233 Point Sites Represents 233 Clusters	Has 932 Woody Plots	2,796 Observation Units

Sampling details by land cover scheme

Sampling details by land cover scheme	Clusters	Plots	Sample size
1. Total # of sample plots in Forestland	116	464	49.8%

Steps	Description

2. Total # of sample plots in Cropland	63	252	27.0%
3. Total # of sample plots in Grassland	27	108	11.6%
4. Total # of sample plots in Settlement	13	52	5.6%
5. Total # of sample plots in Wetland	8	32	3.4%
6. Total # of sample plots in Other land	6	24	2.6%
Total # of Sample plots for the Inventory	233	932	-

Estimated man days required for the biophysical assessment

Statistics	Team 1	Team 2	Team 3	Team 4	Team 5	Total
Average / Day	2	2	2	2	2	10 Clusters
Average / Day	8	8	8	8	8	40 Plots
In 23.3 Days	186.4	186.4	186.4	186.4	186.4	932 Plots

Overall timeline for sampling

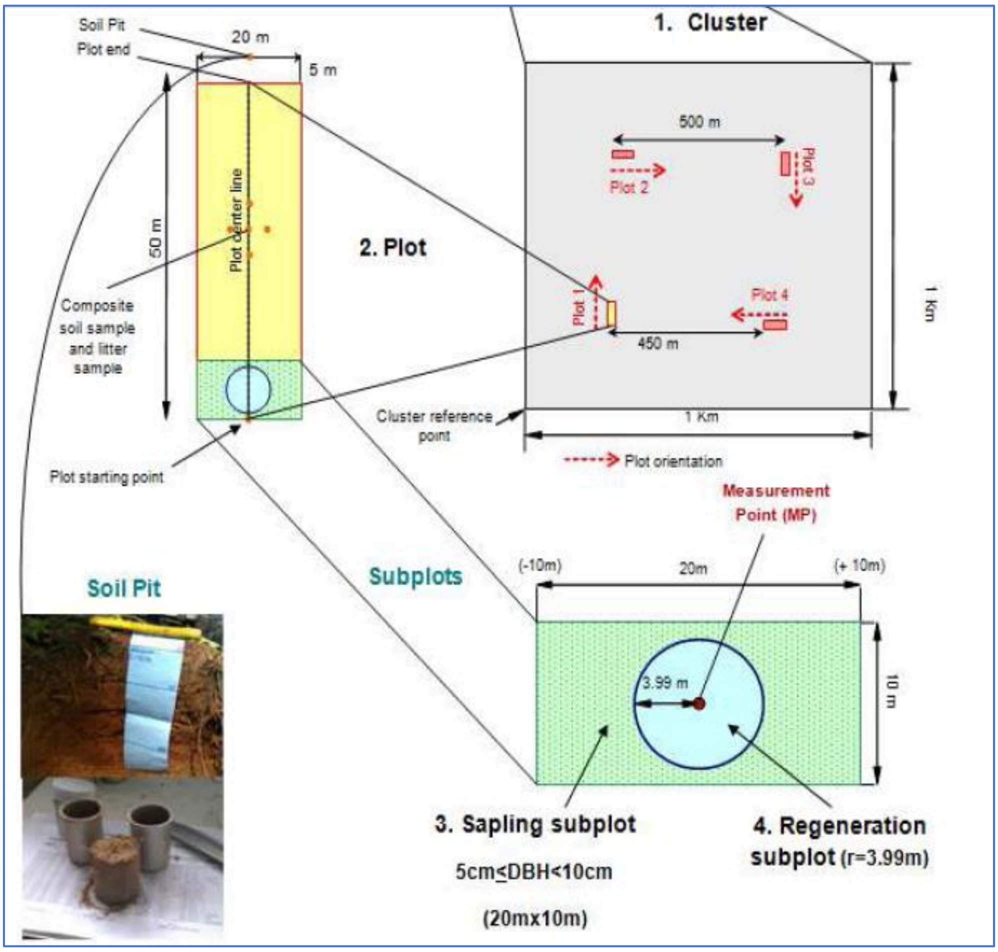
Statistics	5 Field Teams	Total
Average / Day	2 – 3 Clusters	40 - 60 Plots
MD = 19 to 24	8 – 12 Plots / Team	40 - 60 Plots
Utmost 21 Days	-	932 Plots

The Soil Samples

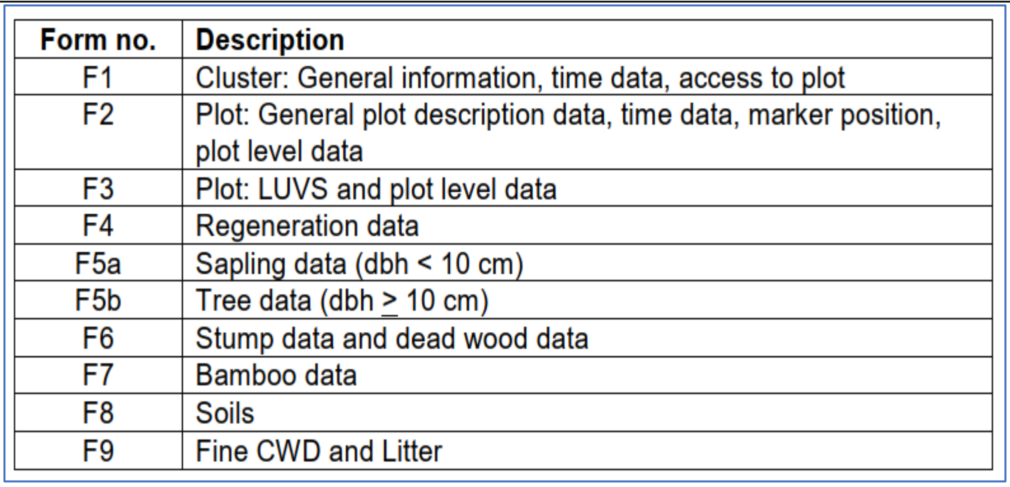
- Soil profile pits = 77
- Auger samples = 308
- Litter samples = 77

Dry litter samples should be collected in a quadrant of 1 m^2, and weighed on a balance.

Important Notes

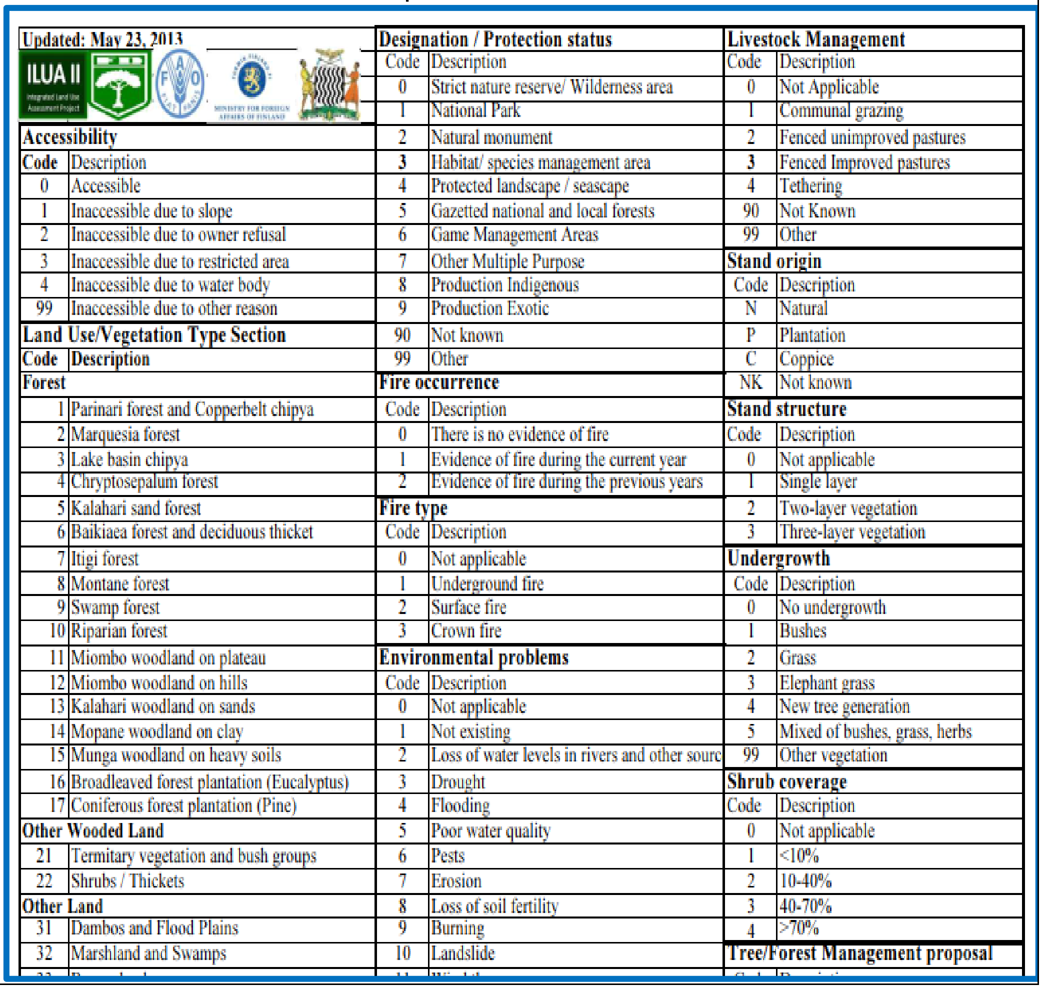
Steps	Description
	1. A single dot (is usually PLOT 1) observed on a map represents a cluster of 4 sample plots as on the figure to the right side of this slide. Each site has 4 planned observation units (sample plots), therefore a cluster has 12 sample units 2. The geographical location of the first sample plot at each observation site has calculation and determined coordinates, and 3. The subsequent 3 sample plots should be established *insitu* at 500m apart to the North (360^0) to the East (90^0) to the South (180^0) directions, to a point 500m to the west where the first plot is located in the south west corner of each grid 4. For some selected sites, a soil profile pit should be established some 5 m away from the edge of Plot No 1, and 4 auger samples collected around the pit in NEWS sites  **Figure 4.4 Cluster and Sample Plot** Provided below is a list of field forms description and corresponding information level. Field data will be recorded electronically on the ZEMA app using mobile devices which will be linked to the climate change portal. The data will be downloaded and entered in Open-FORIS (OF) Collect database at the Forestry Department (FD) headquarter in Lusaka for further analysis. The electronic field forms are summarized in Table, and described more detailed in the Field Manual and are contained in the MRV mobile Application.

Steps	Description



Form no.	Description
F1	Cluster: General information, time data, access to plot
F2	Plot: General plot description data, time data, marker position, plot level data
F3	Plot: LUVS and plot level data
F4	Regeneration data
F5a	Sapling data (dbh < 10 cm)
F5b	Tree data (dbh > 10 cm)
F6	Stump data and dead wood data
F7	Bamboo data
F8	Soils
F9	Fine CWD and Litter

Data Codes in the baseline sample frame that should be considered.



Updated: May 23, 2013

Accessibility

Code	Description
0	Accessible
1	Inaccessible due to slope
2	Inaccessible due to owner refusal
3	Inaccessible due to restricted area
4	Inaccessible due to water body
99	Inaccessible due to other reason

Land Use/Vegetation Type Section

Code	**Description**
Forest	
1	Parinari forest and Copperbelt chipya
2	Marquesia forest
3	Lake basin chipya
4	Chryptosepalum forest
5	Kalahari sand forest
6	Baikiaea forest and deciduous thicket
7	Itigi forest
8	Montane forest
9	Swamp forest
10	Riparian forest
11	Miombo woodland on plateau
12	Miombo woodland on hills
13	Kalahari woodland on sands
14	Mopane woodland on clay
15	Munga woodland on heavy soils
16	Broadleaved forest plantation (Eucalyptus)
17	Coniferous forest plantation (Pine)
Other Wooded Land	
21	Termitary vegetation and bush groups
22	Shrubs / Thickets
Other Land	
31	Dambos and Flood Plains
32	Marshland and Swamps

Designation / Protection status

Code	Description
0	Strict nature reserve/ Wilderness area
1	National Park
2	Natural monument
3	Habitat/ species management area
4	Protected landscape / seascape
5	Gazetted national and local forests
6	Game Management Areas
7	Other Multiple Purpose
8	Production Indigenous
9	Production Exotic
90	Not known
99	Other

Fire occurrence

Code	Description
0	There is no evidence of fire
1	Evidence of fire during the current year
2	Evidence of fire during the previous years

Fire type

Code	Description
0	Not applicable
1	Underground fire
2	Surface fire
3	Crown fire

Environmental problems

Code	Description
0	Not applicable
1	Not existing
2	Loss of water levels in rivers and other sourc
3	Drought
4	Flooding
5	Poor water quality
6	Pests
7	Erosion
8	Loss of soil fertility
9	Burning
10	Landslide

Livestock Management

Code	Description
0	Not Applicable
1	Communal grazing
2	Fenced unimproved pastures
3	Fenced Improved pastures
4	Tethering
90	Not Known
99	Other

Stand origin

Code	Description
N	Natural
P	Plantation
C	Coppice
NK	Not known

Stand structure

Code	Description
0	Not applicable
1	Single layer
2	Two-layer vegetation
3	Three-layer vegetation

Undergrowth

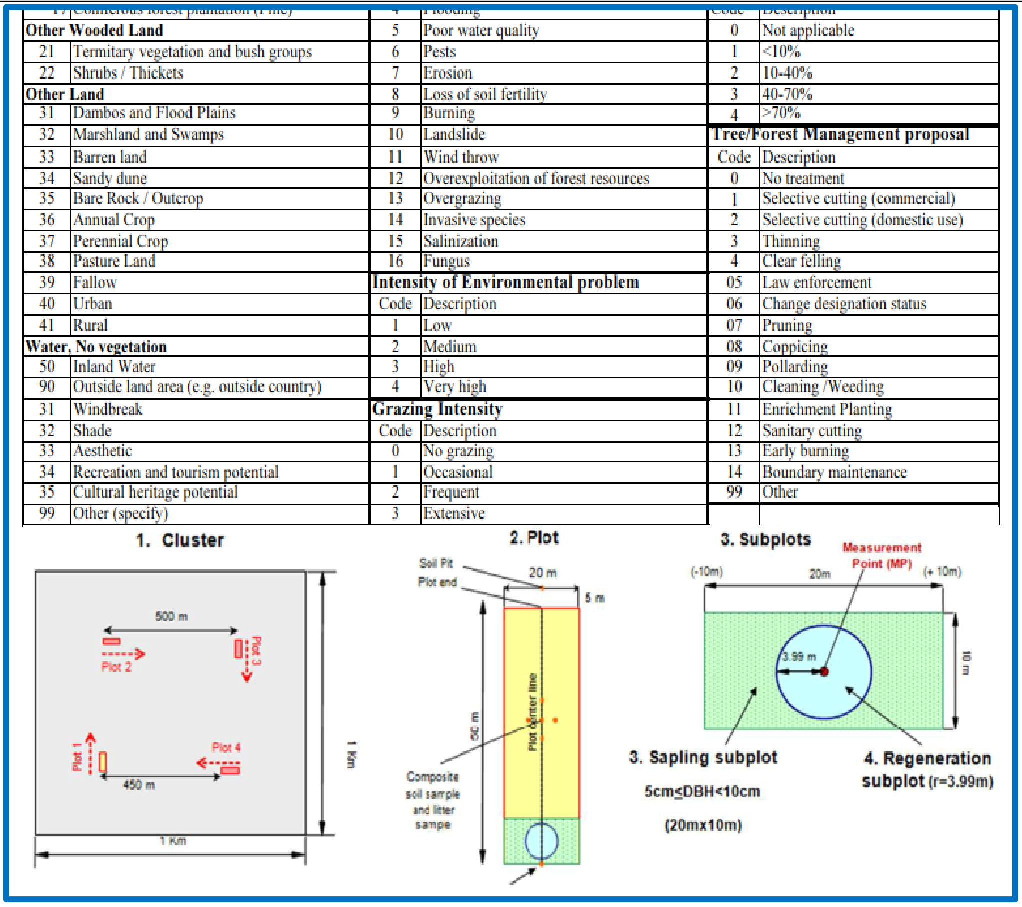
Code	Description
0	No undergrowth
1	Bushes
2	Grass
3	Elephant grass
4	New tree generation
5	Mixed of bushes, grass, herbs
99	Other vegetation

Shrub coverage

Code	Description
0	Not applicable
1	<10%
2	10-40%
3	40-70%
4	>70%

Tree/Forest Management proposal

Steps	Description

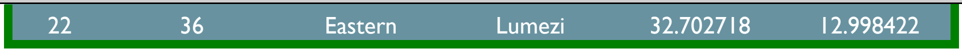


Other Wooded Land		5	Poor water quality	0	Not applicable
21	Termitary vegetation and bush groups	6	Pests	1	<10%
22	Shrubs / Thickets	7	Erosion	2	10-40%
Other Land		8	Loss of soil fertility	3	40-70%
31	Dambos and Flood Plains	9	Burning	4	>70%
32	Marshland and Swamps	10	Landslide	**Tree/Forest Management proposal**	
33	Barren land	11	Wind throw	Code	Description
34	Sandy dune	12	Overexploitation of forest resources	0	No treatment
35	Bare Rock / Outcrop	13	Overgrazing	1	Selective cutting (commercial)
36	Annual Crop	14	Invasive species	2	Selective cutting (domestic use)
37	Perennial Crop	15	Salinization	3	Thinning
38	Pasture Land	16	Fungus	4	Clear felling
39	Fallow	**Intensity of Environmental problem**		05	Law enforcement
40	Urban	Code	Description	06	Change designation status
41	Rural	1	Low	07	Pruning
Water, No vegetation		2	Medium	08	Coppicing
50	Inland Water	3	High	09	Pollarding
90	Outside land area (e.g. outside country)	4	Very high	10	Cleaning /Weeding
31	Windbreak	**Grazing Intensity**		11	Enrichment Planting
32	Shade	Code	Description	12	Sanitary cutting
33	Aesthetic	0	No grazing	13	Early burning
34	Recreation and tourism potential	1	Occasional	14	Boundary maintenance
35	Cultural heritage potential	2	Frequent	99	Other
99	Other (specify)	3	Extensive		

Source: ILUAII

Provided below are some of the coordinates for the sample plots.

ID	Zone	Province	District	XCOORD	YCOORD
1	36	Eastern	Chadiza	32.502737	14.198430
2	36	Eastern	Chadiza	32.504593	13.995495
3	36	Eastern	Chadiza	32.602731	13.998424
4	36	Eastern	Chadiza	32.702728	13.998423
5	36	Eastern	Vubwi	32.802726	13.998425
6	36	Eastern	Kasenengwa	32.302726	13.798428
7	36	Eastern	Kasenengwa	32.102725	13.698435
8	36	Eastern	Kasenengwa	32.302724	13.598427
9	36	Eastern	Chipangali	32.504580	13.495497
10	36	Eastern	Chipangali	32.702723	13.398424
11	36	Eastern	Chipangali	32.802717	13.398423
12	36	Eastern	Chipangali	32.602719	13.098425
13	36	Eastern	Chipangali	32.702718	13.098424
14	36	Eastern	Katete	31.902743	14.398438
15	36	Eastern	Katete	32.302733	14.198429
16	36	Eastern	Katete	31.702739	14.098435
17	36	Eastern	Katete	32.004599	13.995505
18	36	Eastern	Lumezi	33.002723	13.198425
19	36	Eastern	Lumezi	32.902720	13.098423
20	36	Eastern	Lumezi	32.302721	12.998434
21	36	Eastern	Lumezi	32.504567	12.995488

Steps	Description
	 22 36 Eastern Lumezi 32.702718 12.998422
Step 3: Training and calibration	**Step 3a.** As a first step in the data collection, the MRV Coordinator and the Trainer organize and prepare a training event for the persons identified in sub-step 1c as data collectors. All the crew members taking part in forest carbon measurement should understand the basic ideas behind forest carbon measurement and how to use all the materials and equipment to obtain appropriate results needed. The training should cover the following topics as a minimum requirement: a) Overview of the National Forest Monitoring and Assessment Plan; and Introduction of Training Facilitators b) Technical Updates and Overall Expectations of the Field Teams Training Outcomes c) Introductions to the biophysical sampling design (Forest Inventory) d) Introductions to Biophysical Sampling Design (Soil Sampling) e) Introduction to Field Manuals – Biophysical Assessments (All Field Forms and Updates) f) Introduction to tree taxonomy g) Introductions to Field Tools, Equipment and Materials – Biophysical Assessments h) Communication, Field Safety i) How to use different tools in the field j) Learning the Practice of plot establishment k) Travel to Training Site 3/4 for Practical l) GPS Route Navigation Practical including how to conduct field measurements with GPS and identification of reference points m) Conducting the field data collection on 2 Temporary Inventory Plots (using the tools, tree identification, recordings n) Field Teams Debriefing Reports o) Quality Assurance Expectations p) Field Coordination Expectations q) How to use the electronic Tablet and enter data on the MRV mobile App r) Quality management practices **Step 3b.** The Trainer implements the training event following these basic principles: a) Environment for active participation, where participants can ask questions and share opinions b) Encourage communication between the data collectors c) Record attendance of the collectors d) Assess the capacity of the data collectors at the end of the training and record the results. **Step 3c.** The MRV Coordinator and the Trainer prepare a report summarizing the training actions taken, the attendance and the results of the assessment of capacity.
Step 4: Distribute the sample	**Sub-Step 4a.** The MRV Coordinator in collaboration with MRV Forestry Sector Lead and MRV provincial sector leader decides on sample units to be assessed.

Steps	Description
units among Data Collectors	**Sub-Step 4b.** The MRV Coordinator allocates sample units to Data Collectors in each district. The MRV Coordinator uses a list of locations in each district to distribute the samples to the collectors. **Sub-Step 4c.** The Coordinator records the number of sample areas, the Data Collectors assigned to assess those areas
Step 5: Data collection by Data Collectors	**Step 5a.** Identify the local community leaders and establish contact prior to arriving at the cluster site **Step 5b.** Explain clearly to the local community leaders the purpose of the visit. Visual aid materials such as maps, aerial photograph or satellite image of the target area may be useful in the discussions. Briefly explain measurements to be carried out, use of the data and information collected **Step 5c.** In collaboration with the local people, clearly identify areas to be sampled. **Sub-Step 5d.** Access to the plot: Make reference to pre-drawn locations of the plots on topographical maps. Record the GPS coordinates where the field vehicle is stationed, the date, the departure/start time, bearing and distance to 1st plot of the day. Navigate to predetermined latitude and longitude using a GPS. **Sub-Step 5e.** At the plot center/corner, mark a 'waypoint' on GPS and record GPS coordinates, accuracy, elevation, and waypoint number on data sheet. To record a GPS location, place the GPS at the plot center/corner and let it record for > 5 minutes prior to marking a 'waypoint'. [3]The minimum precision level should be ±5 m. Leaving the GPS at one location for several minutes allows the GPS to get a more accurate location by averaging many location acquisitions. The longer the GPS acquires locations the more accurate the final location. The accurate of the location is estimated and is displayed by the GPS. If there is heavy vegetation cover, it may take a longer time to acquire an accurate location. In some cases, it may be necessary to move slightly or devise a way of getting the GPS higher in the air to acquire satellite signals. **Sub-Step 5f**. Label the plot based on plot labeling described in Section 3.0 1. A single dot (is usually PLOT 1) observed on a map represents a cluster of 4 sample plots. Each site has 4 planned observation units (sample plots), therefore a cluster has 12 sample units 2. The geographical location of the first sample plot at each observation site has calculation and determined coordinates, and 3. The subsequent 3 sample plots should be established *insitu* at 500m apart to the North (360^0) to the East (90^0) to the South (180^0) directions, to a point 500m to the west where the first plot is located in the southwest corner of each grid 4. For some selected sites, a soil profile pit should be established some 5 m away from the edge of Plot No 1, and 4 auger samples collected around the pit in NEWS sites 5. Temporary Plots. For temporary plots place a wooden stake at the plot center in circular plots and at each corner in square/rectangular plots. This will be used to facilitate verification of plot measurements where required.

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[3] Sarah M. W et.al, 2012: Standard Operating Procedures for Terrestrial Carbon Measurement

Steps	Description
	6. Permanent Plots. Permanent plots shall be marked using materials that will last longer than the project lifetime. For square or rectangular plots mark each of the corners with galvanized metal pin), including the corners for each nest size. **Step 5 g. Area Correction due to Slope** This correction factor accounts for the fact that distances measured along a slope are projected to the horizontal plane, they will be smaller. a) Measure the slope using a clinometer. If the slope is greater than 10% record the exact slope for later correction of plot area. (i). Two people are required to measure slope. (ii). The person with the clinometer shall identify the eye-level sight of the partner. (iii). The person with the clinometer should stand in the center of the plot and the partner should go to the edge of the larger nested plot. (iv). The person with the clinometer standing in the center of the plot shall then aim at the eye-level location in the partner and record the angle reading displayed in the clinometer. This angle is the slope angle and could be recorded as degrees (unit should be delineated in field sheets). b) Describe land and vegetation conditions of plot and if there is anything unique or unusual in the plot or directly surrounding the plot. This could include things such as small streams, trails, large boulder or termite nest, and proximity to a paved road. c) For permanent plots only: write detailed instructions on how to access the plot in the future. Note any hazards encountered in the route to the plot. d) Establish plots as explained below. e) Mark center of the plot with wooden stake wrapped with flagging tape. This plot center mark will be used to identify the plot center during any third-party verification or quality checks.

Procedure	
Step 6: Measurement of Trees	**Steps 6a to 6c should be undertaken for the following**: 1. Forestry Regeneration data collected (REGENERATION, SHRUBS (DBH < 5 cm, live seedlings, saplings, shrubs. Tick count.) Plot radius = 4.99 m 2. Forestry Sapling data collected (Trees 5 cm < DBH <10 cm are recorded in 20 m X 10 m subplot.) 3. Forestry Trees data collected (Trees DBH > 10 cm are recorded in 20 m X 50 m plot.) 1. **Step 6 a Tree Height Measurements**. The height of trees, is usually done by creating two right triangles. The distance from the object and the person measuring is measured and two angles are measured. The actual height is then calculated using trigonometry during data analysis. The following steps should be taken 1. Walk around the tree and find the best location to view the top of the tree. 2. Stand far enough away from the tree so that the top of the tree is less than 90 degrees above the line of sight. 3. Measure total tree height a. Always stand up-slope of the tree. Standing down-slope of the tree should only take place when no other option exists. b. Using clinometer, measure the angle in % to top of the canopy of the tree (a %) c. Using clinometer, measure the angle in % to base of the tree (b %) d. Using Laser Range Finder or measuring tape, measure distance from eye of person measuring tree to the tree (dis_{tree}) in meters. Be certain that the distance measured is horizontal and not along the slope. Record the horizontal distance to the nearest 0.01 meter 4. Repeat measurements in another location, thus measuring tree height in two locations. 5. If you are not able to stand far enough from the tree so that the top of the tree is less than 90% above you, then take the measurements (a) and (b) in degrees (units on left side of clinometer). CAREFULLY NOTE ON THE DATA SHEET THE CHANGE IN UNITS! Tree height must be calculated differently if degrees are used![4]

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[4] Sarah M. W et.al, 2012: Standard Operating Procedures for Terrestrial Carbon Measurement

Step 6 b measuring DBH

The following steps should be carried out in measuring the DBH:

1. Assign one person to record the data and all others should be measuring and marking trees. The recorder should stand in the center of the nested plot being measured. He or she should track those measuring the trees and should try and ensure that no trees are missed.
2. To avoid either missed trees or double recording, measurement should begin to the North and the first tree should be flagged. After a tree is measured, a chalk mark facing the center of the plot should be placed on tree to allow the person recording the data to track measured and unmeasured trees.
3. Count the number of saplings (defined as trees <5 cm DBH and >1.3 m tall) in the smallest plot (e.g. 2 meter radius plot) and record on data sheet. (After field data collection, the number of saplings will be combined with the average sapling weight to estimate total sapling biomass.
4. For temporary plots, trees should not be tagged. .
5. In **permanent** measurement plots, all trees of appropriate sizes for each nested plot should be tagged with the placement of an *aluminum* numbered tag and nail or alternatively fishing line or wire (see Figure below). The risk of theft of these materials must be considered
6. Measure the tree parameters required for the allometric equation to be used (e.g. DBH, DHB and H) for all trees of appropriate sizes for each nested plot. Steps for measuring DBH of all trees of appropriate sizes for each nested plot are described below. If other tree parameters are required for the allometric equation to be used, this SOP should be altered to explicitly describe the procedures to be followed. It is important that the diameter tape is used properly using the following steps to ensure consistency of measurements:
    a. Record the name of the tree, based on tree naming system developed prior to field data collection.
    b. **Tree Pole placement**: For each tree, place the Tree Pole (1.3 m plastic pole) against the tree to indicate the location of measurement (e.g. DBH). Placement of the Tree Pole depends on the slope of the ground, leaning angle of the tree, and shape of the tree bole
    i. **Slope:** Always place tree pole and measure diameter on the *upslope* side of the tree
    ii. **Leaning tree**: Always measure the height of a measurement (1.3 m) parallel with the tree, *not* perpendicular to the ground. Therefore, if the tree is leaning, measure underneath the lean, parallel with angle of tree. If a tree is not straight,

a tape measure must be used to measure the bole distance from ground to DBH.

iii. **Dead tree**: If a tree is in dead class 1 mark as dead on data sheet. Trees are considered alive if there are green leaves present. Even if there are only one or two green leaves present the tree is considered alive. However, in deciduous forests during a season when trees drop their leaves (i.e. dry season) a branch or the stem must be cut to verify that the cambium is alive in order to determine if the tree is alive or dead.

iv. **Multi-stem tree**: If the tree is multi-stemmed with forking below the point of measurement (e.g. 1.3 m), measure the diameter on each stem and tag the stems that exceed the minimum diameter for the nest. Record it as if each stem were a different tree on the data sheet, but with a note that the stems make up one tree.

Step 6 c Buttressed tree.

1. If the buttress is shorter than 1.3 m, measure the DBH at the standard (1.3 m) height.
2. If the buttress is taller than 1.3 m, measure the diameter at 30 cm above top of buttress. In cases where buttress is too tall and out of reach, the following procedure shall be followed:

   i) Use portable retractable ladder and lean ladder against tree to allow for measurement of DBH 30 cm above from the top of the buttress.

   ii) If ladder is unavailable, and taking into consideration the safety of field crew, climb the tree to take measurement 30 cm above the top of the buttress. In fluted buttress, it is possible to carve steps on the buttress itself to allow climbing to top of buttress. Extreme caution should be employed and climbing should only be performed when conditions are deemed safe by field crew leader.

   iii) If ladder is unavailable, and climbing is considered unsafe, retractable poles should be use. Poles shall be placed against the tree, at the edge of its circumference, projecting the diameter at exactly 30 cm above top of buttress down to the ground. An observer is required to ensure poles are properly placed at the very edge of tree's circumference in a way that linear distance between poles represents the diameter of tree at 30 cm above end of buttress. The **linear distance** between the two poles shall be measured. At least two measurements shall be taken on opposite sides of tree using this method, and then averaged to estimate tree DBH.

   Note: The distance between poles shall be measured linearly, and thus proper measuring tape shall be used. Poles can be made from tall saplings found outside the sampling plot in the forest or by linking Tree Poles together (e.g. with pvc connectors).

7. **Diameter measurement:** Tree diameter should be measured to the nearest 0.1 cm (e.g. diameter of 10.2 cm *not* 10 cm).
    i. If the diameter tape has a hook, push the hook into the bark of the tree slightly to secure it and pull the tape to the right. The diameter tape should always start left and be pulled right around the tree, even if the person taking the measurement is left-handed. As the diameter tape wraps around the tree and returns to the hook the tape should be above the hook. The tape should not come around the tree below the hook. The tape should not be upside down; the numbers must be right side up. (see Figure below)
        b. If a liana or vine is growing on a tree that is going to be measured, do not cut the liana to clear a spot to measure the tree's diameter. If possible, pull the liana away from the trunk and run the diameter tape underneath. If the liana is too big to pull away from the trunk, estimate the diameter of the liana and subtract from total tree diameter. Cutting a liana from a tree should only be done if there are no other options. The same standard should be followed for any other type of natural organisms (mushrooms, epiphytes, fungal growths, termite nests, etc.) that are found on the tree.
    i. Place chalk mark on the tree to indicate to crew members that the tree has been measured.
8. **Other tree parameters:** Measure all other tree parameters included in the biomass regression equation to be used. If the allometric equation to be used requires height as an input for each tree/palm measured, two measurements of height should be taken to improve the precision of measurements, especially if it is difficult to identify the top of the tree/palm measured. See SOP Measurement of Height on how to measure tree height.
9. **Boundary trees:** Occasionally trees will be close to the border of the plots. The plots are relatively small and will be expanded to estimate biomass carbon on a per hectare basis. It is therefore important to carefully decide if a tree is in or out of a plot. To definitively determine whether the tree is in or out of the plot, use a tape measure to measure out from the plot center (or plot corner) to the base of the boundary tree. If the plot is on sloped ground, make sure the measurement follows the slope. If more than 50% of the base of the trunk is within the boundary of the nest, the tree is in. If more than 50% of the base of the trunk is outside of the boundary, it is out and should not be measured. If it is exactly on the border of the plot, flip a coin to determine if it is in or out.
10. When all of the trees in the plot have been measured, there should be a double-check to see that all of the trees have been measured.

Table 6.1 Forestry Sapling data collected (Trees 5 cm < DBH <10 cm are recorded in 20 m X 10 m subplot.)

		Performance Indicators	Top Height [m]	Tree number	Species name	Location along plot axis [m]	Location (Left m)	Location (Right m)	DBH (cm)	Height of DBH (if not 1.3 m) [m]	Bole (height) [m]	Use	Quality	Health	Causative Agent	Severity	Origin
		District															
		Chiefdom															
		Village															
		Ward															
		Forestry ID															
		Date...(Day/Month/Year)															
		Site Name															
		Sample Plot Number															
		Cluster Number															
		Land use/Vegetation type section(LUVs Code)															
		Location(GPS)															
		Sample ID															
		Stratum															
		Plot slope on average (degrees)															

Easting(m)……(UTM x coordinate)															
Northing(m)…(UTM x coordinate)															
Altitude(m)……..(above sea level)															

Table 6.2 Forestry Trees data collected (Trees DBH > 10 cm are recorded in 20 m X 50 m plot.)

Performance Indicators	Top Height [m]	Tree number	Species name	Location along plot axis [m]	Location (Left m)	Location (Right m)	DBH (cm)	Height of DBH (if not 1.3 m) [m]	Bole (height) [m]	Use	Quality	Health	Causative Agent	Severity	Origin
District															
Chiefdom															
Village															
Forestr ID															
Date…(Day/Month/Year)															
Site Name															
Sample Plot Number															
Cluster Number															
Land use/Vegetation															

type section(LUVs Code)															
Location(GPS)															
Sample ID															
Stratum															
Plot slope on average (degrees)															
Easting(m)......(UTM x coordinate)															
Northing(m)...(UTM x coordinate)															
Altitude(m)........(above sea level)															

The table 6.3 below should be filled for **Forestry Regeneration data collected (REGENERATION, SHRUBS (DBH < 5 cm, live seedlings, saplings, shrubs. Tick count.) Plot radius = 4.99 m**

Performance Indicators	Species Name	Number of similar seedlings	Number of similar seedlings/ saplings (DBH class [cm]) <1.3m	Number of similar seedlings/ saplings (DBH class [cm]) >1.3m and d<1	Number of similar seedlings/ saplings (DBH class [cm]) 1–1.9	Number of similar seedlings/ saplings (DBH class [cm]) 2–2.9	Number of similar seedlings/ saplings (DBH class [cm]) 3–3.9	Number of similar seedlings/ saplings (DBH class [cm]) 4–4.9
Chiefdom								
Forestry ID								

Name of person conducting Measurement								
Community Supervisor/Approver								
Date (Day/Month/Year)								
Site Name								
Sample Plot Number								
Cluster Number								
Land use/Vegetation type section (LUVs Code)								
Location (GPS)								
Sample ID								
Stratum								
Plot slope on average (degrees)								
Easting(m)......(UTM x coordinate)								
Northing(m)...(UTM x coordinate)								
Altitude(m)........(above sea level)								

Step 7: Measurem	a. The nest size within which bamboo will be measured will be dependent on the prevalence of bamboo. If highly prevalent, then the smaller nest size can be used. Otherwise, all bamboo patches should be measured in the medium nested plot.

ent of Bamboos

b. Measure the bamboo parameters required in the biomass regression equation developed. This would include things such as height (using a clinometer), the basal diameter (using DBH tape), and the number of culms in a patch. Note: the exact measurements made will be dependent on the factors included in the allometric equation used.

The following table should be used to fill in data for **Forestry Bamboo Data collected BAMBOO (diameter > 5 cm) Plot size: 20 m X 25 m**

Table 6.4

Performance Indicators	Species name	Status A=Alive ; D=Dead	Average Diameter [cm]	Average height [0.5 m]	Number of stems in clump
Chiefdom					
Farm ID					
Name of person conducting Measurement					
Community Supervisor/Approver					
Date (Day/Month/Year)					
Site Name					
Sample Plot Number					
Cluster Number					
Land use/Vegetation type section (LUVs Code)					
Location (GPS)					
Sample ID					
Stratum					

Plot slope on average (degrees)					
Easting(m)……(UTM x coordinate)					
Northing(m)…(UTM x coordinate)					
Altitude(m)……..(above sea level)					

Step 8: Non-Tree Woody Vegetation Measurements

1. Identify which shrubs have stems originating from inside the area of the clip plot. These shrubs shall be cut at ground level. Any shrubs which have branches hanging into the plot but whose roots are located outside the area of the plot shall ***not*** be clipped and measured.
2. Weigh clipped vegetation. If shrubs are being sampled separately from other non-tree vegetation, do not include non-tree vegetation when weighing vegetation. Record the total weight of shrubs within the clip plot.
3. If there are no shrubs within the clip plot area, the clip plots should *not* be moved. Instead the shrub biomass shall be recorded on the data sheet as 'zero'.
4. Take a sub-sample of vegetation. This should be a subset of the total sample and shall be made up of a mix of species and vegetation found within the total sample. Place vegetation temporarily in a sample bag.
5. Repeat steps 1-6 for the remaining three locations.
6. Combine sub-samples into one sub-sample bag.
    a. Weigh the subsample bag empty. Record weight.
    b. Combine the subsamples from all 4 subplots into one subsample bag.

Weigh the subsample bag with the subsample inside. Record the actual weight

a. Label the subsample bag with the plot identification number, subsample identification number, and weight of subsample.
b. Take the subsample bag and the subsample from field. Bring them to the laboratory and dry the subsample. Reweigh subsample. This subsample will be used to create a wet-to-dry ratio. This ratio will then be used to estimate the total dry weight of shrubs found within the clip plot.
c. It is allowable for there to be a delay between field data collection and laboratory analysis. However, cloth sample bags must be placed in a location that allows air drying to occur.

Table 6.5

	Sample ID #	Weight of bag or sheet (g)	Weight of bag + material (g)	Weight of subsample bag (g)	Weight of subsample bag + subsample material (g)	Area of Sample Plot (A) m^3
Chiefdom						
Farm ID						
Name of person conducting Measurement						
Community Supervisor/Approver						
Date (Day/Month/Year)						
Site Name						
Sample Plot Number						
Cluster Number						
Land use/Vegetation type section (LUVs Code)						
Location (GPS)						
Sample ID						
Stratum						
Plot slope on average (degrees)						
Easting(m)......(UTM x coordinate)						
Northing(m)...(UTM x						

coordinate)						
Altitude(m)........(above sea level)						

Step 9: Herbaceous Vegetation

1. Identify all herbaceous vegetation that has stalk base originating from inside the area of the clip plot. This vegetation shall be cut at ground level. Any vegetation which have stems and leaves hanging into the plot but whose base is located outside the area of the plot shall ***not*** be clipped and measured.
2. Weigh clipped vegetation.
3. Any vegetation type that is being measured using another method (e.g. palms, bamboo, non-tree woody vegetation (shrubs), and/or saplings) must ***not*** be included when cutting and weighing the herbaceous vegetation. Record the total weight of herbaceous vegetation within the clip plot.
4. If there is no herbaceous vegetation within the clip plot area, the clip plots should *not* be moved. Instead the herbaceous biomass shall be recorded on the data sheet as 'zero'.
5. Take a sub-sample of vegetation. This should be a subset of the total sample and shall be made up of a mix of species and vegetation found within the total sample. Place vegetation temporarily in a sample bag.
6. Combine sub-samples into one sub-sample bag.
    a. Weigh the subsample bag empty. Record weight.
    b. Combine the subsamples from all 4 subplots into one subsample bag.
    c. Weigh the subsample bag with the subsample inside. The weight should be between 100- 300 g. Record the actual weight.
    d. Label the subsample bag with the plot identification number, subsample identification number, and weight of subsample.
    e. Take the subsample bag and the subsample from field. Bring it to laboratory and dry the subsample. Reweigh the subsample. This subsample will be used to create a wet-to-dry ratio. This ratio will then be used to estimate the total dry weight of non-woody vegetation found within the clip plot.
7. Where plots are grouped in Clusters, it is allowable for samples from all four plots to be combined into one subsample sample.
8. It is allowable for there to be a delay between field data collection and laboratory analysis. However, sample bags must be placed in a location that allows air drying to occur.

Table 6.6

	Sample ID #	Weight of bag or sheet (g)	Weight of bag + material (g)	Weight of subsample bag (g)	Weight of subsample bag + subsample material (g)
Chiefdom					
Farm ID					
Name of person conducting Measurement					
Community Supervisor/Approver					
Date (Day/Month/Year)					
Site Name					
Sample Plot Number					
Cluster Number					
Land use/Vegetation type section (LUVs Code)					
Location (GPS)					
Sample ID					
Stratum					
Plot slope on average (degrees)					
Easting(m)……(UTM x coordinate)					
Northing(m)…(UTM x					

coordinate)					
Altitude(m)........(above sea level)					

Step 10: Measurement of Litter

1. If needed, remove all vegetation to allow litter to be collected.
2. Collect all litter inside the frame. A knife can be used to cut pieces that fall on the border of the sampling frame. Place the litter on the plastic sheeting or tarp.
3. Weigh litter. Record the total weight of litter within the clip plot.
4. If there is no litter within the clip plot area, the clip plots should *not* be moved. Instead the litter shall be recorded on the data sheet as ‘zero’.
5. Take a sub-sample of litter. This should be a subset of the total sample and shall be made up of a mix of litter types found within the total sample. Place subsample temporarily in a sample bag.
6. Repeat steps 1-6 for the remaining three locations.
7. Combine all four subsamples into one subsample bag.
    a. Weigh the subsample bag empty. Record weight.
    b. Combine the subsamples from all 4 subplots into one subsample bag.
    c. Weigh the subsample bag with the subsample inside. The weight should be between 100- 300 g. Record the actual weight.
    d. Label the subsample bag with the plot identification number, subsample identification number, and weight of subsample.
    e. Take the subsample bag and subsample from field. Bring to the laboratory and dry the subsample. Reweigh the subsample. This subsample will be used to create a wet-to-dry ratio. This ratio will then be used to estimate the total dry weight of litter found within the clip plot.
8. Where plots are grouped in Clusters, it is allowable for samples from all four plots to be combined into one subsample.
9. It is allowable for there to be a delay between field data collection and laboratory analysis. However, sample bags must be placed in a location that allows air drying to occur.

The following table should be used to fill in Forest Litter Data

Table 6.7

	Litter Weights from 0.5 x 0.5m quadrat (Litter Weight (grams))	Litter Weights from 0.5 x 0.5m quadrat (Litter Composite Sample Label)	Fine Coarse Woody Debris (diameter > 2cm and < 10 cm). Measure over bark. Plot size: Radius 3.99 (same plot as regeneration and shrubs) **Diameter [cm]**	Fine Coarse Woody Debris (diameter > 2cm and < 10 cm). Measure over bark. Plot size: Radius 3.99 (same plot as regeneration and shrubs) **Length [m]**	Fine Coarse Woody Debris (diameter > 2cm and < 10 cm). Measure over bark. Plot size: Radius 3.99 (same plot as regeneration and shrubs) **Count similar parts**	Fine Coarse Woody Debris (diameter > 2cm and < 10 cm). Measure over bark. Plot size: Radius 3.99 (same plot as regeneration and shrubs) **Decay [code] Decay: S=Solid, R=fully/partially rotten**
Chiefdom						
Forest ID						
Name of person conducting Measurement						
Community Supervisor/Approver						
Date (Day/Month/Year)						
Site Name						
Sample Plot Number						
Cluster Number						
Land use/Vegetation type section (LUVs Code)						
Location (GPS)						
Sample ID						

Stratum						
Plot slope on average (degrees)						
Easting(m)……(UTM x coordinate)						
Northing(m)…(UTM x coordinate)						
Altitude(m)……..(above sea level)						

Step 11: Sampling Soil Carbon

1. Remove all vegetation and litter from the sampling location. Because the carbon concentration of organic materials is much higher than that of the mineral soil, including even a small amount of surface material can result in a serious overestimation of soil carbon stocks.
2. There are two options for sampling the soil: using a standard soil corer (option 1) or digging a small pit (option 2). Sampling forest soils with a standard soil corer can often present difficulties as the corer can hit roots frequently, which makes it difficult to extract a full core.
3. Option 1 – Soil corer method
    a. Insert the soil corer/probe steadily to standard depth of 30 cm.
    b. If the soil is compacted, use a rubber mallet to fully insert. If the probe will not penetrate to the full depth, do not force it as it is likely that a stone/root is blocking its route and if forced the probe will be damaged. If blocked withdraw the probe, clean out any collected soil, and insert in a new location.
    c. If depth of soil at sampling point is less than standard depth measured, then the depth of the soil sampled must be recorded.
    d. Carefully extract the probe and put soil into a cloth bag. Assign bag a unique ID number.
    e. To reduce variability, repeat steps a-d at a total of 4 points per sampling location / tree plot.
    f. Mix all four samples thoroughly to a uniform color and consistency. It is important to take special care to remove pieces of litter and charcoal from samples at any sites
    g. Place one thoroughly mixed subsample into a labeled sample bag. Ensure total weight of soil in bag is greater than

the minimum soil weight required by the soil laboratory (if soil is very wet, this should be taken into consideration in determining mass of soil contained in soil sample bag).

   h. For each sampling plot, take an additional two cores for determination of bulk density. When taking cores for measurements of bulk density, care should be taken to avoid any loss of soil from the cores.
   i. Therefore, each sampling plot (e.g. tree plot) will have three soil samples: 1 bag for soil carbon estimation, 2 bags for bulk density estimation.

4. Option 2- Soil pit method

   Four small pits, one at each of the four sampling locations, will be dug and aggregated into one sample.

   a. Dig a soil pit 30 cm deep, making sure that one of the walls is perpendicular to the soil surface. A folding entrenching shovel (military type, with a flat shovel) is usually light and versatile for digging the pit, however any digging instrument can be used.
   b. Using the shovel take a slice of soil from one of the walls of the soil pit. The slice should be uniform throughout the 30 cm profile, i.e. an equal amount of soil should be collected from the first 15 cm as the last 15 cm. Soil carbon usually decreases with depth, and if the slice collected contains more soil from the top of the pit versus the bottom the soil carbon estimate will be biased.
   c. Repeat steps a-c at the other 3 sampling locations.
   d. Mix all four samples thoroughly to a uniform color and consistency. It is important to take special care to remove pieces of litter and charcoal from samples at any sites.
   e. Place one thoroughly mixed subsample into a labeled sample bag. Ensure total weight of soil in bag is greater than the minimum soil weight required by the soil laboratory (if soil is very wet, this should be taken into consideration in determining mass or soil contained in soil sample bag).
   f. For each sampling plot, two estimates of bulk density shall be taken using a bulk density ring. This should take place at 2 out of the 4 sampling locations.
      i. After removing the soil for carbon measurements, place the bulk density ring over the mid-point of the soil pit. This would normally be at 15 cm.

Cover the ring with a piece of wood and hammer the ring into the side of the soil pit (avoid compacting the soil).

      i. When the ring is flush with the side of the soil pit dig around the ring until the soil ring can be removed along with all the soil inside. If soil falls out of the ring, the process must be repeated.
      ii. Carefully place the soil contained in the bulk density ring into a sample bag and label

j. Therefore, each sampling plot (e.g. tree plot) will have three soil samples: 1 bag for soil carbon estimation, 2 bags for bulk density estimation.

5. It is allowable for there to be a delay between field data collection and laboratory analysis. However, sample bags must be placed in a location that allows air drying to occur.
6. Promptly send soil samples to a professional lab for analysis.

The following table should be used to fill in data on **soil carbon**

Table 6.8

	Sampling Depth (cm)	Sampling method(Coring or open pits)	Soil bulk density (Grams/cm3)	Carbon concentration (%)	soil mass (M)	total volume (Vt)
Chiefdom						
Forest ID						
Name of person conducting Measurement						
Community Supervisor/Approver						
Date (Day/Month/Year)						
Site Name						
Sample Plot Number						
Cluster Number						
Land use/Vegetation type section (LUVs Code)						

Location (GPS)							
Sample ID							
Stratum							
Plot slope on average (degrees)							
Easting(m)……(UTM x coordinate)							
Northing(m)…(UTM x coordinate)							
Altitude(m)……..(above sea level)							

Step 12: Measurement Of Standing Dead Wood

Each standing dead trees should be classified into two classes :
Class 1: Dead tree with branches and twigs and resembles a live tree except for absence of leaves (make sure tree is dead and not deciduous)
Class 2: Trees ranging from those containing small and large branches to those with bole only
By classifying trees into these two simplified classes, a conservative estimate of biomass will be taken.

Class 1 trees:

1. Follow the same measurement protocols as for the measurement of live trees, including the measurement of tree variables (e.g. DBH, H) (see SOP Measurement of Trees). If species/genus specific allometric equations require different field measurements, rules must be included in this SOP stating which field measurements will be made for which type of dead tree (for example – for all Class 1 dead trees, the 'other' tree allometric equation will used and DBH of dead trees will be measured.) If nested plots are used, only dead trees of the appropriate size (e.g. DBH) should be measured for each nest. Mark tree as 'Dead' on datasheet.

Class 2 trees (see Figure below):

1. The biomass of these trees is based on estimating the volume of the remaining tree and multiplying the volume by the wood density.
2. Measure DBH using methods for live trees. If nested plots are used, only dead trees of the appropriate DBH should be

measured for each nest.

3. Measure the diameter at the base of the tree. ($\mathbf{D}_{base}$)
4. Measure height of stem (H) either using a clinometer and measuring tape or laser range finder (see SOP Measurement of tree height) or through direct measurement using tape measure (e.g. when dead wood is less than 2 m high)
5. Measure diameter at top of stump ($\mathbf{D}_{top,}$) either through direct measurement (e.g. when diameter at top can be reached directly) or through the use of a relascope. Alternatively, do not take a measurement at the top of the stump and write 'None' or 'NA' on datasheet.

The following table should be used to fill in data for **Forestry Stump data collected (diameter > 10 cm). Measure over bark) Plot size: 20 m X 50 m – NOTE THAT STUMP DATA IS COLLECTED OVER THE ENTIRE PLOT LENGTH**

Table 6.9

	Species name	Location (Left m)	Location (Right m)	Diameter(cm)	Height (cm)	Years (Code)	Diameter at the base (cm)	Diameter at top of stump (cm)
Chiefdom								
Forest ID								
Name of person conducting Measurement								
Community Supervisor/Approver								
Date (Day/Month/Year)								
Site Name								
Sample Plot Number								

Cluster Number								
Land use/Vegetation type section (LUVs Code)								
Location (GPS)								
Sample ID								
Stratum								
Plot slope on average (degrees)								
Easting(m)……(UTM x coordinate)								
Northing(m)…(UTM x coordinate)								
Altitude(m)……..(above sea level)								

Step 13 Measurement of Lying Dead Wood

Dead wood is grouped into three dead wood classes: sound, intermediate, and rotten. Prior to field measurements, samples of each dead wood class shall be collected for demonstration purposes. So that consistent measurements are made throughout sampling, all field members must be trained on what type of dead wood will be considered in each class.

1. Starting at the tree plot center (or the sampling point when lying dead wood measurements are not associated with tree plots), determine a random compass bearing. This can be done using various methods such as using a random number table. Another method is to use a watch that has a second hand. At a random moment one individual can look at his/her watch and then the direction the second hand is facing will be used as the compass bearing.
2. Using the compass bearing, walk 100 paces from the plot center. (For permanent tree plots, sampling must take place outside the tree plot boundary. For temporary tree plots, the sampling can take place within the tree plot boundary)
3. Walk 5 more steps (These additional steps reduce bias in choosing the sampling location)
4. Lay out two 50 m lines at right angles outside plot. Determine the direction of the first line using same random compass angle as above and place the other line at right angle to first. If necessary, 4 25 m lines can be laid out. However, the lines should not overlap or cross into tree plot.

5. Along the length of the line, measure the diameter of each intersecting piece of coarse dead wood (≥ 10 cm diameter). Calipers work best for measuring the diameter. When measuring the diameter of dead wood it is not always possible to place a tape around the log. It can also be dangerous because logs are usually home to snakes, spiders, etc. If you are going to measure the diameter of the piece of dead wood with a diameter tape, make sure the route is clear before placing your hand underneath the log.

6.

A piece of dead wood should only be measured if: (a) more than 50% of the log is aboveground, and (b) the sampling line crosses through at least 50% of the diameter of the piece—see figures below. Some examples are displayed in the Figure below.

7. If the log is hollow at the intersection point, measure the diameter of the hollow; the hollow portion in the volume estimates is excluded.
8. Assign each piece to one of three density states: sound, intermediate, or rotten. To determine what density class a piece of dead wood fits into, each piece will be struck with a machete. If the machete does not sink into the piece (bounces off), classify it as sound. If the machete sinks partly into the piece, and there has been some wood loss, classify it as intermediate. If the machete sticks into the piece, if there is more extensive wood loss, and the piece is crumbly, classify as rotten. Record on data sheet.
9. The volume of lying dead wood and then carbon stocks will be estimated using the diameters of each piece of wood and the length of the line transect.

The following table should be used to fill in data for **Forestry deadwood data collected FALLEN DEADWOOD (diameter > 10 cm) Plot size: 20 m X 50 m –NOTE THAT DATA ON FALLEN DEADWOOD IS COLLECTED OVER THE ENTIRE PLOT LENGTH**

Table 6.10

	Species name	Diameter 1 [cm]	Diameter 2 [cm]	Length (m)	Count similar parts	Decay [code]
Chiefdom						

Forest ID						
Name of person conducting Measurement						
Community Supervisor/Approver						
Date (Day/Month/Year)						
Site Name						
Sample Plot Number						
Cluster Number						
Land use/Vegetation type section (LUVs Code)						
Location (GPS)						
Sample ID						
Stratum						
Plot slope on average (degrees)						
Easting(m)......(UTM x coordinate)						
Northing(m)...(UTM x coordinate)						
Altitude(m)........(above sea level)						

Step 14: Measurement and Estimation	Collect wood samples for each density class for density determination (dry weight per green volume). The number of wood samples will depend on the variability between tree species within the forest. A minimum of 10 samples should be collected for each density class of each species group. For example, for a forest containing mixed broadleaf and palm species , a minimum of 10 samples of dead wood from each tree group should be collected per density class—for a total number of 30 samples for broadleaf species and

of Dead Wood Density Classes	30 for palms. 1. For sound class of dead wood: a. Using a chainsaw or a handsaw, cut a complete disc from the selected piece of dead wood. b. Measure the diameter (L1 and L2) and thickness (T1 and T2) of the disc to estimate volume (Figure below). The dimensions of the sample should be recorded on data sheet. The fresh weight of the disc does not have to be recorded. c. All samples shall be placed in a labeled cloth bag. d. Samples shall be stored in location in manner that allows for air drying to take place prior to laboratory measurements. e. This sample will then be taken to the laboratory 2. For intermediate and rotten classes: a. Collect a contiguous sample of the dead wood that is not too small nor too large (i.e. that fit in the graduated cylinder). b. Place sample in a bag, label the bag. Make sure sample doesn't break into smaller pieces when transporting it. If the sample is very crumbly, it can be placed on a piece of clear plastic wrap (e.g. cling wrap as used in food storage), and tightly wrapped around the piece of wood. c. This sample will be taken to the laboratory. Carefully transport sample to laboratory where it volume will be measured. 3. Train all field crew members on how different pieces of dead wood are should be classified, based on the sampling that was conducted.
Step 15: Measurement Of Canopy Cover	To measure canopy cover, measurements of presence or absence of canopy cover will be made at different points within a square sampling plot. These sampling plots do not need to be located in association with tree plot measurements. The location of each sampling location must be determined prior to entering the field. 1. Navigate to sampling location using a GPS. 2. Walk an additional 10 steps in the direction of travel. This will be the first sampling point. 3. Starting at this point, determine a random compass bearing. This can be done using various methods such as using a random number table. Another method is to use a watch that has a second hand. At a random moment one individual can look at his/her watch and then the direction the second hand is facing will be used as the compass bearing.

	4. Using this compass bearing, lay out a 15 m transect. 5. A measurement of the presence/absence of canopy will be made every 3 m along this transect. 6. Starting at 0 cm, use the Densitometer to determine the presence/absence of vegetation. Looking through the densitometer you can see two spirit levels. When both are centered you are looking directly overhead. In the center of the field of vision there is a small circle. If you can see vegetation (leaves, branches, twigs, etc.), mark the data sheet to indicate the presence of canopy cover. 7. Move forward 3 m and repeat until reaching 15 m (6 recordings) 8. Move tape measure 3 m to your right and repeat measurements along transect. Move tape measure 4 more times until 6 transects have been completed. A total of 36 presence/absence measurements should be taken at each sampling location.
Step 16: Area of Canopy Opening	1. Once the logging gap has been identified, walk around the area to determine how many felled timber trees are located within the specific logging gap. The felled timber trees and all killed and/or damaged trees caused by tree felling will be measured as one logging gap plot. Measurements must be taken for each felled timber tree. 2. Locate the stump and crown of each felled tree. Be sure to verify that the crown is from the selected stump by determining the angle of the tree fall, species and distance from stump. 3. Walk around the entire gap, locating every section of canopy gap formed. Mentally divide the gap into different non-overlapping ovals or rectangles. Shapes must either be either: oval, circle, rectangle or square. They cannot be complex shapes unless detailed angles are taken). Draw shapes onto data sheet. 4. Measure and record the length and width of each shape with either the Range Finder or the tape measure. **Remember** – to measure the area of an oval one must measure diameter of major axis *and* minor axis.
Step 17: Tree Crown Area from the Ground	This is used to estimate the crown area of a tree. These measurements are used for specific purposes including formulating relationships between tree biomass and crown area for use in aerial imagery analysis. The purpose of the field measurements must be clearly delineated and a sampling design created prior to implementation of this SOP. The sampling design must include steps for determining which trees will be measured. 1. For each tree to be measured, measure the DBH and species of tree using the procedures in SOP Measurement of Trees.

2. At each tree to be measured a total of four measurements of the angle and distance to canopy should be taken.
    a. For each cardinal direction stand with your back to the tree trunk. If clearer sight of the first branch with leaves is not aligned with a cardinal direction, be sure the subsequent three sides are perpendicular to each other. Using the clinometer, estimate the angle in degrees to the first branch with leaves ($\angle_1$).
    b. Use the range finder, measure the distance from the eye of the person measuring the trunk to the branch (d_1) in meters. Be certain that the distance measured is horizontal and not along a slope.

Step 18 Fire measurements

	Fire occurrence[5]	Fire Area (ha)	Fire type(severity)[6]
Chiefdom			
Forest ID			
Name of person conducting Measurement			
Community Supervisor/Approver			

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[5] 0 There is no evidence of fire
1 Evidence of fire during the current year
2 Evidence o fire during

[6] 1. Unburned / Very Low
2. Low
3. Moderate
4. High
5. Very high

Date (Day/Month/Year)			
Site Name			
Sample Plot Number			
Cluster Number			
Land use/Vegetation type section (LUVs Code)			
Location (GPS)			
Sample ID			
Stratum			
Plot slope on average (degrees)			
Easting(m)……(UTM x coordinate)			
Northing(m)…(UTM x coordinate)			
Altitude(m)……..(above sea level)			

Step 19: Data assembly	**Sub-Step 6a.** After the data collection is completed, the MRV Coordinator ensures data is well compiled and archived in readiness for analysis. **Sub-Step 6b.** The MRV Coordinator checks that all necessary data and sample information is archived and included in the final database.

5.0 SOP DATA ANALYSIS-BIOPHYSICAL ASSESSMENTS

Procedure

<table>
<tr>
<td>Tree Plots/Sub-plots-Extrapolation to Hectare</td>
<td>Following field data collection, during data analyses, any measurements taken at the plot level are extrapolated to the area of a full hectare to produce carbon stock estimates on a ‘per hectare’ basis.
Extrapolation is done by the use of scaling factors that are calculated as the proportion of a hectare (10,000 m2) that is occupied by a given nested plot or clip plot:
$$Scaling\ Factor = \frac{10{,}000m^2}{Horizontal\ Area\ of\ Nest\ (m^2)} \text{.............}7.1$$</td>
</tr>
<tr>
<td>Data Analysis for Above Ground Biomass</td>
<td>Table 6.11 Above ground biomass for tress AGB $_{tree}$
<table>
<tr><th></th><th>DBH (cm) from Table 6.2</th><th>H(tree height) m From Table 6.2</th><th>ABG $_{tree}$=0.112*(p*D^2*H)$^{0.916}$</th></tr>
<tr><td>1</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>n</td><td></td><td></td><td></td></tr>
</table>
Table 6.12 Above ground biomass for Sapling AGB $_{sapling}$
<table>
<tr><th></th><th>DBH (cm) from Table 6.1</th><th>H(tree height) m From Table 6.2</th><th>ABG $_{sapling}$=0.112*(p*D^2*H)$^{0.916}$</th></tr>
<tr><td>1</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>n</td><td></td><td></td><td></td></tr>
</table>
Table 6.13 Above ground biomass for Sapling AGB $_{pole}$</td>
</tr>
</table>

	DBH (cm) from Table 6.3	H(tree height) m From Table 6.3	$ABG_{pole}=0.112*(p*D^2*H)^{0.916}$
1			
2			
3			
n			

Table 6.14 Above ground biomass for AGB_{bamboo}

	DBH (cm) from Table 6.4	H(tree height) m From Table 6.4	$ABG_{bamboo}=0.112*(p*D^2*H)^{0.916}$
1			
2			
3			
n			

Table 6.15 Above ground biomass for Sapling $AGB_{understory}$

	Weigh biomass in sample plot (kg) W_T (derived from table 6.5)	Area of Sampling Plot (A) (derived from table 6.5)	$AGB_{understory}$ $AGB_{understory} = (W_T * A * 10)$ (tonnes/ha)
1			$ABG_{understory}=0.112*(p*D^2*H)^{0.916}$
2			
3			
n			

It should be noted that any individual carbon pool of the given formula can be ignored if it does not contribute significantly to the total carbon stock.

C(LU) = C(AGTB)+C(AGPB)+C(AGSB)+C(AGUB)+C(L)+C(WN)+SOC [7]

where,
C(LU) = carbon stock density for a land-use category [ton ha-1];
C(AGTB) = carbon in above ground tree biomass [ton ha-1];
C(AGPB) = carbon in above ground pole biomass [ton ha-1];
C(AGSB) = carbon in above ground sapling biomass [ton ha-1];
C(AGUB) = carbon in above ground under storey biomass [ton ha-1];
C(L) = carbon in litter [ton ha-1];
C(WN) = carbon in woody necromass [ton ha-1];
SOC = soil organic carbon [ton ha-1].

The total carbon stock is then converted to tons of CO2 equivalent by multiplying it by 44/12, or 3.67 (Pearson et al., 2007).

Table 6.16

AGB_{tree}	AGB_{pole}	$AGB_{sapling}$	AGB_{Bambo}	$AGB_{understory}$	$AGB_{total} = (AGB_{tree} + AGB_{pole} + AGB_{sapling} + AGB_{Bambo} + AGB_{understory})$

According to[8], the allometric equations for biomass usually consist of information on trunk diameter at breast height DBH (in cm), total tree height H (in m), and wood-specific gravity (in g/cm³). Ignoring variations in wood density results in poor prediction of the stand. Wood-specific gravity is hence an important predictive variable in the regression model.

The choice of the best predictive allometric equations (models) in estimating the stand is developed by [9]Chave et al. (2005) on

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[7] Wayan S. D et.al, 2010: Standard Operating Procedures for Field Measurement

[8] Wayan S. D et. al, 2010: Standard Operating Procedures for Field Measurement

[9] Chave, J., et al. (2015), Improved Allometric Models to Estimate the Above Ground Biomass of Tropical Trees; Global Change Biology

the basis of climate and forest stand types. Equation (a) is good for moist forest stand, equation (b) for dry forest stand, and equation (c) for wet forest stand[10]:

ABG = 0.0509 * ρ D2 H……………………………………………………..7.2[11]

ABG=0.112 * (ρ D2 H)0.916 ……………………………………………..7.3

AGB = 0.0776 * (ρ D2 H)0.940 ……………………………………………..7.4

where,
ABG = above ground biomass [kg];
ρ = wood specific gravity [g cm^{-3}];
D = tree diameter at breast height [cm]; and
H = tree height [m].

After taking the sum of all the individual weights (in kg) of a sampling plot and dividing it by the area of sampling plot for trees (2000 m^2) and saplings poles (500 m^2), the biomass stock density is attained in kg m^{-2}.

This value can be converted to ton/ha by multiplying it by 10.
The biomass stock density of a sampling plot will be converted to carbon stock densities after multiplication with the IPCC (2006) default carbon fraction of 0.5.

Before a specific equation is used, it is good practice to test whether the equation can be applied by taking a small number of empirical measurements and comparing the predicted outcome with the measured outcome.
How the established allometric equation fits new observations can be tested using a reduced Chi-Square goodness-of-fit test.
This test analyzes whether the variability between predicted biomass values and true biomass values is equal to the ’natural’ variability in biomass values (Subedi et al., 2010)

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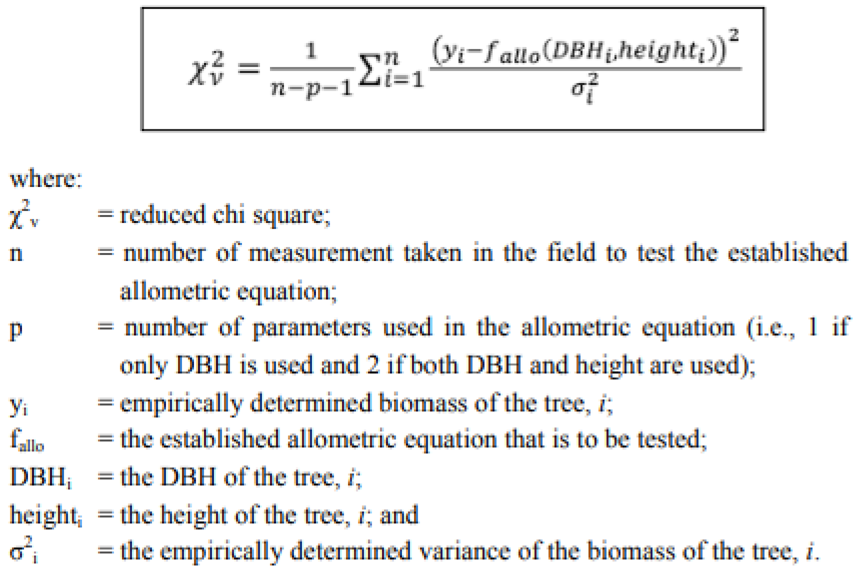
[10] Wayan S. D et. al, 2010: Standard Operating Procedures for Field Measurement

[11] Wayan S. D et. al, 2010: Standard Operating Procedures for Field Measurement

	 $\chi_v^2 = \frac{1}{n-p-1}\sum_{i=1}^{n}\frac{\left(y_i - f_{allo}(DBH_i, height_i)\right)^2}{\sigma_i^2}$ where: χ^2_v = reduced chi square; n = number of measurement taken in the field to test the established allometric equation; p = number of parameters used in the allometric equation (i.e., 1 if only DBH is used and 2 if both DBH and height are used); y_i = empirically determined biomass of the tree, *i*; f_{allo} = the established allometric equation that is to be tested; DBH_i = the DBH of the tree, *i*; $height_i$ = the height of the tree, *i*; and σ^2_i = the empirically determined variance of the biomass of the tree, *i*. …............................7.5 where: χ 2 v = reduced chi square; n = number of measurement taken in the field to test the established allometric equation; p = number of parameters used in the allometric equation (i.e., 1 if only DBH is used and 2 if both DBH and height are used); yi = empirically determined biomass of the tree, i; fallo = the established allometric equation that is to be tested; DBHi = the DBH of the tree, i; heighti = the height of the tree, i; and σ 2 i = the empirically determined variance of the biomass of the tree, i. The allometric model assumed to be a ’good fit’ when the reduced chi square equals is one (or close to).
Volume Equations	Different approaches can be used for different trees, depending on whether it is possible to measure the diameter at the top of

of an Individual Standing Dead Tree	a given dead tree. To estimate the biomass of an individual standing dead tree, the estimated volume is multiplied by the average density calculated for ‘sound wood’ Option 1: Diameter at top (Dtop) was measured directly: Volume estimated assuming tree is a truncated cone: $Volume = \frac{(\pi \times Height).}{12}\ (D^2 base + (D\ base\ .\ D\ top) + D^2 top)$……………………………………………7.6 2. Option 2: Diameter at top (Dtop) was measured using a Relascope: Volume estimated assuming tree is a truncated cone: $Volume = \frac{(\pi \times Height)}{12}.\ (D^2 base + (D\ base\ .\ D\ top) + D^2 top)$…………………………………………………7.7 Option 3: Diameter at top (Dtop) estimated using taper equation $Dtop = Dtop - (H.\ \frac{(D\ top - DBH)}{130.100}$……………………………………………………………………………………7.8 Volume estimated assuming tree is a truncated cone: $Volume = \frac{(\pi \times Height)}{12}.\ (D^2 base + (D\ base\ .\ D\ top) + D^2 top)$……………………………………………………7.9 Option 4: Diameter at top (Dtop) is assumed to be zero. Volume estimated assuming tree is a cone: $Volume = 1/3.\ \pi.\ \frac{(Dbase)^2}{2}\ .\ H$……………………………………………………………………………………………7.10

Analysis for Trees	Input Data Variables: Species, tree health (live status; health<5:living tree; health=5:dead tree), diameter at breast height dbh in cm, top height H in m, bole height Hbole in m Parameters: Root to Shoot (RS) -0.28 and C fraction of dry matter (CF) -0.49 [12] **Tree Top Height** $H=1.3+dbh^2/(a+bd)^2$…………………………………………………………………………………………………7.11 Note: Height Model regression parameters a and b computed by clusters.[13] **Bole Volume** $Vbole=0.81*pi*(0.01*dbh/2)^2*Hbole$…………………………………………………………………………7.12 **Stem Volume** $V=0.67*pi*(0.01*dbh/2)^2*H$…………………………………………………………………………………7.13 **Above Ground Biomass** $AGB=exp(2.342*LN(dbh)-2.059)/1000$…………………………………………………………………………7.14 **Below Ground Biomass** $BGB=AGB*RS$………7.15 **Total Biomass in Tree** $BM=AGB+BGB$…………………………………………………………………………………7.16 **Above Ground Carbon** $AGC=CF*AGB$…………………………………………………………………………………7.18 **Below Ground Carbon**

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[12] Intergovernmental Panel on Climate Change (IPCC) (2006). Agriculture, Forestry and Other Land Uses, 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[13] GRZ (2014) ILUA-II Data Processing for Biophysical Assessment, Zambia.

	$BGC=CF*BGB$……………………………………………………………………7.18 **Total Carbon in Tree** $C=AGC+BGC$……………………………………………………………………7.19 [14]
Laboratory Measurements and Data Analysis for Dead Wood Density	1. Dry Weight: Place samples in drying oven at 70o C until sample reaches constant weight (i.e. all moisture is evaporated). Record the dry weight (g). 2. 2.Volume: If the wood disc sampled from the field is a regular shape (e.g. circular disk) the 'calculated volume' method below can be used. If the wood disc is an irregular shape, the 'water displacement volume' method shall be used. a. Calculated Volume Estimate Method: i. Calculate the volume using the measurements taken in the field $Volume= \pi \times \left(\frac{Diameter1+ Diameter 2}{2} /2\right)^2 \times \frac{Width1 +Width 2}{2}$……………………………7.20 Where: Volume = Volume of sample;cm3 Diameter1 = First diameter of sample; cm Diameter2 = Second diameter of sample; cm Width1 = First width of sample; cm Width2 = Second width of sample; cm ii. Calculate density using the following formula: $Density = \frac{Dry Weight}{Volume}$……………………………………………………………7.21 Where: Density = Density of sample; g/cm3 Volume = Volume of sample; cm3 Dry Weight = measured dry weight of sample; g

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[14] Abbreviations used in the calculations (ILUA, 2014): AGB = above-ground biomass BGB = below-ground biomass AGC = above-ground carbon BGC = below-ground carbon BA = basal area

	iii. Calculate the mean the density for that wood density class. b. Water Displacement Method: The most commonly used technique to measure the volume of irregularly shaped objects. i. Create a subsample from the wood sample brought from the field. This subsample must fit inside the graduated cylinder to be used. ii. Weigh the subsample created and record weight. iii. Fill the graduated cylinder to a known volume (e.g. 1L). Make sure there is enough water to submerge the piece and enough empty room in the graduated cylinder to allow water to rise without spilling over. iv. Place dead wood sample inside the graduated cylinder. v. Using the very fine elongated needle, push sample under the water until completely submerged. Make sure water doesn't spill over or rise above the last milliliter marking on the graduated cylinder. vi. On the data sheet, record the volume of water displaced by submerging the sample. That is the volume of the sample collected. vii. Calculate density using the following formula: $\text{Density} = \frac{\text{Dry Weight}}{\text{Volume}}$ ……………………………………………………7.22 Where: Density = Density of sample; g/cm3 Volume = Volume of sample; cm3 Dry Weight = measured dry weight of sample; g c. Calculate the mean the density for that wood density class
Data Analysis for Woody Necromass (Dead Organic Matter) **Data Analysis for Non tree woody**	$\text{Total dry weight} = \frac{\text{sample dry weight}}{\text{sample fresh weight}} \times \text{total fresh weight}$ ……………………………………7.23 $\text{Carbon content} = 0.5 \times \text{total dry weight}$ After taking the sum of all the individual weights (in kg) of a sampling plot and dividing it by the area of a sampling plot for

<table>
<tr>
<td>vegetation</td>
<td>woody necromass ($0.25\ m^2$), the biomass stock density is attained in kg m^{-2}. This value can be converted to ton/ha by multiplying it by 10.

The biomass stock density of a sampling plot will be converted to carbon stock densities after multiplication with the IPCC (2006) default carbon fraction of 0.5[15].</td>
</tr>
<tr>
<td>Data Analysis for Litter</td>
<td>Table 6.17 Biomass Litter
<table>
<tr><th></th><th>weight of the fresh field sample of litter (W field fresh) -Derived from table 6.7</th><th>weight of the oven-dry sample of litter (W dry sample) Derived from table 6.7</th><th>weight of the fresh sample of litter (W wet sample) Derived from table 6.7</th><th>biomass of litter (t ha-1) equation 7.3</th></tr>
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</table>

To determine the litter biomass, samples are taken destructively in the field within a small area of $0.25\ m^2$.</td>
</tr>
</table>

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[15] Wayan S. D et. al, (2010) Standard Operating Procedures for Field Measurement

Fresh samples are weighed in the field with a 0.1 gr precision; and a well-mixed sub-sample is then placed in a marked bag.

A sample is taken to the laboratory and oven dried until constant weight to determine water content.

For the amount of biomass per unit area is given by:

$$WL = \frac{W\ field\ fresh}{P} \times \frac{W\ dry\ sample}{W\ wet\ sample} \times \frac{1}{10000} \ldots\ldots 7.23$$

where:
WL = biomass of litter (t ha-1);
W field fresh = weight of the fresh field sample of litter, destructively sampled within an area of size P [g];
P = size of the area in which litter were collected [ha];
W dry sample = weight of the oven-dry sample of litter taken to the laboratory to determine moisture content [g]; and
W wet sample = weight of the fresh sample of litter taken to the laboratory to determine moisture content [g][16].

Data analysis for Stumps

Table 6.18 Biomass for Stump

	stump diameter (Dstump) derived from Table 6.9	**stump height (Hstump)** derived from Table 6.9	**AGB (Equations 7..31 and 7.32)**	**BGB (Equation 7.37)**	**Total Biomass Stump (BMstump)**

---

[16] Wayan S. D et. al, (2010)Standard Operating Procedures for Field Measurement

Estimate the breast height diameter of the tree before felling in order to be able to compute its below-ground biomass.
Note: A model to estimate dbh as a function of stump diameter and stump height[17]

Input Data
Variables: Species, stump diameter (Dstump) in cm and stump height (Hstump) in cm
Parameter: drywood density factor (WD) -619kg/m^3
Derived variables: Estimated diameter at breast height (est_d) –computed with a model using NAFORMA data from Tanzania where 32000 live sample trees used in a data analysis:

Calculation

Diameter at 1.3 m
$Est\_dbh= D\ stump+0.38524*(1.3-Hstump)-0.20325*1.3-Hstump)*Dstump$…………………………..7.28

Ground level diameter (d0)
$D0=(est\_ dbh -0.38524*1.3)/ (1- 0-0.20325*1.3)$………………………………………………………………..7.29

Stump Volume above ground (V_AG)
Computed with a cylinder model between 0m up to Hstump
$V\_AG=(pi*(d0/200)^2+pi* (Dstump/200)^2)/2* Hstump$………………………………………………………………..7.30

---

[17] The model to estimate dbh as a function of stump diameter and stump height is based on data from NAFORMA, Tanzania (Vesa 2013, unpublished). The model is based on data from 32 000 living sample trees recorded in forest land plots in Tanzania. The variables in the modeling data were as follows: dbh, stump level diameter, and stump level height.

Volume and Biomass for tree before felling
Computed similarly as for trees

$AGB=V\_AG*WD/1000$………7.31

$=V\ AG*619/1000$………7.32

AG biomass of stump
Computed with the help of dry wood density factor

Top Height
$Hf=1.3+est\_dbh^2/(a+b*est\_d)^2$…………………………………………………………………………………………………7.33

Where a and b are height model regression parameters computed by clusters

Stem Volume
$Vf=0.67*pi*(0.01*est\_dbh/2)^2 *Hf$……………………………………………………………………………………………7.34

Stem Volume Removal
$Vrem=Vf-V\_AG$……7.35

AG Biomass
$AGBF=exp(2.342*LN\ (est\_dbh)-2.059/1000$……………………………………………………………………………7.36

Below ground Biomass
$BGB= AGBf*RS$……7.37

Stump Total Biomass
$BMstump=AGB+BGB$………7.38

Stump Total Carbon

$Cstump=CF*BMstump$……7.39

Data Analysis for lying Dead Wood

Table 6.19 Lying Dead wood

	Length (m) Derived from Table 6.10	Diameter 1 [cm] Derived from Table 6.10	Diameter 2 [cm] Derived from Table 6.10	Dead Wood Volume (V_DW)(equation 7.40) applying equations 7.42 and 7.43 for decayed or solid dead wood	**Deadwood Biomass (equation 7.41**

Input data:
Variables:
Diameter (D1 and D20) in cm
Deal wood length (L) in cm
Decay status (solid or partially/fully rotten)
Count of similar particles
Conversion factors
Dry wood density factor (WD) 619kg/m^3
Derived Variables
Volume (V_DW)-Computed with a cylinder model
Biomass (AGB_DW)-Computed with the use of wood density factor. Decayed dw is 50% of biomass of solid dw.
Carbon (C_DW)- Computed with the help of C from biomass

Calculation

Deadwood Volume

V_DW=pi * ((D1/200)^2+pi*(D2/200) ^{2})/2)*L…………………………………………………………7.40

Deadwood Biomass

AGB_DW=V_DW/1000……………………………………………………………………………………7.41
V_DW*=619/1000 for solid dw…………………………………………………………………………7.42
50%* V_DW*619/1000 for decayed dw………………………………………………………………7.43

DW Carbon

C_DW=CF*ABG_DW……………………………………………………………………………………7.44

Total Deadwood and Litter Biomass

Table 6.20. Total Deadwood and litter

	Lying Dead wood(total) Table 6.19	**Stump(Total) Table 6.18**	**Litter (Table 6.17)**	**Total Dead wood and Litter(tonnes/hectare)**
1				
2				
3				
4				

Data Analysis for Soil Organic Carbon

Soil Organic Carbon

	(%C) carbon concentration [%]. *Derived from table 6.8*	(dp) The total depth at which the sample was taken [cm] *Derived from table 6.8*	(ρ) soil bulk density [g cm-3]; *Derived from table 6.8*	**(SOC) Soil organic carbon stock per unit area (t ha-1); Equation 7.45**
1				
2				
3				

4				

Soil samples from each of the three depths are composted and well-mixed per sampling plot and then prepared for carbon measurement by removing stones and plant residue > 2mm as well as by grinding.

The carbon stock density of soil organic carbon is calculated as (Pearson et al., 2007):

$SOC = \rho \times dp \times \%C$ ……………………………………………………………………………… …………….7.45

Where:
SOC = Soil organic carbon stock per unit area (t ha-1);
ρ = soil bulk density [g cm-3];
dp = the total depth at which the sample was taken [cm]; and
%C = carbon concentration [%].

Reliability Estimates

Reliability estimates are only computed for trees on the forest land. The variable of interest is only the mean volume (in m^3 /ha).

Ratio estimator for mean volume of forest (m^3 /ha) is computed as follows:

where
n = number of clusters (in forest land),
xi = sum of plot sections’ volumes (m3) in cluster i,
pi = area of plot sections in forest in cluster I (in ha).

Variance of the proportion estimates, with clusters of unequal size (variance of ratio estimator), is as follows:

∑ ∑ = · − − = · n i i i i n x px n n p x 1 2 2 ( ) 1 ( ) 1 var( )

where n = number of clusters (in forest land),
xi = sum of forest plot sections' volumes (m3) in forest in cluster i,
pi = sum of plot section areas in forest in cluster i (in ha), x = forest mean

volume estimate (in m^3 /ha).

The other estimates are computed as follows:

- Standard error (m^3 /ha): SE = var(x)
- Relative standard error (%): RSE = SE * 100 / x
- Sampling error (95%, m^3 /ha) SAE = SE* t_value
- Relative sampling error (95%, %) Rel.SAE=SAE*100/X

Ratio estimator for mean volume of forest (m^3/ha) is computed as follows:

$$\overline{x} = \frac{\sum_i^n x_i}{\sum_i^n p_i}$$

Where;
n = number of clusters (in forest land)
x_i = sum of plot sections volumes (m^3) in cluster, i,
p_i = area of plot sections in forest in cluster per (in ha)

Variance of the proportion estimates, with clusters of unequal size (variances as follows:

	$var(\overline{x}) = \frac{1}{(\sum_i^n p_i)^2} * \frac{n}{n-1} * \sum_{i=1}^{n}(x_i - \overline{x}\ p_i)^2$ Where; n = number of clusters (in forest land) x_i = sum of plot sections volumes (m^3) in cluster, i, p_i = area of plot sections in forest in cluster per (in ha) The other estimates are computed as follows: Standard Error (m^3/ha): $SE = \sqrt{var(\overline{x})}$ Relative Standard Error (%): $RSE = SE * 100/\overline{x}$ Sampling Error (95%, m^3/ha): $SAE = SE * t\_value$ Relative Sampling Error (95%, %): $RSAE = SAE * 100/\overline{x}$
Calculation of confidence and uncertainty	**Step 2 a. Calculate the arithmetic mean using equation 1 below:** $\overline{x} = \frac{1}{n}\sum_{i=1}^{i=n} x_i$,---equation 1 Where $\overline{x}$ is the mean, x is the sampled value, and n is number of sample units **Step 2 b. Calculate standard deviation provides a measurement of variation from the average value using equation 2 below:** $S = \sqrt{\frac{1}{n-1}\sum_{i=1}^{i=n}(x_i - \overline{x})^2}$ ---equation 2 Where S is the sample standard deviation, x is the sampled unit value, n is the number of sample units, and $\overline{x}$ is the arithmetic mean. This equation is applicable to simple random sampling.

Step 2 c calculate the standard error provides the standard deviation of the mean.

$SE_{\overline{x}} = \frac{s}{\sqrt{n}}$--*equation 3*

Where SE is the standard error, $\overline{x}$ is the arithmetic mean, s is the sample standard deviation, and n is the number of sample units. This equation is applicable to simple random sampling.

Step 2 d: The confidence interval gives the estimated range of values likely to include an unknown population parameter at the chosen confidence level.

*CI=t** $SE_{\overline{x}}$--*equation 4*

Where *CI* is the half width of the confidence interval at a specific confidence level or absolute error, often 95% or 90%, t is the t-value, function of the confidence level and the number of sample units, SE is the standard error, and, $\overline{x}$ is the mean.

Step 2 e: Calculate uncertainty or relative margin of error which is estimated as a percentage, using the half width of the confidence interval as a percent of the mean.

$Uncertainty = \frac{Cl}{\overline{x}}$--*equation 5*

Where CI is the half width of the confidence interval at a specific confidence level, and, $\overline{x}$ is the mean.

$U_{total} = \sqrt{U_1^2+U_2^2+\cdots..+U_n^2}$-----------------------------------*equation 6*

	Where U_{total} is the total percentage uncertainty in the product of the quantities, at the chosen *CI*, and U_n is the percentage uncertainty associated with each of the quantities. $U_{total} = \frac{\sqrt{(U_{1*}x_1)^2+(U_{2*}x_2)^2+\cdots\ldots+(U_{n*}x_n)^2}}{\lvert x_1+x_2+\cdots..+x_n \rvert}$-------------------------*equation 7* Where U_{total} is the total percentage uncertainty in the product of the quantities, at the chosen CI, U_n is the percentage uncertainty associated with each of the quantities, and X_i

6.0 SOP QUALITY ASSURANCE/QUALITY CONTROL

Those responsible for aspects of data collection and analysis should be fully trained in all aspects of the field data collection and data analyses. Standard operating procedures should be followed rigidly to ensure accurate measurement and re-measurement. It is highly recommended that a verification document be produced and filed with the field measurement and calculation documents that show that QA/QC steps have been followed.

Quality Management	
QA / QC procedures	**Sub-step Q1.** The Coordinator provides warning labels or excludes impossible transitions through logical checks built into response design. **Sub-step Q2.** The Coordinator conducts ongoing hot, cold and auxiliary data checks during data collection and conduct regular review meetings among all interpreters. Auxiliary data checks: use an external data source, such as externally created maps, to compare to the sample unit classification. Discrepancies between the two datasets can be flagged for rechecking. Confirmed differences between the two datasets can be documented to showcase why sample-based area estimation may give difference results than other data sources. Cold checks: sample units that are randomly selected from the data produced by interpreters. The decisions made by the interpreters are reviewed by the coordinator or group of interpreters meeting together. If the error by the interpreter reflects a systematic error in their interpretation, it is discussed directly with the data analysts and the affected sample units are corrected. t checks: sample units that are flagged as low confidence. These marked sample units should be further reviewed by the coordinator or group of interpreters meeting together. Once reviewed, labels that are deemed to be incorrect on these sample units should be adjusted by the interpreter.

6.1 Quality Assurance

6.1.1Data Collection in the Field:

During all data collection in the field, the crew member responsible for recording must repeat all measurements called by the crew member conducting the measurement. This is to ensure the measurement call was acknowledged and that proper number is recorded on the data sheet. In addition, all data sheets should include a 'Data recorded by' field with the name of the crew member responsible for recording data. If any confusion exists, the transcribers will know which crew member to contact.

After data is collected at each plot and before the crew leaves the plot, the crew leader shall double check to make sure that all data are correctly and completely filled. The crew leader must ensure the data recorded matches with field conditions, for instance, by verifying the number of trees recorded.

6.1.2 Data Sheet Checks:

At the end of each day all data sheets must be checked by team leaders to ensure that all the relevant information was collected. If for some reason there is some information that seems odd or is missing, mistakes can be corrected the following day. Once this is verified and potential mistakes checked, corrected data sheets shall be handed over to the person responsible for their safe keeping while the crew is still in the field. Data sheets shall be stored in a dry and safe place while in the field. After data sheets have been validated by crew leaders, the data entry process can commence.

6.1.3 Field Data Collection Hot Checks:

After the training of field crews has been completed, observations of each field crew and each crew member should be made. A lead coordinator shall observe each field crew member during data collection of a field plot to verify measurement processes and correct any errors in techniques. It is recommended that the crew chiefs switch to a different crew to ensure data collection procedures are consistent across all field crews. Any errors or misunderstandings should be explained and corrected. These types of checks should be repeated throughout the field measurement campaign to make sure incorrect measurement techniques have not started to take place.

6.1.4 Data Entry Checks:

To ensure that data is entered correctly, the person entering data (whether during fieldwork or after a return to the office) will recheck all of the data entered and compare it with the original hard copy data sheet before entering another sheet. It is advised that field crew leaders either enter the data, or participate in the data entry process. Crew leaders have a good understanding of the field sites visited, and can provide insightful assistance regarding potential unusual situations identified in data sheets. Communication between all personnel involved in measuring and analyzing data should be used to resolve any apparent anomalies before final analysis of the monitoring data can be completed. If there are any problems with the plot data (that cannot be resolved), the plot should not be used in the analysis.

6.2 Quality Control

6.2.1 Field Measurement Error Estimation

A second type of field check is used to quantify the amount of error due to field measurement techniques. To implement this type of check, a complete re-measurement of a number of plots by people other than the original field crews is performed. This auditing crew should be experienced in forest measurement and highly attentive to detail. A total of 10% of plots (or clusters if clustered plots are used) should be randomly or systematically chosen to be re-measured. Where clustered plots are used, all plots within a selected Cluster shall be measured. All trees shall be re-measured in each plot. Field crews taking measurements should not be aware of which plots will be re-measured whenever possible.

After re-measurement, data analysis is conducted and biomass estimates are compared with estimates from the original data. Any errors discovered could be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

For all the verified plots:

$$\textit{Measurement Error (\%)} = \underline{\textit{(t C/ha of Measured plot-t C/ha of re-measured Plot)}}\quad \textit{X 100}$$

T C/ha of re-measured plot

Quality Control Check:

After all data has been entered into computer file(s), a random check shall be conducted. Sheets shall be selected randomly for re-checks and compared with data entered. Ten percent of all data sheets shall be checked for consistency and accuracy in data entry. Other techniques such as data sorting and verification of resulting estimates shall be employed to ensure data entered properly corresponds to field sites visited. Personnel experienced in data entry and analysis will be able to identify errors especially oddly large or small numbers. Errors can be reduced if the entered data is reviewed using expert judgment and, if necessary, through comparison with independent data.

6.2.3 QA/QC of Laboratory Measurements

Standard operating procedures (SOPs) should be created and rigorously followed for each part of all laboratory analyses. All instruments should be calibrated.

For example, all combustion instruments for measuring total C or C forms should be calibrated using commercially-available certified C standards. SOPs should include steps to calibrate and check analyses. Blanks can be analyzed, or analytical runs can include a check sample of known C concentration. One standard per batch/run should be included in the samples sent to a remote lab as an additional check of the quality of the instruments and lab procedures.

All balances for measuring dry weights should be calibrated against known weights. Where possible, 10-20
% of samples could be reanalyzed/reweighed to produce an error estimate.

7.0 SOP DATA STORAGE AND ARCHIVING

Field equipment

Field log book/electronic field log book Laptop computer
Desktop computer
Connection to
network server
Scanner

This SOP describes the methods for storing and archiving data in a simple yet safe and retractable way, so data can be accessed whenever necessary. Data storage and archiving is a very important and final component of the data collection process. The basic framework involving data storage and archiving follows.

7.1 Data Storage in the Field

In the field one person is responsible for storing and keeping the field data sheets; this person can also be the person who also validates the data on the sheets and is one of the team leaders.

If the data entry process is being done or started in the field, these sheets will be used after which they must be returned to the person responsible for their safe keeping. These sheets are stored in a dry and safe place where they cannot be tampered with until they are transported to the office.

7.2 Data storage in the Office

In the office, all original field data sheets shall be scanned and compiled into a document to be stored electronically. This avoids any changes to be made to the original sheets.

7.2.1 Hard copy

The original data sheets are photocopied and are kept in separate location. The data sheets are placed in a special jacket folder in the filing cabinet with the location name and date written on the label. Inside of these jackets there are folders with the different types of data collected (Biomass, Logging, Skid trails, Roads and Decks, Regrowth, Wood Density etc.). After all data has been entered into a digital format and SOP QA/QC completed, the two sets of data sheets are then stored in secure fireproof filing cabinets in two separate locations.

7.2.2 Soft Copy

The scanned data sheets are stored on a computer in the office, along with all tools with the entered data, including data entered in the field laptop. These data files are backed up on a server. Folders containing data and folders containing tools should be properly named and adequately organized. All digital data collected and compiled (photos, proposal and report for exercise) are also stored in the archive file on both the desktop in the office and on the server. On the server there are a few folders in which all data are placed as follows:

1. '*Field Data*', in which sub folders are created and are named the same way (Location) as the hard copy folder so as to have a uniform filing system. In each sub folder there are two folders; pictures and scanned data sheets in which the respective information are placed;
2. '*Data Analysis*' in which all completed tools are placed after the data entry has been completed;
3. '*Template*' in which all tool templates and field data sheets used in the data analysis are placed;
4. '*Documents*' in which all documents related to the project are placed; and
5. '*Field Proposal & Report'* in which all field exercise proposals and report are placed.

7.2.3 Procedure for Data File Backup

Any file(s) that is updated during the data analysis will be backed up to a network server. This back up will be done daily on the office computer(s), and at the end of every week they must be saved on an external hard drive and the folder on the server which is specifically designated for this data storage.

7.2.4 Procedure for Compiling and Managing Field Logbook or Electronic Log Book

This logbook will be both of an electronic form and of the traditional book keeping format (a book). Both log forms will be updated simultaneously and twice for each field venture, before and after each trip. Logbooks will be used for recording the logistics of the field exercise, and providing explanation about field campaigns (e.g. date of departure to the field and date of returning, number of plots, location, field crew, challenges etc.). Each field campaign will be given a unique reference number and each report will also be given a reference number related to that of the campaign. This is to facilitate cross referencing processes.

Upon returning to the office after field records are entered, the logbooks will be stored in a secure filing cabinet or placed on the network server via desktop computers respectively, after being updated. Upon the completion of field reports of which each report will be given a unique reference number, the logbooks will be revisited and the report number will be inserted for future references.

It is important to restrict access to logbooks and information only to users, as they alone are responsible for making changes.

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Ministry of Green Economy and Environment

Zambia Integrated Forest Landscape Project

Improving lives through Sustainable Management of Natural Resources

The Zambia Integrated Forest Landscape Project is a Government initiative which provides support to rural communities in the Eastern Province to allow them to better manage the resources of their landscapes so as to reduce deforestation and unsustainable agricultural expansion; enhance benefits they receive from forestry, agriculture, and wildlife; and reduce their vulnerability to climate change.

Simultaneously the project is creating the enabling environment for emission reduction purchases to be done through the subsequent phase - the Zambia Eastern Province Jurisdictional Sustainable Landscape Programme (EP-JSLP).

The ZIFL- Project is a product of cooperation between the Government of Zambia, the World Bank & partners.

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