NATIONAL FORESTRY RESOURCES MONITORING AND ASSESSMENT OF TANZANIA (NAFORMA)

GCP/GLO/194/MUL

NAFORMA Field Manual – biophysical survey

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Abbreviations

Asl	Above sea level
DBH	Diameter at the breast height (1.3 m)
DEM	Digital Elevation Model
FAO	Food and Agricultural Organization
FBD	Forestry and Beekeeping Division
FRA	Forest Resources Assessment Programme
GHG	Green House Gas
GIS	Geographic Information Systems
GO	Governmental Organization
GPS	Global Positioning System
ILUA	Integrated Land Use Assessment
INA	Information Needs Assessment
MNRT	Ministry of Natural Resources and Tourism
NAFORMA	National Forestry Resources Monitoring and Assessment
NFI	National Forest Inventory
NGO	Non-governmental Organization
NWFP	Non-wood Forest Product
PDA	Personal Digital Assistant, mobile device
PSP	Permanent Sample Plot
REDD	Reduced Emissions from Deforestation and Forest Degradation
SFM	Sustainable Forest Management
USDA	United States Department of Agriculture
UTM	Universal Transverse Mercator

Acknowledgements

In its current format, the NAFORMA field manual and corresponding inventory design is the combined product of the efforts of a large number of people and institutions. The field manual compilers would initially like to extend their gratitude to all contributors to the development of NAFORMA and in particular the below mentioned.

The NAFORMA Field Manual bases on the experiences and the field manual of the Integrated Land Use Assessment (ILUA) of FAO (FAO 2009). Therefore, we want to thank Anne Branthomme, Dan Altrell, and Mohamed Saket (all FAO FOMR) for providing us their valuable knowledge and input for formulating this field manual.

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During June 2009, prior to the development of the NAFORMA sampling design, methodology and manuals an Information Needs Assessment (INA) for NAFORMA was conducted. A large number of stakeholders, representing various institutions, organizations and initiatives (GO as well as NGO), were interviewed to get their input on what biophysical and socioeconomic information NAFORMA should provide. The findings of the INA were the starting point for the development of the sampling design and methodology. NAFORMA is therefore grateful to the following organizations and institutions and their dedicated staff for their valuable inputs to the INA for NAFORMA:

- Ministries: MNRT (FBD & Wildlife), Ministries of Agriculture, Environment, Lands, Livestock, Water and Planning and PRALOG;
- Research Institutions: TAFORI, IRA, SUA, REPOA;
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Definitions

Abiotic: Pertaining to the non-living parts of an ecosystem, such as soil particles bedrock, air, and water.

Afforestation: The establishment of a forest or stand in areas where the preceding vegetation or land use was not forest.

Agroforestry: A collective name for land-use systems and practices in which trees and shrubs are deliberately integrated with non-woody crops and (or) animals on the same land area for ecological and economic purposes.

Biotic factor: Any environmental influence of living organisms (e.g., shading by trees, damage by animals) in contrast to inanimate (i.e., abiotic) influences.

Bole height: Bole height refers to merchantable height that is defined as the distance from the base of the tree to the first occurrence of the lowest point on the main stem, above the stump, where utilization of the stem is limited by branching or other defect.

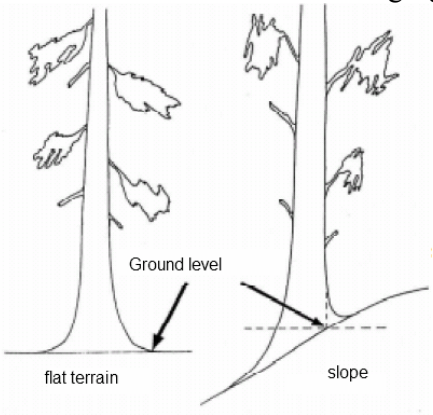
Breast height: Breast height is the height of 1.3 m from the ground level, or if the ground level cannot be defined, from the seeding point. See more explanations and special cases in the section *Tree diameter measurements.*

Dead tree: A tree is regarded as dead tree if it does not have any living branches. Trees that are alive but so badly damaged that cannot grow in the next growing season (e.g. trees felled by storm) are regarded as dead trees.

Edaphic: In ecology *edaphic* refers to plant communities that are distinguished by soil conditions rather than by the climate.

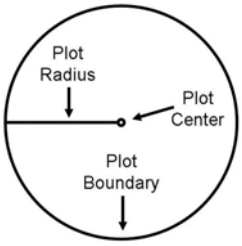
Forked tree: If the forking point is below the breast height (1.3 m), the tree is recorded by giving a unique stem number for each fork, and all stems get the same tree number. If the forking point is above the breast height, a tree is recorded as one stem.

Ground level: Ground level is described as in the following figure.



Living tree: A live tree must have living branches. The tree must be able to survive at least to the next growing season/next year.

Plot radius, centre and boundary: as in the next figure.



Sample tree: A live tree selected for measurements of additional parameters.

Seeding point: Seeding point is usually at the ground level. Trees that grow on the top of a stone or old stump, the seeding point is the point where the seeds have started to grow.

Shrub: Shrubs are woody perennial plants, generally of more than 0.5 m and (usually) less than 5 m in height on maturity and without a definite crown.

Stump height: Stump height is the level of the upper most root collar. If no root collars exist, stump height is expected to be 15 cm from the ground level.

Tally tree: Live or dead standing tree in the concentric circular plot.

Tree: A tree is at least 1.35 m perennial wooded plant with distinct stem capable of reaching 5 meters height *in situ*. Cactuses and palms are regarded as trees in the data collecting phase, but distinguished in the data analysis phase. Bamboos and shrubs are not recorded as trees.

Tree height: Tree height is measured as the distance from the ground level up to the highest point of the tree. If the seeding point is higher than the ground level (e.g. in case where a tree growing on the top of a stone), the tree height is measured from the seeding point. See more explanations and special cases in the section *Tree height measurements.*

1. Introduction

In Tanzania, the state and trends of the forestry resources are largely unknown. The existing information is fragmented and outdated. Reliable information on Tanzanian forest resources is mainly constrained by the lack of institutional capacity. Under the National Forest Programme of Tanzania, the National Forestry Resources Monitoring and Assessment (NAFORMA) was identified as a priority activity for the Forest and Beekeeping Division (FBD). The results of NAFORMA are needed to support the national policy processes for the enhancement of sustainable forest management (SFM) while at the same time addressing issues of Reduced Emissions from Deforestation and Forest Degradation (REDD) and Green House Gas (GHG) as international reporting obligations.

Yet, the demand of the stakeholders in Tanzania for data and information on the state of the forestry resources is continuously expanding. This project is planned to develop complete and sound baseline information on the forest and tree resources, assist the FBD to set up a specialized structure and put in place a long term monitoring system of the forestry ecosystems. The inventory will eventually yield information about vegetation cover, forest resources, forest utilization, and importance of forests and forest product for communities in Tanzania. When the inventory exercise is based on statistically sound sampling design, careful field work, and advanced data analysis, the final inventory report will provide estimates for biomass and carbon in Tanzanian forest lands. This information will serve emerging demands when building up forest monitoring system and international carbon trade schemes.

Proper planning is crucial for the project to meet its goals. This includes preparation of field manual to enable field crews to collect relevant data for the project. The purpose of this field manual is to provide the FBD inventory staff with structured information on the inventory techniques that will lead to the achievement of the intended output.

The manual focuses on:

- Sampling design;
- Measurement practices;
- Biophysical parameters;
- Inventory field forms.

The use of GPS is explained in the separate technical manual. The checklist for tree species codes and names is also published in a separate volume.

This document contains the fieldwork instructions for measurement of biophysical parameters on clusters and concentric circular sample plots of the NAFORMA Project in Tanzania. A separate manual and corresponding field forms has been compiled for the socioeconomic component of NAFORMA (the household survey). The forest inventory system and these manuals are based on experiences of Integrated Land Use Assessments (ILUA) advised by FAO and successfully implemented in several countries worldwide (FAO 2009). In addition to ILUA approach, the NAFORMA sampling design and these guidelines have been tailored using experiences and

practices adopted from other forest inventories, including Finland National Forest Inventory (NFI), India NFI, Laos NFI, and regional forest inventories in Mozambique, Zambia, Turkey, Australia, USA and South-East Asia. The concentric plot design to be used in the NAFORMA is adopted from small scale inventories carried out in several locations in Tanzania (Malimbwi *et. al*. 2005).

Some "traditional parameters" have been omitted from the field forms, because some of them can nowadays be derived with help of other forest or tree parameters, Geographic Information Systems (GIS), digital map data or digital satellite images: for example plot altitude and aspect are derived from Digital Elevation Model (DEM), ecological zone (as FRA Global Ecological Zone) from GIS data and degree of forest degradation is determined using field data (i.e. utilizing species data, canopy coverage, stump data, damages, human impact) and satellite image analysis.

NAFORMA Field Forms dated 1st March 2010 must be used with this document (see Annex 1).

2. Sampling design

2.1. Sampling

NAFORMA sampling design is following a stratified systematic cluster sampling. The sampling design takes account cost estimation and error estimation. The objectives of the sampling design study were:

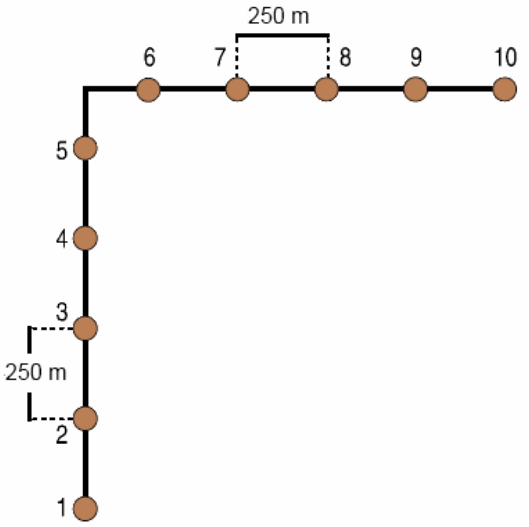
- Further analyze the utility of available remote sensing, digital mapping and inventory data in Tanzania for SFM/carbon pool and carbon pool change estimates and international reporting requirements;
- Study feasibility and provide recommendations on possible alternative sampling and plot designs, including
    - Error estimates;
    - Information comes available also at the district level;
    - Budget and other constraints must be met.
- Recommendations on whether a possible Multi-source Inventory could provide district level forest inventory data for Tanzania.

Three variables (Table 1) are employed in composing the strata, namely

a) time to measure a cluster;
b) mean volume of the growing stock on land on a cluster; and
c) slope.

These sampling strata are different with respect to distance between clusters and number of plots within a cluster. The number of plots in a cluster varies from 6 to 10, depending on the estimated difficulty to access the plots. However, the number of plots is always the same within one stratum. The distance between plots within a cluster is 250 m (Figure 1). The distance between clusters varies by stratum, from 10 to 45 kilometres. All together there are 3 419 clusters and 32 660 plots.

Figure 1. Cluster design



The results of the sampling design study will be reported more detailed in a separate document. The exact locations of sample plots are presented on the inventory field maps.

Table 1. Variables employed in composing NAFORMA strata

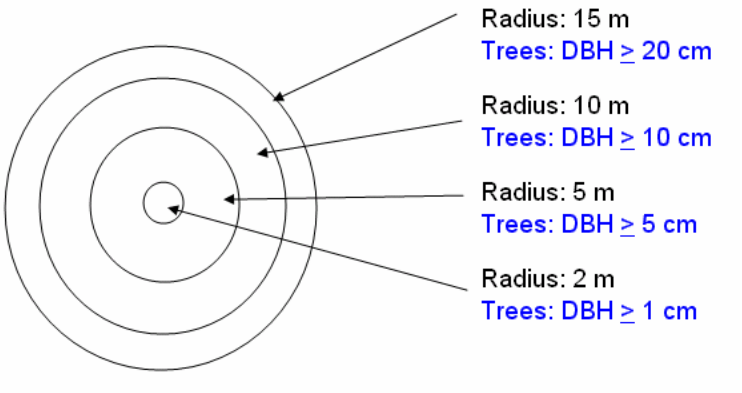
Strata No.	Time (minutes)	Mean volume on land (m^3/ha)	Slope (%)	Number of plots/cluster	Land area represented (mill.ha)
1	0–480	0–27	0<=10	10	83
2	0–480	27<=61	0<=10		
3	0–480	61<=118	0<=10		
4	0–480	118<–	0<=10		
5	480–960	0–27	0<=10		
6	480–960	27<=61	0<=10		
7	480–960	61<118	0<=10		
8	480–960	118<–	0<=10		
9	>960	0–27	0<=10		
10	>960	27<–61	0<=10		
11	>960	61<–118	0<=10		
12	>960	118<–	0<=10		
13	0–960	0–61	10<=20	8	4.6
14	0–960	61<–	10<=20		
15	>960	0–61	10<=20		
16	>960	61<–	10<=20		
17	0–	0–118	20<=slope	6	0.5
18	0–	118<–	20<=slope		

2.2. Sample units

The sampling unit is a concentric circular sample plot (Figure 2). The plots are grouped into clusters for practical reasons in order to take into account the inventory costs. The measurement unit, the cluster, should be as a rule of thumb be measurable within one working day for a field crew. However, for difficult clusters a crew may take more than one day to accomplish the measurements.

Sample plot information is collected in the plot area and observations are also carried out on the area surrounding the plot. Plot information is collected and recorded for example about land use, vegetation type, soil, and forests products and services. Also information about shrubs, regeneration, dead wood, stumps and bamboos is collected. For each tree inside the plot species and breast height diameter is recorded. Every 5th tree in the cluster is selected as sample tree and more parameters are recorded.

Figure 2. Concentric sample plot

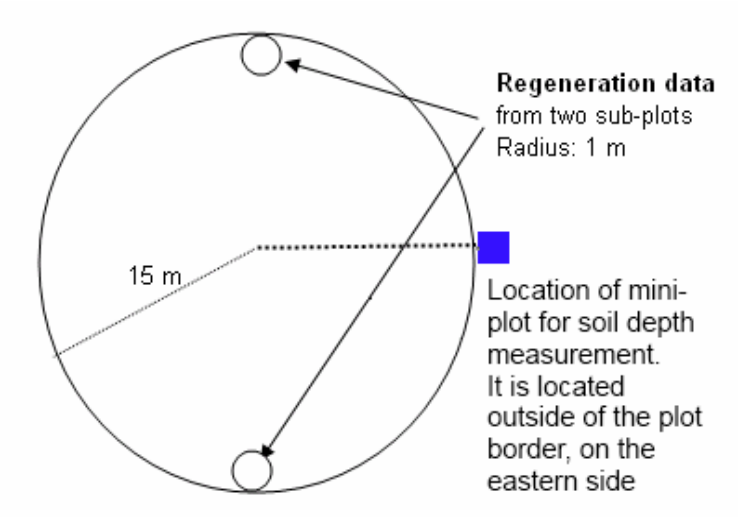


Note: All distances indicated are horizontal distances.

The use of concentric plots in forest inventory aims at increasing the accuracy of the measurement and sampling intensity of large trees, and simultaneously at saving time. Tropical natural forests are characterized with having negative exponential diameter distribution such that there are several small size trees and the number of trees decreases with increasing tree size. The concentric plot design ensures that small trees are measured in small plots and large trees (which constitute most of the biomass per unit area) are measured in large plots. This arrangement results in measuring approximately the same number of trees for the different size classes.

The inventory collects data also about the regeneration and soil. Because the measurement activities in the plot centre point may cause substantial damage to small seedlings in that spot, the regeneration data are collected from two subplots just at the border of outer plot radius, and the soil depth measurements are done outside the plot border.

Figure 3. **Location of regeneration sub-plots and soil sampling in the plot**



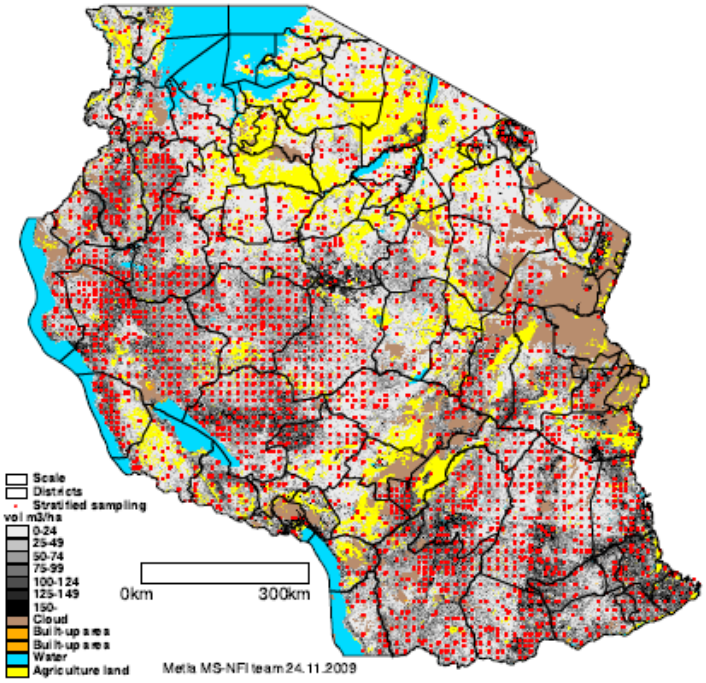
Most of the plot parameters are observed representing the surrounding area. The surrounding area is expected to be to some extent homogenous with the plot area with respect to the land use, vegetation type, accomplished measures and proposed future management. The stand parameters should be estimated as an average of the whole surrounding the plot.

The tally tree measurements are restricted by concentric circular plot. The maximum radius of the plot is 15 m. Every fifth tally tree in a cluster is measured as a sample tree.

Every fourth cluster in stratum is permanent. There are 856 permanent clusters. On permanent clusters GPS measurements are done using high-precision GPS receiver, other measurements and markings are done in such way that remeasurement is possible. Other clusters are temporary.

The scheme for the locations of clusters in Tanzania is presented in Figure 4.

Figure 4. Location of clusters in Tanzania



3. Preparations for the fieldwork

This part includes recommendations to prepare and carry out fieldwork activities. The fieldwork is described step by step for a sample plot, together with recommendations on the data collection techniques.

3.1 Overview of data collection process

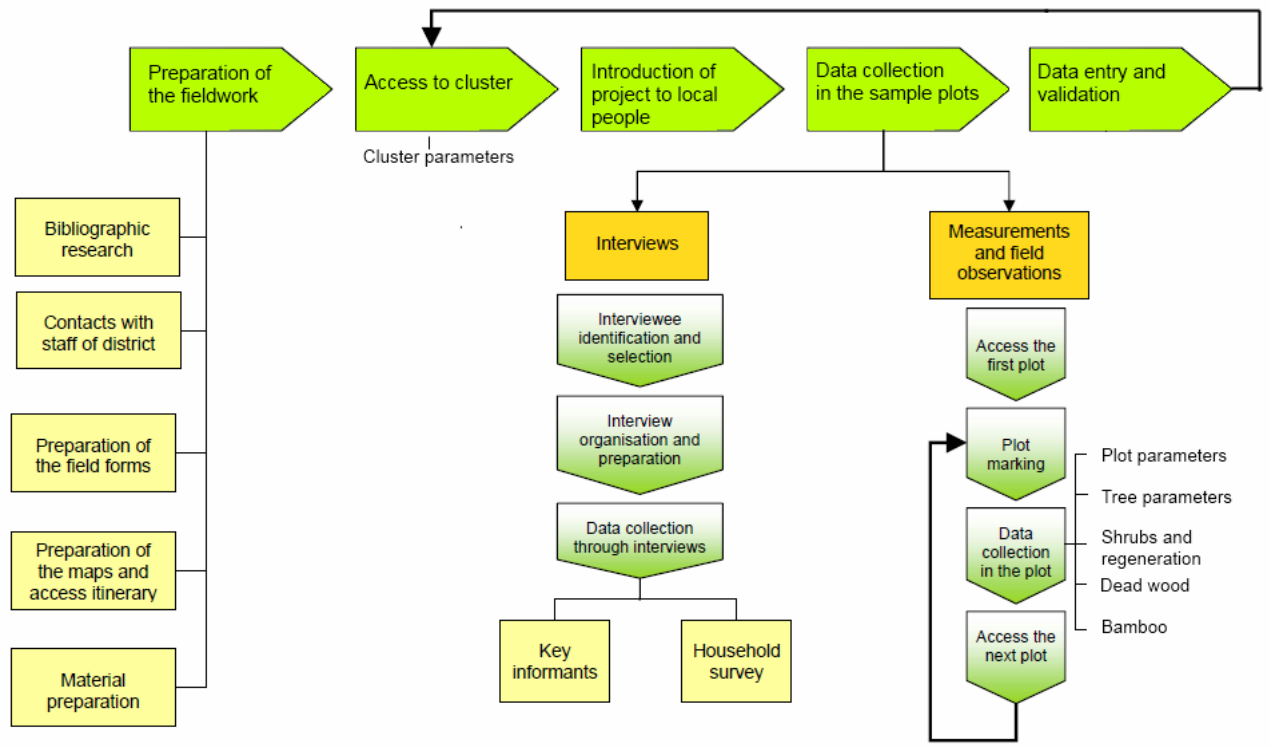
Data is collected by the field crews for clusters and sample plots. The main information sources for the assessment are:

- Field measurements and observations in sample plots and surrounding the plot area;
- Interviews with local people, land owners or users, key external informants such as foresters responsible for the area where the cluster is located and selected households (the household survey– for which a separate manual has been developed).

Those two sources of information imply the use of different methods and approaches that complement each other.

The process for data collection is summarized in next figure.

Figure 5. Data collection procedures in NAFORMA



3.2 Field crew composition

A recommended field crew consists of the following members:

- Crew leader;
- 2 members to biophysical field measurements (enumerators);
- 2 members to socioeconomic interviews;
- Driver;
- Wildlife guard;
- Tree identifier.

Hence the composition of a NAFORMA field crew is at least eight members. Two persons will be dedicated to the interviews carried out in the context of the household survey. One crew member is nominated to act as assistant crew leader. One or two tree identifiers from the local communities should be recruited.

In order to collect information on the various land uses, the field crew will be formed with at least one person familiar in this area of expertise. It is desirable that some members of the field crews are hired locally and act as guides and tree identifiers in the field. The crew leader and/or his assistant should be experienced in participatory interview techniques to collect socio-economic data from local people. Additional persons may be included to improve performance of the field crews when conditions

require greater resources, for example it may be necessary to have a cook in the camp. It is preferable that the field crews include both men and women to facilitate the interviews and it is also advised to include forestry students for capacity building.

The responsibilities of each crew member must be clearly defined and their tasks are proposed as follows below.

The **crew leader** is responsible for

- Organizing all the phases of the fieldwork, from the preparation to the data collection. He/she has the responsibility of contacting and maintaining good relationships with the community and the informants and has a good overview of the progress achieved in the fieldwork; he/she has the responsibility of maintaining harmony and good working spirit within the crew;
- Specifically preparing the fieldwork: carry out the bibliographic research, prepare field forms and collect the maps;
- Planning the work for the crew;
- Contacting local forestry officers, authorities and the community. Introduce the survey objectives and the work plan to the local forestry staff and authorities, and request their assistance to contact the local people, identify informants, guides and workers;
- Administer the location and access itinerary of clusters and plots;
- Taking care of logistics of the crew: organize and obtain information on accommodation facilities; recruit local workers; organize access to the clusters;
- Interviewing external informants and local people;
- Filling in the forms and take notes;
- Ensuring that field forms are properly filled in and that collected data are reliable;
- Organizing meetings after fieldwork in order to sum up daily activities;
- Organizing the fieldworks safety;
- Submitting data for entry into the computer.

The **assistant of the crew leader** will:

- Help the crew leader to carry out his/her tasks;
- Take necessary measurements and observations;
- Make sure that the equipment of the crew is always complete and operational;
- Supervise and orient the workers;
- Take over in the team leader's absence.

The **enumerators** will carry out the field measurements and interviews.

The **temporary helpers** are assigned the following tasks, according to their skills and knowledge of local species, language and practices:

- Help to measure distances;
- Open ways to facilitate access and visibility to technicians;
- Provide the common/local name of forest species;
- Inform about access to the cluster and plots;
- Provide information about the forest uses and management;
- Carry the equipment.

Training of the crews on the survey methodology should be undertaken in theoretical and practical sessions in the beginning of the fieldwork where techniques of different forest and tree measurements, tally of data and techniques of interviews will be explained and practiced. The names and contact details of the crew members and NAFORMA key persons must be written down in field form 7 (Annex 1) for communication in case of emergencies and queries that may arise in the field.

The crew leader is responsible for planning the work schedule in an efficient way. In the field, crew leader locates the plot centre coordinates, defines the surrounding area, records time for time study, determines slope corrections on sloping areas and records tree measurements. The crew leader is responsible for the quality of the work of crew members.

The crew members measure slope percentage, regeneration (i.e. number of seedlings), tally and sample trees, dead wood, and stumps. They also take tree measurements.

Above description is simply the normal way of working, but it is not necessary to follow it exactly. Seedlings, sample trees and dead wood etc. can be measured by any crew member who is free to do it.

3.3 Preparations

The preparation of fieldwork consists of the following phases:

A. Bibliographic research;
B. Contacts to districts and local communities;
C. Preparation of the field forms and maps;
D. Field equipment (maintenance, checking).

A. Bibliographic research

In an ILUA, auxiliary information is necessary to prepare the field survey and carry out the interviews. Existing reports on forest and natural resource inventories, farming systems, national policy and forestry community issues, local people, etc. have to be studied to enable the crew members to understand and to build better knowledge on the local realities. If a target cluster is located in plantation forests, the forests' history and management plans needs to be examined, especially planting year and time of previous treatments are important details to be found. In many cases *Land use* and *Forest ownership* needs to be studied before going to the field.

B. Contacts

Each field crew, through its leader, should start its work by contacting key staff in the District in order to get information and access to the area where the clusters are located. These local staff may help contacting the authorities, community leaders and land owners in order to introduce the field crew and its programme of work in the area. The local staff may also provide information about access conditions to the site

and about the people who can be locally recruited as guides or workers. They may also inform the local people about the project.

An introduction letter to district and village governments should be written by the Permanent Secretary, asking for support and assistance for the field crews.

C. Preparation of the field forms and maps

The National Project Coordinator will ensure that the necessary field forms to cover the clusters are prepared and assigned to each crew. For each cluster there are 6 different field forms, of one or more pages are needed. The forms are described in details in Chapter 5.

The use of secondary data sources, particularly maps and existing management plans, is necessary to determine information such as names of administrative centre (administrative maps), accessibility and forest ownership. Some sections of administrative data in the form may be filled in during the preparation phase, and be verified in the field.

The crew leader must ensure that enough forms are available to carry out the planned field data collection.

Maps and printed aerial photographs/satellite images covering the study area should be prepared in advance to help the orientation in the field. These may be enlarged and reproduced, if necessary.

Prior to the field visit, each crew must plan the itinerary to access the cluster, which should be the easiest and least time consuming. In fact this should be done the previous day before visiting the cluster. Advices of local informants (local forestry staff, for example) are usually valuable and help saving time in searching the best option to access the cluster.

The cluster and plot locations will be delineated on topographic maps and eventually on aerial photographs/satellite images, if available. The plot locations in the cluster are to be indicated together with their respective coordinates in the UTM (datum Arc1960) as well as in latitude/longitude.

An enlarged section of the map corresponding to the area surrounding the cluster will be prepared (photocopy or printed copy) and used to draw the access itinerary to the first plot.

The plot order for data collection may vary according to conditions of accessibility. It is determined during the preparation phase.

Reference objects (roads, rivers, houses) that contribute to the better orientation of the crew in the field should be identified during the planning phase.

The numbers of the sample plots are entered into the GPS receiver according to following: (five digits cluster number) + "P" (=Plot) + (two digits Plot number), e.g. for cluster 243, plot 3: 00243P03.

D. Field equipment per crew

The equipment needed by each field crew are described in the following table

Table 2. Equipment by field crews

Equipment needed	Number required	Comments
Measurement tools		
Compass (360°)	1	In degrees Water proof model
GPS receiver (Geographic Positioning System) and extra batteries + charger	1	If some cases the combination of GPS receiver and PDA device with Bluetooth connection
Measuring tape, 20 m	2	Metric
Measuring tape, 50 m	1	Metric
Diameter tape / Caliper	1	mm scale
Tree height and land slope measuring equipment	1	Suunto hypsometer with 15m, 20m and % scales to measure both tree height, in meters, and slopes, in percent
Spherical densitometer	1	Canopy coverage measuring equipment. Concave model.
Coloured flagging ribbon	Several rolls	
Waterproof bags to protect measurement instruments and forms	As necessary	
Soil auger	1	
Plastic packs for soil samples	As necessary	For soil samples in PSP clusters/plots only
Plastic basin	1	For soil samples in PSP clusters/plots only
Spade	1	
Digital camera, extra memory card, extra batteries, and charger	1	
Machete / Bush-knife	As necessary	
Pocket knife	1	
Colour spray	1	For marking of trees on PSPs
Clothing		
Boots and waterproof outfits	For permanent team members	
Helmet	For permanent team members	Optional, for are where there are risks for branches to fall
Documents, papers		
Field forms	As necessary	
Field manual	As necessary	

Flora and species check list	As necessary	
Munsell Soil Colour Chart	1	
Topographic maps, field maps and printed aerial photo/satellite image	As necessary	
Pens and markers	As necessary	
Supporting board / writing tablet	1	To take notes
Hand calculator	1	
Clipboard	2	To take notes
A4/A3 size flipchart	1	For photo identification
File	1	
Newspapers	As necessary	For collection of samples (plants/ leaves)
Other equipment (camping, security, communication…)		
Mobile phone	At least 1	
Radio phones	1+1	One for the field team, one for the driver
First aid kit	1	With phone numbers of hospitals / emergency
Flashlight and batteries	As necessary	
Camping equipment and cooking utensils	1	Food and water as required

The list of equipment is specified by measurement type in the following table.

Table 3. Equipment by measurement types

Measurement type	Equipment required
CLUSTER, PLOT	
Plot locations	GPS, maps, list of plot coordinates
Area determination	50m measuring tape, slope correction table
Plot border marking	Coloured flagging ribbon, metal/wooden poles
Slope	Suunto hypsometer with clinometer
Photo documentation	Digital camera, flipchart
Canopy coverage (Trees)	Spherical densiometer
Soil depth	Spade
Soil colour	Munsell Soil Colour Chart
Soil texture	*See guidelines and Annex 3.*
Soil sample	Plastic packs, marker pen
TREES	
Species code and name	Species check list
Tree diameter	1.3 m stick; Diameter tape or caliper
Stump diameter	Diameter tape or caliper
Tree height	Clinometer, 20/50m measuring tape
Bole height	Clinometer, 20/50m measuring tape
Stump height	Measuring tape or caliper
Marking of 3 closest trees to plot centre	Spray paint
DEAD WOOD	

Species code and name	Species check list
Dead wood diameters (2)	Diameter tape or caliper
Dead wood length	20/50m measuring tape
Decay class	Pocket knife
SHRUBS AND REGENERATION	
Shrub coverage	If applicable use spherical densiometer
Mean shrub height	If applicable use Suunto hypsometer
Number of seedlings	1 m stick
BAMBOO	
Species code and name	Species check list
Bamboo average diameter	Diameter tape or caliper
Bamboo average height	Suunto hypsometer

4. Vegetation classification

The vegetation classification adopted in the Tanzanian NAFORMA is mainly adopted from Hunting Technical Services (1995) map (called as *Hunting map* here in the text) with few modifications to reflect actual ground conditions that are noticeable in the map. The classification embraces eight land cover types, four of which are dominated by natural vegetation. These classes together with *Cultivated land* occupy the major part of the land area of Tanzania.

The eight land cover types are sub-divided into 28 sub types, of which 16 are mainly natural vegetation. Four are sub-divisions of *Cultivated Land*, the remainder being largely un-utilized areas or water features.

The preferred and final classification for land cover is purely physiognomic in nature. Essentially, this means that discrimination between types and sub-types is directed by relative appearance in terms of stature, stratification, canopy closure and the relative composition of the three major layers of trees, shrubs/bushes, and grasses/herbs.

In this section, the distinction between the eight land cover types is addressed. Whereas the levels of discrimination between the major land cover types were quite clear in the original *Hunting map*, this was not the case between the sub-types. In the current classification, some of the less clear sub types have been dropped or merged into more distinctive types. For example the *inundated* sites are only noticeable in the wet season. If the survey is carried out in the dry season this feature becomes difficult to notice. Inundated sites therefore have been dropped in the current classification. Similarly *unspecified* density is considered to be ambiguous and hence also dropped. Each type is described in terms of its natural physiognomy in the proceeding paragraphs. The detailed summary of the vegetation classification is presented in Annex 4.

LAND COVER TYPES

FOREST

A continuous stand of trees many of which may attain a height of 50 m. Species composition is quite different from that of the woodland except in areas where Forest has been disturbed and pioneer species dominate temporarily. The most important discrimination concerns the structure of the stand. True high forest has three canopy layer; emergents, middle and lower canopy. The main canopy of semi-mature and mature trees dominates the structure, with a regenerative canopy beneath. Occasional emergents or "rogues" forms the uppermost, but fragmented third canopy. These layers are ecologically important. They constitute the diversity of the cover types and provide a wide variety of habitat for many species of mammals, birds, insects, reptiles and amphibians. Forests are further characterized by the presence of lianas, climbers and creepers, and also epiphytes including ferns and, occasionally, orchids.

Forest is normally regarded as an ecological climax but this is not always so. Certain climatic and (to some extent) edaphic conditions are required for its full development.

In Tanzania, Forest normally occurs at altitude, where precipitation and the recycling of nutrients under conditions of rapid decomposition are sufficient to sustain the structure. Forests also occur at lower elevations where water table levels and micro-climate conditions allow the persistence of tree species. Forest has four subtypes**: 1)** *Humid Montane*, 2) *Lowland*, 3) *Mangrove* and 4) *Plantation*.

Image 1. Semi-evergreen lowland forest, Kitulangalo

WOODLAND

This constitutes the largest vegetation type in Tanzania. The woodland has three subtypes: *Closed* (>40%), *Open* (10–40%) and *Woodland with Scattered Cropland*. The canopy coverage in woodland ranges between 20–80%, and height between 5–20 m although occasionally being taller. Wet woodland is dominated by *Brachystegia/Julbernadia sp.* (Miombo woodland). Dry woodland is usually dominated by *Acacia.* The distinction between *Closed Woodland* and *Open Woodland* is made at a perceived canopy closure of 40 percent. One essential feature is that the trees should possess recognizable stems, normally single, that may be measured for both diameter and height. This infers the presence of a marketable timber product, which may be important for the future development planning.

Woodland is characterized by only two main strata - the main canopy itself, which may vary widely in species composition but is generally uniform in stature, and a shrub / herb-layer beneath, which often contains regenerating saplings of the species comprising the main canopy. The density of this understorey layer is closely dependent upon the closure of the upper canopy and light penetration to ground level. In areas of *Closed Woodland*, the ground cover layer may be almost absent. Most woodlands are deciduous. Therefore the best time to choose satellite imagery is May-July when rains have stopped and the trees are in full flush.

Image 2. Closed miombo forest

BUSHLAND

Bushland differs from Woodland in two principal ways. Stature is less, rarely exceeding 5 m and normally between 1–3 m in height. Single-stemmed plants are almost nonexistent. The exception is when there are occasional trees termed as emergents. Bushland is fundamentally defined as being predominantly comprised of plants that are multi-stemmed from a single root base.

Bushland is one of the most varied types with six sub-divisions. The six subtypes of bushland are as follows: *Thicket*, *Dense bushland*, *Bushland with scattered cultivation*, *Bushland with emergent trees*, *Thicket with emergent trees* and *Open bushland*. Bushland also occurs in a wide range of densities. As *Dense bushland* or *Open bushland*, this may be merely temporary, as it often forms little more than a fallow stage in shifting agricultural or charcoal production areas. Given time the cover may change to a Wood land or Forest. A typical example of bush land as a result of charcoal production is Bwawani beside the Dar es Salaam-Morogoro road. However as Thicket it may be argued a local climax. The best example is the Itigi thicket where, ecologically this vegetation is not expected to change. Both thicket and bushland may be interrupted by cropland.

Image 3. Thicket

Image 4. Thicket with emergents

GRASSLAND

Grassland is another type possessing marked variety, with four sub types. Open Grassland, is mostly confined, to the plains of the Serengeti, Masai Steppe, and to alpine areas of the Southern Highlands where exposure and edaphic conditions do not allow the natural development of anything more than a grass or herb. For the most part, this type occurs as its Sub-types in combination with either a limited Wooded or Bushed component, or with scattered subsistence cultivation. In addition, many areas mapped as grassland may be associated with seasonally inundated areas referred to as "*Mbuga*", but a term deliberately avoided within the classification and legend. *Wooded grassland* and *Bushed grassland* both comprise an assessed ground cover percent of trees or bushes below 10 percent of total. The grassland sub types are: *Wooded grassland*, *Bushed grassland*, *Grassland with scattered cropland*, and *Open grassland*.

Image 5. Alpine grassland of Southern Tanzania, Makete district

Image 6. Wooded grassland

CULTIVATED LAND

Four sub-types are recognizable within the *Cultivated land* type. The physiognomy varies widely in accordance with the significance of the tree and crop component associated with each unit. The agroforestry systems whereby contain permanent tree crops (timber and fruit) which are mixed with permanent and annual agricultural crops (yam, beans, banana, coffee, etc) such as the *Chagga*, *Meru* and *Haya* (*Bukoba*) home gardens are recognized as one sub-type. The tree crops (*Gravillea, Albizia, Cordia, Citrus, Acrocarpus,* etc) which form the upper canopy act as shade to the lower canopy crops (banana, coffee, beans). Cultivation with herbaceous crops (e.g. maize, sorghum, millet, sugar cane, sisal, rice) where the tree component may be reduced to the occasional fruit tree or trees retained to demarcate field boundaries is a sub-type that approaches open grassland. At the other extreme, cultivation with pure woody crops of cashew, tea, coffee, mango, citrus, jackfruit and coconut are common and identifiable as a sub-type. The last sub-type is where the woody crops are mixed in varying proportions such as the area between Mlandizi and Dar es Salaam. Such areas normally contain mixed fruit tree species such as mango, coconut, citrus and cashew.

The physiognomy approaches a *Closed woodland*, or *Woodland with scattered cropland*. The sub-types for cultivated land are therefore: *Agro-forestry systems*, *Cultivated land with wooded crops*, *Cultivated land with herbaceous crops* and *Cultivated land with mixed tree cropping*. Here the role of the trees as shade provider is diminished.

Image 7. Cultivated land with mixed tree cropping

OPEN LAND

There are four Open Land sub-types included in the classification as follows: *Bare soil*, *Salt crusts*, *Rock outcrops*, and *Ice-cap/Snow*. The common feature is that the vegetation cover is almost or entirely absent in each case, although many rock outcrops often bear small pockets of xerophytes that are botanically very interesting. These units are not represented extensively upon the maps. *Bare Soil* type may be more widely represented, but is generally confined to the larger lake shores and the sandy coastal lines.

WATER FEATURES

Water Features include the Indian Ocean and the great lakes of Tanzania. Inland water bodies are recognized to the level of the minimum mapping unit (equivalent to about 100ha). The third sub-type is Permanent swamp/marsh, and this unit is quite extensive, particularly in the western part of the country (in the shallow catchments feeding Lakes Tanganyika and Rukwa) and in the east, in the floodplains of the Ruvu and Ruaha Rivers. Such swamps may bear varied vegetation. Grasses may be present, but sedges and rushes predominate. Occasionally, *Papyrus* occurs in almost pure stands.

OTHERS

These include urban areas, air fields and other infrastructure (e.g. power line, railways, and mining sites). Urban areas contain considerable wood biomass which is often forgotten in carbon stock estimations.

Image 8. Wood biomass in urban areas, Dar es Salaam

5. Data collection in the field

5.1 Introduction of the project to local people

If the cluster area is inhabited, the crew must establish contact with local people and on arrival to the site, meet with contacted persons and others, village representative, closest government institution in place, owners and/or people living in the cluster area. In many cases, it will be necessary to contact the local population before visiting the area in order to inform them about the visit and request permission to access the property. An introductory meeting may also be organized.

The crew must briefly introduce and explain the aim of the visit and study. A map or an aerial photograph/satellite image, showing the target inventory area, may be very useful to facilitate the discussion. It is important to ensure that both local people and the field crew understand which area will be studied. The aim of the NAFORMA must also be clearly introduced to avoid misunderstandings or raise false expectations. Cooperation and support from local people are essential to carry out the fieldwork. It is easier to achieve this support if the first impression is good. Nevertheless, it must be stressed that the fieldwork consists only of data collection and not local development or law enforcement project. Some key points about the project introduction are mentioned in Box 1.

Key points to be stressed during the presentation of the project to the local people are as follows:

- An objective of this study is to collect data on land uses to support national decision making by interacting with the local users. The collected land use information will be used by the country and the international community. The objective is to generate reliable information for improved land use policies that takes into account people's reality and needs. Hopefully, this can lead to natural resources being managed in a sound and sustainable way. It could help also in the mitigation of the poverty.
- This project is part of a programme for land use data collection over the whole world.
- The data are collected from two sources:
  (1) Measurements of the forests and trees outside the forests and other land use practices;
  (2) Interviews with local communities using land including forest users and other people who are knowledgeable of the area. Measurement examples to be mentioned may be: tree diameter and height, as well as forest species composition. Data on agricultural cropping system, water, pest, energy source and livestock will be collected by interviews. The field crew should equally be interested in the local people's perception on land use changes, the main products extracted from land, land use related problems, and will therefore interview land users.
- The clusters where the survey will be carried out are distributed throughout the country.

- Some or all of the clusters/plots surveyed in the country will be monitored in the future, with the aim of assessing land use changes and development of forest resources.

5.2 Access to plot

The plots locations will be pre-drawn on the topographic maps (and aerial photographs/satellite images, if available). Reference coordinate system coordinates with grid are also drawn on satellite image maps.

At the place of leaving the vehicle, the coordinates of the departure time and location on foot towards the first plot must be read on GPS and filled into the Cluster Form.

Orientation in the field will be assured with the help of a GPS where the locations of each plot are registered as waypoints. A local guide will be useful to access the plots more easily. If plot centre cannot be accessed using GPS e.g. due to dense canopy coverage, the crew must record coordinates in the closest available position and then measure the remaining distance to the plot centre point with help of the compass and measuring tape. In this case, the team leader records the distance and direction into the Plot Form.

The plots can be measured from 1 to 10, or in the reverse order; this is decided during the preparatory phase. However, the crew should follow the original plot numbering when recording the data into the forms.

5.3 Selection of tally and sample trees

Tree number, *stem number* in case of a forked tree, *species name* (and dialect), *DBH*, *Heath* status and *Tree Origin* will be recorded of **all trees**. Trees are selected and measured in each plot in the following manner:

i) Within 2 m radius: all trees with DBH ≥ 1 cm will be recorded;
ii) Within 5 m radius; all trees with DBH ≥ 5 cm will be recorded;
iii) Within 10 m radius; all trees with DBH ≥ 10 cm will be recorded;
iv) Within 15 m radius; all trees with DBH ≥ 20 cm will be recorded.

A tree is in the plot, if the estimated centre point of its base is inside the plot boundary. Plot radii are corrected on slopes steeper than 5 percent (read more in the section *Slope correction*).

All trees within the subplot's borders are recorded, both live and dead trees. Cactuses and palms are recorded as trees. Information about bamboos is filled into the Bamboo Field Form.

The data collection starts at the plot starting point and continues from the north in clockwise direction.

Every 5th tree **in the cluster** is selected as a sample tree. If the 5th tree is a dead tree, then the next live tree is selected as a sample tree. The crew measures the following parameters from the sample trees: stump diameter, stump height (default=15 cm above ground), total tree height and bole height (for trees DBH≥20 cm). In order to facilitate the finding of sample trees, these are flagged with coloured ribbon, as the field crew advances.

Note: Bole height is **measured** for each sample tree DBH≥20 cm, but **estimated for every tally** tree where DBH≥20 cm. Bole height refers to merchantable height that is defined as the distance from the base of the tree to the first occurrence of the lowest point on the main stem, above the stump, where utilization of the stem is limited by branching or other defect.

All bamboo clumps occurring in the plot will be serially numbered and separate series of numbers will be used for each different bamboo species.

5.4 Marking of trees

In a permanent sample plot which is located in Forest or Woodland vegetation types, the field crew marks the 3 closest trees to the centre point with a painted dot. The selected trees must be greater than 10 cm of DBH, and they must be alive. The dot is painted or sprayed at the stump height level to the side toward the plot centre point. The appropriate diameter of the dot is 2–3 cm. The marked trees are ticked off as *Marked* in the Tree Form.

5.5 Tree diameter measurements

Tree diameter is measured over bark, at 1.3 m breast height above the ground with the exception of particular cases mentioned below. Measurement may be carried out using the diameter tape or with the use of the caliper. Both devices should have metric scale and the smallest unit in millimeters. Diameter is recorded in centimeters with one decimal digit (millimeter). If a caliper is used, the measurement is always carried out at right angles to plot's centre point (Figure 6), also for non-circular shape trees. If a tree is leaning in flat terrain, the measurement point is at that side where tree leans (Figure 7). Make sure the caliper tightly holds the stem, in order to prevent the caliper clasps from grasping without compressing the bark.

If the diameter tape is used, make sure it is not twisted and is well stretched around the tree in a perpendicular position to the stem. Nothing must prevent a direct contact between the tape and the bark of the tree to be measured.

Note: All tree diameters on the permanent sample plots should be recorded using the diameter tape.

Figure 6. Measurement of DBH with caliper

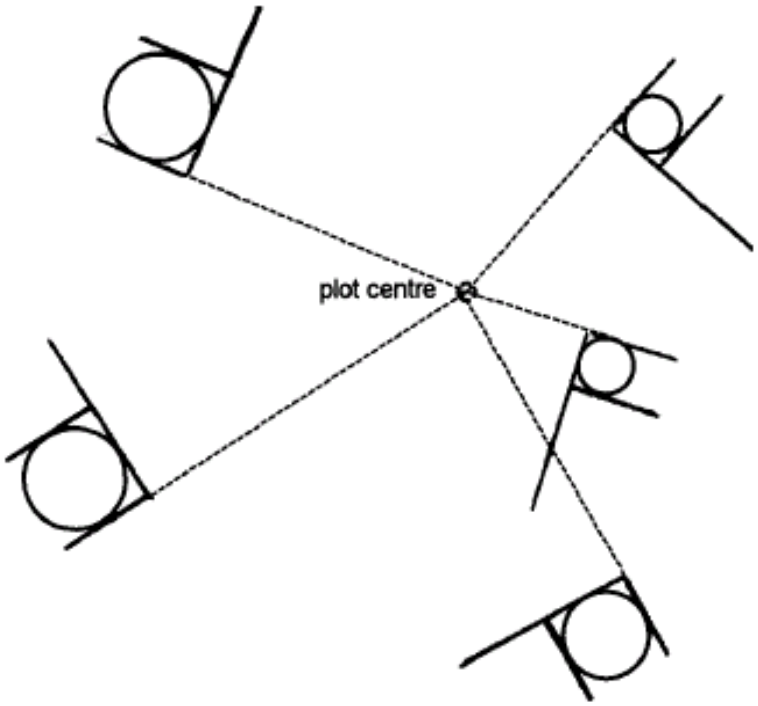
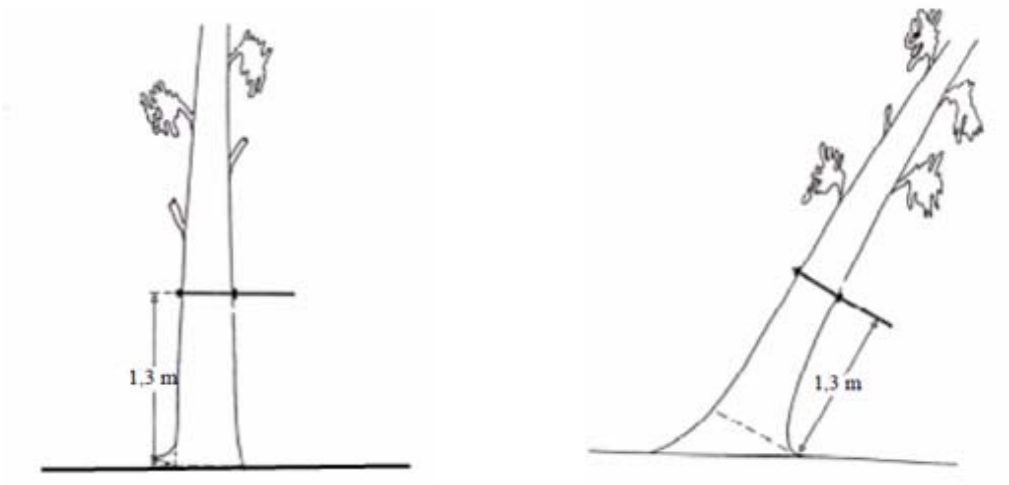
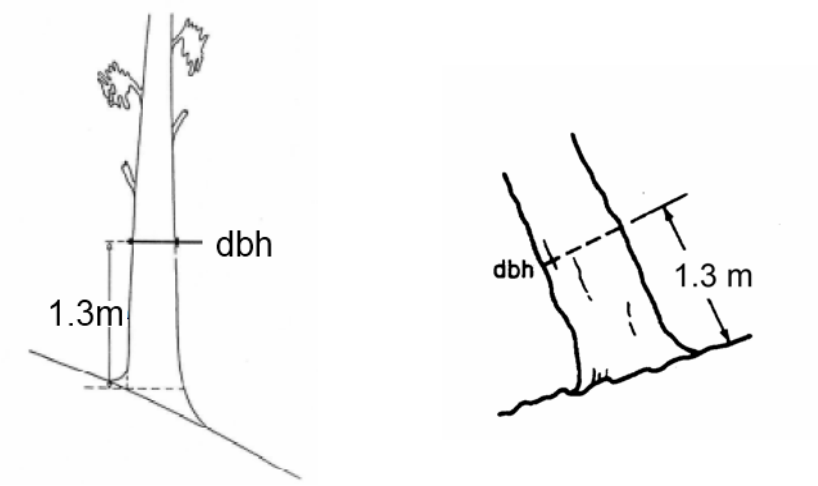


Figure 7. Diameter measurement in flat terrain



When a tree is growing on slope, the measurement point is located at the upper side of slope. This is also the rule for a leaning tree on slope (Figure 8).

Figure 8. Diameter measurement of trees on slope



There are several cases where a **forked tree** exists. The first thing is to determine the point where the tree forks.

1) If the fork originates (the point where the core is divided) below 1.3 m height, each stem reaching the required diameter limit will be considered as a stem to be measured, and the diameters is measured at 1.3 m height.
   On field form the first measured fork is recorded with a new tree number, and then all other forks get the **same tree number but a running stem number**, as follows:

Figure 9. Recording of tree and stem number of a forked tree

Tree No.	Stem #	Species code	Species name (+
1		102	
2	1	111	
	2		
	3		
3		112	
4		112	

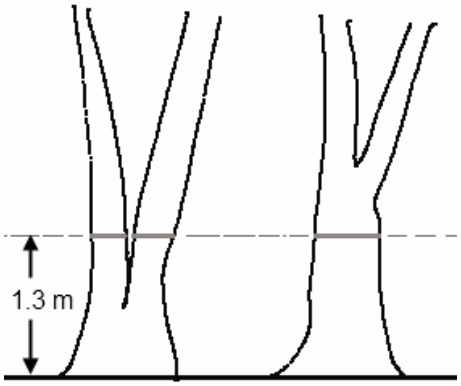
Note: In this field form tree number 2 is a forked tree with 3 stems (forks) to be recorded. Tree number and species are recorded only once, but unique stem number is given for each fork.

A living stem can be a sample tree. For a forked sample tree record the stump diameter at the default stump height level (15 cm above ground). This stump diameter usually refers to the stump diameter of the whole tree. If a forked

sample tree originates below 15 cm, then write a remark to that stem as '***fork below 15 cm***'.

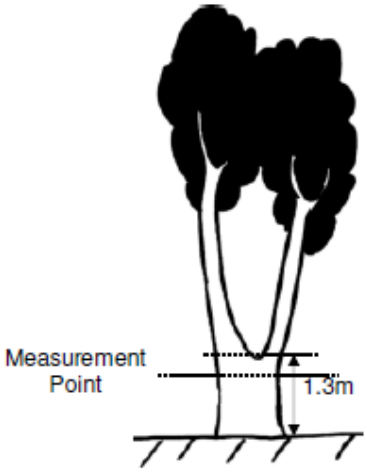
A fork can be dead or alive. Record this information into *Health* status.

Figure 10. Diameter measurement points for a forked tree



2) If a fork originates at 1.3 m or a higher, the tree will be counted as a single tree. The diameter measurement is thus carried out **below** the forks' intersection point, just below the bulge that could influence the DBH.

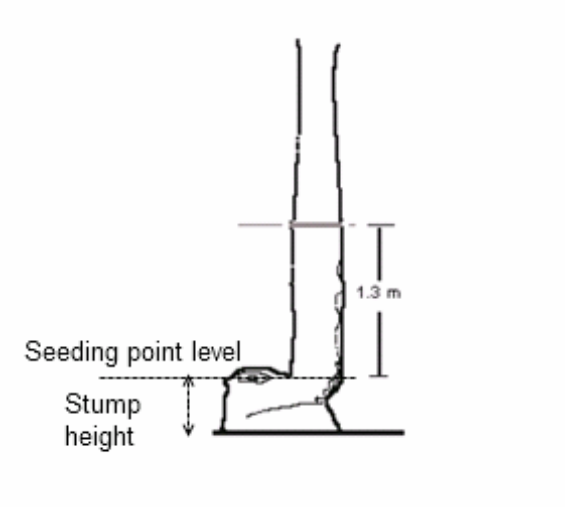
Figure 11. Examples of forks' intersection at the 1.3 m height



Coppice tree: Coppice shoots considered similarly as forked trees. The measuring height is 1.3 m above the seedling point.

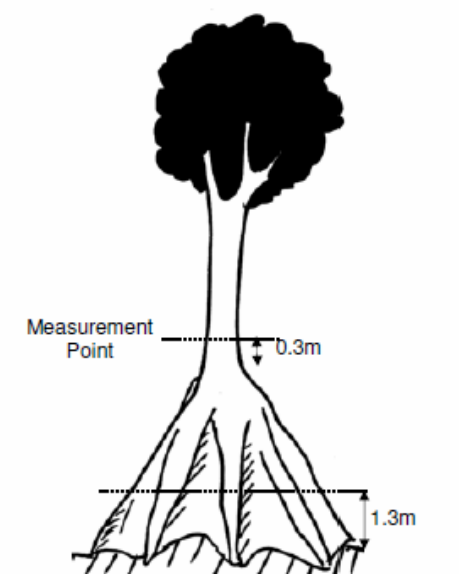
Record also the stump height (cm) for each coppice shoot. This is the height of the estimated level where the shoot originates.

Figure 12. Diameter and stump height measurements of a coppice tree



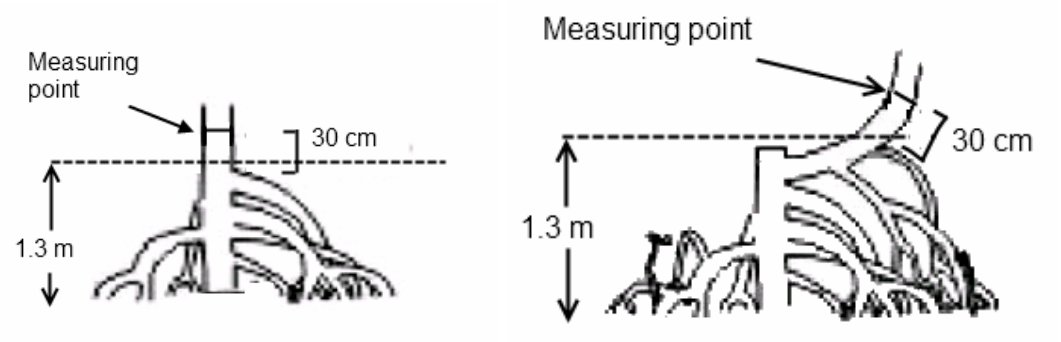
Trees with an enlarged stem base or buttressed tree: diameter measurement is made at 30 cm above the enlargement or main width of buttress, if the buttress/enlargement reaches more than 90 cm height above the ground (see Figure 13).

Figure 13. Diameter measurement of a tree with large buttress



Trees with aerial roots exceeding 130 cm from the ground: diameter is measured 30 cm above the upper root (see Figure 14). Among *Rhizophora* genus (mangrove) there are some species of which usually contain prop roots above 130 cm from the ground. Some upper roots are well established in the mangrove mud, while others have just started forming, or are formed from within the canopy. Therefore only roots originating from the central stem and touching the mangrove soil or permanent water body are considered, when pointing out the 'upper root'.

Figure 14. Diameter measurement of a tree with aerial roots

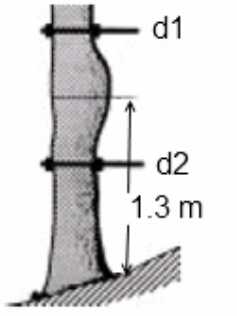


a) Growing mangrove stem b) Cut mangrove stem

Trees with irregular shape at 1.3m level

Trees with bulges, wounds, hollows and branches, or other reasons causing irregular shape at the breast height, are to be measured above and beneath the deformation, and the average of both is the calculated as DBH of the tree (Figure 15).

Figure 15. Diameter measurement of deformed trees



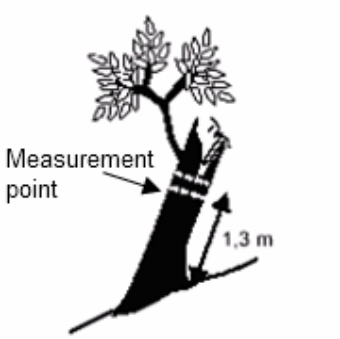
$$DBH = (d1 + d2)/2$$

Other special cases

The diameter of a tree with a horizontally protruding stem should be measured 130 cm along the stem, even if this is less than 130 cm above the floor.

A case of damaged and broken stem where the DBH measurement is done below 1.3 m is presented in Figure 16.

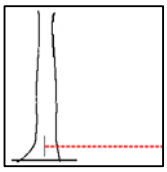
Figure 16. Diameter measurement of a damaged and broken stem



5.6 Tree height measurements

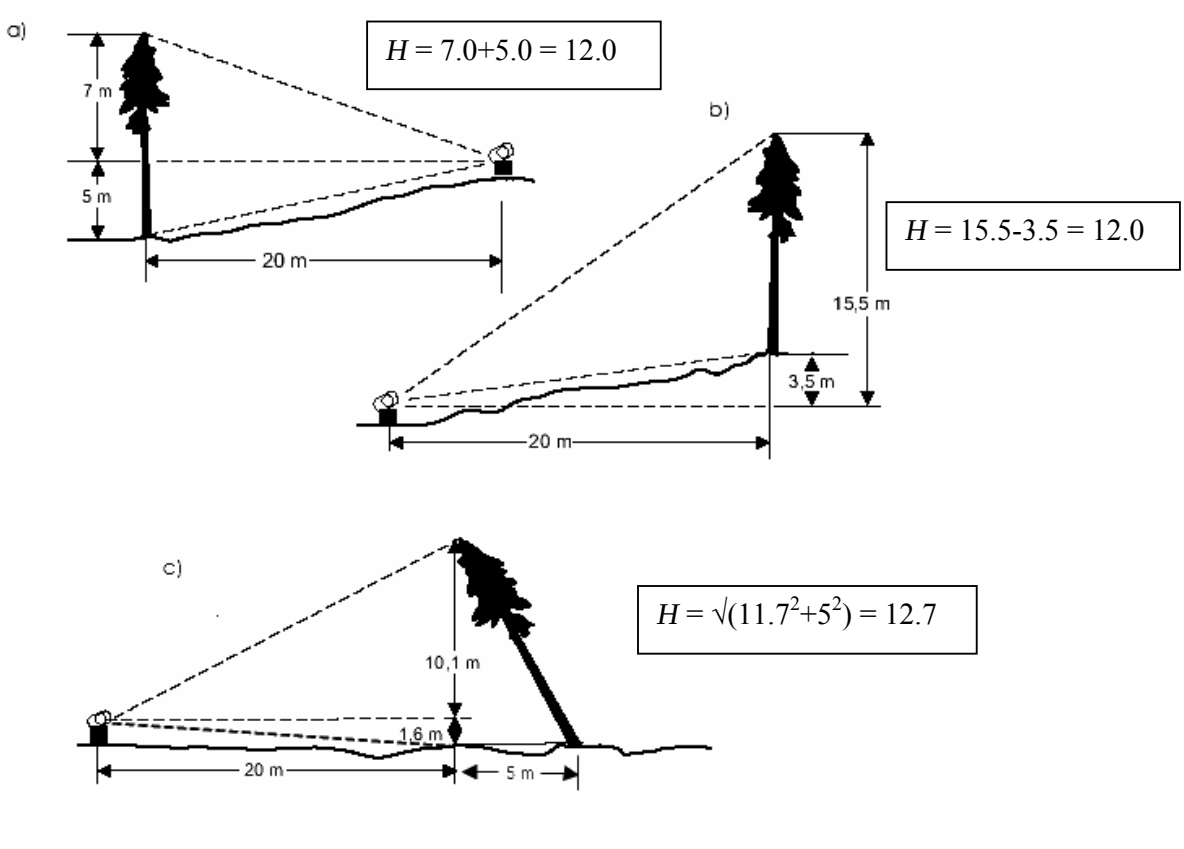
Tree height measurement may be carried out by means of several instruments such as: dendrometric table, Blume-Leiss, Suunto, Haga, Bitterlich relascope. In the NAFORMA, Suunto hypsometers are in use.

A height measurement is done in the following stages:



1. Measure 20 meters horizontal distance to the tree:
   - If tree top is at the same vertical line with the base of the tree, measure the distance from the middle of the tree base;
   - If the tree leans, follow the rule presented in Figure 17c;
2. Observation to the top of the tree;
3. Observation to the base of the tree;
4. Addition or subtraction of the results of these two observations as follows:
   - addition if the operator is focusing downwards to the base of the tree (see Figure 17a);
   - subtraction if the operator is focusing upwards to the base of the tree (Figure 17b).

Figure 17. Tree height measurements



Note: You can get the height of a tree

a) By adding the results above and below the horizontal measurement (7.0+5.0)*;*

b) By subtracting from the total the difference between the base of the tree and the horizontal line (15.5-3.5);

c) By applying the Pythagorean theorem. Measure first the height of the tree top, then measure the horizontal distance from the stump point to the top point projected on the horizontal level. Apply equation: H= $\sqrt{(\text{Height}^2+\text{Distance}^2)}$

5.7 Dead wood measurements

Dead wood are tree parts that are lying on the ground. The field crew determines dead wood parts which are inside the plot area (within the radius of 15 m). The length and diameter at **both ends of all pieces** of fallen wood with diameter larger or equal than 10 cm within the plot area measured.

Tree species of dead wood is detected, if possible. Lianas, bamboos, cactuses and palms are included to the dead wood if they exceed the given diameter limit.

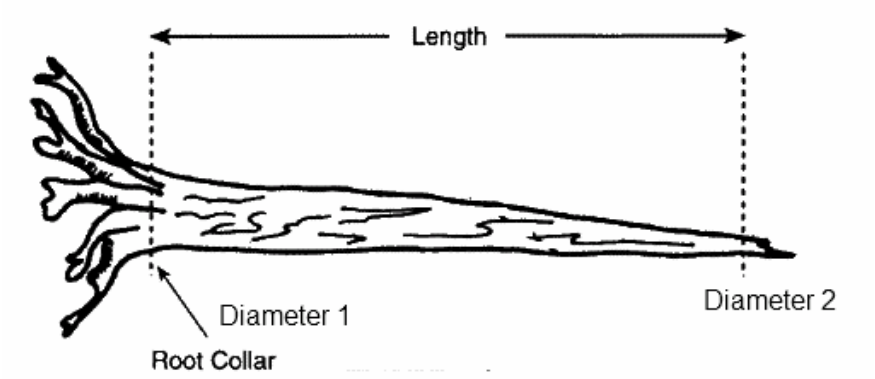
Two diameter measurements are carried out: the first measurement in the base part of the stem (or branch), the second in the other end (Figure 18). The diameters are measured over bark if bark still exists; otherwise without bark. For measurements at the bases of fallen, buttressed trunks, diameters are measured above the buttress. The total length of the stem is also recorded.

Measurements of length are made to the plot border. Hence when a stem crosses the plot border, the length is measured to/from that limit where the stem's centre line crosses the border.

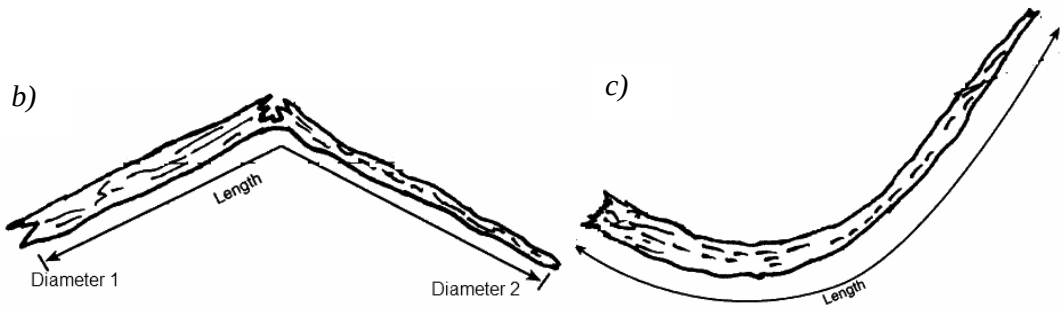
If a part of laying stem has been removed from the plot (e.g. for making charcoal), the remaining main wood particles are recorded if they are equal or exceed diameter of 10 cm. If there are several dead trees or dead wood parts on the plot (as braches), then the recorder can tally the estimated mean dimensions of dead wood and give the total number of stems/parts.

Figure 18. Dead wood measurements

a)



Note: Record this type of dead tree into two forms: *Dead Wood* data (Form *5a)* and *Stump* data (Form *5b*). Stump diameter is equal to *Diameter 1* in the figure above.



Decay class is detected applying two classes: solid wood or (partially) rotten wood. This can be detected by as pushing a knife into the wood. Decay class is used when we compute dead wood biomass and carbon: rotten coarse woody debris has lower density value than a solid wood.

A dead laying stem can contain the stump part with some roots. In case of a broken dead tree the stump can be located in the plot. In both cases the stump data is recorded into the Stumps section on the field form **5b** and the text 'Dead wood' is written into the field 'Possible use'.

5.8 Soil sampling procedures

Soil information is increasingly required as part of the forest ecosystem and carbon reporting. Soil physical properties that are relatively easy to describe in the field include **soil depth, soil texture, soil colour, soil structure** and soil surface features (FAO, 2006). In the NAFORMA, main surface features of landforms (e.g. slope position, slope gradient class) are taken from GIS. In addition, information about erosion is recorded.

Except for soil depth, these parameters should be documented for the top 30-cm soil. Soil depth should include depth of the top soil where possible depth the impermeable layer.

Soil depth

In each sampling plot outside the eastern side of the outer plot border (see Figure 2), a mini-plot of 1 m x 1 m should be marked out. The organic litter covering the soil surface should be carefully removed to expose the dark-coloured humus soil. A hole of 50 cm x 50 cm should be excavated to 40 cm to expose a fresh face. This will give an indication of the depth of dark-coloured top-soil as well as the depth of the mineral soil to 40 cm depth. The **depth of the dark-coloured soil** should be measured accurately with a ruler or tape.

Soil colour

Soil colour should be described from a dry or field moist (or moistened) sample for a give sample using standard Munsell Soil Colour Chart. The Munsell guide supplies 7

charts for a basic collection of 7 **hue codes** (10R, 2.5YR, 7.5YR, 10YR, 2.5Y and 5Y) plus a two page Grey Chart (blue and green colours and a grey scale for submerged soils).

A sample of a page from Munsell Soil Colour Book is shown in Annex 3c. The page shows that the HUE is 10YR. If our sample corresponds the last chip of the sixth row, then the soil has a value= 3, and chroma= 6. Hence, the soil colour is quoted as '10YR/3/6'. On the opposite page the corresponding 'word description' reads as 'dark yellowish brown'. The value is very useful for characterizing soil organic matter content of mineral horizons.

Soil Texture Determination

Soil texture refers to the relative primary particle size distribution of 'sand, silt, and clay' particles in a given soil. Soil texture can be determined accurately in the laboratory by standard mechanical analysis using soil sieved to pass through a 2-mm sieve.

A rough estimate of soil texture can however be made in the field by assessing the way the soil feels between fingers when it is dry or moist. The feeling varies from 'gritty' for sand soil, to flowery for silt. Silt feels 'soapy' when moist while clay feels 'sticky'.

A scheme of field soil texture determination by the 'Feel Method' is attached in Annex 3a. The description of soil particles is presented in Annex 3b.

Soil Structure

Soil structure refers to the grouping of soil particles (sand, silt, clay, organic matter and fertilizers) into aggregates. See more about soil structure in section 6.3 and

Figure 21.

Soil samples

Soil samples are collected in the selected permanent sample plots (PSPs) only. These plots are indicated in the inventory design maps and plans. There are two sets of samples: 1) soil for bulk density sample (2 units) and 2) loose soil sample (2 units).

> **Sample 1**: 2 bags (**soil for bulk density samples**)
> The first set of samples will be collected from the mini-pit. First, a steel core cylinder (5 cm x 5 cm) should be carefully driven into the top-soil (0 – 15cm depth) to obtain an undisturbed sample of the organic soil which should be emptied into a labeled polythene bag.
> The second sample is taken using the steel core a sample representing 30 – 40 cm depth, similarly. Each bag should contain a tag with Cluster ID, Plot ID, crew number, date and soil depth range (0–15 / 30–40).
>
> **Sample 2**: 2 bags (**loose soil samples**)
> The second set of soil samples will be loose soil samples for soil organic matter, texture and colour determination. The samples will be collected by a soil auger or a clean sampling spade from **five points randomly** spaced at least 5 m from the plot centre within each plot. Two samples are taken at each location: one at 0 – 15 cm depth and one at 30 – 40 cm depth.
>
> Drilled soil samples should be placed onto a plastic basin (separately for samples from two depth ranges), thoroughly mixing them by hand and collecting a sub-sampled of composite sample (weighing 250 g per plot), and placing it into a well-labeled sample bag. The tag should contain the following information: Cluster ID, Plot ID, crew number, date and depth range (0–15 / 30–40).

The remaining soil from drilled samples should be used to describe soil colour, soil texture and soil structure. The samples should be transported to the laboratory as soon as possible. The parameters to be measured in the laboratory are as follows: pH in H_2O or in $CaCl_2$, organic carbon, particle size analysis (soil texture), and bulk density.

5.9 Photo of the plot

Each inventory uses the digital camera to record the view on the plot. Photos will be used to document the plot characteristics as vegetation type, and to possibly ease the relocation of the plot in the future reassessments. Collected photos will also be utilized as training materials in the future.

The camera setting should be set to *Auto* position, and with using wide focus a field member captures a photo. The crew should add a flipchart hanging on a tree with the following information: Cluster ID and Plot ID.

The photo should include both some soil and vegetation, if available. On private lands close to human settlements the crew should ask a permission to take a photo. Whenever possible, the photo should be taken from then south edge of a plot towards to north. On deep slopes (more than 20%) the photo can also be captured at right angles to the slope. In any case, avoid taking photos against the sun light.

Data about each photo photos are recorded on the *Plot Form*. The crew writes down the image ID Number in the camera's memory stick. In the office the photos are transferred from the camera into a separate '*NAFORMA Photos*' folder, and where each photo is renamed as follows:

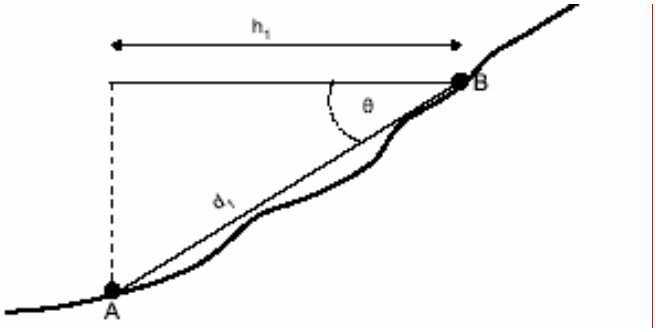
C*xxxxx*P*pp*.jpg
where *xxxxx* refers to cluster ID, and *pp* refers to plot ID.

5.10 Slope corrections

All reference distances, such as distance between plots, are expressed as horizontal distances in forest inventory. Plot areas are also computed upon horizontal plane. When the terrain is flat, distances can be measured directly. But on sloping terrain the horizontal distances differ from direct distances (see Figure 19). A corrected distance is taken from a slope correction table (Annex 2) and these distances are applied at all slopes above or equal to 5 percents.

A. Distance

Figure 19. Distances on slope



Note: The distance between two points, measured along slope (d_1) is always longer than an equivalent horizontal distance (h_1). On slope terrain, the horizontal distance must be multiplied by a factor that corresponds to the inclination, in order to obtain a corrected distance.

Slope is measured using a clinometer or Suunto hypsometer. The unit in this inventory is percent. Where distances are measured using a measuring tape on sloping ground, slope distance will need to be corrected back to horizontal using the following equation:

$$Horizontal\ distance = Slope\ distance \times Cos(\sigma)$$

Where σ = slope angle in degrees.

The equation can be written in the following form when slope angle is in percentages:

$$Horizontal\ distance = Slope\ distance \times Cos(Atan(\alpha/100))$$

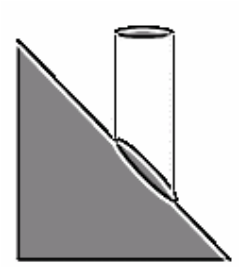
Where α = slope angle in percentages (%).

The slope correction table for distances is presented in Annex 2.

Note: The points recorded by the GPS will reflect horizontal distance. No corrections for distances on slope are required.

B. Plot area

Where the plot is on sloping ground, the plot radius is adjusted to always measure a fixed area on the vertically projected slope using the following equation:



$$Radius = \sqrt{(Area / (\pi \times Cos(\sigma)))} = \sqrt{(\pi \times r^2 / (\pi \times Cos(\sigma)))} = r / \sqrt{(Cos(\sigma))}$$

Where σ = slope angle in degrees.

The table for corrected plot radii on slope is presented in Annex 2.

6 Description of field forms and parameters

6.1 Overview

There are 6 different forms for biophysical data, as indicated in the next table.

Table 4. Field forms description and corresponding information level

Form No.	Information
1	Cluster: General cluster description data
2	Plot: General plot description data, location, and measuring time
3a	Shrubs: Coverage and mean height of shrubs/bushes.
3b	Regeneration: Number of seedlings and saplings
4	Trees: Tree measurements (DBH ≥1 cm) from concentric circular plots
5a	Dead wood measurements
5b	Stump measurements
6	Bamboo measurements

If a plot contains so large a number of trees/dead wood/bamboo clumps that all data cannot be accommodated in one single form sheet, additional form sheets in continuation may be used.

6.2 Form 1: Cluster

One form will be filled for each cluster. The form contains general information about location and identification of the cluster, and data for time study (see Table 5).

Table 5. Cluster Form parameters

Cluster parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Region code	National region code	Region code list, see Annexes	Number	Code be recorded at the office
District code	National district code	District code list, see Annexes	Number	Code be recorded at the office
District name		Inventory plan and map	Text	
Crew number		Inventory plan	Number	
Map sheet(s)	Map sheets IDs where the cluster is located	Topographic maps	Map sheet codes.	
Accessibility		*See codes below*	Number	
GPS Coordinates		GPS receiver	Numbers. North/East UTM Coordinate with no decimals	3D measurement only ($\geq$ 4 satellite signals)
UTM Zone number		GPS receiver, maps	Number	Hemisphere: S (south)
GPS Receiver model name			Text. Brand and type.	
Real-time correction (GPS)			Yes / No (Default= No)	Real-time correction, as OmniStar signal
Post-differential correction (GPS)			Yes / No (Default= No)	Post-differential correction done for data
Direction to the 1st plot	Direction from starting to the first plot	GPS receiver / Map	Number. Unit: degrees.	
Distance to the 1st plot	Distance from starting to the first plot	GPS receiver / Map	Number. Unit: meters.	
Time study				
Date			Day, Month, Year	

Cluster parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
			(dd/mm/yy)	
Start time	Time when crew leaves the vehicle		Hours, Minutes (HH / MM)	
End time	Time when crew returns to the vehicle		Hours, Minutes (HH / MM)	
Return to the cluster	Crew returns to the same cluster another day			Date and ending time are recorded
Remarks			Text	

Condition of **accessibility** is recorded for each cluster. If at least one plot can be accessed and measured, then the cluster is accessible. There is also an accessibility code for each plot on the Plot Form. Accessibility is indicated according to option list:

Accessibility (Cluster)			
Code	**Text Code**	**Description**	**Explanation**
0		Accessible	Where topographic and road or river network makes it possible to reach the site
1		Inaccessible due to slope	Very steep hill making the field work dangerous
2		Inaccessible due to owner refusal	Where the owner does not allow one to enter the site either by fencing or by not giving permission
3		Inaccessible due to restricted area	E.g. military areas, border areas, land mines areas
4		Inaccessible due to water body	Where a water body does not allow to sample or reach the site
99		Inaccessible due to other reason	To be specified in Remarks

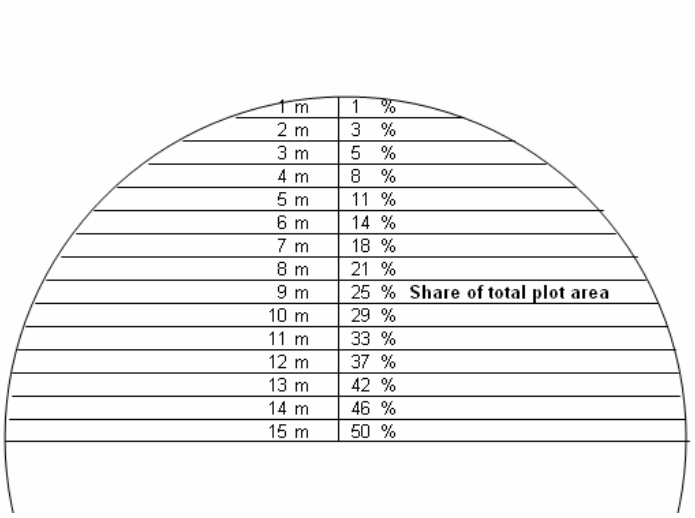
6.3. Form 2: Plot

Plot Form will be filled in for each sample plot contained in the cluster. The forms will include the general data on the plot and the information on its location and access.

On a shared plot (i.e. at the border of two land use types) the crew needs to fill in two forms for the same plot, so that the plot is divided into parts A and B. The major part of a shared plot is recorded as Plot A. A small sketch representing the shared plot with land use borders will be drawn on the margin of the field form. The share is presented as percent of the total plot area within a circle of 15 m radius; see Figure 20 for quick help.

Figure 20. A schematic of proportional shares in a circle[1]

Circle radius: 15 m		
Height of the Arc	Area	Share
1	7.2	1%
2	20.2	3%
3	36.8	5%
4	56.0	8%
5	77.4	11%
6	100.6	14%
7	125.4	18%
8	151.3	21%
9	178.4	25%
10	206.3	29%
11	234.9	33%
12	264.0	37%
13	293.6	42%
14	323.5	46%
15	353.4	50%
Circle area	706.9	m2



The crew records the parameters for Sample Plot Form as listed in Table 6.

Table 6. Plot Form parameters

Plot parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Plot number	Plot number within cluster	Inventory plan	Number (1–10)	On shared plot, add **A** or **B**
Share	Estimated share of total plot area (radius of 15 m)	Estimated in the spot	Number, percentage (%). Default=100% (full plot)	

[1] Computed using free application available at http://www.handymath.com/cgi-bin/arc18.cgi

Plot parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
PSP plot	Permanent sample plot		Yes / No Default: No	
Group Leader	Group leader name		Text	
Accessibility code	*See codes in the previous section*	Field observation		
GPS Coordinates	Location of the plot centre point	GPS receiver	Numbers. North/East UTM coordinates with no decimals	Aim to receive 3D measurement (≥ 4 satellite signals)
Direction to plot centre	Direction from GPS measurement point to the plot centre point	Compass	Number. Unit: degrees.	Required if proper GPS signal cannot be recorded in the plot centre
Distance to plot centre	Distance from GPS measurement point to the plot centre point	Measuring tape	Number. Unit: meters.	Required if proper GPS signal cannot be recorded in the plot centre
Description of plot centre	Description how to relocate plot centre.	Compass, Measuring tape	Text	Bind location into visible, stable object as stone, cliff, marked trees, ditch, etc.
Date	Measurement date		Day, Month, Year (dd/mm/yy)	
Start time	Time of arrival at the plot		Hours, Minutes (HH / MM)	
End time	Time of leaving the plot		Hours, Minutes (HH / MM)	
Region code	National region code	Region code list, see Annexes	Number	Code be recorded at the office
District code	National district code	District code list, see Annexes	Number	Code be recorded at the office
District name		Inventory plan; Map	Text	
Division		Map	Text	
Ward		Map	Text	
Village		Map	Text	
Forest name		Map	Text	
Slope	Slope inside the plot area	Field measurement	Number. Unit: percentage (%)	Slope is computed as average of two measurements (uphill and downhill)
Photo	Photo ID in	Capture also	Digital photo file	

Plot parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
	camera and File name in computer	a sign with *Cluster No* and *Plot No*.		
Land use	Land use code	Field observation	Number / Text code	
Vegetation	Vegetation code	Field observation	Number / Text code	
Ownership	Ownership code	Map, Documents, Interviews	Number	
Canopy coverage	Canopy coverage of trees at the plot centre point.	Field measurement	Number, 0–100. Unit: percentage (%).	
Undergrowth	Undergrowth code	Field observation	Number	
Damage	Damage code	Field observation	Number	2 fields; in the plot
Severity	Damage severity code	Field observation	Number	2 fields
Planting year	Planting year is recorded in plantation forests only, if this information is available	Forestry documents and plans	Number. Unit: Year	
Soil depth		Field measurement	Number. Unit: cm.	
Soil colour	Soil colour code	Field observation	Munsell Soil Colour Book code	
Soil texture	Soil texture code	Field observation	Number	
Soil structure	Soil structure code	Field observation	Number	
Soil sample	Soil sample collected to the laboratory		Yes / No	
Erosion	Erosion code	Field observation	Number	
Grazing	Grazing code	Field observation	Number	
Water catchment	Water catchment code	Field observation	Number	
Human impact	Human impact code	Field observation	Number	3 fields
Estimated time	Estimated time of occurrence of *Human impact*.	Field observation, Interviews, Documents	Number. Years.	
Non-wood forest products (NWFP) and services		Field observation, Interviews	Number	3 fields

Plot parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Management proposal		Field observation	Number	2 fields
Biodiversity		Field observation, Interviews	Number + Text	3 fields
Remarks			Text	

The codes for aggregated data are explained more detailed below.

Accessibility
Condition of accessibility is recorded for each sample plot. If a plot is not accessible but the land use, vegetation or ownership types can be observed in the field or detected from other sources (as from maps or aerial photos/satellite images), these data are filled into the field form.

Accessibility is indicated according to the following option list:

Accessibility (Plot)			
Code	**Text Code**	**Description**	**Explanation**
0		Accessible	Where field conditions makes it possible to reach the plot
1		Inaccessible due to slope	Very steep hill making the field work dangerous
2		Inaccessible due to owner refusal	Where the owner does not allow one to enter the site either by fencing or by not giving permission
3		Inaccessible due to restricted area	E.g. military areas, border areas
4		Inaccessible due to water body	
99		Inaccessible due to other reason	To be specified in Remarks

Land use
Land use refers to dominant land use purpose for humans at the time of observation. Land use is observed within the plot's outer boundary (radius of 15 m). If a plot is located at the edge of two land use types, it must be shared (see instructions for ***Share*** code) and two Plot Forms are filled in and **all trees** on both shared plots are recorded on separate field forms. Shared plots should never have more than 2 land uses.

If a plot is not accessible but the land use can be observed, this information needs to be filled into the field form.

Land use			
Code	**Text Code**	**Description**	**Explanation**
1		Production forest	Land designated for production and extraction of products (wood, fibre, bio-energy and/or non-wood forest products). Includes concessions, exploitation licenses, community forests etc.
2		Protection forest	Protected forest lands. Including also nature reserves, soil conservation, water and watershed protection, protection against erosion and landslides.
3		Wildlife reserve	National parks, game reserves, game controlled areas etc
4		Shifting cultivation	
5		Agriculture	Incl. agro-forestry
6		Grazing land	
7		Built-up areas)	Urban or rural, or mixed. Including roads, buildings, power lines etc.
8		Water body or swamp	Seasonal, Permanent or Swamp
99		Other land	To be specified in Remarks

Vegetation type

Vegetation type is recorded on all land types. If a plot is not accessible but the vegetation type can be observed in the field, this information needs to be filled into the field form. See Annex 4 for more detailed information about vegetation classification.

Vegetation type			
Code	**Text Code**	**Description**	**Explanation**
101	Fhm	**Forest**: Humid Montane	Catchment forest, ≥ 800 m asl
102	Fl	Forest: Lowland	Groundwater forests, some coastal forests, < 800 m asl.
103	Fm	Forest: Mangrove	Area of forest and other wooded land with mangrove vegetation.
104	Fp	Forest: Plantation	Note: Detect *Planting year* in Plot data
201	Wc	**Woodland**: Closed (>40%)	Beekeeping, Hunting, Recreation, Grazing, Conservation, Timber production
202	Wo	Woodland: Open (10–40%)	
203	Wsc	Woodland: Scattered cropland (Unspecified density)	Shifting cultivation
301	Bt	**Bushland**: Thicket	*below 5 m*
302	Bd	Bushland: Dense	Grazing
303	BSc	Bushland: Scattered cultivation	Shifting cultivation
304	B(et)	Bushland: Emergent trees	
305	Bt(et)	Bushland: Thicket with emergent trees	
306	Bo	Bushland: Open	Hunting, Recreation, Grazing

Vegetation type			
Code	**Text Code**	**Description**	**Explanation**
401	Gw	**Grassland**: Wooded	Hunting, Recreation, Grazing
402	Gb	Grassland: Bushed	
403	Gsc	Grassland: Scattered cropland	Cultivation
404	Go	Grassland: Open	Hunting, Recreation, Grazing
501	Caf	**Cultivated land**: Agro-forestry system	*Chagga* home gardens with timber and fruit trees shading coffee, banana, beans, yams
502	Cwc	Cultivated land: Wooded crops	Monocultures of tea, cashew nuts, cloves, coffee
503	Cbc	Cultivated land: Herbaceous crops	Maize, wheat, rice, bananas, cotton, sisal
504	Cmc	Cultivated land: Mixed tree cropping	Fruit (coconut, mango, orange), cashew, grain vegetables
601	Bsl	**Open land:** Bare soil	
602	Sc	Open land: Salt crusts	Mining for salt
603	Ro	Open land: Rock outcrops	Recreation
604	Ice	Open land: Ice-cap / snow	
701	Wo	**Water:** Ocean	
702	Wi	Water: Inland water	Lake, river, seasonal water body
703	Wsc	Water: Swamp	
800	Others	**Other areas**	Urban and rural build-up areas, air fields, infrastructure (power lines, railways, mining sites)

Ownership

Ownership refers here to the legal right to freely and exclusively use, control, transfer, or otherwise benefit from a forest. Ownership can be acquired through transfers such as sales, donations, and inheritance. Forest ownership refers here to the ownership of the trees growing on land classified as forest, regardless of whether or not the ownership of these trees coincides with the ownership of the land itself.

If a plot is not accessible but the ownership type can be observed, this information needs to be filled into the field form.

This parameter is recorded on all land types.

Ownership			
Code	**Text Code**	**Description**	**Explanation**
1		Central government land	Owned by central government, or by government-owned institutions or corporations
2		Local government land	Owned by local government (district)
3		Village land	Owned by a collective, a group of co-owners, or a community who hold exclusive rights and share duties.
4		Private land	Owned by private enterprises, industries, individuals or families, private co-operatives, corporations,

			religious and educational institutions, pension or investment funds, NGOs, nature conservation societies or other private institutions.
5		General land	Public land that does not belong to any of the above categories
90		Not known	No information available on the land ownership

Canopy coverage

Canopy coverage **caused by trees** is measured using the spherical densiometer. This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types. The measured value (%) will be recorded in the form. (Note: Shrub coverage will be estimated separately in classes).

Soil colour

Soil colour of the upper horizon of the soil below the humus layer will be determined and classified using a Munsell Soil Colour Chart and respective codes (see Annex 3c for an example of Munsell Soil Colour Chart).
This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Soil texture

Soil texture refers to relative occurrence of clay, silt and sand particles. Examine the texture of the soil in the region of the pit where the humus and the mineral soil are mixed by feeling with the hand and classify it in one of the following categories and record the code number. See Annex 3 for determining the soil texture by the *Feel Method*. This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Soil texture			
Code	**Text Code**	**Description**	**Explanation**
0		No soil	E.g. built-up area, water
1		**Sand**. Soil having mostly sand particles.	A wet sample does not stain hands.
2		**Loamy sand**. Soil in which sand particles are predominant but also containing silt.	Slightly sticky, but no ribbons can be formed.
3		**Sandy loam + Sandy clay loam + Sandy clay**	Makes a sound, when rubbed between the fingers close to the ear. Allows to be formed into a stick of cigarette size.
4		**Loam**. Soil having mostly silt and with some clay.	Only a relatively thick ribbon can be formed which will break soon after formation from its own weight. Rubbing between fingers makes a very light sound only.
5		**Clay loam**. Soil having higher percentage of clay loam particles but also having some sand and silt	Forms a thin ribbon which will readily break from its own weight when about 2–4 cm long. No sound when rubbed between fingers.

6		**Clay**. Soil contains mostly clay particles.	Highly plastic and slippery when handled. Allows to be formed into a thin string.
7		**Silt + Silt loam + Silty clay loam + Silty clay**	Substrate particles smaller than sand and larger than clay. Silt is easily transported in water or other liquids and is fine enough to be carried long distances by air as 'dust'.
8		**Rock**	
99		Other	To be specified in Remarks

Soil structure

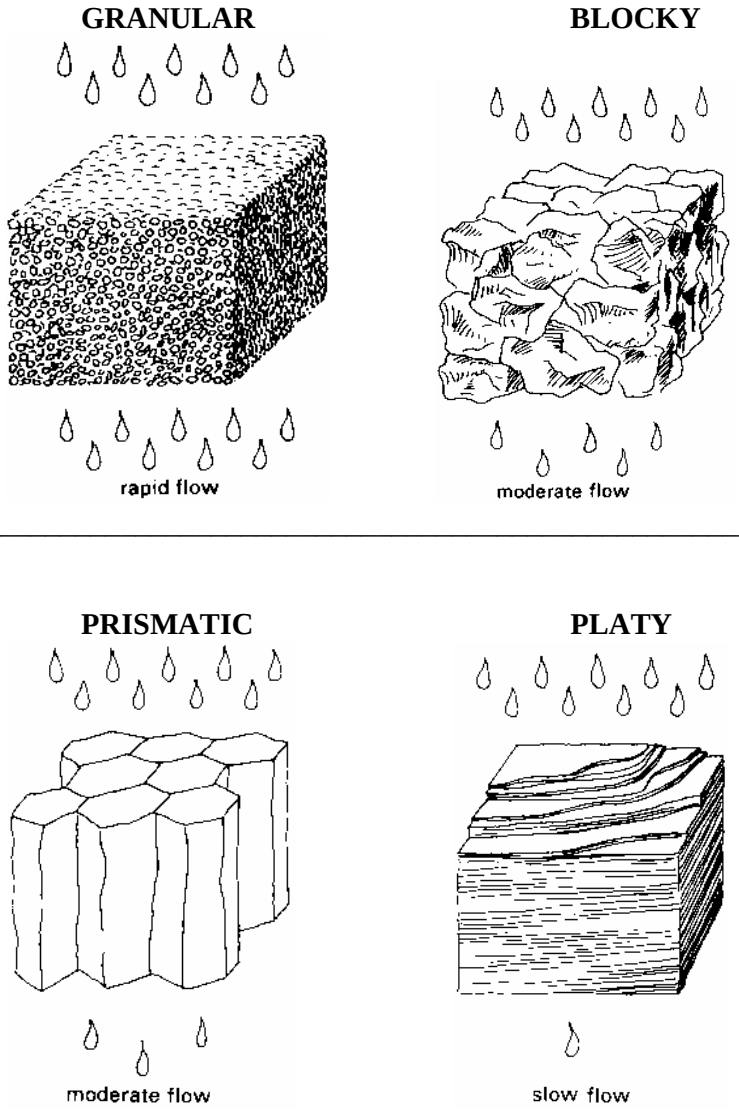
Soil structure refers to the grouping of soil particles (sand, silt, clay, organic matter and fertilizers) into aggregates. These are called peds. Soil structure also refers to the arrangement of these aggregates separated by pores and cracks (Figure 21).[2]

This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Soil structure			
Code	**Text Code**	**Description**	**Explanation**
0		No soil	
1		Granular	If the topsoil is granular, the water enters easily and the seed germination is possible.
2		Blocky	Blocky soil looks like irregularly-shaped blocks. Movement of the water is moderate.
3		Prismatic	Movement of the water in the soil is predominantly vertical and therefore the supply of water to the plant roots is usually poor.
4		Platy	When present in the topsoil, a platy structure blocks the entrance of water; seed germination is difficult due to poor aeration.

[2] FAO. 2006. Guidelines for Soil Description. 4th edition. 95 p.

Figure 21. Examples of soil structures



Undergrowth

Undergrowth refers here to the dominating type of brush (small trees, bushes, or grasses) growing beneath taller trees in the forest.

This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Undergrowth			
Code	**Text Code**	**Description**	**Explanation**
0		No undergrowth	
1		Bushes	
2		Elephant grass	
3		Grass	
4		Herbs	
5		New tree generation	
99		Other vegetation	To be specified in Remarks

Damage

Damage refers to the causative agents that have been identified to cause damages to several **live trees** in the plot (diseases, insects, animals, etc.). Individual tree damage is recorded in the Tree Form as *Health status*, as well as dead trees.

This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Damage			
Code	**Text Code**	**Description**	**Explanation**
0		No damage	Naturally open area, or normal tree vegetation where might be some individual trees damaged by insects, fungus or other reason but otherwise forest is in good condition
1		Fire	Disturbance caused by fire.
2		Insects, fungus or diseases	Disturbance caused by insect pests or by fungus. Disturbance caused by diseases attributable to pathogens, such as bacteria, fungi, phytoplasma or virus.
3		Other biotic agents	Disturbance caused by biotic agents other than insects or diseases, such as wildlife browsing, grazing, physical damage by animals, etc. Specify in Remarks.
4		Wind or other abiotic factor	Disturbances caused by abiotic factors, such as storm, drought, air pollution, etc. Specify in Remarks.
5		Human activities	Cuttings, firewood collecting, debarking, other human-made damages

Damage severity

Damage severity parameter is recorded adjoining with *Damage* code. Damage severity is an estimate of the prevalence of damages **to the live trees**, and it is needed to predict future mortality. If substantial numbers of living trees are classed as very severely damaged (class 3), mortality is likely to remain high for a long time.

Damage severity			
Code	**Text Code**	**Description**	**Explanation**
0		No	No damages
1		Slight	Evidences of damages are visible, but not causing long-term damages. Only few trees are affected.
2		Serious	Damages are clearly visible, probably causing long-term damages or loss of growth. Several trees are affected.
3		Very serious	Damage is finally causing wide mortality of trees, or hinders them growing. Mortality is likely to remain high for a long time.

Erosion
Erosion refers to the condition in which the earth's surface is worn away by the action of water and wind. Erosion is recorded on all vegetation types.

Erosion			
Code	**Text Code**	**Description**	**Explanation**
0		No erosion	No evidence of soil erosion
1		Light erosion	Slight erosion where only surface erosion has taken place.
2		Moderate erosion	Where mild gullies and rills are formed on the top surface of the soil.
3		Heavy erosion	Areas which have deep guillies, ravines, land slips etc.

Grazing
Grazing refers to the intensity of grazing in the forest land or bush land. It refers to the impact animals have on forage growth and reproduction and on soil and water quality (see e.g. Holechek & Galt 2000). This parameter is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Grazing			
Code	**Text Code**	**Description**	**Explanation**
0		No grazing	There is no evidence of grazing
1		Occasional	Only choice plants and areas show use. There is no use of poor forage plants.
2		Frequent	Most range shows use. 1/3 – 2/3 of primary forage plants showing use.
3		Extensive	Lands can be severely hedged. There is evidence of life-stock trailing to forage. More than 2/3 of primary forage plants showing use.

Water catchment
Water catchment refers to the importance of area in collecting and feeding water into rivers, lakes and undergrowth water reserves.
This parameter is recorded on all vegetation types.

Water catchment			
Code	**Text Code**	**Description**	**Explanation**
0		Bare land	No water catchment value
1		Low	The area has vegetation but it is not a particular source of water
2		Medium	Seasonal rivers providing water to lower land areas
3		High	Area contains lakes, ponds, rivers, or it is a forest land which collects/feeds water to lower land areas

Non-wood forest products/services

Data about non-wood forest products (NWFP) and services is recorded on *Forest, Woodland,* and *Bushland* vegetation types. These data refer to non-wood products and services provided by the trees, forest and other wooded land.

There are three data input fields in the field form to record this variable.

Non-wood forest products/services			
Code	**Text Code**	**Description**	**Explanation**
0		No data	
1		Fruits, nuts, seeds, roots, berries, etc	Vegetable foodstuffs and beverages provided by fruits, nuts, seeds, roots, etc.
2		Mushrooms	Foodstuffs provided by mushrooms.
3		Fodder	Animal and bee fodder provided by leaves, fruits, etc
4		Rattan	
5		Plant medicines	Medicinal plants (e.g. leaves, bark, roots) used in traditional medicine and/or for pharmaceutical companies.
6		Herbs and spices	
7		Dying / tanning	Plant material (bark and leaves) providing tannins and other plant parts (especially leaves and fruits) used as colorants.
8		Other plant products	Specify in Remarks
9		Wildlife	Provides habitat for wildlife
10		Beekeeping activities	
11		Windbreak	Acts as a windbreaker
12		Shade	Provides shade
13		Aesthetic	Provides landscape beauty
14		Recreation and tourism potential	Including ecotourism, hunting or fishing as leisure activity. Unique feature.
15		Cultural heritage potential	Including religious / spiritual potential
99		Other	Specify in Remarks

Human impact

Human impact or influence refers to a disturbance or change in ecosystem composition, structure, or function caused by humans. There are three data input fields in the field form to record this variable. Human impact is recorded on *Forest, Woodland*, and *Bushland* vegetation types.

Human impact			
Code	**Text Code**	**Description**	**Explanation**
0		No impact	No cutting or other impact; or the cutting has happened more than 5 years ago.
1		Selective cutting (commercial)	
2		Selective cutting (domestic use)	

Human impact			
Code	**Text Code**	**Description**	**Explanation**
3		Clear felling	Removal of all trees has been carried out. The generation of forest is done by planting, seeding or coppicing.
4		Shifting cultivation	
5		Silvicultural treatment	e.g. pruning, planting, climber cutting, weeding, boundary clearing, fire line construction
6		Illegal cutting	
7		Burning or/and ringbarking	
8		Charcoal production	
9		Timber sawing	
10		Honey hunting	
11		Medicinal activities	Collecting of medicinal plants (e.g. leaves, bark, roots) used in traditional medicine and/or for pharmaceutical companies
12		Sacred place	
13		Land-use change (from forest, woodland or bushland)	Specify previous Land use class in Remarks
14		Afforestation	Establishment of forest through planting and/or deliberate seeding on land that, until then, was not classified as forest. Implies a transformation of land use from non-forest to forest. Specify previous *Land use* type in Remarks
15		Mining, Sand collection	Mining and land extraction activities
99		Other	Specify in Remarks

Management proposal

The proposed action is suggested to be done during the next 3 years. This information is used to estimate the potential amount of silvicultural and sustainable harvesting activities to be done on forest lands. There are two data input fields in the field form to record this variable.

Management proposal is recorded on Forest and Woodland vegetation types.

Management proposal			
Code	**Text Code**	**Description**	**Explanation**
0		No treatment	
1		Selective cutting (commercial)	
2		Selective cutting (domestic use)	
3		Thinning	In the case of plantation
4		Clear felling	
5		Silvicultural treatment	e.g. pruning, planting, climber cutting, weeding, boundary clearing, fire line construction
6		Law enforcement	E.g. actions due to illegal activities
7		Change status	E.g. productive to protective or vice versa. Explain in *Remarks*.

Biodiversity

Specify recorded species or other special characteristics if possible. Digital photos of rare forest objects can also be captured (make notice in Remarks). The information about biodiversity may help us to locate new important biodiversity 'hotspots' and to target more detailed surveys into those areas.

There are three data input fields in the field form to record this variable.

This parameter is recorded on *Forest*, *Woodland*, and *Bushland* vegetation types.

Biodiversity			
Code	**Text Code**	**Description**	**Explanation**
0		No data	
1		Big mammals	Lion, elephant, rhino, etc
2		Other mammals	
3		Reptiles	
4		Birds	
5		Insects, Butterflies	
6		Climbers	
7		Plants (excl. trees and bamboos)	
8		Epiphytes	
9		Fungus	
10		Rare biotope	e.g. spring, oasis
99		Other	

6.4 Form 3: Shrubs and regeneration

Shrub data is recorded on *Forest*, *Woodland*, and *Bushland* vegetation types.

This form contains the information on shrubs on the circular 15 m radius. The crew records the parameters of shrubs as presented in Table 7.

Table 7. Shrub measurements

Shrub parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Plot number	Plot number within cluster	Inventory plan	Number, 1–10	On shared plot, add **A** or **B**
Shrub coverage	Shrub coverage class	Field observation	Number	
Mean shrub height		Field observation	Number. Unit: m. Accuracy: 0.5 m.	

Shrub coverage
Shrub coverage refers to vertical projection of the shrub canopies as percentage of the total ground area. This parameter is usually visually estimated, but if the use of spherical densitometer is possible, this device can also be used.

Shrub coverage			
Code	**Text Code**	**Description**	**Explanation**
0		No data / Not applicable	
1		<10%	Sparse shrub canopy cover
2		10% – 39%	Very open shrub canopy cover
3		40% – 69%	Open shrub canopy cover
4		≥ 70%	Closed shrub canopy cover

Tree regeneration is recorded on *Forest*, *Woodland*, and *Bushland* vegetation types.

This part contains the information on tree regeneration on the circular 1 m radius subplot. The crew records the following information about regeneration, i.e. about seedlings and saplings:

Table 8. Regeneration parameters

Regeneration parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Species code		Tree species check list	Number	
Species name	Local species name	Field observation	Text	
Dialect	Dialect for recording species name		Text	
Number of seedlings and saplings		Field measurement	Number	

6.5 Form 4: Trees

Tree data is recorded on all land types.
This form consists of a table where information related to all the trees measured in the concentric plots will be recorded (Table 9). Each tree is recorded as tally tree, and **every 5th tree within the cluster** as sample tree. In a shared plot which is located at the edge of two *Land Use* types, record trees on both plots parts into separate field forms.

Table 9. Tree Form parameters

Tree parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Plot number	Plot number within cluster	Inventory plan	Number, 1–10	On shared plot, add **A** or **B**
Tree number			Number	
Stem number	Forked stem below 1.3 m.		Number	For a single stem tree leave this field empty
Species code		Tree species check list	Number	
Species name	Local species name	Field observation	Text	
Dialect	Dialect for recording species name		Text	
DBH	Diameter at the breast height (1.3 m)	Field measurement	Number. Unit: cm, Accuracy: 0.1 cm	above bark
Health	Health status code	Field observation		
Tree origin	Origin of tree	Field observation	Text code.	
Stump height		Measurements of sample trees, and Forked trees	Number. Unit: cm. Accuracy: 1 cm.	Default: 15 cm above ground
Stump diameter		Measurements of sample trees	Number. Unit: cm. Accuracy: 0.1 cm	
Total height		Measurements of sample trees	Number. Unit: m. Accuracy: 0.5 m.	
Bole height		Sample trees (measured) Tally trees (estimated)	Number. Unit: m. Accuracy: 0.5 m.	Recorded when DBH $\geq$ 20 cm
Remarks	Additional text		Text	
Marked	Tree marked with paint or spray paint		Yes / No	Default: No

Health status

Health status refers to the current observed condition of a tally tree and to main causative agent. Health status is recorded of every tally tree.

Health status			
Code	**Text Code**	**Description**	**Explanation**
1		Healthy tree (Default)	A tree is healthy when it does not show symptoms of disease or other that have any substantial effect on the tree's growth and vitality.
2		Diseased tree	A tree is affected when it shows symptoms of disease or attack by insects that affect the tree's growth and vitality.
3		Burnt tree, will possibly recover	
4		Burnt tree, will possibly die	
5		Affected by *Ficus* sp.	*Ficus* which may eventually destroy its host.
6		Other damage agent	Specify in Remarks
7		Dead tree	Dead standing tree. Laying dead tree data is recorded on Dead Wood Form.

Tree origin

This parameter describes the origin of a tally tree. On afforested sites, please remember to add the code for '*Afforestation'* on the Plot Form (*Human impact*).

Tree origin			
Code	**Text Code**	**Description**	**Explanation**
	N	Natural (Default)	Natural regeneration of stand by seed
	P	Planted	Artificial regeneration by seeding or planting
	C	Coppice	Regeneration by shoots from stump or roots
	Nk	Not known	

6.6 Form 5a: Dead wood

This form consists of a two tables, where the upper table contains information related to all dead wood materials laying on the ground within the radius of 15 m plot. Dead wood consists of fallen trees, and large branches on the ground surface; stumps are recorded separately into the second table in *Form 5b***.**

The crew collects data from dead wood particles ≥ 10 cm thick. Each dead wood part is recorded with two diameter measurements: one in the stump part of stem, other in the top part of the stem. The data recorded of the dead wood is presented in Table 10.

Dead wood data is recorded on *Forest*, *Woodland*, and *Bushland* vegetation types.

Table 10. Dead wood measurements

Dead Wood parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Plot number	Plot number within cluster	Inventory plan	Number, 1–10	On shared plot, add **A** or **B**
Species code			Number	
Species name		Field observation	Text	Record species name if possible
Dialect			Text	
Diameter 1	Diameter at the stump part of stem	Field measurement	Number. Unit: cm. Accuracy: 1 cm	If bark exists, record above bark
Diameter 2	Diameter at the top part of stem	Field measurement	Number. Unit: cm. Accuracy: 1 cm	In case top of tree, record 0
Length	Measured length of wood part	Field measurement	Number. Unit: m. Accuracy: 0.5 m	
Number of stems	Number of similar size dead wood parts	Field observation	Number	
Decay	Decay class (consistency) for coarse woody debris	Field observation	Text: S- Solid R- Rotten	Use knife to detect decay class.
Remarks			Text	

Decay refers to the decomposition of wood substance caused by the action of wood-destroying fungi, resulting in softening, loss of strength and mass. Use one of the following two options to describe the decay class.

Decay			
Code	**Text Code**	**Description**	**Explanation**
	S	Solid wood material (Default)	
	R	Fully or partially rotten wood material	

6.7 Form 5b: Stumps

Stump data is recorded on all land types.

This form consists of a two tables, where the lower table contains information related to stumps (all stumps with stump diameter ≥ 10 cm) within plot radius of 15 m. The stump diameter is measured outside bark immediately under the cutting point (felling cut). If the bark is damaged or missing, a judged addition for bark is done. When a stump is taller than 1.3m the diameter is measured at the 1.3 m height (DBH).

Because in NAFORMA one aim is to get estimates for the annual removal, it is essential to collect data about the estimated year of cutting, especially for stumps that are less than three years old. In some cases this data will be challenging to estimate, but the team should also ask from local people if they have some knowledge about the right timing.

Stump parameters are listed in Table 11.

Table 11. Stump measurements

Stump parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Plot number	Plot number within cluster	Inventory plan	Number, 1–10	On shared plot, add **A** or **B**
Species code			Number	
Species name		Field observation	Text	Record species name if possible
Dialect			Text	
Diameter	Diameter at the stump height (default= 15 cm)	Field measurement	Number. Unit: cm. Accuracy: 1 cm	Record above bark. If bark is missing, a judged addition for bark is done.
Height	Stump height	Field measurement	Number. Unit: cm. Accuracy: 1 cm.	
Year of cutting	Estimated cutting year	Field observation, local knowledge	Number. Unit: year.	If this data is missing, it is assumed that the tree was felled down more than 3 years ago.
Possible use(s)		Field observation, interviews	Text	
Remarks			Text	

6.8 Form 6: Bamboo

Bamboo data is recorded on *Forest*, *Woodland*, and *Bushland* vegetation types, whenever applicable.

This form contains information related to bamboo clumps (all bamboo shoots taller than 1.3 m) within plot radius of 15 m. The average diameter is at the breast height (1.3 m above ground). Dead and alive bamboos are recorded separately, when possible. The parameters for bamboo measurements are listed in Table 12.

Table 12. Bamboo measurements

Bamboo parameters				
Object	**Definition**	**Source**	**Format**	**Notes**
Cluster number	Cluster ID in Tanzania	Inventory plan	Number	
Plot number	Plot number within cluster	Inventory plan	Number, 1–10	On shared plot, add **A** or **B**
Species code			Number	
Species name		Field measurement	Text	Record species name if possible
Dialect			Text	
Alive	Alive / Dead	Field observation	Text code	A = Alive D = Dead
Average diameter	Mean diameter at 1.3 m above ground	Field measurement	Number. Unit: cm. Accuracy: 1 cm	
Average height	Mean height of bamboos in clump	Field measurement	Number. Unit: m. Accuracy: 0.5 m	
Number of stems	Number of bamboo stems in clump	Field measurement	Text	
Remarks			Text	

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Annex 1.
Field Forms

Note: Printed forms from PDF files are used in the field. These are examples for this manual.

NAFORMA Page ____/____

1. CLUSTER FORM

Cluster No.			
Region code			
District code		District name	
Crew No.			
Map sheet(s)			
Accessibility code			

Starting position *(where the field crew leaves the vehicle)*

GPS Y (Northing)		*UTM (Arc1960), no decimals*	
GPS X (Easting)		UTM Zone number	
GPS Receiver model name		Real-time correction	yes / no
Direction to the 1st plot	degrees	Post-diff. correction	yes / no
Distance to the 1st plot	m		

Time study - Cluster

Date (dd/mm/yy)		
Start time (HH / MM)		*time when leaving the vehicle*
End time		*time when returning to the vehicle*

If return to the cluster

Date (dd/mm)	
Start time (HH / MM)	
End time	

Remarks

Data input to the computer

Date (dd/mm/yy)	
Name	

Form No. 1, Dated 1.3.2010

NAFORMA Page ____/____

2. PLOT FORM

Cluster No.			Date		(dd/mm/yy)
Plot No.			Start time		
Share	%	in case of shared plot, fill in 2 plot forms	End time		
Permanent plot	Y / N		Region code		
Group Leader			District code		
Accessibility code			District name		
Plot location		*UTM*	Division		
GPS Y (Northing)			Ward		
GPS X (Easting)			Village		
Direction to plot centre		degrees	Forest name		
Distance to plot centre		m	Slope		%
Description of plot centre					

	number	*file name* (CxxxxxPxx.jpg)
Photo		

In the plot

Land use		Damage	Severity	Soil depth		cm
Vegetation		(1)		Soil colour		
Ownership		(2)		Soil texture		
Canopy coverage	%	Plantation forests:		Soil structure		
Undergrowth		Planting year		Soil collected	Y / N	

Surrounding the plot

				Estimated time
Erosion		Human impact (1)		years ago
Grazing		Human impact (2)		
Water catchment		Human impact (3)		

Non-wood forest products and services

NWFP (1)		Management proposal (1)	
NWFP (2)		Management proposal (2)	
NWFP (3)			

Biodiversity (1)		*Specify*
Biodiversity (2)		
Biodiversity (3)		

Remarks

On slope apply the Slope Correction Table!

Form No. 2, Dated 1.3.2010

NAFORMA

Page ____/____

3a. SHRUBS

Plot radius: 15 m

Cluster No. ____

Plot No. ____

Shrub coverage class ____ **0**: No data; **1**: <10%; **2**: 10 - 39%; **3**: 40 - 69%; **4**: > 70%

Mean shrub height ____ m

3b. REGENERATION

Radius: 1 m (2 sub-plots)

No.	Species code	Species name (+Dialect)	Number of seedlings and saplings: 10 cm tall - DBH< 1 cm
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Remarks

Form No. 3, Dated 1.3.2010

NAFORMA

4. TREE FORM

Cluster No. ____

Plot No. ____

Tree No.	Stem #	Species code	Species name (+Dialect)	DBH (cm)	Health	Origin (N/P/C)	Sub-sample tree data *Every 5th tree in the cluster*				Remarks	Marked
							Stump diam. (cm)	**Stump** height (cm)	**Total** height (0.5 m)	**Bole** height (0.5 m)		

Number of trees to be carried to the next plot for sub-sampling: _____

Form No. 4, Dated 1.3.2010

NAFORMA

5a. DEAD WOOD

Cluster No. ____

Plot No. ____

Plot radius: 15 m
Min. diam.: 10 cm

Tree No.	Species code	Species name (+Dialect)	Diam 1 (cm)	Diam 2 (cm)	Length (0.5 m)	Number of stems	Decay (S / R)	Remarks
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

5b. STUMPS

Plot radius: 15 m
Min. stump diameter: 10 cm

No.	Species code	Species name (+Dialect)	Diam. (cm)	Height (cm)	Estim. year	Possible use(s)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

NAFORMA Page ____/____

6. BAMBOO

Cluster No. ____

Plot No. ____

Plot radius: 15 m

No.	Species code	Species name (+Dialect)	Alive=A Dead=D	Average diameter (cm)	Average height (0.5 m)	Number of stems
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

Remarks

Form No. 6, Dated 1.3.2010

NAFORMA

7. CREW CONTACT DETAILS

No	Name	Title	Mobile phone	E-mail
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Form No. 7, Dated 1.3.2010

Annex 2.
Slope Correction Tables

Table A2.1. Slope corrections for distance measurements

	Length (m)				
slope %	**5**	**10**	**20**	**50**	**100**
5	5.01	10.01	20.02	50.06	100.12
10	5.02	10.05	20.10	50.25	100.50
15	5.06	10.11	20.22	50.56	101.12
20	5.10	10.20	20.40	50.99	101.98
25	5.15	10.31	20.62	51.54	103.08
30	5.22	10.44	20.88	52.20	104.40
35	5.30	10.59	21.19	52.97	105.95
40	5.39	10.77	21.54	53.85	107.70
45	5.48	10.97	21.93	54.83	109.66
50	5.59	11.18	22.36	55.90	111.80
55	5.71	11.41	22.83	57.06	114.13
60	5.83	11.66	23.32	58.31	116.62
65	5.96	11.93	23.85	59.63	119.27
70	6.10	12.21	24.41	61.03	122.07
75	6.25	12.50	25.00	62.50	125.00
80	6.40	12.81	25.61	64.03	128.06

Table A2.2. Slope corrections for plot radius measurements

	Radius (m)			
slope %	**2**	**5**	**10**	**15**
5	2.00	5.01	10.02	15.02
10	2.01	5.03	10.06	15.09
15	2.03	5.07	10.14	15.21
20	2.05	5.13	10.25	15.38
25	2.08	5.20	10.40	15.61
30	2.12	5.30	10.59	15.89
35	2.17	5.41	10.83	16.24
40	2.22	5.56	11.12	16.68
45	2.29	5.73	11.47	17.20
50	2.38	5.95	11.89	17.84
55	2.48	6.20	12.41	18.61
60	2.61	6.52	13.04	19.57
65	2.77	6.92	13.83	20.75
70	2.97	7.42	14.84	22.26
75	3.23	8.08	16.17	24.25
80	3.60	8.99	17.99	26.98

Annex 3a
Determining Soil Texture by Feel Method

Place approximately one tablespoon of soil in the palm. Add a drop of water at a time and knead the soil to break down all aggregates. Soil is at the proper consistency when it is plastic and mobile, like moist putty.
(Percentages below refer to the **Clay percentage range**).

I. Does the soil remain in a ball when squeezed?

NO

1. Is the soil too dry? If yes, start over.
2. NO, the soil is not too dry. Is the soil too wet?
3. YES, the soil is too wet; add dry soil to soak up the water.
4. NO, the soil is not too wet. **Texture equals SAND [0–10%]**.

YES

Place ball of soil between thumb and forefinger gently pushing the soil with the thumb, working it upward into a ribbon. Form a ribbon of uniform thickness and width. Allow the ribbon to emerge and extend over the forefinger, breaking from its own weight. ->

II. Does the soil form a ribbon?

NO. Texture equals **LOAMY SAND [0–15%]**.

YES ->

III. Does the soil make a weak ribbon less than 1 inch long before breaking?

YES. Excessively wet a small pinch of soil in palm of hand and rub with forefinger. Does the soil feel very gritty?

YES. Texture equals **SANDY LOAM [0–20%]**.

NO. Does the soil feel very smooth?

YES. Texture equals **SILT or SILT LOAM [0–27%]**.

NO. Neither grittiness nor smoothness predominates:

-> Texture equals LOAM [7–27%].

NO ->

IV. Does the soil make a medium ribbon 1 inch to 2 inches long before breaking?

YES. Excessively wet a small pinch of soil in palm of hand and rub with forefinger.

1. Does the soil feel very gritty?

YES. Texture equals **SANDY CLAY LOAM [20–35%]**.

NO. Does the soil feel very smooth?

YES. Texture equals **SILTY CLAY LOAM [27–40%]**.

NO. Neither grittiness nor smoothness predominates.

–> Texture equals CLAY LOAM [27–40%].

NO –>

V. Does the soil make as strong ribbon 2 inches or longer before breaking?

YES. Excessively wet a small pinch of soil in palm of hand and rub with forefinger. Does the soil feel very gritty?

YES. Texture equals **SANDY CLAY [35–55%]**.

NO. Does the soil feel very smooth?

YES. Texture equals **SILTY CLAY [40–60%]**.

NO. Neither grittiness nor smoothness predominates.

–> Texture equals **CLAY [40–100%]**.

Annex 3b.
Description of Soil Particles

Clay: Clay is less than 0.002 mm in diameter. Clay particles are extremely small, and can be seen only through an electron microscope. Dry, it forms very firm blocks, strongly homogeneous. Clay feels sticky and resists to pressure when wet. It easily forms into a ball and a quite thin ribbon at least 5 cm long. It is very plastic and sticky when very humid (feels like modelling clay). When a sample contains more than 40% clay, it is very difficult to moisten it. Water drains very slowly through clay soil. Therefore, clay soil remains saturated after a heavy rain. When this happens, there is little air in the soil, and plant roots cannot find oxygen.

Silt: Silt is 0.002–0.05 mm in diameter. Silt particles can be seen only through a microscope. When it is dry, it feels dusty, like flour. It is smooth and slightly sticky (like talc), and sometimes almost soapy, when wet. It does not resist to pressure and is therefore difficult to mould: it forms into a ball that easily breaks apart; if you squeeze it between your thumb and fingers, it will not form ribbons.

Sand: Sand is the largest size rock particle in soil (0.05–2 mm) in diameter. Sand particles can be seen without a microscope. Coarse sand particle feels gritty. A wet sand can not form a ball that holds together. When mixed with other materials (clay or silt), it appears when the wet sample was crushed for a while between fingers. In case of very dry samples, small hard fragments of clay, difficult to moisten, may likely looks like sand, and the same applies to a large quantity of fine gravel (sand size stops at 2 mm). Sandy soils have lots of air spaces between particles, so water drains quickly through these soils. They do not hold water and nutrients very well.

Loam: Loam is a mixture of sand, silt, and clay particles. Usually loam is easy to dig, and is neither too dry nor too wet during the growing season. The texture is determined by estimating the proportion of the sand, silt and clay size particles. It can be done by taking one or two table spoonfuls of soil in one hand and adding water drop by drop to the soil as it is being worked in the hand until a sticky consistence is reached. The soil is then rolled into a ball and ribbon and texture determined. This test is meaningful only if the soil is well moistened.

The next figure represents the different texture classes and the corresponding proportion of sand, silt and clay.

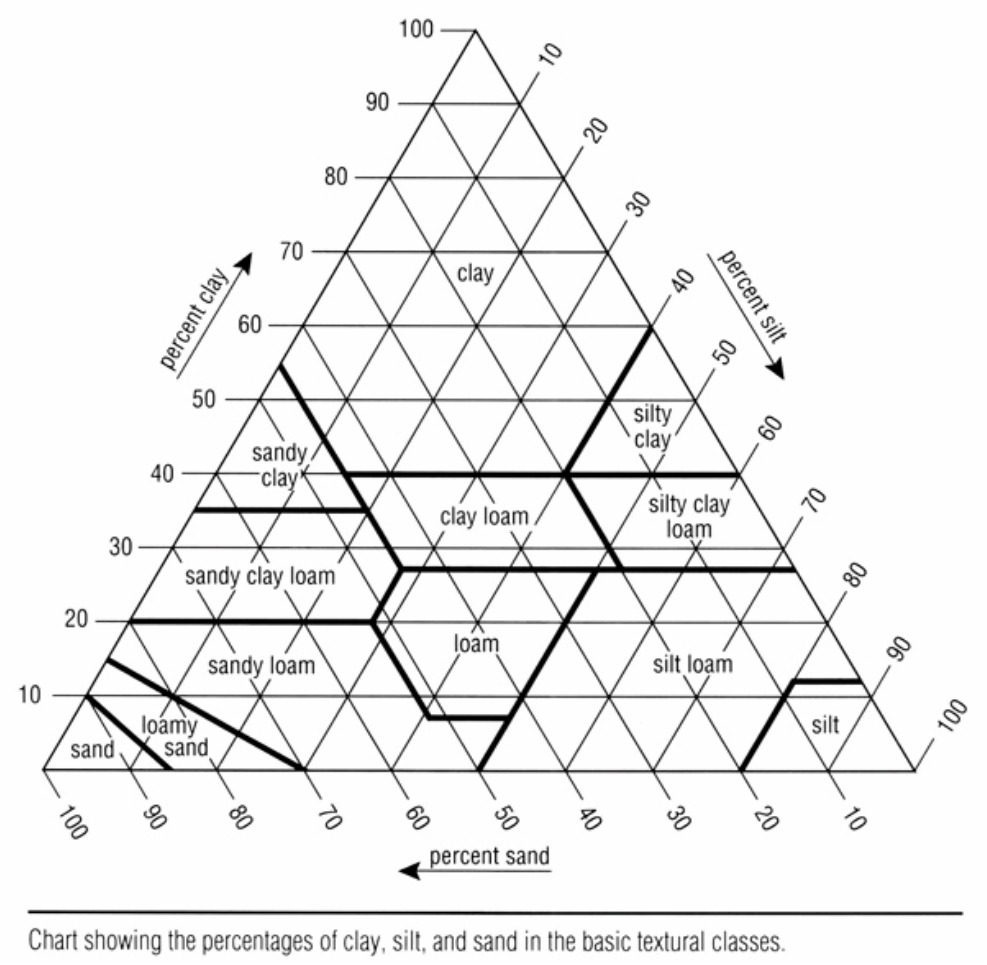
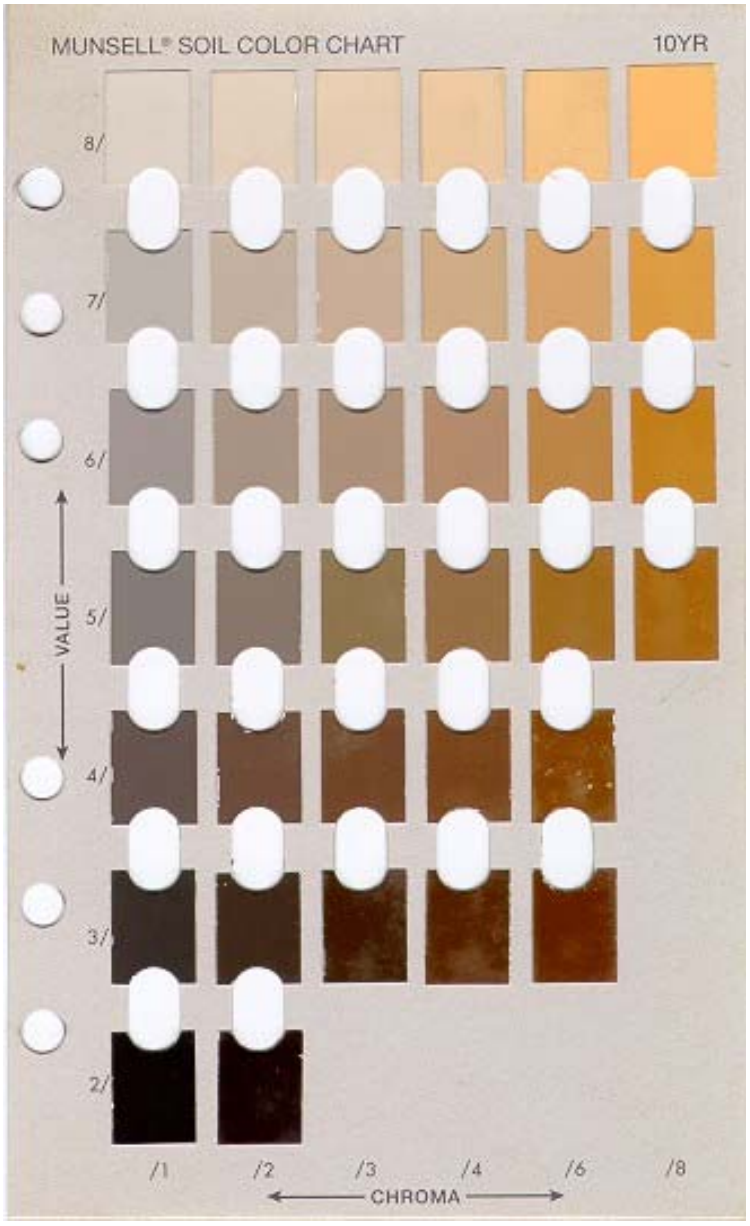


Chart showing the percentages of clay, silt, and sand in the basic textural classes.

Source: United States Department of Agriculture (USDA)

Annex 3c.
Example of Munsell Soil Coulour Chart

A sample of a page from Munsell Soil Colour Book is shown below. The page shows that the HUE is 10YR. If our sample corresponds the last chip of the sixth row, then the soil has a value= 3, and chroma =6. Hence, the soil colour is quoted as '10YR/3/6'. On the opposite page (not shown here), the corresponding 'word description' states 'dark yellowish brown'. The value of the chart is useful for characterizing soil organic matter content of mineral horizons[3].



[3] FAO (2006). Guidelines for Soil Description - P43, Table 46.

Annex 4.
Legend to the Vegetation Classification

The field forms require filling in the vegetation class using the given codes (Table A4.1). The letter code should be used by field crews as it is easier to remember. It is very important that the field crews are well acquainted with the vegetation types and subtypes as these data will be the basis of stratification according to vegetation types. Further more the data will provide ground truth information for the remotely sensed data. Features of the sub types have been described in terms of implied land use, crown density and height in an effort to elaborate the distinction of one vegetation sub-type to another. For the sake of FRA 2010 reporting the sub-types have been matched (in the last column) with the FRA Global classification system.

Table A4.1. Legend to the vegetation classification

NAFORMA vegetation Classification					Characteristics				FRA Global Class
Numeric Code	**Text Code**	**Name**	**Implied land use**	**Land cover type**	**Crown Density Trees (height ≥ 5m)**	**Bushes and shrubs (height <5m)**	**Grass / Herbaceous**	**Height**	
101	Fhm	Forest: Humid Montane	Catchment forests, ≥800 m asl,	**Forest**	10 –100 %			≥5 m	Forest
102	Fl	Forest: Lowland	Groundwater forests, some coastal forests, <800 m asl.		10 –100 %			≥5 m	Forest
103	Fm	Forest: Mangrove			10 –100 %			≥5 m	Forest
104	Fp	Forest: Plantation			10 –100 %			≥5 m	Forest
201	Wc	Woodland: Closed (>40%)	Beekeeping, Hunting, recreation, grazing, conservation, timber production	**Woodland**	40 – 100%			≥5 m	Forest (Closed Forest)
202	Wo	Woodland: Open (10–40%)			10 – 40%			≥5 m	Forest (Open Forest)
203	Wsc	Woodland: Scattered cropland	Shifting cultivation		Unspecified density				OWL,OL
301	Bt	Bushland: Thicket		**Bushland**	0 – 5%	10 – 100 %		<5 m	OWL

NAFORMA vegetation Classification					Characteristics				FRA Global Class
Numeric Code	Text Code	Name	Implied land use	Land cover type	Crown Density Trees (height ≥ 5m)	Bushes and shrubs (height <5m)	Grass / Herbaceous	Height	
302	Bd	Bushland: Dense	Grazing		0 – 5 %	10 – 100 %		<5 m	OWL
303	BSc	Bushland: Scattered cultivation	Shifting cultivation		0 –5 %	10 – 100 %		<5 m	OWL
304	B(et)	Bushland: Emergent trees			5 – 10 %	10 – 100 %		<5 m, emergent trees are >5 m	OWL
305	Bt(et)	Bushland: Thicket with emergent trees			5 – 10 %	10 – 100 %		<5 m, emergent trees are ≥5 m	OWL
306	Bo	Bushland: Open	Hunting, recreation, grazing		0 – 5 %	10 – 40 %		<5 m	OWL
401	Gw	Grassland: Wooded	Hunting, recreation, grazing	**Grassland**	0 – 5 %		5 – 100 %		OL
402	Gb	Grassland: Bushed				0 – 5 %	5 – 100 %		OWL
403	Gsc	Grassland: Scattered cropland	Cultivation				0 – 100 %		OL
404	Go	Grassland: Open	Hunting, recreation, grazing				0 – 100 %		OL
501	Caf	Cultivated land: Agroforestry system	*Chagga* home gardens	**Cultivated land**	5 – 100 %				OL, OLWTC
502	Cwc	Cultivated land: Wooded crops	Tea, Cashewnuts, Cloves		5 – 100 %				OWLTC
503	Cbc	Cultivated land: Herbaceous crops	Maize,Wheat,Rice, Bananas,cotton, sisal		0–5 %				OL

NAFORMA vegetation Classification					Characteristics				FRA Global Class
Numeric Code	**Text Code**	**Name**	**Implied land use**	**Land cover type**	**Crown Density Trees (height ≥ 5m)**	**Bushes and shrubs (height <5m)**	**Grass / Herbaceous**	**Height**	
504	Cmc	Cultivated land: Mixed tree cropping	Grain vegetables, fruit				0 – 100 %		OL
601	Bsl	Open land: Bare soil		**Open**					OL
602	Sc	Open land: Salt crusts	Mining for salt						OL
603	Ro	Open land: Rock outcrops	Recreation						OL
604	Ice	Open land: Ice-cap / snow							OL
701	Wo	Water: Ocean		**Water**					Not included
702	Wi	Water: Inland water	Lake, river						IW
703	Wsc	Water: Swamp							IW
800	Others	Other areas	Urban and air fields, infrustructure (powerline, railways, mining sites)	**Other**					OL

Annex 5.
Codes for Region and Districts

Regions

Sorted by Region

Region	Code
Arusha	002
Dar es Salaam	007
Dodoma	001
Iringa	011
Kagera	018
Kigoma	016
Kilimanjaro	003
Lindi	008
Manyara	021
Mara	020
Mbeya	012
Morogoro	005
Mtwara	009
Mwanza	019
Pwani	006
Rukwa	015
Ruvuma	010
Shinyanga	017
Singida	013
Tabora	014
Tanga	004

Sorted by Code

Code	Region
001	Dodoma
002	Arusha
003	Kilimanjaro
004	Tanga
005	Morogoro
006	Pwani
007	Dar es Salaam
008	Lindi
009	Mtwara
010	Ruvuma
011	Iringa
012	Mbeya
013	Singida
014	Tabora
015	Rukwa
016	Kigoma
017	Shinyanga
018	Kagera
019	Mwanza
020	Mara
021	Manyara

Annex 5.

Districts 1/2

Region Code	District	District Code
001	Dodoma Rural	004
001	Dodoma Urban	005
001	Kondoa	001
001	Kongwa	003
001	Mpwapwa	002
002	Arumeru	002
002	Arusha	003
002	Karatu	004
002	Monduli	001
002	Ngorongoro	005
003	Hai	005
003	Moshi Rural	004
003	Moshi Urban	006
003	Mwanga	002
003	Rombo	001
003	Same	003
004	Handeni	006
004	Kilindi	007
004	Korogwe	002
004	Lushoto	001
004	Muheza	003
004	Pangani	005
004	Tanga	004

Region Code	District	District Code
005	Kilombero	003
005	Kilosa	001
005	Morogoro	002
005	Morogoro Urban	005
005	Mvomero	006
005	Ulanga	004
006	Bagamoyo	001
006	Kibaha	002
006	Kisarawe	003
006	Mafia	006
006	Mkuranga	004
006	Rufiji	005
007	Ilala	002
007	Kinondoni	001
007	Temeke	003
008	Kilwa	001
008	Lindi Rural	002
008	Lindi Urban	006
008	Liwale	004
008	Nachingwea	003
008	Ruangwa	005
009	Masasi	003
009	Mtwara Rural	001
009	Mtwara Urban	005
009	Newala	002
009	Tandahimba	004

Region Code	District	District Code
010	Mbinga	003
010	Namtumbo	005
010	Songea Rural	002
010	Songea Urban	004
010	Tunduru	001
011	Iringa Rural	001
011	Iringa Urban	006
011	Kilolo	007
011	Ludewa	005
011	Makete	003
011	Mufindi	002
011	Njombe	004
012	Chunya	001
012	Ileje	005
012	Kyela	003
012	Mbarali	007
012	Mbeya (R)	002
012	Mbeya Urban	008
012	Mbozi	006
012	Rungwe	004
013	Iramba	001
013	Manyoni	003
013	Singida (R)	002
013	Singida (U)	004

Annex 5.

Districts 2/2

Region Code	District	District Code
014	Igunga	002
014	Nzega	001
014	Sikonge	005
014	Tabora Urban	006
014	Urambo	004
014	Uyui	003
015	Mpanda	001
015	Nkasi	003
015	Sumbawanga Rural	002
015	Sumbawanga Urban	004
016	Kasulu	002
016	Kibondo	001
016	Kigoma Rural	003
016	Kigoma Urban	004
017	Bariadi	001
017	Bukombe	005
017	Kahama	004
017	Kishapu	008
017	Maswa	002
017	Meatu	006
017	Shinyanga Rural	003
017	Shinyanga Urban	007

Region Code	District	District Code
018	Biharamulo	004
018	Bukoba Rural	002
018	Bukoba Urban	006
018	Karagwe	001
018	Muleba	003
018	Ngara	005
019	Geita	006
019	Ilemela	008
019	Kwimba	004
019	Magu	002
019	Missungwi	007
019	Nyamagana	003
019	Sengerema	005
019	Ukerewe	001
020	Bunda	004
020	Musoma (R)	003
020	Musoma Urban	005
020	Serengeti	002
020	Tarime	001
021	Babati	001
021	Hanang	002
021	Kiteto	005
021	Mbulu	003
021	Simanjiro	004