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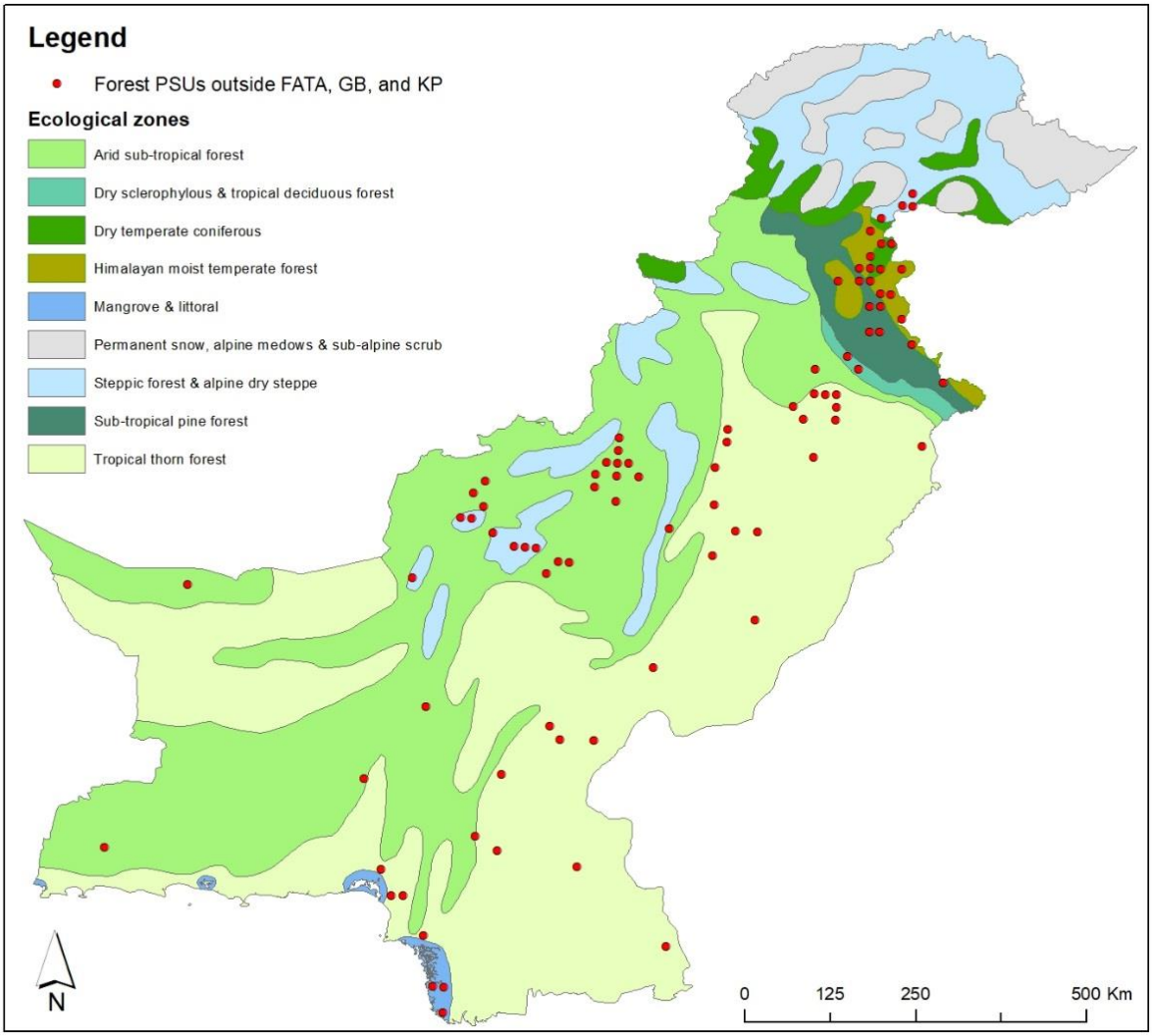
WWF

Develop Forest Reference Emission Levels/Forest Reference Level and National Forest Monitoring System (NFMS)-Measurement and Reporting and Verification (MRV) System for REDD+



National Forest Inventory and Field Surveying Manual

Version 1.1

December 2017

arbonaut

WWF

Table of Contents

1. INTRODUCTION

This manual outlines the procedures to carry multi-purpose forest inventory and field survey measurements to meet the objectives in scope of the FREL/FRL/NFMS project in Pakistan. The purpose of this inventory is to collect necessary reference data for:

- an informed decision to include the most relevant pools in the national FREL/FRL.
- integrating existing provincial forest inventory data and newly collected data for developing national emission factors (Tier 2)
- collecting reference data for land use and cover map validation and ground-truthing
- validating the forest boundary demarcation produced by WWF
- assessing and enhancing national and provincial capacities for forest inventories
- designing the National Forest Inventory as a component of the National Forest Monitoring System

The manual has been developed after reviewing the methodologies applied in the context of international practices and the past provincial forest carbon inventories completed recently in KP and GB. The document includes a presentation of the field forms to guide locating, establishing field plots, conducting plot- and tree-level measurements and implementing quality control. The effective field campaign is planned to cover one cluster in a day in hilly areas, two clusters in plan areas and half cluster in each day in mangroves.

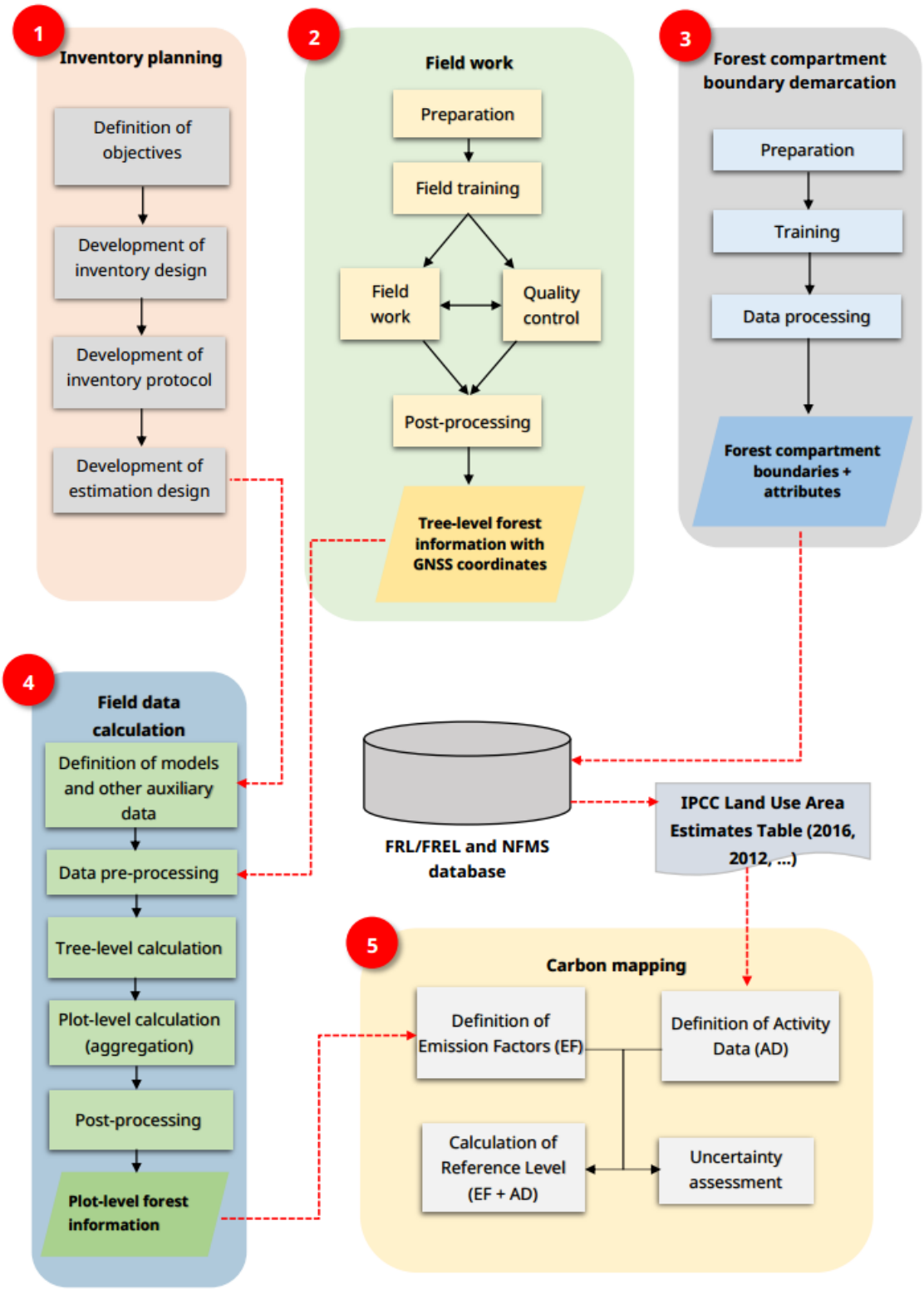


Figure 1. The pilot forest inventory and boundary demarcation workflow developped in scope of the FREL/FRL and NFMS project (Arbonaut 2017).

2. PREPARATION

2.1. FIRST-PHASE SAMPLING

Systematic sampling grids are generated to cover the territory of Pakistan for the first phase (Phase I) sampling for IPCC Land Use classes to be used for preliminary wall-to-wall land use map preparation and forest inventory design. Due to the non-availability (restrictions of use) of the recent land cover/land use spatial data for designing the sample set (stratification), independent systematic grids are generated. The systematic sample plots are initiated from 10' x 10' grids (≈16 km x 18 km) to cover the entire territory of Pakistan. The systematic grids and the sample plots are created using Open Data and Open Source Tools and is a part of desktop based Satellite Land Monitoring System (SLMS) workflow to be implemented for REDD+ FRL/FREL and NFMS/MRV in Pakistan.

The systematic grid with 50 m x 50 m sample plots is laid and individual plots have been classified as forest/non-forest plots through visual interpretation procedure using the available Google Earth imagery and Landsat imagery where very high resolution imagery has not been available. More details are found in the interim report.

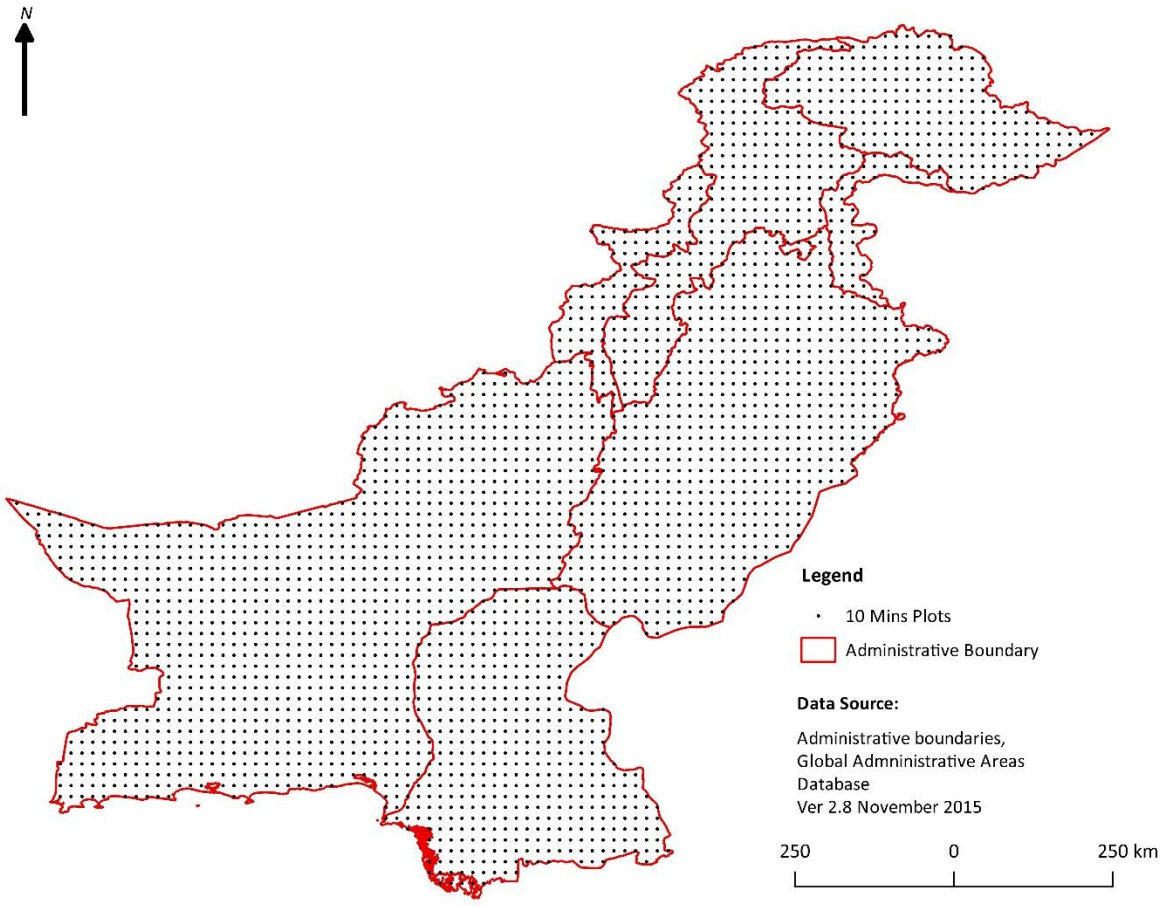


Figure 2. Systematic first-phase sample units at 10' intervals.

2.2. SECOND-PHASE SAMPLE

The forest classified plots (88) are sub-sampled following a stratified sampling approach relying on the clusters as primary sampling units (PSU) and five nested plots as secondary sampling units (Figure 3). The primary sampling unit is located in the middle and the four secondary sampling units (SSU) are 200 meters apart forming corner points of a square (Figure 4)

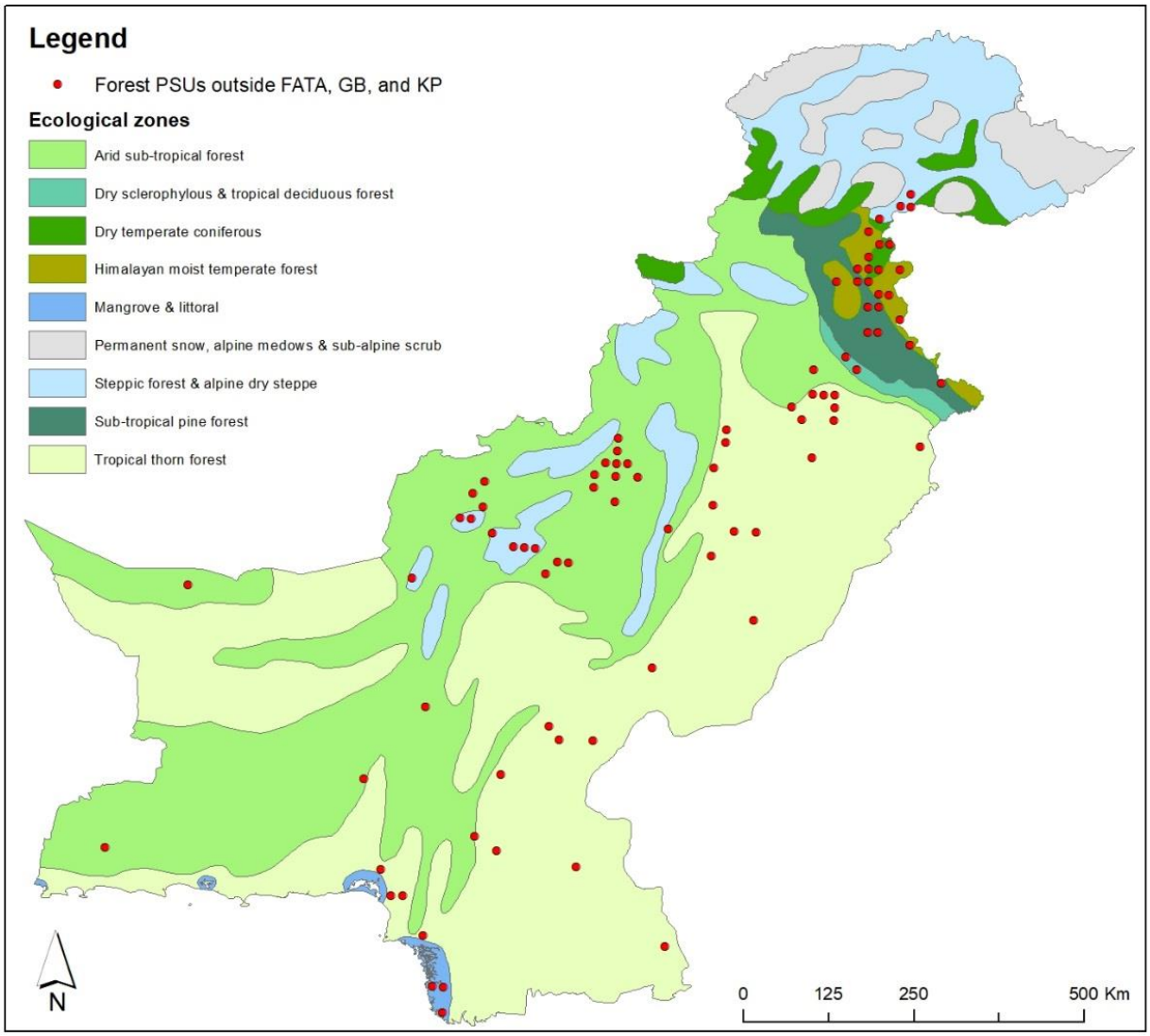


Figure 3. Locations of 2nd phase primary sampling units.

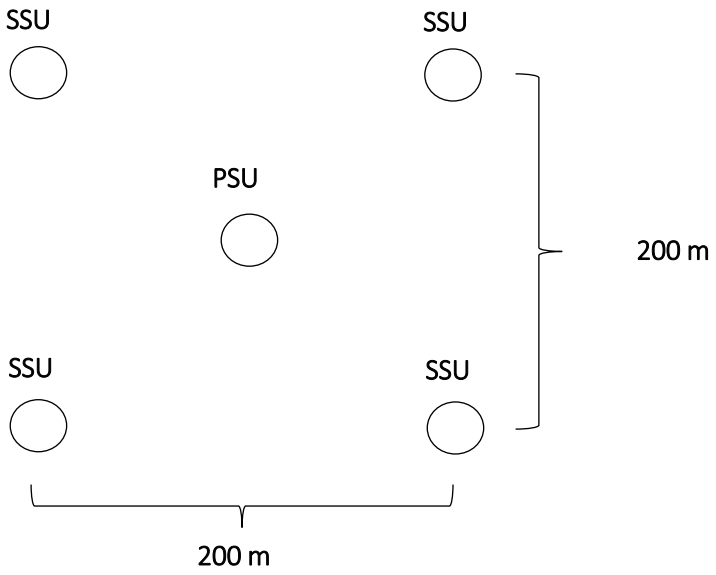


Figure 4. Clustered primary and secondary sample units (plots).

2.3. OVERVIEW OF THE FIELD WORK

Two measurements teams will be responsible for recording forest inventory data. Data from the sample plots will be collected on the analogic field sheets. The goal is that two field teams consist of three members in each team finishes one cluster per day in hilly areas and mangroves, and two clusters in plan areas and . Data quality control and backups are ensured on a daily basis for the field recorded data. The data is stored in Open Foris Collect database continuously and a copy of the data is sent to Arbonaut for near-real time calculation of the results.

In addition to two field plot measurement teams, one quality control (check survey) team will be formed from the inventory crew members who did not participate in original measurements of the sample plots. Quality control team will be revisiting total 12 of randomly sampled PSUs to verify measurement quality, modelling data and provide continuous feedback to the inventory crews.

2.4. PREPARATION OF FIELD MAPS

Field maps are used for planning navigation to the plots and to locate the plots in the cluster. Essentially, three types of maps are recommended.

Index Map locating all the sample plots with administrative unit boundaries, roads, location of villages/settlements in an appropriate scale (generally 1:100,000, 1:250,000, 1:500,000 scale) to plan the field works, transportation and logistics. Index Maps can be prepared at provincial level and printed in A1 size paper (59.4 x 84.1 cm)

Topographical Map (generally 1:50,000, 1:25,000 scale) to navigate to the designed plots. The most recent National Topographical maps are commonly used (if available). Alternatively, online maps such as Google Map, Open Street Map etc. can also be used, in case recent topographical maps are not available. Such online maps can be downloaded via GIS tools (such as QGIS, ArcGIS etc.) and

enlarged/reproduced to appropriate scale as necessary and printed. The locations of the plots should be marked in the Topographical Map along with the index/Plot ID, location of major landmarks, location of accommodation/camp site, location of essential services (such as police station, hospitals etc.), location of nearest village/settlement, bridges, foot trail etc. to enable proper navigation to the plot location and back to the camp site.

Mobile devices (tablet/phone) with GPS, map applications such as Google Map etc. are widely used to navigate to the locations. Offline maps can be downloaded in case of non-availability of internet coverage in the study area. Offline maps of the study area are recommended to download in the office prior to field works.

Cluster/Plot Map is used locate the plots on recent very high-resolution satellite image/aerial photograph (if available) and also to visualize the land use and terrain of the location. Freely available Google Earth, Bing Image and other very high-resolution images can be used to produce these large scale (1:5000 to 1:2500 scale) maps along with the location plots, land marks, and other features such as roads, village locations etc. Plot Maps are prepared for each individual cluster/plots. It is also advisable to include tabular list of coordinates of the plots (PSU/SSUs) in an appropriate projected UTM system and their location names in the map. Cluster/Plot map can be composed in A3 paper size for each of the cluster along with the list of plot coordinates, name of Tehsil, village/location name.

Various mobile applications such as Google Earth mobile version can also be used to visualize the plots on top of very high-resolution images and navigate to the plot using in-built GPS in the mobile devices.

Theas maps should be prepared in projected map coordinates (easting, northing) in meters used in the country. In case of Pakistan, the projected SRS are UTM 41N, UTM 42N and UTM43N with WGS 1984 datum as shown in Figure 7. The GPS also needs to be set in the projected UTM SRS. Appropriate UTM zones (41, 42 or 43) are automatically set in the GPS units.

Samples of Index Map, Topographic Map and Plot Map are attached in Annex 6.

2.5. FIELD DATA COLLECTION PROCEDURE

2.5.1. NAVIGATION TO SAMPLE PLOTS

The sample plots will be positioned with hand-held GNSS-devices. The GNSS-assisted navigation procedure is planned as follows:

1) Routes to the plots must be planned in the base camp using maps, satellite image and local resource persons. Destination plot coordinates are marked in GNSS, for example, on a weekly basis. If using a car for approaching, the point where to leave the car is marked in the GNSS as a waypoint. Other possible points of interest, e.g. a waypoint where to leave the trail, are marked, as well.

2) Use the maps and waypoints to navigate to the point where to leave the car. Check the point with the GNSS, if necessary. Try to locate landmarks to verify your location. Navigate to the plots by using the map, compass and GNSS. Plan the easiest and shortest possible route to reach the PSU and from one plot to another by considering their accessibility and local guide.

3) When arriving to the plot, do not try to walk directly to plot centre but set a bearing of 20 m in GNSS and select an open point within the bearing of 20 meter to the plot centre where the GNSS works well. Collect GNSS data 0.5–1 min to get a fixed position. The GNSS will average and calculate the current location and display the remaining distance and bearing to the plot centre when set on the navigation

mode.

4) Use the compass and linear tape to go exactly to the plot centre as directed by bearing and distance displayed by the GNSS device.

2.5.2. ESTABLISHMENT OF A SAMPLE PLOT FROM THE PRIMARY REFERENCE POINT

Primary and secondary sample plots are nested circular plots. All living trees and standing deadwood stems with DBH1 above 5 cm and stumps are measured from the full plot of 17.84 meters (~1000 m^2). The plot holds two subplots, 5.64 meters (~100 m^2) for counting seedlings and shrubs. All shrubs and seedlings are cut down and record its fresh weight. collect the sample in plastic or cotton bags to find the oven dried biomass. If the amount of shrubs and seedling in 5.64 m is large and difficult to carry then reduce the radius to 2.82 m and if still, the number is large then collect from 1.41 m. . If there is same kind of shrubs species in plots of one cluster then we keep the sample from one plot and for the

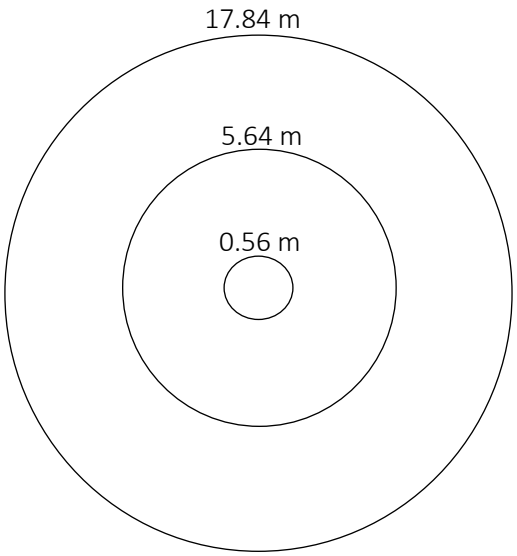


Figure 5. Nested circular field plot.

other plots we just record its sample weight and destroy the sample.Downed and stump deadwood with minimum diameter above 5 cm are measured from 17.84-meter plot, as well. The above-ground non-tree, litter and soil samples are taken within 0.56 meter plots (~1 m^2) (Figure 5).

If the centre point of the plot is in the middle of a tree, the staff is moved to the north side of the tree beside the trunk. If the sample plot is contained different land use classes and the plot centre is in forest, it is shifted with the minimum distance to a cardinal direction (N, S, E, or W) so that the entire plot remains completely inside the forest class. If plot is moved, write the distance of change into remarks. If the plot cannot be fitted entirely into forest even by moving it, the plot is established along the line where ever it has the maximum coverage of forest. In that case, the portion of forest from entire area is marked in percents into plot remarks. In the previous case, the plot should still be measured. The same rule applies in case the plot centre falls inside other land use classes. The centre point of the sample plot is marked with a wooden, at minimum 40 cm long pole that has been tagged with ribbon. Number the stick with the unique plot identification number. The exact location of the plot can be found later with the help of the ribbon marked stick.

When establishing the plot, it is important not to disturb the centre of the plot which will be measured

for litter or downed dead wood during measurements. The pools which can be easily be disturbed, like litter, should be the first thing to be measured. This way the rest of the work can be done without worrying about destroying samples.

GNSS is set to measure the accurate centre point location immediately after the plot centre has been reached. This way the GNSS device has enough time to average the point location while the plot variables are measured.

Before leaving the sample plot, GNSS device should be checked whether necessary number of location readings has been recorded. The centre point coordinates (x, y, z) are saved to GNSS device before leaving the sample plot. The coordinates are differentially corrected afterwards (if possible) to get the most accurate location.

When the GNSS device has been set to measure the centre point, the field measurements can be started. To determine clockwise from the compass North which of trees remain inside the sample plot Haglöfs Vertex is used.

2.5.3. FORM 1: CLUSTER INFORMATION (PRIMARY SAMPLING UNIT)

Cluster No

Each Cluster is uniquely numbered with pre-indexed number/code or ID. The Cluster No is generated in GIS.

Plot No

Plots (PSU and SSUs) are numbered 1-5 in a cluster. The Primary Sampling Unit (PSU) is numbered 5 for every PSU. The bottom-left SSU is numbered 1 and serially 2,3 and 4 in clockwise direction as shown in **Error! Reference source not found.** The PlotID is a combination of <ClusterNo>-<PlotNo> and is automatically generated in GIS/database. In the given example, for ClusterNo 344, the PSU plot is

Figure 6. Cluster No, Plot No and Plot ID

numbered 5, hence the PlotID is 344-5. Likewise, other plots have IDs 344-1, 344-2, 344-3 and 344-4 serially in clockwise direction. Therefore, each PSU and SSUs are uniquely identified as a composite of

ClusterNo and PlotNo.

Inventory Date[1]

Date of the measurement day according in the form of 'month-day-year', i.e. mm-dd-yy (e.g., 08-22-2017) in Gregorian Calendar.

Province/Territory

Name of the Province and federally administrated semi-autonomous territories viz. Gilgit Baltistan (GB), Khyber Pakhtunkhwa (KP), Azad Jammu & Kashmir (AJK), Federally Administered Tribal Areas (FATA), Islamabad Capital Territory (ICT), Punjab, Sindh and Balochistan

Crew/Team leader

Team leader is identified by writing initials of his/her full name.

Crew No

Number given to the team (if any) as Team 1, Team 2 etc.

Map Sheet

Map sheet index number of field map used for navigation or national topographical map (if used). Mention type of map used and map sheet index number.

District

Name of the Administrative District where the cluster/plot is located. The district name for each cluster/plot is obtained from the plot list prepared. A list of district names attached in Annex 5.

Forest Range

Name of the forest range under forest division/sub-division where the cluster/plot is located.

Valley Name

Name of valleys in hilly/mountainous regions of Pakistan in GB, KP, FATA, AJK, Punjab and Balochistan where the cluster/plot is located. The list of valley names attached in Annex 5.

Village/Settlement Name

Name of Tehsil or settlement where the cluster/plot is located. The Tehsil name is obtained from the plot list prepared.

Accessibility Code

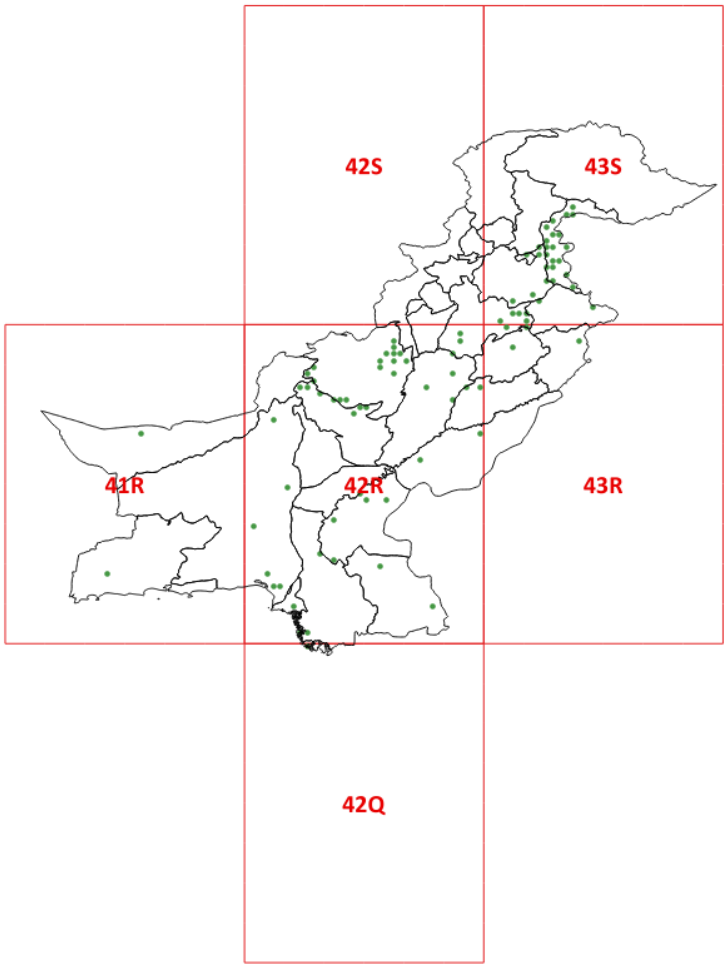
Accessibility is possibility to reach on-location of the cluster/plot via vehicle and/or foot and without any restrictions on measurement/observations due to security restrictions or due to restrictions of access/observations/measurement in privately owned land by the land owner. Accessibility codes are defined as:

[1] It is important to log dates in standard mm-dd-yy format for avoiding errors in data entry into database.

Code	Accessibility	Description
0	Accessible	On-site measurement/observation possible)
1	Inaccessible due to Slope	Inaccessible due to steep terrain, cliff, risk of landslide
2	Inaccessible due to Water Body	Inaccessible due to location of plot within river, lake, pond, reservoir, lagoon etc.
3	Inaccessible due to Restricted Area	Inaccessible due to international border, military area, sensitive area, conflict area, line of control, unsecure area etc.
4	Inaccessible due to Owner's Refusal	Inaccessible due to restrictions of access/observations/measurement in privately owned land by the land owner
5	Inaccessible due to Other Reasons	Inaccessible due to other valid reasons, reason to be specified

GPS UTM Zone

Universal Transverse Mercator map projection zone of the cluster/plot shown GPS. The territory of



Pakistan lies in UTM Zones of 41, 42 and 43 in Northern Hemisphere. The latitude rows are Q, R and S as shown. The UTM zone is shown in GPS. Only zones 41, 42 and 43 needs to be specified (rows Q, R and S are not required) in the form.

GPS Receiver Model

Figure 7. UTM Zones in Pakistan Territory

Brand name and model number of GPS receiver. E.g. Garmin 60CSx, Garmin64S etc.

Waypoints WP#

GPS Waypoints (WP#) are navigational markers or landmarks recorded in the GPS while navigating to the Cluster center (i.e. PSU). The waypoints are recorded in GPS and logged by the Team Leader in the form for future reference as well as is useful to navigate back to the camp site/vehicle after the inventory works. Following data are entered in the Waypoint log.

Parameter/Data	Description
WP#	Waypoint number as recorded in GPS set (automatic/manual)
GPS X	Easting in meters in given UTM coordinates
GPS Y	Northing in meters in given UTM coordinates
Waypoint Description	Brief description of major landmarks where waypoint is recorded in GPS. For e.g. vehicle park, road junction, tea stall/shop, big rock, distinctive tree by the road etc.

Time Log in Cluster

Time log of field travel and observations are recorded for future reference and time management in the inventory. Logging time, i.e. the time of recording the plot variables in the form of hour:minutes, i.e. 08:04. Exact logging time is specified. Team leader checks from his watch and records.

Parameter/Data	Description
Start Time (HH:MM):	Time when leaving the vehicle
Arrival Time (HH:MM):	Time when cluster center PSU is reached
End Time:	Time when returning to vehicle

Remarks

Any brief description remarks of the cluster related to the surrounding environment, terrain, population habitation, use, bio-climate, ecology, ownership, issues etc.

2.5.4. FORM 2: PLOT - GENERAL AND FOREST LAND USE

Cluster No

Each Cluster is uniquely numbered with pre-indexed number/code or ID. The ClusterNo is generated in GIS. In FORM 2, the ClusterNo is entered as the same ClusterNo from FORM1.

Plot No

Plots (PSU and SSUs) are numbered 1-5 in a cluster. The Primary Sampling Unit (PSU) is numbered 5 for every PSU in the cluster. The bottom-left SSU is numbered 1 and serially 2,3 and 4 in clockwise direction as shown in above Figure 6.

Accessibility Code

Accessibility is possibility to reach on-location of the plot via vehicle and/or foot and without any restrictions on measurement/observations due to security restrictions or due to restrictions of access/observations/measurement in privately owned land by the land owner. Accessibility codes are used as above defined.

Land Ownership

Legal ownership of the land where the plots (PSU/SSUs) are located. This information can be obtained by enquiring with the local forest guide, local people and verified with the forest range office/department. The codes used for ownership are:

Code	Land Ownership	Description
1	Federal Government	Land owned by Federal Government of Pakistan
2	Provincial Government	Land owned by Provincial Government
3	State Government	Land owned by the State Government
4	Tribal Land	Land owned/managed by Tribal Jirga
5	Private Land	Privately owned land
6	Protected Area	National Park, Wildlife Sanctuary, Game Reserve, Protected Wetland, Protected and Reserved Forest, Biosphere Reserves etc.
7	Other <specify>	Other land ownership <to be specified>
99	Not Known	If land ownership type is not known due to unverified/unreliable information or no available information

Map Coordinate (UTM)

Coordinates of plot (PSU/SSU) located on the map and used for navigation. The coordinates are entered from the list or field map coordinate table in UTM (41, 42, 43) Zones.

Measurement Time Log

Time log of field measurement/observations made at the PSU/SSU plot. The time log includes measurement time of tally trees, sample trees, deadwood, litter, soil organic carbon, taking photographs, land use and land use subtype, land use change and GPS data collection. Exact logging time is recorded.

Parameter/Data	Description
Arrival Time (HH:MM)	Arrival time at PSU/SSU
Start Time (HH:MM)	Start time of measurement at PSU/SSU
End Time (HH:MM)	Completion time of measurement at PSU/SSU

GPS Coordinates

Coordinates are recorded the throughout the time of the measurement in a plot. When possible, DGPS is used and post-processed to increase accuracy. The PlotID (ClusterNo-PlotNo) should be marked also on the GPS before starting the location recordings.

If Differential GPC (DGPS) is used, the following parameters are recorded.

Parameter/Data	Description
GPS Receiver ID	Receiver ID of the rover GPS unit
Base Station ID	Base Station Receiver ID
GPS Point ID	ID of GPS point, this is generally Plot ID entered in the DGPS unit. If different log the entered ID in the DGPS unit for the specific PlotID (ClusterNo-PlotNo)

Antenna Height(m):	Measured height of the GPS antenna setup if tripod is used (follow DPGS manual if needed)	
Logging Start Time (HH:MM)	Start time of DGPS log	
Logging End Time (HH:MM)	Finish time of DGPS log	
X	Averaged X coordinates	Take the readings of averaged coordinates at the end of field measurement. Averaging can be set for 30 seconds/60 seconds
Y	Averaged Y coordinate	
Z	Averaged Z coordinate	
File Name	File name of log file	

Download the log file from the rover GPS unit and Base GPS Unit every evening to the field computer. Also maintain the start end log of base station, using the log as shown below:

Base Station ID	Base Station Receiver ID
Logging Start Time (HH:MM)	Start time of DGPS log
Logging End Time (HH:MM)	Finish time of DGPS log
Antenna height	Measured height of the GPS antenna setup if tripod is used (follow DPGS manual if needed)
File Name	File name of log file.

If handheld GPS is used

Parameter/Data	Description	
GPS Receiver Model	Model of GPS used (E.g. Garmin 60CSx, Garmin64S etc.)	
GPS UTM Zone	UTM Zone shown in GPS unit (41/42/43)	
Accuracy (m)	Accuracy shown on GPS unit at the time of logging	
X	X coordinates (Easting) in UTM	Set the averaging for 30 seconds and log the GPS throughout the plot measurement (2-3 hours). Record the coordinates at the end of completion of the plot measurement such that the coordinates are the 30 sec averages for the period of 2-3 hours, thus increasing the accuracy.
Y	Y coordinates (Northing) in UTM	
Z	Elevation	

Terrain Parameters

Slope of the terrain in % gradient measured using Haglöfs Vertex.

Aspect of the terrain in eight cardinal direction North, North East, East, South East, South, South West, West, North West.

Erosion Code is used to denote the level of erosion observed in the terrain where the plot is located. The level of erosion is subjectively observed. The codes for various levels of erosion are

Code	Erosion Level	Description
0	No Erosion	No erosion

1	Gullies	Evidence of erosion shown by deep excavation of soils mainly caused by excessive water and exposing bare rocks at the bottom
2	Rills	Evidence of erosion shown by removal of surface soils and mainly caused by droplets of rain water
3	Sheet	Evidence of erosion shown by even removal of the surface layer of the soil mainly caused by water moving runoffs
4	Root Exposure	When there is not enough soil therefore the roots of the plants are exposed
5	Rock Outcrop	Rocks protrusions from surface of the soil due to erosion processes
6	Others <Specify>	Other forms of erosion to be specified

Main site type (mineral soil, peat lands, wetlands)

The main site type is used to classify the forest land into mineral soils, peat lands and wetlands. The stand is deemed as peat land, if the organic layer is peat. Otherwise, the main site type is mineral soil.

IPCC Land Use Code

1) Forest Land

This includes all land with woody vegetation consistent with thresholds used to define Forest Land in Pakistan:

- Minimum area for forest 0.5 ha
- Minimum crown cover (CC) is 10 %
- Minimum height of 2 meters

If the land use is forest, Forest Type/Strata is ticked by the following options:

For example, forest type of Tropical dry deciduous is selected as

Tropical		Temperate	
	Littoral and swamp forest (Mangroves)		Moist Temperate Forests
✓	Tropical dry deciduous		Montane Dry Temperate Coniferous Forests
	Tropical thorn forest		Dry temperate Juniper and Chilghoza Forests
	Riverine Forest		Dry Temperate Broad-Leaved Forests
Sub-Tropical			Northern Dry Scrub
	Montane sub-tropical scrub forests	**Alpine**	
	Sub-tropical broad-leaved forests		Sub-Alpine Forests
	Sub-tropical pine forests		Alpine Scrub
Plantation Forest		**Others (specify)**	
	Linear – Road Side Plantation		Shrubs/Bushes
	Linear – Railway Side Plantation		Farm Forest/Orchards
	Linear – Canal Side Plantation		
	Irrigated – Farm Plantation		
	Non-Irrigated Plantation		

For forest land use class and specific forest type, **Density Class** of the **forest stand** is defined as 'Dense' or 'Sparse'

Tree Canopy Cover is defined by ground surface covered by the vertical projection of the tree canopies within a plot of 17.84 m, expressed as percentage of the total ground area in the plot.

Tree Canopy Cover %	Description
No Trees	
<5%	Very few trees
5-10%	Sparse tree canopy cover
10-40%	Very open tree canopy cover
40-70%	Open tree canopy cover
>70%	Closed tree canopy cover

Tree canopy cover is expressed based on ocular/visual observations of the forest canopy in the plot. If available, semi-hemispherical photograph should be taken using mobile phone camera (with fisheye lens or camera app[1]). Mobile tools such as Gap Light Analysis Mobile Application (GLAMA)[2] can be used in the field to estimate the tree canopy cover.

2) Cropland

This includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category. Land where over 50 % of any defined area is used for agriculture. This may be currently cropped or in fallow and may include areas for grazing of livestock.

3) Grassland

This includes rangelands and pasture lands that are not considered Cropland. It also includes herbs and brushes that fall below the threshold values used in the Forest Land category

4) Settlements

These include all developed land, including transportation, infrastructure and human settlements of any size, unless they are already included under other categories.

5) Wetlands

These include areas of peat extraction or land that is covered or saturated by water for all or part of the year (e.g. peatlands), and they do not qualify for the IPCC classes 1-4It also includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

6) Other Land

This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories.

2.5.5. FORM 3: PLOT INFORMATION – LAND USE AND LAND USE CHANGE

[1] Various mobile apps are available in Android/IoS such as Instafisheye Live for Android

[2] GLAMA can be downloaded from https://play.google.com/store/apps/details?id=com.mobilesglama for Android devices

Cluster No

Each Cluster is uniquely numbered with pre-indexed number/code or ID. The ClusterNo is generated in GIS. In FORM 2, the Cluster No is entered as the same Cluster No from FORM 1.

Plot No

Plots (PSU and SSUs) are numbered 1-5 in a cluster. The Primary Sampling Unit (PSU) is numbered 5 for every PSU in the cluster. The bottom-left SSU is numbered 1 and serially 2,3 and 4 in clockwise direction as shown in above Figure 6.

Sub-Classes for Other land uses

The appropriate type is ticked from the following options according to the plot center point reference:

Grassland		Cropland	
	Alpine/Summer Pastures		Crop Irrigated
	Winter Pastures		Crop Rainfed
	Rangeland		Crop in Flood Plain
Other Land			Crop Marginal and Irrigated Saline
	Barren Land/Bare Soil/Desert		Agroforestry
	Rock		Fruit Orchard
	Snow		Plantations (Banana, Tea, Palm, etc.)
	Glacier		
Wetland		Settlement	
	River/Stream/Canal		Built-Up (cities/villages)
	Lake/Pond/Reservoir		Infrastructure (airport, port, highway, industrial complex etc.)
	Swamp/Peat Land		
	Estuary/Lagoon		

Disturbances Observed in Plot

Disturbances observed/visible in the plot due to human activities and/or natural causes. Multiple options can be selected out of the provided list:

- No-Disturbances
- Logging
- Grazing
- Tree Plantation
- Fire
- Landslide
- Shifting Cultivation
- Construction
- Others (to be specified)
- Non-known

Disturbances Occurred Year(s)

Known year(s) when the above disturbances started/occurred. This is enquired to the forest ranger, local guide/people with local knowledge.

Severity of Disturbances

Severity of observed/identified disturbances that might have caused deforestation, degradation, reforestation or regeneration. Levels of severity are indicated as:

Code	Severity of Disturbances	Description

1	Slightly	The evidence of the effects of disturbances is not so visible
2	Moderately	Some visible effects of the disturbances are observed
3	Heavily	Strong effects of the disturbances are observed

Deforestation/Forest Degradation Observed in Plot

Causes of deforestation/degradation observed in the plot. Causes can be multiple.

Natural Causes		Anthropogenic Causes	
	Natural Fire		Agriculture Expansion
	Pests/Insects		Livestock Rearing/ Overgrazing
	Disease		Logging
	Flood		Fuelwood Removals
	Landslide/Erosion		Mining
	Wind		Dam
	Drought		Roads
	Desertification		Conflict

Land Use Change and Forests in Plot

Known land use changes occurred in the plot during the decades of 1996-2000, 2000-2004, 2004-2008, 2008-2012 and 2012-2016. This information can be obtained upon enquiring to the forest ranger, local guide and population. The enquired information may need to be cross-verified with other reliable sources or multiple sources.

0	Forest Remaining Forest
1	Cropland converted to Forest
2	Grassland converted to Forest
3	Wetlands converted to Forest
4	Settlements converted to Forest
5	Other Land converted to Forest
6	Forest converted to Cropland
7	Forest converted to Grassland
8	Forest converted to Wetlands
9	Forest converted to Settlement
10	Forest converted to Other Land
99	Not-Known

Any Remarks/Description of Plot

Any brief description remarks of the plot related to the surrounding environment, terrain, population habitation, use, bio-climate, ecology, ownership, issues etc. Also write here the distance of change, if plot is moved from its original position and the portion of forest land use if full coverage of forest cannot be achieved with a maximum 100 meter shift.

2.5.6. FORM 4: ABOVE-GROUND AND BELOWGROUND BIOMASS OF TREES

2.5.6.1. DEFINITIONS

Breast height: A fixed height of 1.3 metres above the ground level. If the ground level cannot be defined, the breast height is determined as 1.3 metres from the seeding point.

Broken tree: A broken tree may be either living tree or dead tree. If the tree has been broken below 1.3 metres, the tree is classified as a stump, and thus not measured.

Dead tree: A tree is regarded as dead, if it does not have any living branches. Trees that are alive but so

badly damaged that they cannot grow until the next growing season (e.g., trees damaged by storm) are regarded as dead trees.

Forked tree: A tree is forked, if the forking point is at breast height. If the forking point is below breast height, each stem is regarded as a separate tree.

Point of measurement: Point of measurement of diameter in case of buttressed or malformed tree. The point of measurement is recorded as a distance from the ground to the measurement point.

Living tree: A living tree must have living branches and leaves, and it must be able to survive until the next growing season.

Sample tree: A tree selected for the measurement of additional variables that are often generalised to cover the tally trees.

Seeding point: Seeding point is usually at the ground level. For trees growing on the top of a stone or old stump the seeding point is determined as the point where the seed has started to grow.

Tally tree: A living tree and shrubs within the plot radius fulfilling the diameter threshold of 5 cm.

Tree: A perennial woody plant that has many secondary branches clearly above the ground on a single main stem or trunk with clear apical dominance.

2.5.6.2. TALLY TREES

Tally trees are measured from the sample plots with radius of 17.84 m. All trees which have DBH1 of 5 cm or more are measured from this largest plot. It is best to start measurements always from the same cardinal direction, North, and move from tree to tree clockwise until all trees are measured. Every tree gets a unique ID number starting from 1, and tree species is defined. Diameter at breast height at 1.3 meter is measured from every tree following the international standards. Each tally tree is marked with the number (ID) of that tree by marking the number on the bark with paint.

2.5.6.3. TREE VARIABLES

Tree ID

Unique ID give for each tree of a plot. Starts from 1 on every plot.

Species Code

The tree species code list organised in the alphabetic order according to both the local and scientific names are found as Annex 3 of this manual.

Species Name

Tree species can be marked by using the predefined species list or by writing the species name using local or scientific name.

Diameter at breast height, DBH1 (x.x cm)

Diameter at breast height is measured from every tree using the breast height of 1.3 meters. Diameter is measured preferable using a calliper for trees under 50 cm and with the diameter tape for the trees above 50 cm. The diameter is measured always with the measurers back towards the centre of the plot. If the tree trunk is clearly not circular, diameter can be measured from two perpendicular directions and taking the average of two measurements. If the tree trunk has some anomaly, like a branch on the breast height location, the diameter should be taken above the anomaly as close as possible, but making sure the tree trunk is normal on that location.

It is best to create a measurement stick which has two lengths, a marker on 1.3 meters and a total length of the stick which is 1.37. This stick can be used as the measure stick when taking the DBH measurements. Trees with a forked stem below 1.3 m will have a DBH measurement for each of those forked stems (Annex 4). When using a calliper for DBH measurements, it is important not to hit the calliper too hard on the bark, because this would change the DBH measurement itself by breaking the bark. Moreover, when using a measurement tape for DBH measurements, it is important to have the measurement tape horizontally level. Otherwise, the DBH will be overestimated. In both cases, calliper and measurement tape, it is important to make sure that there are no anomalies on the measurement point. If there is some anomaly, a bulge or a polyporaceae, the measurement should be taken directly above the anomaly where the stem is normal again. This type of tree cannot be sample tree. Also, any change in point of measurement should be marked into comment field .

Broken top (1/0)

All trees are marked if they have broken top or not. 1 is for broken top, and 0 is for normal. If a tree has a broken top, it cannot be selected as sample tree, but the following tree will be selected instead.

2.5.6.4. SAMPLE TREES

Sample trees are selected from all measured alive trees by selecting every 5th tree starting from tree no. 1. If the selected tree has a broken top or has some anomaly at the breast height, it will not be selected as sample tree. In that case the next tree in order will be sample tree, however, the next sample tree will be selected based on the same order still. This means that if plot has 25 trees, the sample trees would be trees 1, 6, 11 16, 21. However, if tree no. 11 has broken top, the selected sample trees would

be 1, 6, 12, 16, 21. The sample trees will be measured for second DBH with breast height at 1.37 meters, top height, bole height, and in case of leaning trees also base length for both top height and bole height.

Diameter, DBH2 (x.x cm):

The second DBH measurement is taken as some of the locally developed allometric models and past inventories refer to these diameter measurements. This measurement helps to develop a calibration model to make all the past inventory data compatible with the international standards. DBH2 is measured similarly and all the same rules apply as DBH1, but the breast height is at 1.37 meters. Only sample trees are measured for both DBH1 and DBH2.

Tree height (x.x m)

Tree height is measured for the sample trees, which are labelled as every 5th tree when viewing at the plot centre from the compass North towards South and further from South to South. Tree height is measured using a hypsometer (Haglöfs Vertex). Tree height is measured from the seeding point of a tree to the tree top.

Make sure the equipment is correctly calibrated every morning and every time the weather changes considerably, which might affect the equipment. The Haglöfs Vertex manual is found as attachment.

Bole height (x.x m)

Bole height is measured from sample trees only. Bole height is measured from the starting point of the tree up to the lowest living branch. The same principles apply as for the tree height measurements.

Tree base length and bole base length (x.x m)

The tree base length and bole base length are measured only for heavily leaning sample trees. Tree base length is the distance on the ground from the base of the tree to the location directly under the top of the tree. Bole base length is the same but for the bole height.

Stem height for a tree with broken top (x.x meter)

If a living tree has a broken top, its height is always measured.

2.5.7. FORM 5: DEAD WOOD INFORMATION

TREE/PARTICLE ID

Unique ID give for each tree of a plot. Starts from 1 on every plot.

SPECIES CODE

If the species can be identified, the species code is with the trees and particles following the IDs presented in Annex 3. If not, then the code is 999.

SPECIES NAME

If the species can be identified, the local or scientific name is indicated.

CATEGORY

The deadwood items found on the plots are classified into 3 sub-categories.

STANDING DEAD WOOD

All the standing dead trees with DBH1 measured at 1.3 m height greater than 5 cm are enumerated within the full 17.84 m plot. DBH1, top height and decomposition state must be recorded for all the standing dead trees.

The specific decomposition stage classes for standing dead wood are:

1) Tree with branches and twigs and resembles a live tree (except for leaves);
2) Tree with no twig, but with persistent small and large branches;
3) Tree with large branches only;
4) Bole (trunk) only, no branches.

DOWNED DEAD WOOD

Downed branches and stems of trees and brush with minimum DBH above 5 cm , which have fallen and lie on or above the ground are measured from the 17.84 m. Only the proportions of dead wood stems and their fragments lying insideare measured. The measurements to be carried are the length (m) inside the plot and diameters (cm) at the two ends of the wood or fragment particle.

STUMPS

All the stumps with diameter above 5 cm are enumerated within the full 17.84 m plot,. The stump diameter is measured in two diagonal directions, its lowest and highest heights with a measuring tape from the level of seeding point.

DECOMPOSITION CLASS (1,2,3)

Dead wood samples of the tree density classes, one sample should be collected and sent to the laboratory for wood density determination. Parts of the dead stems or branches outside the plot borders should be excluded. This should be carried out by striking the wood with a machete as:

1) Sound (blade does not sink or is bounced off).
2) Intermediate (blade partly sinks into the piece of wood or there has been some wood loss).
3) Rotten (blade sinks well into the piece, there is extensive wood loss and the piece is crumbly).

A small sample (up to 500 grams) from each decomposition class is extracted and taken to the laboratory. These samples are extracted from the lying dead wood pieces from the nearest location of the PSU centre. The sub-samples to be taken to the laboratory must be labelled appropriately, with permanent marker. The labels must include the sample details in the following format *PlotId/Date/Fresh mass*.

DBH/Diameter 1 (x.x cm)

The first end diameter measurement for downed deadwood, stump diameter or DBH at 1.3 meters for standing trees.

Diameter 2 (x.x cm)

The second end diameter measurement for downed deadwood or stump.

Tree height / length (x.x m)

Tree height or particle length measured in meters

Standing tree, base length (x.x m)

The standing dead tree base length is only measured for heavily leaning sample trees. Tree base length is the distance on the ground from the base of the tree to the top of the trunk.

Standing tree broken top (1/0)

All the standing dead trees are marked if they have broken top or not. 1 is for broken top, and 0 is for normal.

2.5.8. FORM 6: LITTER INFORMATION

Non-tree biomass Litter, herbs, grasses and soil biomass are extracted from the 0.56 m sub-plots.The litter layer is defined as all dead organic surface material on top of the mineral soil. Similarly, all the leaf litter and wood litter less than 5 cmin diameter within the subplot are collected and their fresh weights determined in the field with a weighing balance. The sample weighted on site after taring the balance to exclude the plastic bag weight. A sub-sample for plot is taken, weighed, placed in a zip-locked polythene bag, labelled and then taken to the laboratory to determine the oven dry mass and carbon content. The labels must include the sample details in the following format *Site/PlotId/Date/Fresh mass* (e.g. Joensuu/4/2017-08-21/495gr). Other relevant information can be also recorded in the field sheets.

2.5.9. FORM 7: SOIL ORGANIC CARBON (SOC) FOR MINERAL SOILS

From the plot location, scrape away surface litter to obtain a uniformly thick slice of soil from the surface to the required depth from each spot. Collect the sample using the auger or chisel and put it in a clean bucket. Samples from the different depths are placed in separate buckets. Mix soil in the bucket thoroughly and take about 0.5 kg sub-sample and put in a clean and free from any contamination sampling bag. Label each sampling bag clearly to identify the sample. Finally, clearly fill in soil sample information sheet.

A cylindrical metal sampler of 5 cm diameter and 5 cm long will be used to sample undisturbed soil. The core will be driven to the desired depth (0 – 10, 10 – 20 and 20 – 30cm) using a hammer and the soil sample carefully removed to preserve the known soil volume existed in situ using the soil knife. The soil sample is then transferred into a clean sampling bag without spilling it and label the sample bag clearly. Fill in soil sample information sheet including the details for the name of sample collector, address, date, area and location.

Before sending soil samples to the laboratory, it is necessary to ensure that proper identification marks are present on the sample bags and labels placed in the bags. Pack the samples properly in clean bags and take samples directly to the laboratory.

2.5.10. FORM 8: PLOT PHOTOGRAPHS

Photographs at each PSU and SSU are taken towards the compass direction in North, East, South and West from the plot centre. The corresponding Photo number/ID/ file name as shown in the camera with other site characteristics are noted in the field sheets.

Other photographs (if taken) in the plot, which may include soil sample, litter sample, herbarium sample, flora biodiversity, fauna biodiversity occurrence, forest canopy semi-hemispherical etc. also needs to be recorded appropriately with photo number/ID/filename in the form.

Setting of the digital camera (mobile phone camera/camera) needs to be set to display the filenames on the screen.

2.5.11. FORM 9: DATA QUALITY ASSURANCE AND DIGITALISATION

12 clusters are re-visited for quality control. The control clusters are selected randomly from the clusters that have been measured by other teams. The control plots are re-measured by a different team than the measurer of the original plot using the same measurement procedures with the exception that the control plot is relocated on the same place than the original plot. The relocation is done with the help of the original plot centre pole. The control plot measurements are recorded in the corresponding field forms.

As part of the quality control, also the recorded data files should be quality controlled. Furthermore, it is important to quality check the field data after the day's work. The field team leaders go through all field forms to check there has not been any major mistakes or discrepancies in the day's data. If there are problems, the field team can try and solve the problem on the spot or by revisiting the plot the next day.

During the field campaign, data is sent to office when appropriate, e.g. once a week. The data is checked in the office for any mistakes and post-processed for the field data calculation. The post-processing includes for example post-processing of GNSS coordinates, and combining data sheets of individual plots into one cluster file. The quality control measurements are then compared at the office to the original measurements for any bias in measurements. Thus, the results of the control plot measurements (original and control measurements) are stored in the digital database and sent for the field data calculation ASAP after measurements.

2.5.12. FORM 10: LAND USE GROUND TRUTHING/VALIDATION

Ground truthing is done for land uses other than forests and if necessary in forest plots for land use land use change mapping purpose. This is done independently to the forest inventory. General information related to land use are collected in the field based on the field observations, logging of GPS positions and interactions with the local guide/people. No measurements are required for the ground truthing. The ground truthing plots are the designed during first phase sampling (10' x 10' grids) and are visited during the NFI on the way to the forest plots. Only selected limited plots are visited.

Validation of classified land use and land use changes might be required due course of calculation of LULUC activity data estimation. Stratified randomly generated plots are required to be visited to collect general data in the FORM 10.

The parameters and their descriptions in FORM 10 are similar to those FORM 1 and FORM 2, therefore elaboration is not done here.

3. QUALITY ASSURANCE AND QUALITY CONTROL

For verifiable and certifiable measurements of carbon stocks, provisions for Quality Assurance (QA) and Quality Control (QC) must be implemented. A QA/QC plan provides confidence that the reported carbon credits are reliable and in compliance to the minimum measurement standards. The QA/QC plan covers procedures for

1. Collecting reliable field measurements
2. Verifying laboratory procedures
3. Verifying data entry and analysis techniques and
4. Data maintenance and archiving

To ensure these procedures are carried out in a consistent and repeatable manner, a set of Standard Operating Procedures is prepared for each step. The following sub-section presents the SOP for each of these procedures to be implemented for developing FREL/FRL and MRV for REDD+ in Pakistan.

3.1. QA/QC FOR FIELD MEASUREMENTS

This "Forest Inventory and Field Surveying Manual" is developed as a comprehensive a '**Standard Operating Procedure (SOP)'** document containing the details of all the steps to be taken in the field inventory and measurements. Proper implementation of this SOP ensures measurements executed by different teams or at different times are consistent and comparable. This SOP covers all the aspect of field measurement along with detailed instructions for navigating to the inventory plot, laying out of the Primary and Secondary Sampling Units (PSU and SSUs), recording the locations of the plots, measurement of trees, classifying deadwood and delineate litter from mineral soils along with the measurements of these, recording of measurements in field tally sheets, entering the recorded data into database. Field crews should be extensively trained in all the procedures of field data collection as accurately as possible. During every field mission, a document should be prepared and filed, which records and verifies that all the steps from the SOP have been followed and listing all the deviations from the SOP, if any. The SOP should be updated if significant deviations and issues from the procedure is encountered during the inventory.

An audit program for field measurement should be established. Typically, the audit program is conducted by a National Technical Team and consists of two level of checks. In the first check, auditors observe members of field crew during data collection on a field plot. Mistakes in procedural errors are corrected in the field and the field crew are re-oriented in the field. This is done as a part of the training. A second type of field evaluation involves complete re-measurement of certain sample plots by the auditors after the completion of field works. About 10-20% of the clusters/plots (12 clusters in current NFI throughout Pakistan) are re-measured independently by an experienced National Technical Team. Field data collected at this stage is compared with the original data to calculate measurement variances. Any errors found should be corrected and recorded, and could be expressed as a percentage of all the pots that have been rechecked to provide an estimate of the measurement error.

Measurement error (in %) for all the verified plots can be calculated as:

$$Measurement\ error\ (\%) = \frac{(biomass\ before\ corrections - biomass\ after\ corrections)}{biomass\ after\ corrections} \times 100$$

3.2. QA/QC FOR SAMPLE PREPARATION AND LABORATORY MEASUREMENTS

Similarly, procedure described in the SOP for sample preparation (for litter, soil organic carbon) should be rigorously followed for sample preparation and lab analysis. Laboratory measurement should also follow a standard/accredited procedure. If a commercial/external laboratory performs the analysis, record of the procedure should be obtained, ensuring a accepted standardized procedure is followed.

For QC, all combustion instruments for measuring carbon should be calibrated using commercially available certified carbon standards. Similarly, all balances for measuring dry weights should be periodically calibrated against known weights. Fine-scale balances should be calibrated by the manufacturer and calibration certification made available. Where possible, 10-20% of the soil samples should be reanalyzed/reweighted to produce an error estimate. Similar procedure should be applied to litter material. Measurement error is estimated using this equation:

$$Measurement\ error\ (\%) = \frac{(number\ of\ errors\ among\ checked\ sample)}{total\ number\ of\ samples\ checked} \times 100$$

If the calculated measurement error is greater than 10%, all the analysis needs to be rerun.

3.3. QA/QC FOR DATA ENTRY

Field data are either collected directly on electronic devices (field computers, tablets, PDAs etc.) using specialized/customized data entry software or written down in field sheets. In the latter case of manual entry on field sheets, data are digitized into spreadsheet or data entry software upon completion of inventory day/mission. In both the cases, errors in field data entry can occur and efforts should be made to check the entry step. In the field, clear communication between all the personnel involved in measuring and entering the data is critical to eradicate apparent anomalies in data entry. Typical mistakes are confusion between diameters or circumferences of trees measured, or the length unit (mm, cm, and inches). All the measurements to be entered in the field sheet/data software must have 'units' clearly indicated. Errors can be reduced by

- spot checks of the entered data by independent personnel,
- range checks - outliers can be identified by checking whether each value is within an expected

If during spot checks or range checks, a significant error are found, all data must be rechecked by independent personnel. To check of data entry errors, an independent person should enter 10-15% of the field sheets into the data entry software. These two data sets can then be compared to check for errors. Any errors detected should be corrected in the master file. The errors in data entry can be estimated as:

$$Measurement\ error\ (\%) = \frac{(number\ of\ errors\ among\ checked\ sample)}{total\ number\ of\ samples\ checked} \times 100$$

If the calculated measurement error is greater than 10%, data must be re-entered.

Customized data entry/analysis software could be developed such that there are data validations and checks built into the system to highlight the potential error in entry. For instance, such checks or data validation could include tests to check if the diameter limits for given nested plot is within the limit set.

Further, expert's knowledge and sometimes common sense needs to be used when reviewing the results of data analysis to make sure the results are realistic. Errors can be reduced if the entered data are reviewed using expert judgment and, if necessary, through comparison with independent data.

3.4. QA/QC FOR DATA ARCHIVING

Proper management of inventory data and archiving is very important for future references and its timely use in analysis. Due to relatively long-term nature of forest inventory works, data archiving and storage is also important in an inventory project. Following procedure is recommended for proper data archiving:

- Original copies of the field measurement (data sheets or electronic files) and laboratory data should be maintained in original form, placed on electronic media, and stored in a secure location. Mobile cameras can be used efficiently to scan/photograph the paper field sheets and electronically stored in the device and/or emailed to office/cloud storage[1] for archiving.
- Copies of all data analyses, models, the final estimates, GIS products, and a copy of the measuring and monitoring reports also should all be stored in a secure location (preferably offsite). It is recommended that a centralized database be used to store and archive all the data and results. Various enterprise free and open source and commercial database systems are available such as PostgreSQL, MySQL, MSSQL, Oracle etc. for data archiving and administration. Preferably, open source database systems such as PostgreSQL can be used to store both data and spatial datasets in a single database with a common interface in GIS applications such as QGIS, ArcGIS etc.
- Given the period for reporting and the pace of production of updated versions of software and new hardware for storing data, electronic copies of the data and report should be updated periodically or converted to a format that can be accessed by new or updated software. Open data formats and web accessible standard interchangeable formats are recommended instead of proprietary formats.

[1] Google Drive, Dropbox, OneDrive, Mega, Box etc. offer limited (5-50 GB) free storage service.

ANNEX 1. INVENTORY TEAM COMPOSITION AND TORS

No.	Key position	Quantity	Terms of references
1	Team Leader	1	In charge of data entry. Directs the Team's activities and assigns responsibilities to the other team members
2	Deputy Team Leader	1	In charge of sample tree height measurements with a Hypsometer.
3	Botanical Assistant	1	Identifies all species (trees and climbers) and measure tree diameters and points of measurement (POM).
4	GNSS Operator	1	Records the coordinates for one primary and four secondary plot reference points. In charge of compiling the list of measured coordinates.
5	Deadwood/Litter/Soil Sampler	1	In charge of non-tree, litter and soil sample collection within plots, and handling the delivery to the lab.

No.	Supporting staff position	Quantity	Job description
6	Driver	2	Team transportation
7	Laborer	Various	Cleaning to improve access, assistance in measuring distances. Assist in any activity that the Team Leader will assign them.

Supervision and quality control team

No.	Role	Quantity	Job Description
1	Team Leader	1	Work site planning, consultations and keeping the relevant stakeholders informed.
2	GIS expert	1	• Prepare necessary maps for planning purposes. • Assist planning team leader specifically on the matter of the GNSS navigation. • In charge for the forest demarcation process
3	Forest inventory quality control measurements and data cleansing	1	• Receive the data sheet from the measurement teams every day to control data quality and orient team leaders in case of lacking data entries or conflicting measurement data. • Manage and back-upping the data sheets or data files. Inform the team leaders in case a plot needs to be revisited due to flaws in data collection. • Enter the data into the database • Provision the data to Arbonaut every week
4	Soil analysis	1	• 10 % of the samples re-assessed in the lab

ANNEX 2. FIELD FORMS

FORM 1: Cluster Information (Primary Sampling Unit)

Cluster No.:	Province/Territory:	Map Sheet:
Inventory Date (mm-dd-yy):	Crew/Team Leader:	Crew No:

District	Forest Range	Compartment No.	Valley Name	Village/Settlement Name

Accessibility Code:	(0) Accessible (1) Inaccessible due to Slope (2) Inaccessible due to Water Body (3) Inaccessible due to Restricted Area (4) Inaccessible due to Owner's Refusal (5) Inaccessible due to Other Reasons <Specify>

Navigation to Cluster (Waypoints):

GPS UTM Zone:	*UTM Zones: 41, 42, 43* *(Check your GPS set)*	GPS Receiver Model:

WP#<GPS Point>	GPS X (Easting in m)	GPS Y (Northing in m)	Waypoint Description
			<e.g. vehicle parking location>

Time Log in a Cluster:

Start Time (HH:MM):	*Time when leaving the vehicle*
Arrival Time (HH:MM):	*Time when cluster center PSU is reached*
End Time:	*Time when returning to vehicle*

Remarks:

arbonaut

WWF

FORM 2: Plot Information (Secondary Sampling Unit) – General and Forest Land Use

Plot ID:

Cluster No.:	Accessibility Code:	(0) Accessible (1) Inaccessible due to Slope (2) Inaccessible due to Water Body (3) Inaccessible due to Restricted Area (4) Inaccessible due to Owner's Refusal (5) Inaccessible due to Other Reasons <Specify>
Plot No.:	Land Ownership Code:	(1) Federal Government (2) Provincial Government (3) State Government (4) Tribal Land (5) Private Land (6) Protected Area (7) Other <Specify> (99) Not Known

Map Coordinates (UTM):

X:	Y:	*Enter coordinates from map for navigation*

Measurement Time Log:

Arrival Time (HH:MM):	*Arrival time at PSU/SSU*
Start Time (HH:MM):	*Start time of measurement at PSU/SSU*
End Time (HH:MM):	*Completion time of measurement at PSU/SSU*

GPS Coordinates:

If DGPS Used

GPS Receiver ID:	Base Station ID:	GPS Point ID:
Logging Start Time(HH:MM):	Logging End Time (HH:MM):	Antenna Height:
Coordinates (Averaged) (UTM) (in m)		
X:	Y:	Z:
File Name:		

If Handheld GPS Used

GPS Receiver Model:	GPS UTM Zone:		Accuracy (m):
GPS Point ID:	Coordinates (Averaged) (UTM) (in m)		
	X:	Y:	Z:

Terrain Parameters:

Slope%:	Erosion Code:	*(0) No Erosion (0) No Erosion (1) Gullies (2) Rills (3) Sheet (4) Root Exposure (5)Rock Outcrop*
Aspect:	Main Site Type:	*(1) Mineral Soil (2) Peat Lands (3) Wetlands*

Land Use:

IPCC Land Use Code: *(LU for PSU/SSU Center)*	*(1) Forest (2) Cropland (3) Grassland (4) Wetlands (5) Settlements (6) Other Land*
If the PSU/SSU has mixed LU, indicate all observed (e.g. 1, 2,3,5):	

If Land Use is (1) Forest, select Forest Type/Strata: <✓tick on the left column of the appropriate type>

	Tropical		Temperate
	Littoral and swamp forest (Mangroves)		Moist Temperate Forests
	Tropical dry deciduous		Montane Dry Temperate Coniferous Forests
	Tropical thorn forest		Dry temperate Juniper and Chilghoza Forests
	Riverine Forest		Dry Temperate Broad-Leaved Forests
	Sub-Tropical		Northern Dry Scrub
	Montane sub-tropical scrub forests		Alpine
	Sub-tropical broad-leaved forests		Sub-Alpine Forests
	Sub-tropical pine forests		Alpine Scrub
	Plantation Forest		Others (specify)
	Linear – Road Side Plantation		Shrubs/Bushes
	Linear – Railway Side Plantation		Farm Forest/Orchards
	Linear – Canal Side Plantation		
	Irrigated – Farm Plantation		
	Non-Irrigated Plantation		

	Density Class
	Dense
	Sparse

	Canopy Cover %:
	No Trees
	<5%
	5-10%
	10-40%
	40-70%
	>70%

FORM 3: Plot Information – Land Use and Land Use Change

Cluster No.:	Plot No.:

If other land use, Sub-Classes for Other land uses: <✓tick on the left column of the appropriate type>

	Grassland		Cropland
	Alpine/Summer Pastures		Crop Irrigated
	Winter Pastures		Crop Rainfed
	Rangeland		Crop in Flood Plain
	Other Land		Crop Marginal and Irrigated Saline
	Barren Land/Bare Soil/Desert		Agroforestry
	Rock		Fruit Orchard
	Snow		Plantations (Banana, Tea, Palm, etc.)
	Glacier		
	Wetland		**Settlement**
	River/Stream/Canal		Built-Up (cities/villages)
	Lake/Pond/Reservoir		Infrastructure (airport, port, highway, industrial complex etc.)
	Swamp/Peat Land		
	Estuary/Lagoon		

Disturbances Observed in Plot: *<Multiple, ✓tick on the left column of the appropriate type>*

	No-Disturbances		Landslide
	Logging		Shifting Cultivation
	Grazing		Construction
	Tree Plantation		Others <Specify>
	Fire		Non-Known

Disturbance Occurred Year(s):	*Enquire to the forest ranger, local guide/people*
Severity of Disturbances:	*(1) Slightly (2) Moderately (3) Heavily*

Deforestation/Forest Degradation Observed in Plot:

	Natural Causes		Anthropogenic Causes
	Natural Fire		Agriculture Expansion
	Pests/Insects		Livestock Rearing/ Overgrazing
	Disease		Logging
	Flood		Fuelwood Removals
	Landslide/Erosion		Mining
	Wind		Dam
	Drought		Roads
	Desertification		Conflict

Land Use Change and Forests in Plot: *<Enquire to the forest ranger, local guide/people>*

1996-2000		(0) Forest Remaining Forest (1) Cropland converted to Forest (2) Grassland converted to Forest (3) Wetlands converted to Forest (4) Settlements converted to Forest (5) Other Land converted to Forest (6) Forest converted to Cropland (7) Forest converted to Grassland (8) Forest converted to Wetlands (9) Forest converted to Settlement (10) Forest converted to Other Land (99) Not-Known
2000-2004		
2004-2008		
2008-2012		
2012-2016		

Any Remarks/Description of Plot:

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FORM 4: Above-ground and BELOW-GROUND biomass of trees (DBH > 5 cm)

Cluster No.:	Plot No.:

	Tally trees (All trees with, DBH1 above 5 cm)					Sample trees (every 5th tally tree)				
Tree ID	Species code	Species Name	DBH1, 1.3 m (x.x cm)	DBH2,1.37m (x.x cm)	Tree height, (m)	Bole height, (m)	Tree, base length, (m)	Bole, base length, (m)	Broken top (1/0)	Deformation (1/0)

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FORM 5: Deadwood Information (standing, downeD and stumps with the MINIMUM DIAMETER aboVE 5 cm)

Cluster No.:	Plot No.:

Tree/particle ID	Species code (if recognizable)	Species name (if recognizable)	Category (STA, DOW, STU)	Decomp class (1,2,3)	DBH/Diameter 1 (x.x cm)	DIameter 2 (x.x cm)	Tree height/length (x.x m)	Standing tree, base length (x.x m)	Standing tree, broken top (1/0)

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FORM 6: SEEDLINGS (DBH1 EQUAL OR LESS THAN 5 CM,), NON-TREE ABOVEGROUND HEIGHT < 1.3 METER) AND LITTER POOL

Cluster No.:	Plot No.:

Seedling Count	Species code	Species Name	Remarks.

Litter				
Sample ID [Cluster no-plot no-fresh mass]	Total fresh amount	Fresh mass of the sub-sample	Oven dry mass of the sub-sample	Carbon content (lab)

Shrub Information					
Sample ID [Cluster no-plot n0-fresh mass]	Radius [1 – 1.41 m, 2 - 2.82 m, 3 – 5.64 m]	Total fresh amount	Fresh mass of the sub-sample	Oven dry mass of the sub-sample	Carbon content (lab)

FORM 7: Soil Organic Carbon (SOC) for mineral soils

Cluster No.:	Plot No.:

Sample ID	Depth (cm)	Stoniness (% coarse fraction of total soil volume)	Bulk Density (kg/m^3) - lab	Organic carbon content (g/g) - lab	Mineral carbon content (g/g) - lab
	0-10				
	10-20				
	20-30				

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FORM 8: Plot Photographs

Cluster No.:	Plot No.:

Site Photographs:

Cardinal Direction	File Name/Numbers
North	
East	
West	
South	

Other Photographs & Descriptions: *<herbarium sample, flora biodiversity, fauna biodiversity occurrence, forest canopy semi-hemispherical etc.>*

Photo	File Name/Number	Description:
Photo#1		
Photo#2		
Photo#3		
Photo#4		
Photo#5		
Photo#6		
Photo#7		

FORM 9: Data Quality Assurance and Digital Entry

Cluster No.:	Plot No.:

	Name	Date (mm-dd-yy)	Signature
Forms filled by			
Forms checked by			
Data entered by			
Data cleaning/validated by			

For Quality Control Survey

Q/C Team Leader	
Q/C Date (mm-dd-yy)	
Remarks	

FORM 10: Land Use Ground Truthing/Validation Form

- *Ground Truthing is done at the specified systematic plots. Validation is done at randomly selected plots.*
- *Both Ground Truthing and Validation are done in **30m x 30m square plots** representing one Landsat pixel*
- *This FORM 10 to be used separately from NFI FORMS 1-9*

Plot No.:	Plot Type: *(1) Ground Truth (2) Validation*

Ground Truth/Validation Plot Information:

Province:	District	Village/Settlement Name
Field Date (mm-dd-yy):	Crew/Team Leader:	Crew No:

Map Coordinates (UTM): *<Enter coordinates from map for navigation>*

UTM Zone:	X:	Y:

Accessibility Code:	*(0) Accessible (1) Inaccessible due to Slope (2) Inaccessible due to Water Body (3) Inaccessible due to Restricted Area (4) Inaccessible due to Owner's Refusal (5) Inaccessible due to Other Reasons <Specify>*
Land Ownership Code:	*(1) Federal Government (2) Provincial Government (3) Tribal Land (4) Private Land (5) Protected Area (6) Other <Specify> (99) Not Known*

Observation Time Log:

Arrival Time (HH:MM):	*Arrival time at Ground Truth/validation Plot*
Start Time (HH:MM):	*Start time of measurement/observation at PSU*
End Time (HH:MM):	*Completion time of measurement/observation at PSU*

GPS Coordinates:

GPS Receiver Model:	GPS UTM Zone:		Accuracy (m):
GPS Point ID:	Coordinates (Averaged) (UTM) (in m)		
	X:	Y:	Z:

Terrain Parameters:

Slope%:	Erosion Code:	*(0) No Erosion (1) Light Erosion (2) Moderate Erosion (3) Heavy Erosion*
Aspect:	Main Site Type:	*(1) Mineral Soil (2) Peat Lands (3) Wetlands*

Land Use:

IPCC Land Use Code:	*(1) Forest (2) Cropland (3) Grassland (4) Wetlands (5) Settlements (6) Other Land*
If the plot has mixed LU, indicate all observed (e.g. 1, 2,3,5):	

If Land Use is (1) Forest, select Forest Type/Strata: <✓tick on the left column of the appropriate type>

	Tropical		Temperate
	Littoral and swamp forest (Mangroves)		Moist Temperate Forests
	Tropical dry deciduous		Montane Dry Temperate Coniferous Forests
	Tropical thorn forest		Dry temperate Juniper and Chilghoza Forests
	Riverine Forest		Dry Temperate Broad-Leaved Forests
	Sub-Tropical		Northern Dry Scrub
	Montane sub-tropical scrub forests		**Alpine**
	Sub-tropical broad-leaved forests		Sub-Alpine Forests
	Sub-tropical pine forests		Alpine Scrub
	Plantation Forest		**Others (specify)**
	Linear – Road Side Plantation		Shrubs/Bushes
	Linear – Railway Side Plantation		Farm Forest/Orchards
	Linear – Canal Side Plantation		
	Irrigated – Farm Plantation		
	Non-Irrigated Plantation		

Density Class:	*(1) Dense (2) Sparse*
Canopy Cover %:	(0) No Trees (1) <5% (2) 5-10% (3) 10-40% (4) 40-70% (5) >70%

If other land use, Sub-Classes for Other land uses: <✓tick on the left column of the appropriate type>

	Grassland		Cropland
	Alpine/Summer Pastures		Crop Irrigated
	Winter Pastures		Crop Rainfed
	Rangeland		Crop in Flood Plain
	Other Land		Crop Marginal and Irrigated Saline
	Barren Land/Bare Soil/Desert		Agroforestry
	Rock		Fruit Orchard
	Snow		Plantations (Banana, Tea, Palm, etc.)
	Glacier		
	Wetland		**Settlement**
	River/Stream/Canal		Built-Up (cities/villages)
	Lake/Pond/Reservoir		Infrastructure (airport, port, highway, industrial complex etc.)
	Swamp/Peat Land		
	Estuary/Lagoon		

Land Use Change and in Plot: *<Enquire to the forest ranger, local guide/people>*

1996-2000		(0) Forest Remaining Forest (1) Cropland converted to Forest (2) Grassland converted to Forest (3) Wetlands converted to Forest (4) Settlements converted to Forest (5) Other Land converted to Forest (6) Forest converted to Cropland (7) Forest converted to Grassland (8) Forest converted to Wetlands (9) Forest converted to Settlement (10) Forest converted to Other Land (99) Not-Known
2000-2004		
2004-2008		
2008-2012		
2012-2016		

Any Remarks/Description of Plot:

Site Photographs in Cardinal Directions: *<taken from plot center>*

North	East	West	South
File Name/Number	File Name/Number	File Name/Number	File Name/Number

Other Photographs & Description: *(if taken>*

Photo#1 Description:	Photo#2 Description:	Photo#3 Description:	Photo#4 Description:	Photo#5 Description:

Quality Assurance and Data Entry

	Name	Date (mm-dd-yy)	Signature
Forms filled by			
Forms checked by			
Data entered by			
Data cleaning/validated by			

ANNEX 3. SPECIES CODE LIST

Code	Common name	Latin name	Code	Common name	Latin name
1	Aam	Mangifera indica	160	Paludar	Abies pindrow
2	Akhrot	Juglans regia	164	Partal	Abies pindrow
3	Alder	Alnus nitida	198	Silver fir	Abies pindrow
4	Aleppo pine	Pinus halepensis	204	Sudani kikar	Acacia albida
5	Amaltas	Cassia fistula	12	Australian Kikar	Acacia aneura
6	Amla	Phyllanthus emblica	57	Cutch tree	Acacia catechu
7	Arizona cypress	Cupressus arizonica	125	Katha	Acacia catechu
8	Arjun	Terminalia arjuna	127	Khalr	Acacia catechu
9	Ash	Fraxinus hookeri	182	Rooikrans	Acacia cyclops
10	Asiatic mangrove	Rhizophora mucronata	79	Gu-Kikar	Acacia farnesiana
11	Asmani	Ailanthus altissima	229	Vilayati Kikar	Acacia farnesiana
12	Australian Kikar	Acacia aneura	159	Palosa	Acacia modesta
13	Babul	Acacia nilotica	167	Phulai	Acacia modesta
14	Bael	Aegle marmelos	13	Babul	Acacia nilotica
15	Bahan	Populus euphratica	131	Kikar	Acacia nilotica
16	Bahari Kachnar	Bauhinia variegata	77	Golden wreath wattle	Acacia saligna
17	Bahera	Terminalia belerica	212	Sunehri Har	Acacia saligna
18	Bakain	Melia azedarach	84	Gum Arabic	Acacia senegal
19	Ban Khor	Aesculus indica	130	Khumbat	Acacia senegal
20	Banjar	Quercus semicarpifolia	195	Shittim	Acacia seyal
21	Banni	Quercus glauca	215	Talh	Acacia Seyal
22	Barin oak	Quercus glauca	186	Samor	Acacia tortilis
23	Barna	Crataeva religiosa	227	Umbrella thorn	Acacia tortilis
24	Barungi	Quercus dilatata	145	Maple	Acer caesium
25	Batangi	Pyrus pashia	224	Trekhan	Acer caesium
26	Batkhar	Celtis eriocarpa	132	Kirmola	Acer oblongum
27	Bed-i-laila	Salix tetrasperma	161	Panhgor	Acer oblongum
28	Beefwood	Casuarina equisetifolia	14	Bael	Aegle marmelos
29	Bel eric myrabolam	Terminalia belerica	19	Ban Khor	Aesculus indica
30	Ber	Zizyphus mauritiana	94	Horse chestnut	Aesculus indica

Code	Common name	Latin name	Code	Common name	Latin name
31	Bhoj Patra	Betula utilis	11	Asmani	Ailanthus altissima
32	Bhora	Rhizophora mucronata	223	Tree of Heaven	Ailanthus altissima
33	Biar	Pinus wallichiana	141	Maharukh	Ailanthus excelsa
34	Birch	Betula utilis	38	Black siris	Albizzia lebbek
35	Bird cherry	Prunus cornuta	118	Kala sirin	Albizzia lebbek
36	Bisee	Salix acmophylla	205	Sufed sirin	Albizzia procera
37	Bishop wood	Bishofia javanica	232	White siris	Albizzia procera
38	Black siris	Albizzia lebbek	3	Alder	Alnus nitida
39	Black locust	Robinia pseudoacacia	193	Sharol	Alnus nitida
40	Black plum	Syzygium cumini	50	Chattian	Alstonia scholaris
41	Blue pine	Pinus wallichiana	64	Dita Bark Tree	Alstonia scholaris
42	Botal bursh	Callistemon viminalis	220	Timar	Avicennia marina
43	Bottle brush	Callisternon viminalis	222	Tivar	Avicennia marina
44	Boxwood	Buxus wallichiana	146	Margosa tree	Azadirachta indica
45	Brown oak	Quercus semicarpifolia	152	Neem	Azadirachta indica
46	Bunj	Quercus baloot	113	Kachnar	Bauhinia purpurea
47	Carob tree	Ceratonia siliqua	174	Purple bauhinia	Bauhinia purpurea
48	Casuarina	Casuarina equisetifolia	16	Bahari Kachnar	Bauhinia variegata
49	Chalghoza pine	Pinus gerardiana	121	Kaliar	Bauhinia variegata
50	Chattian	Alstonia scholaris	31	Bhoj Patra	Betula utilis
51	Chinar	Platanus orientalis	34	Birch	Betula utilis
52	Chinese date	Zizyphus mauritiana	37	Bishop wood	Bishofia javanica
53	Chinese Tallow	Sapium sebiferum	104	Irum	Bishofia javanica
54	Chir pine	Pinus roxburghii	197	Silk Cotton Tree	Bombax cieba
55	Chitta sufoda	Populus caspica	200	Simal	Bombax cieba
56	Coral tree	Erythrina suberosa	114	Kaghzi toot	Broussonetia papyrifera
57	Cutch tree	Acacia catechu	162	Paper mulberry	Broussonetia papyrifera
58	Cyprus pine	Pinus brutia	61	Dhak	Butea frondosa
59	Date palm	Phoenix dactylifera	70	Flame of	Butea frondosa

Code	Common name	Latin name	Code	Common name	Latin name
				the forest	
60	Deodar	Cedrus deodara	44	Boxwood	Buxus wallichiana
61	Dhak	Butea frondosa	191	Shamshad	Buxus wallichiana
62	Dhamman	Grewia optiva	42	Botal bursh	Callistemon viminalis
63	Diar	Cedrus deodara	43	Bottle brush	Callisternon viminalis
64	Dita Bark Tree	Alstonia scholaris	5	Amaltas	Cassia fistula
65	Doghla poplar	Populus euramericana	101	Indian Laburnum	Cassia fistula
66	Dozakh	Gleditsia triacanthos	28	Beefwood	Casuarina equisetifolia
67	Dravi	Cedrela serrata	48	Casuarina	Casuarina equisetifolia
68	Ethiopian teak	Conocarpus lancifolius	67	Dravi	Cedrela serrata
69	Euphrates poplar	Populus euphratica	86	Hill Toon	Cedrela serrata
70	Flame of the forest	Butea frondosa	225	Tun	Cedrela toona
71	Flooded Box	Eucalyptus microtheca	60	Deodar	Cedrus deodara
72	Forest fire	Tecomella undulata	63	Diar	Cedrus deodara
73	Ghalab	Tamarix aphylla	87	Himalayan cedar	Cedrus deodara
74	Ghaz	Conocarpus lancifolius	26	Batkhar	Celtis eriocarpa
75	Frash	Tamarix aphylla	153	Nettle tree	Celtis eriocarpa
76	Gold mohur	Delonix regia	47	Carob tree	Ceratonia siliqua
77	Golden wreath wattle	Acacia saligna	185	Sada sabz	Ceratonia siliqua
78	Golden Shower	Peltophorum pterocarpum	133	Kirrari	Ceriops tagal
79	Gu-Kikar	Acacia farnesiana	213	Taqal mangrove	Ceriops tagal
80	Gul mohar	Delonix regia	68	Ethiopian teak	Conocarpus lancifolius
81	Gul-i-Nishter	Erythrina suberosa	74	Ghaz	Conocarpus lancifolius
82	Gulabi Saru	Cupressus arizonica	138	Lasura	Cordia myxa
83	Guli-pista	Pistacia khinjuk	189	Sebasten plum	Cordia myxa
84	Gum Arabic	Acacia senegal	23	Barna	Crataeva religiosa
85	Gumhar	Gmelina arborea	178	Religious tree	Crataeva religiosa

Code	Common name	Latin name	Code	Common name	Latin name
86	Hill Toon	Cedrela serrata	7	Arizona cypress	Cupressus arizonica
87	Himalayan cedar	Cedrus deodara	82	Gulabi Saru	Cupressus arizonica
88	Himalayan poplar	Populus ciliata	183	Rose wood	Dalbergia sissoo
89	Himalayan spruce	Picea smithiana	194	Shisham	Dalbergia sissoo
90	Himalayan Pencil Cedar	Juniperus excelsa	214	Tahli	Dalbergia sissoo
91	Himalayan Elm	Ulmus wallichiana	76	Gold mohur	Delonix regia
92	Holy oak	Quercus baloot	80	Gul mohar	Delonix regia
93	Honey locust	Gleditsia triacanthos	170	Ponga oil tree	Derris indica
94	Horse chestnut	Aesculus indica	171	Pongam	Derris indica
95	Horseradish Tree	Moringa pterygosperma	172	Punna	Ehretia serrata
96	Hybrid poplar	Populus euramericana	173	Puran	Ehretia serrata
97	Imli	Tamarindus indica	184	Russian Olive	Elaeagnus hot-tensis
98	Indian olive	Olea ferruginea	187	Sanjata	Elaeagnus hot-tensis
99	Indian willow	Salix tetrasperma	56	Coral tree	Erythrina suberosa
100	Indian cork tree	Millingtonia hortensis	81	Gul-i-Nishter	Erythrina suberosa
101	Indian Laburnum	Cassia fistula	209	Sufeda	Eucalvptus camaldulensis
102	Indian Gooseberry	Phyllanthus emblica	135	Lachi	Eucalyptus camaldulensis
103	Ipil Ipil	Leucaena leucocephala	176	Red River Gum	Eucalyptus camaldulensis
104	Irum	Bishofia javanica	139	Lemon Scented Gum	Eucalyptus citriodora
105	Jacaranda	Jacaranda ovalifolia	207	Sufeda	Eucalyptus citriodora
106	Jaman	Syzygium cumini	71	Flooded Box	Eucalyptus microtheca
107	Jamun	Syzygium cumini	210	Sufeda	Eucalyptus microtheca
108	Jand	Prosopis cineraria	136	Lachi	Eucalyptus tereticornis
109	Jangle Jalebi	Pithecolobium dulce	147	Mysore hybrid	Eucalyptus tereticornis

Code	Common name	Latin name	Code	Common name	Latin name
110	Jantar	Sesbania sesban	208	Sufeda	Eucalyptus tereticornis
111	Jerusalem thorn	Parkinsonia aculeata	168	Pipal	Ficus religiosa
112	Kachal	Picea smithiana	9	Ash	Fraxinus hookeri
113	Kachnar	Bauhinia purpurea	211	Sum	Fraxinus hookeri
114	Kaghzi toot	Broussonetia papyrifera	239	Ziarat ash	Fraxinus xanthoxyliodes
115	Kahu	Olea ferruginea	192	Shang	Fraxinus xanthoxyloides
116	Kail	Pinus wallichiana	66	Dozakh	Gleditsia triacanthos
117	Kain	Ulmus wallichiana	93	Honey locust	Gleditsia triacanthos
118	Kala sirin	Albizzia lebbek	85	Gumhar	Gmelina arborea
119	Kala kat	Prunus cornuta	237	Yemane	Gmelina arborea
120	Kali mirch	Schinus molle	62	Dhamman	Grewia optiva
121	Kaliar	Bauhinia variegata	166	Pharawa	Grewia optiva
122	Kamo	Rhizophora mucronata	179	Reshmi oak	Grevillea robusta
123	Kandi	Prosopis cineraria	199	Silver oak	Grevillea robusta
124	Kangar	Pistacia integerrima	149	Mostan Phul	Heterophragma adenophyllum
125	Katha	Acacia catechu	188	Sanp phali	Heterophragma adenophyllum
126	Khaggal	Tamarix aphylla	105	Jacaranda	Jacaranda ovalifolia
127	Khalr	Acacia catechu	154	Nila gul mohar	Jacaranda ovalifolia
128	Khajur	Phoenix dactylifera	2	Akhrot	Juglans regia
129	Khanjak	Pistacia khinjuk	230	Walnut	Juglans regia
130	Khumbat	Acacia senegal	90	Himalayan Pencil Cedar	Juniperus excelsa
131	Kikar	Acacia nilotica	157	Obusht	Juniperus excelsa
132	Kirmola	Acer oblongum	103	Ipil Ipil	Leucaena leucocephala
133	Kirrari	Ceriops tagal	203	Subabul	Leucaena leucocephala
134	Kunro	Rhizophora mucronata	1	Aam	Mangifera indica
135	Lachi	Eucalyptus camaldulensis	143	Mango	Mangifera indica
136	Lachi	Eucalyptus tereticornis	18	Bakain	Melia azedarach
137	Lahura	Tecomella undulata	165	Persian lilac	Melia azedarach
138	Lasura	Cordia myxa	100	Indian cork tree	Millingtonia hortensis
139	Lemon Scented Gum	Eucalyptus citriodora	155	Nim Charneli	Millingtonia hortensis
140	Lombardy poplar	Populus nigra	95	Horseradish Tree	Moringa pterygosperma
141	Maharukh	Ailanthus excelsa	202	Sohanjna	Moringa pterygosperma

Code	Common name	Latin name	Code	Common name	Latin name
142	Majnu	Salix babilonica	150	Mulberry	Morus alba
143	Mango	Mangifera indica	226	Tut	Morus alba
144	Manila Tamarind	Pithecolobium dulce	98	Indian olive	Olea ferruginea
145	Maple	Acer caesium	115	Kahu	Olea ferruginea
146	Margosa tree	Azadirachta indica	111	Jerusalem thorn	Parkinsonia aculeata
147	Mysore hybrid	Eucalyptus tereticornis	163	Parkinsonia	Parkinsonia aculeata
148	Mesquite	Prosopis juliflora	78	Golden Shower	Peltophorum pterocarpum
149	Mostan Phul	Heterophragma adenophyllum	238	Zard fawwar	Peltophorum pterocarpum
150	Mulberry	Morus alba	59	Date palm	Phoenix dactylifera
151	Nakhtar	Pinus roxburghii	128	Khajur	Phoenix dactylifera
152	Neem	Azadirachta indica	6	Amla	Phyllanthus emblica
153	Nettle tree	Celtis eriocarpa	102	Indian Gooseberry	Phyllanthus emblica
154	Nila gul mohar	Jacaranda ovalifolia	89	Himalayan spruce	Picea smithiana
155	Nim Charneli	Millingtonia hortensis	112	Kachal	Picea smithiana
156	Northern Cottonwood	Populus deltoides	58	Cyprus pine	Pinus brutia
157	Obusht	Juniperus excelsa	49	Chalghoza pine	Pinus gerardiana
158	Palach	Populus ciliata	4	Aleppo pine	Pinus halepensis
159	Palosa	Acacia modesta	175	Quetta pine	Pinus halepensis
160	Paludar	Abies pindrow	54	Chir pine	Pinus roxburghii
161	Panhgor	Acer oblongum	151	Nakhtar	Pinus roxburghii
162	Paper mulberry	Broussonetia papyrifera	33	Biar	Pinus wallichiana
163	Parkinsonia	Parkinsonia aculeata	41	Blue pine	Pinus wallichiana
164	Partal	Abies pindrow	116	Kail	Pinus wallichiana
165	Persian lilac	Melia azedarach	124	Kangar	Pistacia integerrima
166	Pharawa	Grewia optiva	83	Guli-pista	Pistacia khinjuk
167	Phulai	Acacia modesta	129	Khanjak	Pistacia khinjuk
168	Pipal	Ficus religiosa	109	Jangle Jalebi	Pithecolobium dulce
169	Plane tree	Platanus orientalis	144	Manila	Pithecolobium dulce

Code	Common name	Latin name	Code	Common name	Latin name
				Tamarind	
170	Ponga oil tree	Derris indica	51	Chinar	Platanus orientalis
171	Pongam	Derris indica	169	Plane tree	Platanus orientalis
172	Punna	Ehretia serrata	55	Chitta sufoda	Populus caspica
173	Puran	Ehretia serrata	233	White poplar	Populus caspica
174	Purple bauhinia	Bauhinia purpurea	88	Himalayan poplar	Populus ciliata
175	Quetta pine	Pinus halepensis	158	Palach	Populus ciliata
176	Red River Gum	Eucalyptus camaldulensis	156	Northern Cottonwood	Populus deltoides
177	Rein	Quercus incana	206	Sufed poplar	Populus deltoides
178	Religious tree	Crataeva religiosa	15	Bahan	Populus euphratica
179	Reshmi oak	Grevillea robusta	69	Euphrates poplar	Populus euphratica
180	Ritha	Sapindus mukorossi	65	Doghla poplar	Populus euramericana
181	Robinia	Robinia pseudoacacia	96	Hybrid poplar	Populus euramericana
182	Rooikrans	Acacia cyclops	140	Lombardy poplar	Populus nigra
183	Rose wood	Dalbergia sissoo	196	Siah poplar	Populus nigra
184	Russian Olive	Elaeagnus hot-tensis	108	Jand	Prosopis cineraria
185	Sada sabz	Ceratonia siliqua	123	Kandi	Prosopis cineraria
186	Samor	Acacia tortilis	148	Mesquite	Prosopis juliflora
187	Sanjata	Elaeagnus hot-tensis	35	Bird cherry	Prunus cornuta
188	Sanp phali	Heterophragma adenophyllum	119	Kala kat	Prunus cornuta
189	Sebasten plum	Cordia myxa	25	Batangi	Pyrus pashia
190	Sesbania	Sesbania sesban	235	Wild pear	Pyrus pashia
191	Shamshad	Buxus wallichiana	46	Bunj	Quercus baloot
192	Shang	Fraxinus xanthoxyloides	92	Holy oak	Quercus baloot
193	Sharol	Alnus nitida	24	Barungi	Quercus dilatata
194	Shisham	Dalbergia sissoo	21	Banni	Quercus glauca
195	Shittim	Acacia seyal	22	Barin oak	Quercus glauca
196	Siah poplar	Populus nigra	177	Rein	Quercus incana

Code	Common name	Latin name	Code	Common name	Latin name
197	Silk Cotton Tree	Bombax cieba	234	White Oak	Quercus Incana
198	Silver fir	Abies pindrow	20	Banjar	Quercus semicarpifolia
199	Silver oak	Grevillea robusta	45	Brown oak	Quercus semicarpifolia
200	Simal	Bombax cieba	10	Asiatic mangrove	Rhizophora mucronata
201	Soap nut	Sapindus mukorossi	32	Bhora	Rhizophora mucronata
202	Sohanjna	Moringa pterygosperma	122	Kamo	Rhizophora mucronata
203	Subabul	Leucaena leucocephala	134	Kunro	Rhizophora mucronata
204	Sudani kikar	Acacia albida	221	Timmar	Rhizophora mucronata
205	Sufed sirin	Albizzia procera	39	Black locust	Robinia pseudoacacia
206	Sufed poplar	Populus deltoides	181	Robinia	Robinia pseudoacacia
207	Sufeda	Eucalyptus citriodora	36	Bisee	Salix acmophylla
208	Sufeda	Eucalyptus tereticornis	236	Willow	Salix acmophylla
209	Sufeda	Eucalvptus camaldulensis	142	Majnu	Salix babilonica
210	Sufeda	Eucalyptus microtheca	231	Weeping willow	Salix babilonica
211	Sum	Fraxinus hookeri	27	Bed-i-laila	Salix tetrasperma
212	Sunehri Har	Acacia saligna	99	Indian willow	Salix tetrasperma
213	Taqal mangrove	Ceriops tagal	228	Van Pilu	Salvadora oleoides
214	Tahli	Dalbergia sissoo	180	Ritha	Sapindus mukorossi
215	Talh	Acacia Seyal	201	Soap nut	Sapindus mukorossi
216	Tamarind	Tamarindus indica	53	Chinese Tallow	Sapium sebiferum
217	Tamarisk	Tamarix aphylla	218	Tarcharbi	Sapium seblferum
218	Tarcharbi	Sapium seblferum	120	Kali mirch	Schinus molle
219	The pepper tree	Schinus molle	219	The pepper tree	Schinus molle
220	Timar	Avicennia marina	110	Jantar	Sesbania sesban
221	Timmar	Rhizophora mucronata	190	Sesbania	Sesbania sesban
222	Tivar	Avicennia marina	40	Black plum	Syzygium cumini
223	Tree of Heaven	Ailanthus altissima	106	Jaman	Syzygium cumini
224	Trekhan	Acer caesium	107	Jamun	Syzygium cumini
225	Tun	Cedrela toona	97	Imli	Tamarindus indica
226	Tut	Morus alba	216	Tamarind	Tamarindus indica
227	Umbrella thorn	Acacia tortilis	73	Ghalab	Tamarix aphylla
228	Van Pilu	Salvadora oleoides	126	Khaggal	Tamarix aphylla

Code	Common name	Latin name	Code	Common name	Latin name
229	Vilayati Kikar	Acacia farnesiana	217	Tamarisk	Tamarix aphylla
230	Walnut	Juglans regia	75	Frash	Tamarix aphylla
231	Weeping willow	Salix babilonica	72	Forest fire	Tecomella undulata
232	White siris	Albizzia procera	137	Lahura	Tecomella undulata
233	White poplar	Populus caspica	8	Arjun	Terminalia arjuna
234	White Oak	Quercus Incana	17	Bahera	Terminalia belerica
235	Wild pear	Pyrus pashia	29	Bel eric myrabolam	Terminalia belerica
236	Willow	Salix acmophylla	91	Himalayan Elm	Ulmus wallichiana
237	Yemane	Gmelina arborea	117	Kain	Ulmus wallichiana
238	Zard fawwar	Peltophorum pterocarpum	30	Ber	Zizyphus mauritiana
239	Ziarat ash	Fraxinus xanthoxyliodes	52	Chinese date	Zizyphus mauritiana
999	Unknown	Unknown	999	Unknown	Unknown

ANNEX 4. DEFINITIONS FOR SEEDING POINT, DBH AT 1.3 M AND POINT OF MEASUREMENT

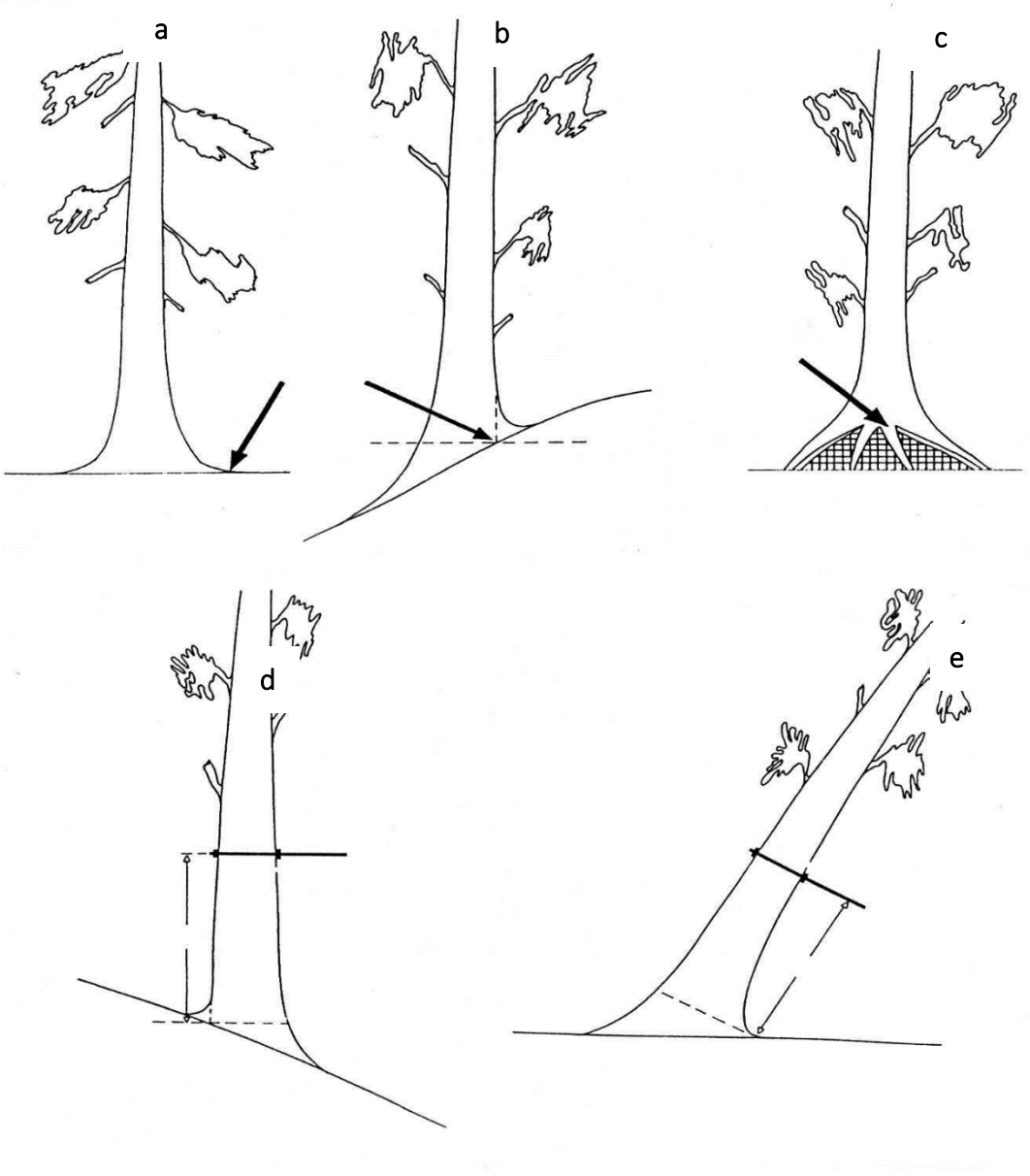


Figure I: Determination of ground level (a, b) and seeding point (c), and measurement of diameter at breast height of trees growing on the slope (d) and trees that are leaning (e).

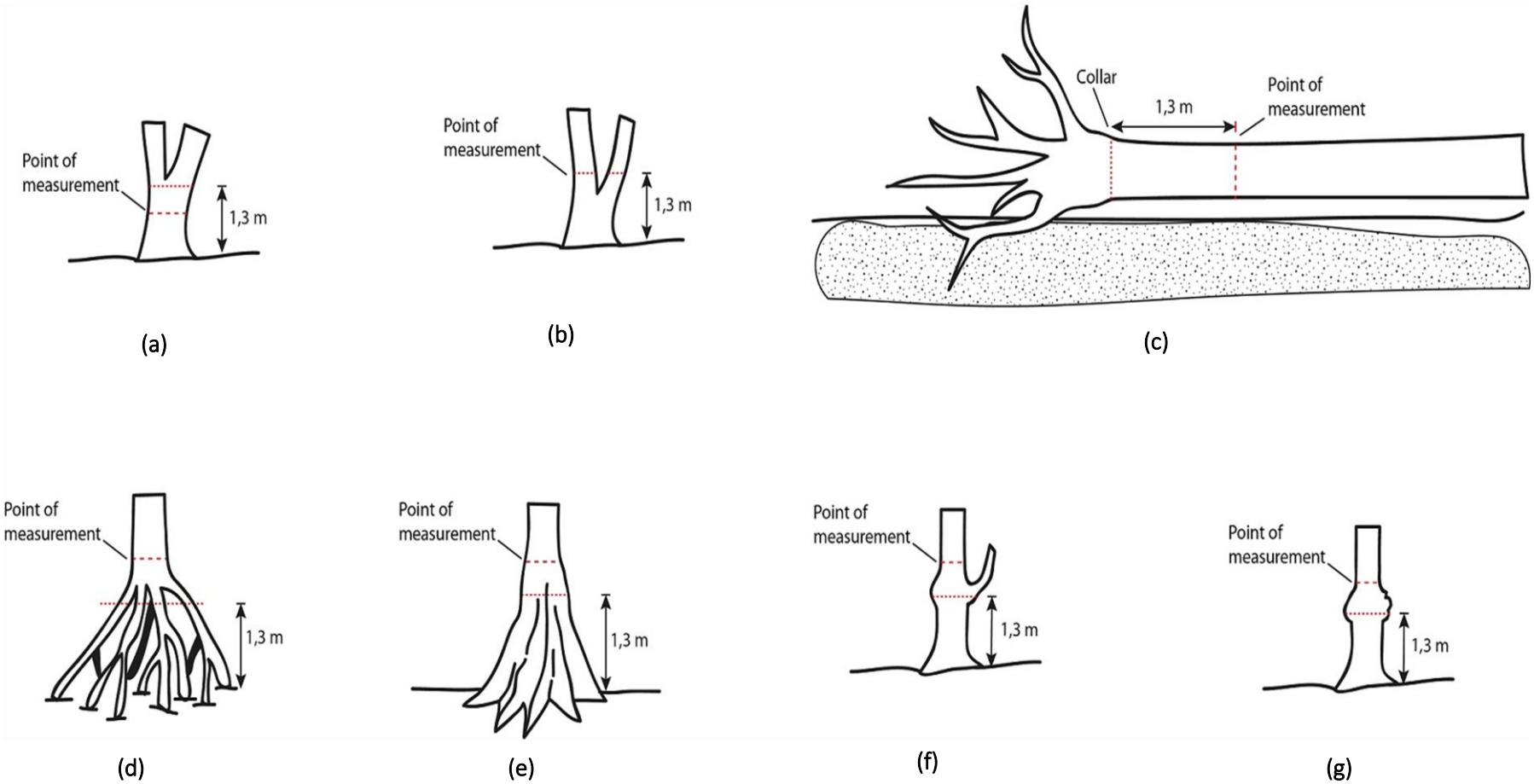


Figure II: ***Point of measurement of tree diameter for trees with abnormalities that occur at the standard point of measurement (1.3 m).***

ANNEX 5. LIST OF DISTRICTS AND VALLEYS

List of Districts

SN	Province	District
1	AJK	Bhimber
2	AJK	Kotli
3	AJK	Mirpur
4	AJK	Poonch
5	AJK	Sudhnoti
6	AJK	Neelum
7	AJK	Haveli
8	AJK	Bagh
9	AJK	Hattian
10	AJK	Muzaffarabad
11	AJK	Bagh
12	Balochistan	Awaran
13	Balochistan	Barkhan
14	Balochistan	Bolan
15	Balochistan	Dera Bugti
16	Balochistan	Gwadar
17	Balochistan	Jaffarabad
18	Balochistan	Jhal Magsi
19	Balochistan	Kalat
20	Balochistan	Kech
21	Balochistan	Kharan
22	Balochistan	Khuzdar
23	Balochistan	Killa Abdullah
24	Balochistan	Killa Saifullah
25	Balochistan	Kohlu
26	Balochistan	Lasbela
27	Balochistan	Loralai
28	Balochistan	Mastung
29	Balochistan	Musakhel
30	Balochistan	Nasirabad
31	Balochistan	Panjgur
32	Balochistan	Pishin
33	Balochistan	Quetta
34	Balochistan	Ziarat
35	Balochistan	Nushki
36	Balochistan	Chagai
37	Balochistan	Sherani
38	Balochistan	Zhob
39	Balochistan	Panjpai

SN	Province	District
40	Balochistan	Harnai
41	Balochistan	Sibi
42	FATA	Bajaur Agency
43	FATA	FR Bannu
44	FATA	FR D.I.Khan
45	FATA	FR Kohat
46	FATA	FR Lakki Marwat
47	FATA	FR Peshawar
48	FATA	FR Tank
49	FATA	Khyber Agency
50	FATA	Kurram Agency
51	FATA	Mohmand Agency
52	FATA	North Waziristan Agency
53	FATA	Orakzai Agency
54	FATA	South Waziristan Agency
55	Gilgit Baltistan	Skardu
56	Gilgit Baltistan	Diamir
57	Gilgit Baltistan	Ghanche
58	Gilgit Baltistan	Ghizer
59	Gilgit Baltistan	Astore
60	Gilgit Baltistan	Gilgit
61	Gilgit Baltistan	Hunza Nagar
62	Islamabad	Islamabad
63	Khyber Pakhtunkhwa	Abbottabad
64	Khyber Pakhtunkhwa	Bannu
65	Khyber Pakhtunkhwa	Batagram
66	Khyber Pakhtunkhwa	Buner
67	Khyber Pakhtunkhwa	Charsadda
68	Khyber Pakhtunkhwa	Chitral
69	Khyber Pakhtunkhwa	D. I. Khan
70	Khyber Pakhtunkhwa	Hangu
71	Khyber Pakhtunkhwa	Haripur
72	Khyber Pakhtunkhwa	Karak
73	Khyber Pakhtunkhwa	Kohat
74	Khyber Pakhtunkhwa	Kohistan
75	Khyber Pakhtunkhwa	Lakki Marwat
76	Khyber Pakhtunkhwa	Lower Dir
77	Khyber Pakhtunkhwa	Malakand PA
78	Khyber Pakhtunkhwa	Mansehra
79	Khyber Pakhtunkhwa	Mardan
80	Khyber Pakhtunkhwa	Nowshera
81	Khyber Pakhtunkhwa	Peshawar
82	Khyber Pakhtunkhwa	Shangla

SN	Province	District
83	Khyber Pakhtunkhwa	Swabi
84	Khyber Pakhtunkhwa	Swat
85	Khyber Pakhtunkhwa	Tank
86	Khyber Pakhtunkhwa	Upper Dir
87	Punjab	Attock
88	Punjab	Bahawalnagar
89	Punjab	Bahawalpur
90	Punjab	Bhakkar
91	Punjab	Chakwal
92	Punjab	D. G. Khan
93	Punjab	Faisalabad
94	Punjab	Gujranwala
95	Punjab	Gujrat
96	Punjab	Hafizabad
97	Punjab	Jhelum
98	Punjab	Kasur
99	Punjab	Khanewal
100	Punjab	Khushab
101	Punjab	Lahore
102	Punjab	Leiah
103	Punjab	Lodhran
104	Punjab	Mandi Bahauddin
105	Punjab	Mianwali
106	Punjab	Multan
107	Punjab	Muzaffargarh
108	Punjab	Narowal
109	Punjab	Okara
110	Punjab	Pakpattan
111	Punjab	Rahim Yar Khan
112	Punjab	Rajanpur
113	Punjab	Rawalpindi
114	Punjab	Sahiwal
115	Punjab	Sargodha
116	Punjab	Sialkot
117	Punjab	Toba Tek Singh
118	Punjab	Vehari
119	Punjab	Chiniot
120	Punjab	Jhang
121	Punjab	Sheikhupura
122	Punjab	Nankana Sahib
123	Sind	Badin
124	Sind	Ghotki
125	Sind	Karachi

SN	Province	District
126	Sind	Khairpur
127	Sind	Mirpur Khas
128	Sind	Naushahro Feroze
129	Sind	Nawabshah
130	Sind	Sanghar
131	Sind	Shikarpur
132	Sind	Sukkur
133	Sind	Tharparkar
134	Sind	Thatta
135	Sind	Umer Kot
136	Sind	Jaccobabad
137	Sind	Kashmore
138	Sind	Qambar Shahdad kot
139	Sind	Larkana
140	Sind	Dadu
141	Sind	Jamshoro
142	Sind	Tando Allahyar
143	Sind	Tando Muhammad Khan
144	Sind	Hyderabad
145	Sind	Matiari

[Source: WWF GIS Database]

List of Valleys

SN	Province	Valley Name
1	GB	Shigar Valley
2	GB	Gilgit Valley
3	GB	Hunza Valley
4	GB	Nagar Valley
5	GB	Skardu Valley
6	GB	Rupal Valley
7	GB	Yasin Valley
8	GB	Naltar Valley
9	GB	Bagrot Valley
10	GB	Chiporsun Valley
11	GB	Chorbat Valley
12	GB	Gorikot Valley
13	GB	Haji Gham Valley
14	GB	Hispar Valley
15	GB	Hopar Valley
16	GB	Kharkoo Valley
17	GB	Ishkoman Valley
18	GB	Kunar Valley
19	GB	Khaplu Valley

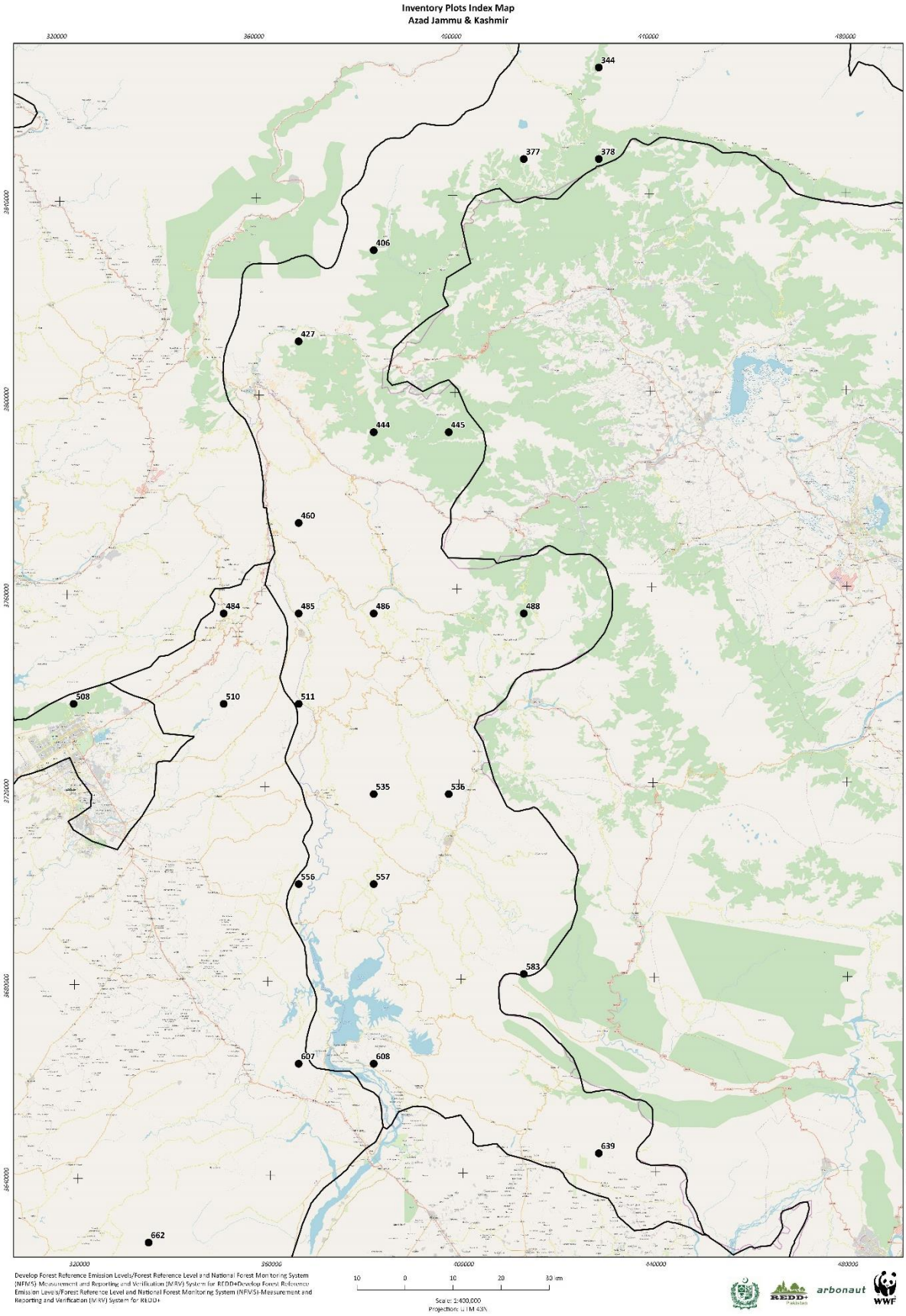
SN	Province	Valley Name
20	AJK	Jhelum Valley
21	AJK	Leepa Valley
22	AJK	Samahni Valley
23	AJK	Bandala Valley
24	AJK	Kas Chanatar Valley
25	AJK	Neelam Valley
26	AJK	Pathika Valley
27	AJK	Bagh Valley
28	AJK	Bhana Valley
29	AJK	Banjosa Valley
30	AJK	Shounter valley
31	KP	Kaghan Valley
32	KP	Swat Valley
33	KP	Chitral Valley
34	KP	Panjkora Valley
35	KP	Naran Valley
36	KP	Allai Valley
37	KP	Battagram Valley
38	KP	Bumburet Valley
39	KP	Kalash Valleys
40	KP	Rumbur Valley
41	KP	Khot Valley
42	KP	Konsh Valley
43	KP	Marandeh Valley
44	KP	Miranzai Valley
45	KP	Shaikhdara Valley
46	KP	Shinkari Valley
47	KP	Siran Valley
48	KP	Tikri Valley
49	KP	Tirat Valley
50	KP	Baroghil Valley
51	KP	Palas Valley
52	FATA	Kurrum Valley
53	FATA	Tirah Valley
54	FATA	Khanki Valley
55	FATA	Tochi Valley
56	Punjab	Dhan Valley
57	Punjab	Soon Valley
58	Punjab	Jhelum Valley
59	Punjab	Phugla Valley
60	Punjab	Soan Sakaser Valley
61	Punjab	Chamkoon Valley
62	Balochistan	Quetta valley

SN	Province	Valley Name
63	Balochistan	Chamman valley
64	Balochistan	Urak valley
65	Balochistan	Moola Valley

[Source: https://en.wikipedia.org/wiki/List_of_valleys_in_Pakistan]

ANNEX 6. SAMPLE OF FIELD MAPS

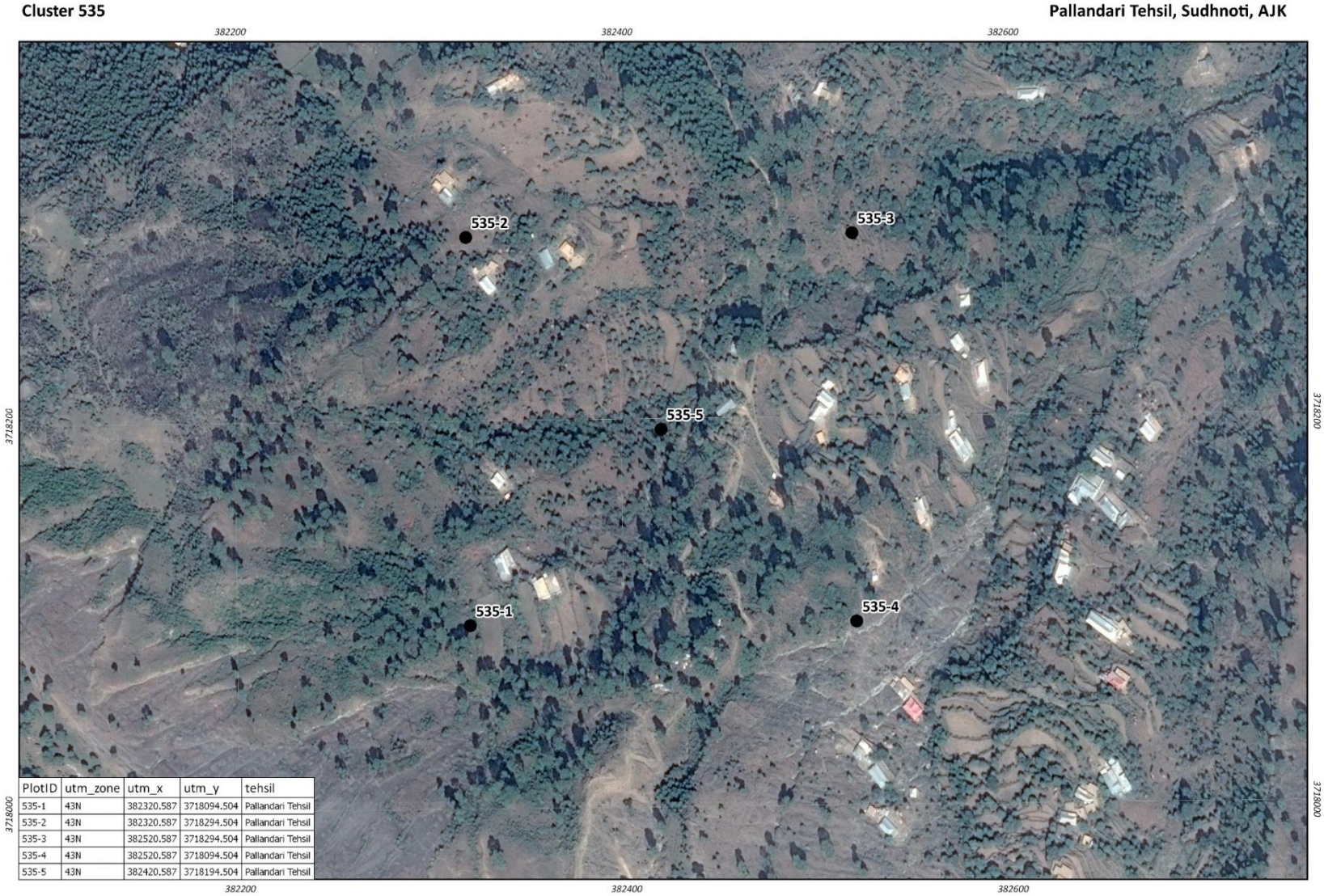
Index Map



Topographic Map

<to be inserted>

Cluster/Plot Map



PlotID	utm_zone	utm_x	utm_y	tehsil
535-1	43N	382320.587	3718094.504	Pallandari Tehsil
535-2	43N	382320.587	3718294.504	Pallandari Tehsil
535-3	43N	382520.587	3718294.504	Pallandari Tehsil
535-4	43N	382520.587	3718094.504	Pallandari Tehsil
535-5	43N	382420.587	3718194.504	Pallandari Tehsil

ADDENDUM to the field measurement manual: Special mangrove forest and palm measurement INSTRUCTIONS

1. Aboveground biomass

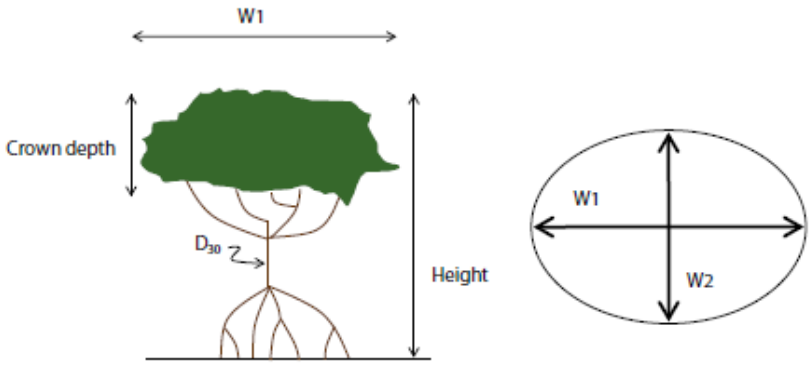
1.1. Measurements

DBH is measured at the diameters of 1.3/1.37 m above the ground.
In the case of Rhizophora species, the diameter above the highest stilt root is measured.

Stilt roots of *Rhizophora spp.*

1.2 Shrub and dwarf mangroves

When mangroves have an aboveground structure of small trees less than a few meters in height, often referred to as dwarf mangrove, scrub, or mangle chaparro. The measured variables are stem diameter at 30 cm aboveground level, crown area, height and crown volume.



Elliptical crown area = $(W1 \times W2/2)^2 * \pi$;

Where W1 is the widest length of the plant canopy through its centre and W2 is the canopy width perpendicular to W1. Crown volume = elliptical crown area * crown depth.
Height is measured from the sediment surface to the highest point of the canopy.
D_{30} is the mainstem diameter at 30 cm.

The field measurement techniques for determining biomass of dwarf mangroves.

1.3 Palms

Through determination of average individual leaf mass (15–25 leaves collected outside the plot) and counting all palm leaves that occur within the sample plot.

1.4 Species and expected distribution

Code	Family; Species	Expected distribution
R	***RHIZOPHORACEAE***	
R1	*Bruguiera gymnorhiza*	Karachi and Indus delta (Hassan) Estuary of Indus (Murray);
R2	*Ceriops tagal*	Karachi and Coast of Sindh (stocks) Mouth of Indus and "Salt water creek" (Murray)
R3	*Ceriops decandra*	Sindh tidal zone; **existence considered doubtful**
R4	*Rhizophora apiculata*	Tidal marshes at the mouth of Indus: Miani Hor, Las Bella (T & S)
R5	*Rhizophora mucronata.*	Mouth of Indus on muddy shores and tidal creeks (Henslow; Las Bella and Makran Coast (Burkill)
M	***MYRSINACEAE***	
M	*Aegiceras corniculatum*	Mangrove swamps at mouth of the Indus (Stocks, Ritchie) Karachi (Jafri): Miani Hor
A	***AVICENNIACEAE***	
A	*Avicennia marina*	Tidal mangrove swamps; Sand spit (stern) China creek, etc. (Jafri), Kalmat Hor
S	***SONNERATIACEAE***	
S	*Sonneratia caseolaris*	Mouth of Indus and Tidal Zone (Common, fide Murray); **Indus delta no specimen seen.**

5. Soil

5.1 Sampling

The first step in mangrove soil sampling is to measure (organic) soil depth to parent materials, bedrock, or coral sands with a probe such as a bamboo pole, soil augur, or steel pole. Soils samples (loose soil) are taken 0-10 cm, 10-20 cm, 20-30 cm, 30–50 cm, 50–100 cm, and >100 cm. at 2-meter intervals.

At the sampling location, remove the organic litter from the surface. Then steadily insert the auger vertically into the soil until the top of the sampler is level with the soil surface. If the auger will not penetrate to full depth, do not force it, as it may be obstructed by a large root; instead try another location. Once at depth, twist the auger in a clockwise direction a few times to cut through any remaining fine roots. Gently pull the auger out of soil while continuing to twist it, to assist in retrieving a complete soil sample. If an undisturbed sample has not been obtained, clean the auger and try another location.

Once an undisturbed soil core has been extracted, a ruler or tape measure can be used to determine the depths from which the samples are collected. Subsample sizes are usually about a 5-cm length of the extracted core and comprise at least 30–50 g of sample mass. Subsamples should be collected at the approximate midpoint of each sample depth.

For maximum efficiency, a single sample can be collected for both bulk density and carbon analysis. Upon collection, samples are carefully placed in a numbered soil container with the site, plot number, soil depth, date and any other relevant information recorded.

5.2 Lab analysis

Upon collection in the field, samples should be oven dried as soon as is practical. If possible, place samples
in a drying oven on the day of collection. If this is not possible, as may be the case when sampling in remote areas, it is recommended that samples be air dried to slow microbial activity. Soil samples collected in remote settings can also be sealed in vacuum bags to protect and preserve them. On returning from the field, soil samples should be oven-dried to a constant mass at 60 °C to avoid reducing carbon contents in higher temperatures (i.e. 105 °C). Typically, it requires at least 48 hours for samples to attain a constant dry mass when dried at 60 °C. Caution should be taken to ensure that samples are thoroughly dried before bulk density and carbon analysis. Carefully breaking up the sample into smaller pieces improves the drying process.