Project "Integrated planning and practices for mangrove management associated with agriculture and aquaculture in Myanmar - 2017P1-MYR"

Forest Inventory
Field Manual

Technical document

Brisbane, 2017

TABLE OF CONTENTS .... ERROR! BOOKMARK NOT DEFINED.

1.   Introduction

The Project "Integrated planning and practices for mangrove management associated with agriculture and aquaculture in Myanmar - 2017P1-MYR" hereafter as UQ – Myanmar Mangrove project is sponsored by Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet) and the University of Queensland, Australia. The project will be carried out by The University of Queensland and Watershed Management Division (WMD), Myanmar's Forest Department (FD).

By investigating issues associated with mangrove conversion and degradation the project will seek for approaches for sustainable restoration and management of mangrove in line with livelihood improvement through aquaculture and other production practices.

A forest inventory will help to understand the current status of mangrove resources in the project area. The data collected from forest inventory is essential for micro-planning for mangrove restoration management, aquaculture in mangroves and other production in the project area. Further scientific field surveys in mangroves and ponds will provide supplementary data for research purposes of the project and UQ.

By providing up-to-date information on the current growing stock (timber volume, number of stems, species composition, regeneration), the inventory results will be the basis for the establishment of a mangrove forest management plan in the project's communities. The forest inventory forms an essential part of the community land use planning for coastal villages. Forest surveys are designed at the start and end of the project and will be used for monitoring and evaluation (M & E) of the project progress, achievement and impacts.

The mangrove forest inventory will be based on the establishment of a network of temporary sample plots. Plot data will be used to calculate forest parameters per-hectare. The per-hectare results will later be multiplied with updated forest area statistics of the project's area (e.g. hectares by mangrove forest type, class, and mangrove owner / user) based on the Myanmar's government records and status maps.

Sample plots will be located within the existing forest status map area (produced by Myanmar forestry authorities), or in case this is unavailable, using a preliminary forest status map produced by interpretation of satellite images.

Because aquaculture ponds in the project area are always associated with mangrove forests, pond surveys will be designed and implemented together with forest inventory to achieve unique output for sustainable aquaculture practices under mangrove. Essential environmental parameters of the water & canals of the aquaculture ponds will be surveyed to evaluate suitability for aquaculture species as well as possible impacts on mangrove plant species.

The objective of the Field Manual is to provide an overview of the general forest inventory sampling design and to guide forest inventory staff during the actual implementation of the field work. The leader of each field team shall make use of this manual throughout the field work to ensure that all data are collected in a standardized manner according to the given instructions. The proposed inventory design has been based on operational field testing, which included the establishment of a few pilot sample plots in May 2017.

2.   Sampling Design

2.1   Base maps for inventory

UTM maps are still commonly used in Myanmar. However for officially use and ground geographical correct all the project maps including base map for forest inventory will be developed in both **Myanmar 2000 datum and UTM WGS84 46N**. This work requires some geo-system conversion which will be addressed in detail in GIS & RS training courses[1] for project and local staff. The maps on Myanmar 2000 datum will be used in the country while UTM WGS 84 which is compatible with popular world geo tools and apps like Google Earth is used for international communications of the project.

2.2   Pre-Stratification of Project Area and Number of Sample Plots

The project area estimated in Google Earth is shown in Figure 1, below. The project area estimated from satellite images and field visits is about 2,400 ha with residential and cropping areas comprising about 200 ha[2]. Thus the total forested area is approximately 2,200 ha. All mangroves within the project are reserve forests and only one inventory system is used for the project's survey.

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[1] The GIS & RS training courses are expected to conduct before forest & pond survey field work
[2] All aquaculture ponds are extensive aquaculture in mangrove land and categorized as mangroves

The pre-stratification forest inventory was conducted by project staff in May 2017. 1217 meter square (13 100 square ft) plots were established and measured (Table 1).

Table 1. Summary of surveyed data

Plot	1	2	3	4	5	6	7	8	9	10	11	12	13
H_{avg}	2.9	2.3	2.9	2.6	3.2	2.3	3.0	3.0	4.0	3.4	3.4	2.4	3.8
SD	1.3	0.8	1.3	0.8	1.2	1.1	1.2	1.1	0.7	0.9	1.5	1.0	1.9
n	10	10	14	11	10	12	14	18	18	17	9	13	9

H_{avg} : Mean height of trees in surveyed plot

SD: Standard deviation of the mean height of trees of surveyed plots

n: number of trees per surveyed plot

Only 03 plots have trees which have diameter at breast height (D) more than 2 cm. Thus we used number of trees per plot as the key inventory parameter to estimate the sample size needed for the forest inventory survey.

The number of sample plots (n) need to be surveyed to provide the desired accuracy of the inventory is estimated by the formula below:

$$n = (t^2 * (CoV\%^2)) / (StE\%^2)$$

The formula shows that the number of sample plots depends on three parameters, which are briefly explained in the following:

1. StE% = Standard Error. The StE, which is expressed in percent, is used to describe the desired accuracy of the inventory with regard to the main inventory parameter (here is number of trees per plot). The tolerated standard error for estimating the number of trees has been set to 5 % for project's mangrove forests.

2. CoV% = Coefficient of variation. The CoV, which is also expressed in percent, is used to describe the variability of the forests. Homogeneously structured forests feature a lower CoV% than heterogeneously structured stands, indicating that the latter require a higher number of sample plots to derive the results with the same statistical accuracy (experience has shown that especially recently logged areas have a high CoV%). Based on surveyed data the CoV% is calculated as 26 %.

3. t = the t-value represents the probability (confidence) level of the inventory result. It is recommended that the probability level should be set to 95%, meaning that with 95% probability the results will be within the range of the standard error. For a probability level of 95% the t-value is 1.96.

Based on the explanations given above, the **required number of sample plots** is ($n = (1.96^2 * (26^2)) / (5^2)) = 103$). To systematically distribute plots in the project's mangrove smoothly the number of plots is round to 100.

2.3   Distribution of Sample Plots

The most up to date forest type (status) maps for the project will be compiled from interpretation of satellite images and based on maps which will be provided by Myanmar Forest Department. The inventory plots will be systematically allocated on the compiled maps using a common map grid (e.g. 100 metres grid based on datum Myanmar2000 or UTM coordinate system); the intersections of the map grid coincide with the centres of the sample plots.

All sample plots will be distributed along the same base grid. The reference area for one sample plot is calculated as follows:

Reference area = forest area / number of sample plots = 2,200 / 100

Applying the given formula, the reference area for one sample plot to be established in production forest is approximately 2.20 ha (2,200 ha / 100 plots). This translates into with a grid density of about 148.3 x 148.3 m (round to ≈ 150 x 150 m). Thus each plot established within the project's mangrove forest represents exactly 2.25 ha.

The grid lines are superimposed onto the inventory base maps 1:10,000 by using GIS technology, which later on – in combination with the application of

GPS devices – constitute the basis for the location of the sample plots in the field. The plot numbers are also marked on the map; they should be consecutively numbered starting from the north/western corner of the project area and ending in the south/east. The plot numbering system is described in detail in chapter 3.2.1 below.

2.4   Shape and Size of Sample Plots

The individual sub-plots have a nested design (see Figure 2) with two areas for tree measurement and one area for regeneration sampling, depending on the tree diameter at breast height (D), thus considerably reducing the time required for the field work:

(1)   Whole plot A (10 x 10 m = 100 m^2): only trees with D ≥ 2 cm will be measured. Non-timber forest products (NTFPs) are also recorded in the 10 x10 m sub-area (only on sub-plots B and D)

(2)   Sub-area B (4 x 4 m = 16 m^2): advanced regeneration in which tree have diameter < 2 cm will be measured. This sub-area is located at the south-centre of the plot (lower-left quadrant).
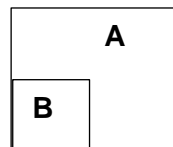
Figure 2. Sample plot layout

In case the Vertex IV (HAGLÖF) is available to use for the project circular plots with radius = 5.645 m can be used (S = 100 m^2). The sub-area for measure regeneration will be the centre of the plot.

Because the project area is flat delta coastal area, slope correction is not applied for this inventory.

3.   Field work

3.1   Access to Sample Plots and Marking of Plots

As described in Chapter 2.2, prior to the start of the field work the sample plot locations will be determined and marked in the office on the available inventory base maps with scale 1:10,000, indicating that the exact coordinates of each sample plot are known. During the field work this information must be translated into an actual location on the ground. This is accomplished by making use of the base map, GPS devices, and field survey with compass and measuring tapes.

The easiest way to locate the sample plot is to enter the coordinates of the sample plot into the GPS (store them as "waypoints") and then use the "GoTo" function, which should be available with all modern GPS devices (this Manual does not contain any GPS user instructions).

It may happen that a sample plot (or at least one of the four sub-plots) is located in a "void" area within the forest stand, e.g. on a road, in a lake or river. If a plot/sub-plot is located on such a void, it is treated as an ordinary plot/sub-plot; where there are no trees to be recorded. Thus all team leaders have to comply with the following instruction: "Never shift a plot/sub-plot."

The sample plots centres need to be marked in order to facilitate their precise re-location during the second forest inventory survey that will be carried out by the end of the project for M & E purpose as well as for any additional samples and data collection for research purposes. This can be done by using durable hardwood posts, which, however, should be marked with colour spray in order to make them easily distinguishable from other woody material occurring in the forest. In addition, the plot number should be painted or sprayed on the closest tree located to the plot centre.

3.2   Measurements and Observations

Measurements and observations are recorded on the Tally Sheet, which is structured in five main parts as presented in Annex 1. The parameters to be recorded are described in the following chapter.

3.2.1 General Information and Site Parameters

Forest structure can vary greatly with sites. In order to optimize the subsequent data analysis it is therefore important to record a number of relevant site parameters. For each individual plot the following data are recorded (note: since site parameters may change markedly over short distances, all recordings exclusively refer to the 10 x 10 m plot area):

1. Sample plot number: number of sample plots as indicated in the inventory base map; the plot number consists of 03 digits, from 001 to 100.

2. Sub-plot:

3. Forest type:

Code	Forest type
1	Mangrove
2	Terrestrial forest

4. Mynamar2000 or UTM coordinate (x)

5. Forest user/owner:

Code	Forest owner/user
1	Forest department solely
2	Individual household
3	Community
4	Others

6. Altitude: record in m

7. Slope: record in degree (°).

8. Forest status class: (reference to forest classification system of Myanmar)

9. Land use and/or type: 2-digit code.

Code	Stand type
01	Degraded mangrove with trees
02	Severely degraded mangrove - Only seedlings & shrubs
03	Regeneration mangrove (mainly young regenerating trees)
04	No forest on a mangrove site
05	Mangrove plantation
06	Natural water (river, creek)
07	Artificial water (pond, canal)

10. Canopy cover: 1-digit code.

Code	Description
1	Dense (>70% canopy cover)
2	Medium (20 – 70% canopy cover)
3	Open (<20% canopy cover)

11. Forest fire: record if there are any signs (ashes, burnt vegetation) that the sub-plot area has been burned recently, i.e. in the last 2 years (Yes/No).

12. Illegal logging/cutting: record if there are any signs (fresh stumps) that the sub-plot area has been logged recently, i.e. in the last 2 years (Yes/No).

13. Inventory date: record as DD/MM/YYYY (example: 16/11/2017).

14. Crew team: record names of inventory crew leader and technical assistant.

3.2.2 Tree-Specific Data

1. Tree mark: Trees measured should be marked with chalk in order to avoid mistakes such as sampling the same tree twice.

2. Species name: record the vernacular tree species name as presented in the tree species list in Annex 2. For tree species, which cannot be identified by the field crew, a sample (twig including leaves and buds) should be taken, which later on needs to be presented to a local expert for identification.

*3. Species code:* X-digit code as presented in the tree species list in Annex 2.

4. Diameter. If trees are large (> 5 m) and have a main stem, then diameter (D) may be measured at 1.3 m height. Because most trees in mangrove forests in project area are small and not possible to measure diameter at breast height (at 1.3 m) the diameter at 30 cm tree height is measured instead.

Diameter30 cm height (D): D will record in centimetres with 1 decimal place for the millimetre reading (example: 7.2 cm). The D is measured with a diameter tape (or calliper) at 0.3 m above ground level.[3]

In order to avoid mistakes while measuring height, a wooden pole of 0.3 m length is used. Before the measurement is carried out it is necessary to remove climbers, vines, loose bark and other irregularities that may cause bias to the correct D reading. The correct techniques for D measurements are depicted in Figure 4 and described below.

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[3] Note: in case the diameter is measured with a calliper, the D should be recorded as the average of two measurements perpendicular to each other.
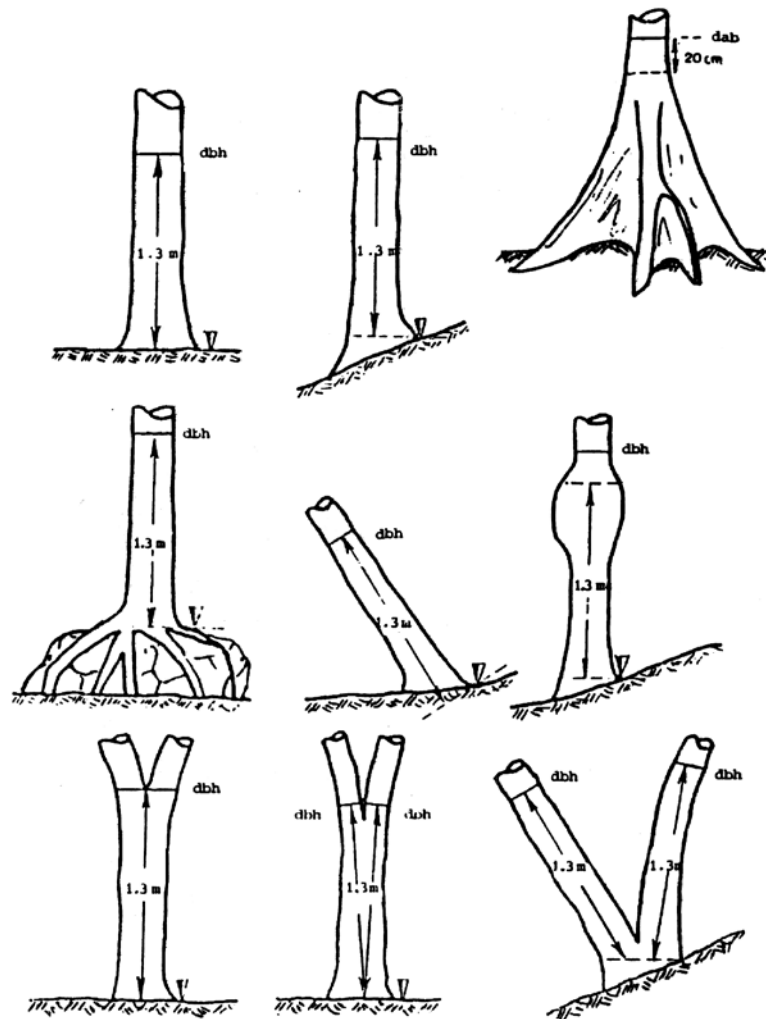
Figure 4: D Measurement Techniques for diameter at 1.3 m. Similar principles are used for measurement at 30 cm height for smaller trees.

Details on correct measurement techniques are as follows:

- on slopes the D is measured from the uphill side of the tree.
- for trees with buttresses, the D is measured 20 cm above the buttress.
- for trees with deformations or abnormalities at 1.3 m height, the D measurement is taken 20 cm above the abnormality.
- if the tree is forked below 1.3 m height, each fork should be treated as a separate tree, i.e. two D measurements will be taken.
- if the tree is forked above 1.3 m height, it is measured as one tree.

- If the tree is leaning the D is measured at 1.3 m on the inside of the lean perpendicular to the stem axis. The 1.3 m breast height of leaning trees is determined along the stem axis.
- For stilt rooted trees, the D is measured 1.3 m above the roots.

5. Tree Height (total): record in meters with 1 decimal place for the decimetre reading (example: 4.6 m). Height stick in metres is used to measure trees because most trees in project mangroves are less than 5 m.

6. Bole height under major canopy: record in meters with 1 decimal place for the decimetre reading (example: 3.8 m).

7. Quality: record as 1-digit code based on the following classes:

Code	Description
1	Good quality: no defects, straight and healthy
2	Medium quality: minor defects such as slightly crooked stem or slight branchiness
3	Bad quality: strong (combined) defects such as strongly crooked stem, strong branchiness, bark damages, deformations (cancer), signs of rot, broken crown, etc

8. Origin: record as 1-digit code.

Code	Description
1	Natural
2	Planted
3	Coppice / root shoot

3.2.3 Regeneration Data

Regeneration data is recorded in the small 4 x 4 m (16 m²) sub-area located in the south-centre of the plot. It is recommended to conduct the regeneration sampling prior to the sampling of the trees with D >= 2 cm. When the sub-plot boundaries are established care must be taken not to accidentally break any of the small trees stocking in the 4 x 4 m sub-area. The following three parameters are recorded:

1. Species name: record the vernacular tree species name as presented in the tree species list in Annex 2. For tree species, which cannot be identified by the field crew, a sample (twig including leaves and buds) should be taken, which later on needs to be presented to a local expert for identification.

2. Species code: X-digit code as presented in the tree species list in Annex 2.

3. Number of stems counted: record the number of stems counted for the respective tree species. Only living trees are counted, dead trees are not taken into consideration.

3.2.4 Non-Timber Forest Products

Non-timber forest products (NTFP) are counted if have.

1. Species name: record the species name as presented in the NTFP species list in Annex 2.

2. Species code: X-digit code as presented in the NTFP species list in Annex 2.

3. Number of plants counted: record the number of plants counted in the 10 x 10 m sub-sample area.

3.2.5 Access to Sample Plot

At the bottom of the Tally Sheet, the crew leader should briefly describe the reference point, which has been used for accessing the sample plot (refer to chapter 3.1. for more details). The Myanmar2000 or UTM coordinates of the reference point, which are determined with the GPS, should be noted down. Besides, bearing (in degree) and distance (in meters) from the reference point to the sample plot centre has to be recorded in order to enable an easy relocation of the sample plot during the control survey.

3.2.6 Water environment

Some key water environmental parameters will be measured to evaluate the impact of hydrology and water properties on mangrove forests. 03 porewater samples will be taken to measure water salinity, pH. Water depth is measured in the plot with specific time at measurement.

3.2.7 Soil properties

Soil samples might be taken for research purpose. The detailed research design and soil survey protocol will be prepared separately. The coordinates and permanent marks of sample plots will help to identify correctly the plot when the soil survey will be conducted.

4.   Inventory Implementation

4.1   Team Composition, Equipment, and Time Requirement

The number of field crews, who will implement the forest inventory, is recommended that at least four. Each field crew will consist of four persons:

- 1 crew leader, UQ's staff. Instructions, tally sheet filling & sample collection
- 1 local staff/expert: tree identification & tree height measurement
- 1 technical assistant, local FD staff (in charge of establishment of plot boundaries and tree measurements)
- 1 labourer (focusing on brush and undergrowth clearing for establishment of sample plot boundaries, transport of equipment, and other supportive activities)

At least one member of the inventory field crew is able to correctly identify the individual tree species.

The inventory crew shall be furnished with the following basic equipment (note: all equipment, including the GPS devices, need to be provided by the contracted Service Provider):

- 1 GPS (including one set of spare batteries)
- 1 compass with 360 deg. scale (e.g. Suunto)
- Height stick
- Vertex (if available)
- 2 diameter tapes for D measurements
- 2 measuring tapes (10 - 20 m), stretch-resistant
- 1 set of surveyor poles for plot demarcation (minimum of 7 poles for demarcating different sub-areas of sample plot) – alternatively, self-made wooden sticks may be used
- 1 Inventory Manual in Burmese language (printed on water-resistant paper)
- 1 inventory base map (scale 1:10,000) indicating sample plot numbers and plot location
- Sufficient number of Tally Sheets
- Miscellaneous: colour marking spray, chalk, clip boards, pens, erasers, plastic bags for collection of unknown plant specimen, binoculars, bush knives, first aid kits
- Water sampling kit and containers for water (if available). Permanent marker for marking bottles with plot number.
- Soil sampling kit for water (if a). Permanent marker for marking bottles with plot number.

5. Inventory Data Analysis

Data entry, data validation, data management, data processing and derivation of results, retrieval of inventory results. Data processing and the statistical analysis of the inventory results will be done by UQ's project staff with support from local project staff.

6. Annexes

ANNEX 1: Tally Sheet

ANNEX 2: Tree Species List

ANNEX 1	Tally Sheet Forest Resource Inventory

General Information and Site Parameters

Sample plot no.		Sub-plot		Forest type	
Coordinate (x)		Coordinate (y)		Forest owner	
Altitude		Slope		For. status class	
Stand type		Canopy cover		Forest fire	
Illegal logging		Inventory date		Crew team	

Tree Data

Tree no.	Species name	Species code	D [cm]	Height total [m]	Height bole [m]	Quality	Origin	Note
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								

Regeneration Data (<2 cm D) – Sub-Plots B

Species name	Species code	Number counted	Species name	Species code	Number counted	Species name	Species code	Number counted

Non-Timber Forest Products

	Species name	Code	Age	Culms counted	Avg. D [cm]	Avg. height [m]
			Old			
			Medium			
			Young			
	Species name	Code	Plants counted	Avg. stems per plant	Avg. dia. [cm]	Avg. length [m]
	Species name	Code	Number	Species name	Code	Number

Access to Sample Plot / Description of Reference Point

Coordinate of Reference Point (X)		Coordinate of Reference Point (Y)	
Bearing from ref. point to plot centre [deg.]		Distance from ref. point to plot centre [m]	

ANNEX 2: Tree Species Codes
(to be prepared by local project staff)

No.	Local name	Botanical name	Type (tree/shrub/ lianas etc.)	Note