添付 17: マングローブ・アクション・リサーチ技術レポート (全容 CD 収納)

The Integrated Mangrove Rehabilitation and Management Project
through Community Participation in the Ayeyawady Delta

Technical Report
for
Action Research of Mangroves
in the Ayeyawady Delta

JICA/FD MANGROVE PROJECT

March 2013

MANGROVE COMMUNITY FORESTRY TASK FORCE /

FOREST DEPARTMENT

JICA EXPERT TEAM (NIPPON KOEI CO., LTD)

Introduction

The Integrated Mangrove Rehabilitation and Management Project through Community Participation in Ayeyawady Delta, so called the JICA/FD Mangrove Project, has 5 outputs and this "Technical Report for Action Research of Mangroves in the Ayeyawady Delta" is regarded as one of key outcomes of Project's Output 3 "Some silvicultural techniques for the rehabilitation and the management of the mangrove and its associated forests for the Ayeyawady Delta are established".

This technical report mainly covers findings and results of the Action Research activities conducted under the Project's Output 3 activities. Also results of "Survey on Damages and Recovery Process of Mangrove Tree Species after the Cyclone Nargis" which was conducted under the Project's Output X activity are described in the report. The report tried to include lessons and findings not only from the Project but also from past similar experiences in the delta area.

Key issues in this report are compiled as "Technical Guideline for Action Research of Mangroves in the Ayeywady Delta" which serve more as guide and for information sharing related to the Action Research, whereas this report more covers information and data obtained from the Action Research.

The Project would like to remind readers of this report that results and analyses presented in this report and in the technical guideline are not "the final" and just "intermediate results", since the Action Research activities conducted in the Project could only compile results of the initial few years of plantation establishment. Therefore, even though some suggestions and recommendations are made in the report, the Project appreciates the readers to interpret these as indicative information. Further continual monitoring is required to elaborate these findings, suggestions, and recommendations into more concrete ones.

Though there are certain limitations in the information presented here, the Project expects the readers to utilize this report as one of references for better mangrove forestry in the delta area.

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List of Attachment

Unit Conversion Table

Item	**Units in Myanmar**	**Metric Units**
Length	1 inch[1)]	2.54 cm
	1 foot[1)]	0.305 m
	1 mile[1)]	1.609 Km
	1 chain = 66 feet[1)]	20.13 m
	1 furlong = 10 chains	201.3 m
	1 mile = 8 furlongs = 1760 yards	
Area	1 acre [1)]	4,046.9 m^2 = 0.405 ha
	1 square mile =640 acres	2.59 Km^2
	1 square feet	0.11 m^2

Abbreviation Table

Abbreviation	Full Description
ARP	Action Research Plantation
CF	Community Forestry
CFUG	Community Forestry User Group
CFECN	Community Forestry Extension Centre Nursery
FD	Forest Department
GIS	Geographic Information System
GPS	Global Positioning System
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
NDVI	Normalized Difference Vegetation Index
NGO	Non Government Organization
NFIO	Natural Forest Improvement Operation
RF	Reserved Forest
Area Abbreviation	**Full Description**
BGL	Bogalay
BYM	Byone Hmwe
GAD	Gaw Du
KADK	Kadonkani (Reserved Forest)
KKKL	Kwa Kwa Ka Lay
KKKP	Kyakankwinpauk (Reserved Forest)
LPT	Laputta
MYM	Myaung Mya
NPT	Nay Pyi Taw
NTP	Nyaung Ta Pin
PNDY	Pyindaye (Reserved Forest)
PNLN	Pyinalan (Reserved Forest)
PYP	Pyar Pon
SPT	Shwe Pyi Thar
TGT	Htaung Gyi Tan
TYK	Thar Yar Kone

Volume 1

Silvicultural Techniques for Mangrove Management through Implementation of Action Research Plantation in the Ayeyawady Delta

1. Introduction

In the vicinity of the project area, there are five (5) Reserved Forests (RFs) which has remaining rich natural resources. Mangrove forest is one of the valuable natural resources and brings up rich ecosystem in delta. However, existing mangrove forests have been degraded by encroachment and conversion to other land uses. Rehabilitation and management of mangrove forests are required to keep the sustainability of natural environment and products from delta.

The Action Research Plantation (ARP) is a main activity of Output 3 component under the project to identify applicable silvicultural techniques and suitable species for rehabilitation and management of mangrove forest in the delta. JICA Expert Team (JET) and Forest Department (FD) had jointly implemented ARP from fiscal year (FY) 2008. 12 ARP sites were established having outer boundary area of 1,587 acres in total. More than 17 species were planted as trial until FY 2011.

2. Objectives

The main purposes of ARP were to i) confirm appropriate tree species through species trial and land treatment trial, ii) establish silvicultural techniques for mangrove and non-mangrove species, iii) grasp growing performance of natural regeneration compared with plantation, and iv) develop appropriate monitoring system for introducing forest inventory in the delta.

3. Silvicultural Techniques introduced in ARP

ARP consisted of three (3) main trials which are Species Trial (ST), Land Treatment (LT) and Natural Regeneration (NR). Objectives and detail contents of each trial are indicated in **Table1-1**. After implementation of ARP, JET and FD monitored growth rate and survival rate in established monitoring plots. Based on monitoring result, JET and FD and tried to examine possible suitable species, species combinations, spacing and other treatments.

Table1-1 Objective and Contents of Design of ARP

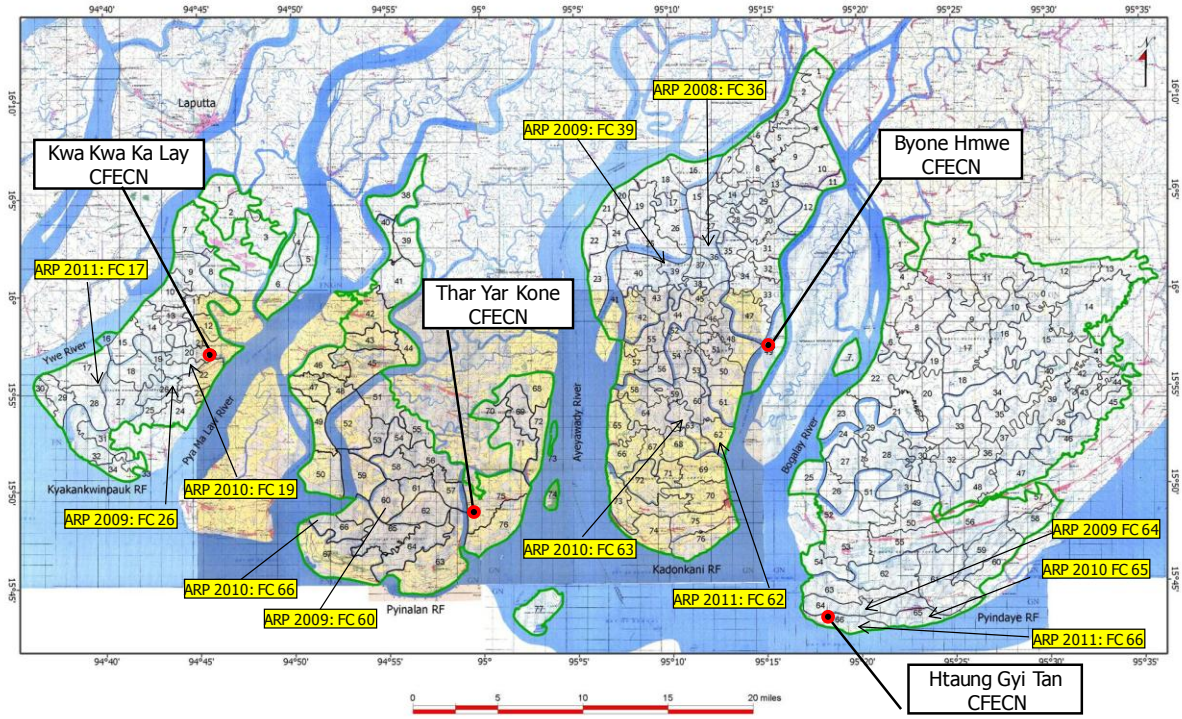
		Objectives	Contents
Species Trial (ST)			
ST-1	Mangrove species	To collect useful information of various mangrove species for applying to FD and CF plantations in the future (In addition to *Avicennia* spp. which is already extensively used by Forest Department and others in the delta).	Following mangrove species were planted as trial. *-Amoora cucullata* *-Avicennia alba* *-Aegiceras corniculatum* *-Avicennia marina* *-Avicennia officinalis* *-Bruguiera gymnorhizza* *-Bruguiera sexangula* *-Ceriops decandra* *-Excoecaria agallocha* *-Heritiera fomes*

		Objectives	Contents
			-Lumnitzera racemosa *-Nypa fruticans* *-Pongamia pinnata* *-Rhizophora apiculata* *-Sonneratia apetala* *-Sonneratia caseolaris* *-Xylocarpus moluccensis*
ST-2	Mixed planting	To find best combination of mixed planting of mangrove species.	Two or three different species were planted together in 6 x 6 feet spacing.
ST-3	Spacing	To confirm suitable spacing for mangrove species.	5 different spacing (1 x 1, 3 x 3, 6 x 6, 9 x 9 and 12 x 12 feet) were applied.
ST-4	Non mangrove species	To determine adequate conditions for fast growing species at mangrove dominated areas.	*Melaleuca leucadendron* and *Casuarina equisetifolia* were planted
Land Treatment (LT)			
LT-1	Mound	To confirm whether mound method is effective for growth of non-mangrove species in the delta.	Mound treatment was applied for fast growing species *Melaleuca leucadendron, Casuarina equisetifolia (Non-mangrove species)*.Mound height was approximate 1.5 feet which was set to exceed the highest water level of treatment sites. For comparison of growth and survival rates, non-mound treatments were also introduced.
LT-2	Weeding	To confirm effectiveness of weeding at initial stage of mangrove plantation establishment.	Weeding was applied before seedling planting. For a comparison of growth and survival rates, non-weeding treatments were also introduced.
LT-3	Mulching	To confirm mulching effects at initial stage of mangrove plantation establishment.	Mulching materials using weeds were covered around planted seedlings. For a comparison of growth and survival rates, non-mulching treatments were also introduced.
LT-4	Ploughing	To confirm ploughing effects at initial stage of mangrove plantation establishment	Surface soils around 5 cm were ploughed by ploughing tools. For a comparison of growth and survival rates, non-ploughing treatments were also introduced.
Natural Regeneration (NR)			
NR	Natural regeneration	To understand growth performance of mangroves in natural regeneration.	Weeding and thinning were applied as Natural Regeneration Improvement Operation (NFIO).

Source: JET, January 2013

4. Location and Outline of ARP

Location of ARP sites is described in **Figure1-1**. 12 ARP sites were established in Kyakankwinpauk Reserved Forest (RF), Pyinalan RF, Kadonkani RF and Pyindaye RF. Target Forest Compartment (FC), plantation year, ARP area and numbers of monitoring plots are summarized in **Table1-2.** Targeted trials conducted in each ARP site are listed in **Table 1-3**. Forest Inventory of ARP sites, including site information and map is indicated in **Attachment-1-1.**



Source: JET, January 2013

Figure1-1 Location of ARP Sites

Table1-2 Summary of ARP Sites

Reserved Forest(Township)	Sr.	Forest Compartment	Planting year	ARP reported area (acre)
Kyakankwinpauk (Laputta)	1	FC-26	FY2009	250
	2	FC-19	FY2010	120
	3	FC-17	FY2011	25
Pyinalan (Laputta)	4	FC-60	FY2009	250
	5	FC-66	FY2010	120
Kadonkani (Bogalay)	6	FC-36	FY2008	212
	7	FC-39	FY2009	200
	8	FC-63	FY2010	80
	9	FC-62	FY2011	25
Pyindaye (Bogalay, Pyar Pon)	10	FC-64	FY2009	200
	11	FC-65	FY2010	80
	12	FC-66	FY2011	25
TOTAL	-	-	-	1,587

Source: JET, January2013

Table1-3 Target Trials of ARP Sites

		1	2	3	4	5	6	7	8	9	10	11	12
Reserved Forest		KKKP			PNLN		KADK				PYND		
Forest compartment		17	19	26	60	66	62	63	36	39	66	64	65
1. Species Trial (ST)													
ST-1	Mangrove species				✔	✔		✔	✔	✔	✔		✔
ST-2	Mixed planting			✔									✔
ST-3	Spacing							✔					✔
ST-4	Non-mangrove species					✔	✔	✔	✔	✔	✔		
2. Land Treatment (LT)													
LT-1	Mound	✔				✔	✔		✔	✔	✔		
LT-2	Weeding	✔	✔	✔								✔	
LT-3	Mulching												
LT-4	Ploughing	✔					✔				✔		✔
3. Natural Regeneration (NR)													
NR-1			✔									✔	

Source: JET, February 2012

5. ARP Monitoring Survey

5.1 Preparation work

ARP monitoring survey aimed to assess effectiveness of each trial based on the growth performance (tree height, tree girth and survival rate) by species. To record locations of monitoring plots, GPS was utilized. The location maps were prepared to make it easy to find monitoring plots in upcoming surveys. To conduct a series of the monitoring survey, equipments and materials indicated in **Table1-4** are used.

Table1-4 Survey Items for ARP Monitoring

	Items	Required Specification	Purpose	Image
1	Portable GPS	Water proof	To record coordination of each monitoring plots. To record waypoint on the ARP boundary.	
2	Measurement staff	More than 10feets (need extension)	To measure tree height	 
3	Marker ink/paint	Black maker Red paint	To mark stake and tree as landmark of plot corners.	-

	Items	Required Specification	Purpose	Image
4	Numbering plate	Laminated	To mark individual number for every target trees in the monitoring plot.	
5	Stapler or Staple Gun		To keep numbering plate on tree stems.	
6	Measurement rope	At least 100 m	To confirm monitoring plot boundary, interval of planting (spacing)	
7	Measurement tape	At least 50 cm	To measure planted tree girth	
8	Location Map	Laminated, color print with grid	To confirm location of monitoring plots with GPS data.	

Source: JET, February 2013

5.2 Implementation of Monitoring Survey

ARP monitoring surveys had been initiated from 2009. However, due to inaccuracy and inconsistency of initial monitoring results, monitoring data of surveys conducted from December 2011 to January 2013 were utilized for compilation and further analysis (Table1-5). JET survey team with FD staff from respective township offices measured tree height and girth of all planted trees within the established monitoring plots. The work volume of ARP monitoring is indicated in **Table1-6.** Based on ARP maps prepared after plantation establishment, JET and FD selected the proper location and size of monitoring plots in each treatment area.

Table1-5 Monitoring Period in ARP

Reserved Forest(Township)	No.	Forest Compartment	Planting year	Monitoring Period (1)	Monitoring Period (2)
Kyakankwinpauk (Laputta)	1	FC26	FY2009	Dec.2011-Jan. 2012	Nov. 2012
	2	FC17	FY2011	Jan. 2012	Nov. 2012
	3	FC19	FY2010	Dec.2011-Jan. 2012	Nov. 2012
Pyinalan (Laputta)	4	FC60	FY2009	Feb. 2012	Nov. 2012
	5	FC66	FY2010	Jan.-Feb. 2012	Nov. 2012
Kadonkani (Bogalay)	6	FC36	FY2008	July-Dec.2010	Aug. 2012
	7	FC39	FY2009	July-Dec.2010	Aug. 2012
	8	FC63	FY2010	Feb.2012	Dec.2012
	9	FC62	FY2011	Feb.2012	Dec.2012
Pyindaye (Bogalay, Pyar Pon)	10	FC64	FY2009	Jan. 2012	Jan.2013
	11	FC65	FY2010	Jan. 2012	Jan.2013
	12	FC66	FY2011	Jan. 2012	Jan.2013

Source: JET, January 2013

Table1-6 Work Volume of ARP Monitoring Survey

Reserved Forest(Township)	Sr.	Forest Compartment	Number of Monitoring plots	Total number of planted tree
Kyakankwinpauk (Laputta)	1	FC26	23	9,805
	2	FC17	26	4,310
	3	FC19	59	4,208
Pyinalan (Laputta)	4	FC60	15	2,944
	5	FC66	18	5,444
Kadonkani (Bogalay)	6	FC36	10	2,674
	7	FC39	9	7,713
	8	FC63	133	5,315
	9	FC62	40	5,426
Pyindaye (Bogalay, Pyar Pon)	10	FC64	16	1,233
	11	FC65	77	3,929
	12	FC66	43	1,548
TOTAL	-	-	469	54,549

Source: JET, January 2013

5.3 Monitoring Procedure and Record Format

The survey team sets monitoring plots with wooden stakes in every corner. Temporally stakes had not remained for long time but there was no substitution at the site. However, real coordinates of the plot corners were recorded by portable GPS. The monitoring record format is attached in **Attachment-1-2**.

5.4 Parameters to Confirm Growth Performance in ARP

Survival rate and mean height of monitoring plots are the main parameters to compare growth performance of ARP treatments. During the project period, since only initial few years of plantation establishment were monitored, there was no significant difference in tree girth among seedlings in the same monitoring plots. Therefore the tree girth was not used to analyze growth performance in this report.

6. Results

6. 1 Summary of ARP Monitoring Results

In ARP, two types of forms were prepared for the monitoring, summary record, and monitoring record. The summary record lists mean tree height average survival rate and average girth of each monitoring plot, whereas the monitoring record describes raw data including height, girth and survival of individual trees in a single monitoring plot. The Summary records of all monitoring plots divided as per each ARP site are attached in **Attachment-1-3** and the monitoring record of all monitoring plots are attached in **Attachment 1-4**. Findings in each ARP site are summarized as follows. To compare survival rate and mean height of monitoring plot, following definitions were tentatively set based on observations and general tendency from the monitoring results of by the project.

Survival Rate	High Middle Low	More than 60% of survival rate Between 40% and 60% of survival rate Under 40% of survival rate
Mean height of monitoring plot	Not specified	Compare with mean height of each species by treatment within the same plot.

6. 2 KKKP FC-26 (Planted year: FY2009)

In the ARP FC-26 of KKKP RF, it aimed to confirm effectiveness weeding for seven species with common spacing of 6”x6”. The results of ARP monitoring are summarized in **Table 1-7** and **Figure1-2**

1) Range of survival rate of *Avicennia officinalis* with line weeding was between 40% and 60% (as a medium level of survival rate) based on monitoring results of Dec.2011 and Oct.2012. However, it seems stable growth performance of mean height and more than 80 inches at three years after planting.

2) *Excoecaria agallocha* with line weeding had the highest survival rate above 60% among trialed species in Dec.2011 and Oct.2012

3) *Sonneratia apetala* and *Heritiera fomes* had low survival rate below 20 % with line weeding in Dec.2011 and Oct.2012. However, the mean tree height of *Sonneratia apetala* was more than 200 inches at three years after planting.

Table1-7 Summary of ARP Monitoring Results in KKKP FC-26

Planted Year: FY 2009

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Dec.2011	Oct.2012	Dec.2011	Oct.2012	Dec.2011	Oct.2012
Ao(10)	6x6	Line weeding	40.6-59.5	39.5-59.3	73.5-100.9	84.7-124.7	1.7-4.5	3.5-5.9
Bs(1)	6x6	Line weeding	51.6	48.4	34.4	51.8	< 0.5	3.1
Xm(2)	6x6	Line weeding	27.8-72.2	27.8-72.2	43.8-53.6	54.3-73.3	1.2-1.3	1.3-1.5
Ea(4)	6x6	Line weeding	65.9-69.4	65.4-69.4	31.3-36.7	43.8-54.7	0.5-1.8	1.4-2.0
Sa(2)	6x6	Line weeding	8.3-12.4	8.3-12.4	166.6-173.1	192.6-238.3	7.8-8.4	11.7-13.1
Hf(1)	6x6	Line weeding	18.1	16.2	24.1	31.9	<0.5	1.1
Ra(1)	6x6	Line weeding	38.7	38.0	57.9	77.9	3.0	3.1
Hf/Ea (2)	6x6	Line weeding Mixplantation	55.6-61.1	50.0-52.8	32.1-40.8	53.9-59.7	<0.5	1.2-1.5

Note1: Ao: *Avicennia officinalis ,Bs: Bruguiera sexangula , Xm: Xylocarpus moluccensis, Ea: Excoecaria agallocha, Sa: Sonneratia apetala, Hf: Heritiera fomes, Ra: Rhizophora apiculata*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Oct.2012)

Source: JET, January 2013

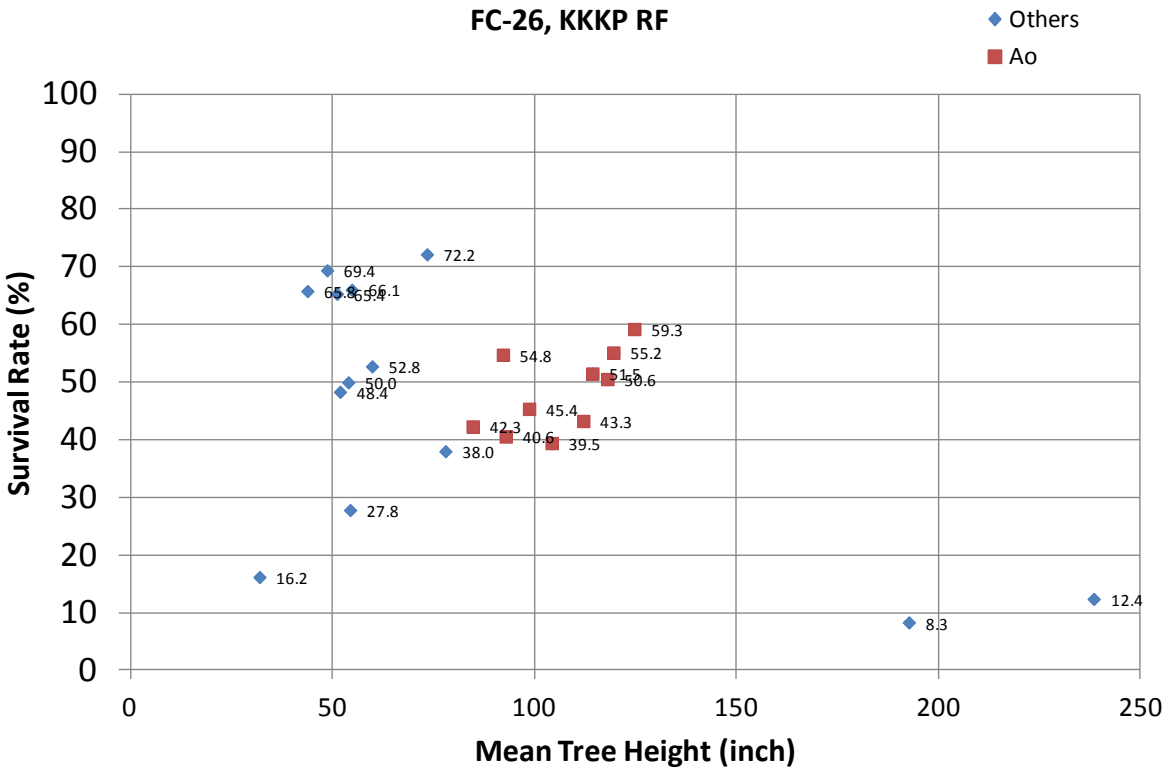


Figure1-2 Monitoring Result of KKKP FC-26 (Mean Height and Survival Rate)

6. 3 KKKP FC-19 (Planted year: FY2010)

In the ARP FC-19 of KKKP RF, treatment aimed to confirm growth of Ao with weeding at both 6'x6'

and 3'x3' spacing. There was also natural regeneration area. The results of ARP monitoring are summarized in **Table1-8** and **Figure1-3**.

1) *Avicennia officinalis* is preferred to 6'x6' spacing with weeding compared with 3'x3' based on the survival rate and mean height except one plot which has the lowest survival rate (22.2%) with 6'x6'.

2) In natural regeneration area, it was monitored almost all the tree survived in Oct. 2012. At least nine species including *Avicennia officinalis* are growing in this area.

Table1-8 Summary of ARP Monitoring Results in KKKP FC-19

Planted Year: FY 2010

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Oct.2012	Jan.2012	Oct.2012	Jan.2012	Oct.2012
Ao(16)	3x3	Weeding	33.9-68.6	32.2-67.8	21.5-48.3	36.7-58.1	<0.5	0.8-2.5
Ao(20)	6x6	Weeding	22.2-86.1	22.2-83.3	36.7-53.0	46.3-72.6	<0.5-1.0	1.6-3.3
Ac,Amo, Cf,Rm, Hf,Ea, Kc,Ao, Sg(9)	-	Natural Regeneration		98.3-100.0		110.5-121.4		4.3-5.1

Note1: Ao: *Avicennia officinalis, Ac: Aegiceras corniculatum, Amo:Amoora cucullata Cf: Kc:Kandelia candel Sg: Sonneratia griffithii, Ea: Excoecaria agallocha, Hf: Heritiera fomes, Rm:Rhizophora mucronata*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Oct.2012)

Source: JET, January 2013

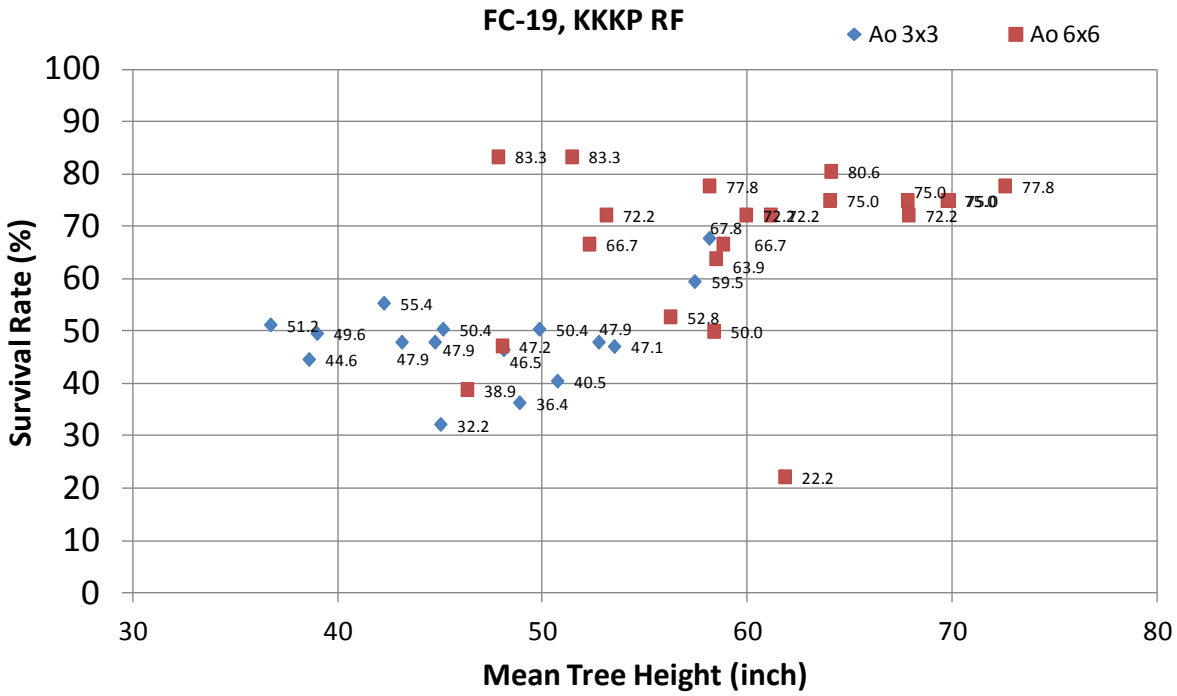


Figure1-3 Monitoring Result of KKKP FC-19 (Mean Height and Survival Rate)

6. 4 KKKP FC-17 (Planted year: FY2011)

In the ARP FC-17 of KKKP RF, it aimed to confirm effectiveness of mound and ploughing treatments by spacing. There was also natural regeneration area. The results of ARP monitoring are summarized in **Table1-9** and **Figure1-4**.

1) *Avicennia officinalis with* 9'x 9' spacing had high survival rate (more than 60%) in this area. it was no big difference between ploughing and no-ploughing. However, mound treatment had negative effects for *Avicennia officinalis* in this area except 3'x3'(medium survival rate, 40%-60%).

2) Almost all the trees of *Casuarina equisetifolia* with spot weeding did not be survived in this area. The reason of tree dead was not cleared but it was occurred just after planting (January 2012). Mound treatment also had negative effects for *Casuarina equisetifolia* because of low survival rate (5%) at one year after planting (Oct.2012).Therefore It is expected insufficiency of ground condition or unsuitability of treatment for *Casuarina equisetifolia*.

Table1-9 Summary of ARP Monitoring Results in KKKP FC-17

Planted Year: FY 2011

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Oct.2012	Jan.2012	Oct.2012	Jan.2012	Oct.2012
Ao(1)	1x1	Plough	9.9	8.1	19.3	28.0	<0.5	<0.5
Ao(2)	1x1	Mound	23.6-45.6	18.7-33.9	12.2-26.0	21.0-32.2	<0.5	0.5-0.9
Ao(1)	3x3	Plough	45.5	40.5	29.5	32.2	<0.5	<0.5

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Oct.2012	Jan.2012	Oct.2012	Jan.2012	Oct.2012
Ao(2)	3x3	No-plough	9.9-15.7	7.4-14.1	18.4-19.3	21.7-27.2	<0.5	0.6
Ao(1)	3x3	Mound	66.1	55.4	29.8	32.2	<0.5	0.6
Ao(1)	6x6	Plough	69.4	52.8	29.9	29.4	<0.5	<0.5
Ao(3)	6x6	No-plough	25.0-33.3	2.8-16.7	12.3-17.5	24.0-31.2	<0.5	0.5-0.7
Ao(1)	6x6	Mound	33.3	11.1	22.8	27.0	<0.5	<0.5
Ao(1)	9x9	Plough	68.8	62.5	38.0	37.2	<0.5	1.1
Ao(7)	9x9	No-plough	62.5-87.5	56.3-81.3	32.4-36.6	33.5-39.8	<0.5	0.8-1.3
Ao(1)	9x9	Mound	12.5	6.3	27.6	30.0	<0.5	<0.5
Ce(4)	3x3	Spot weeding	0.0-7.4	All dead	0.0-27.2	All dead	<0.5	All dead
Ce(1)	3x3	Mound	58.7	5.0	26.8	32.7	<0.5	1.4

Note1: Ao: *Avicennia officinalis, Ac: Aegiceras corniculatum, Ce: Casuarina equisetifolia*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Oct.2012)

Source: JET, January 2013

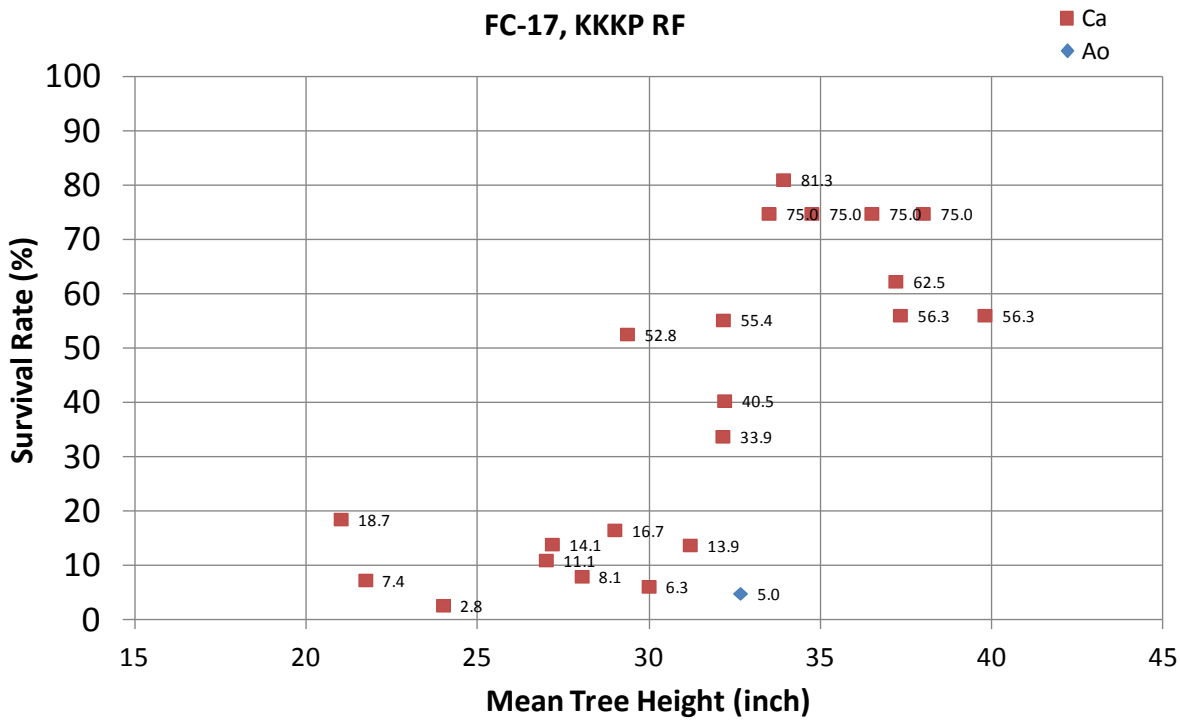


Figure1-4 Monitoring Result of KKKP FC-17 (Mean Height and Survival Rate)

6. 5 PNLN FC-60 (Planted year: FY2009)

In the ARP FC-60 of PNLN RF, there was species trial which introduced eight mangrove spaces as follow. The results of ARP monitoring are summarized in **Table1-10** and **Figure1-5**.

1) *Avicennia officinalis* had stable growth with 6'x6 in this area but its survival rate was medium level (around 50%).

2) *Avicennia marina* was growing faster than other species but it was not recommendable species because of the lowest survival rate (less than 6%)

3) *Xylocarpus moluccensis* and *Lumnitzera racemosa* which had high survival rate (more than 80%) were recommendable species in this area

4) *Avicennia alba* and *Heritiera fomes* had low survival rate (under 40%) which seemed were not suitable in this site condition.

5) *Pongamia pinnata* had been dead at two year after planting. The reason of tree dead was not clear, but it was expected insufficiency of ground condition for this species or unsuitability of planting method in this time.

6) 12' x 12' spacing seemed not recommendable spacing for *Excoecaria agallocha* because of low survival rate and slow growth compared with KKKP-26(planted FY2009 with weeding, 6'x6').

Table1-10 Summary of ARP Monitoring Results in PNLN FC-60

Planted Year: FY 2009

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Feb.2012	Nov.2012	Feb.2012	Nov.2012	Feb.2012	Nov.2012
Am(3)	6x6	*No treatment*	2.1 - 5.6	2.1-5.6	100.4-119.6	120-151.5	2.1-2.5	3.5-4.3
Aa(1)	6x6	*No treatment*	16.7	16.7	51.8	85.5	0.8	3.8
Ao(4)	6x6	*No treatment*	42.5-49.3	42.2-49.0	44.3-61.0	58.2-74.8	0.5-1.3	2.6-3.0
Ea(1)	12x12	*No treatment*	53.5	50.7	21.7	29.5	<0.5	1.0
Lu(1)	6x6	*No treatment*	80.6	80.6	42.5	47.6	<0.5	3.6
Hf(1)	6x6	*No treatment*	33.3	33.3	16.4	30.5	<0.5	0.8
Xm(2)	6x6	*No treatment*	75.0-88.9	86.1-88.9	41.2-47.4	56.0-60.5	<0.5	1.7-1.9
Pp(2)	6x6	*No treatment*	0(dead)	-	0(dead)	-	0(dead)	-

Note1: Am: *Avicennia marina* Aa; *Avicennia alba*, Ao:*Avicennia officinalis, Ea:Excoecaria agallocha, Lu: Lumnitzera racemosa, Hf: Heritiera fomes, Xm: Xylocarpus moluccensis,Pp Pongamia pinnata*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (N ov.2012)

Source: JET, December 2012

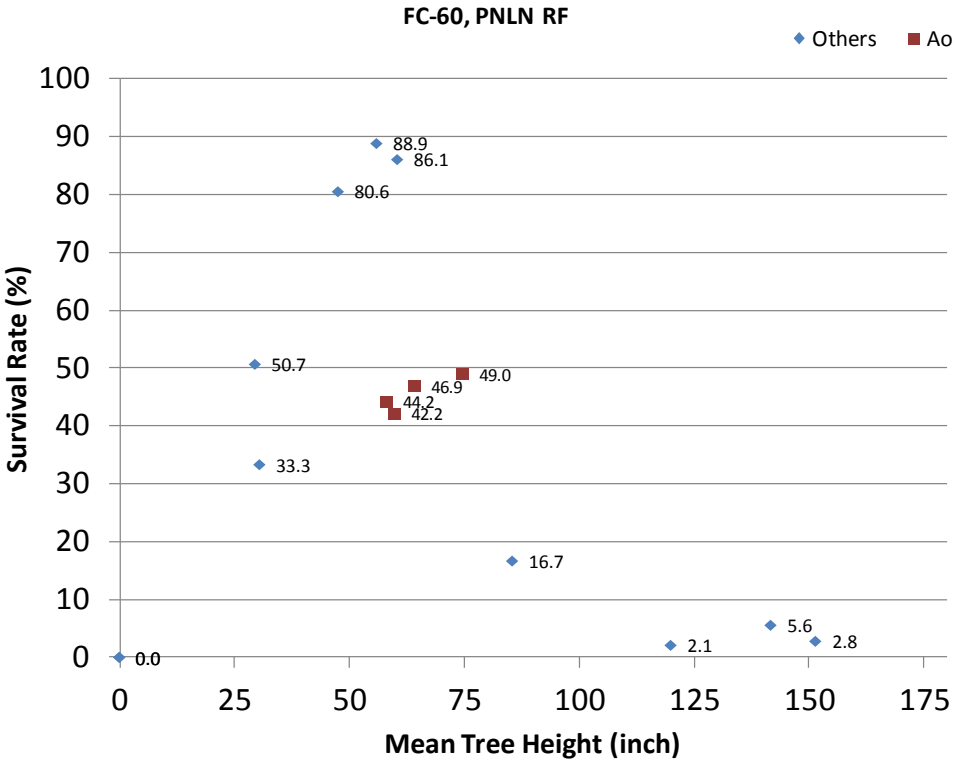


Figure1-5 Monitoring Result of PNLN FC-60 (Mean Height and Survival Rate)

6. 6 PNLN FC-66 (Planted year: FY 2010)

In the ARP FC-17 of PNLN RF, it aimed to confirm effectiveness of line and spot mound treatment for *Avicennia officinalis*, *Bruguiera sexangula*, *Sonneratia apetala* and *Melaleuca leucadendron*. The results of ARP monitoring are summarized in **Table1-11** and **Figure1-6**.

1) Mound treatment was not effective for *Avicennia officinalis* and *Bruguiera gymnorhizza*

2) Growth of *Avicennia officinalis* with 3'x3'spacing was better than KKKP-19 (planted 2010, 3'x3' with weeding),

3) Line mound had positive effect for *Melaleuca leucadendron* plantation compared with spot mound.

3) *Sonneratia apetala* was growing faster than other species but the survival rate was low (around 30%)

Table1-11 Summary of ARP Monitoring Results in PNLN FC-66

Planted Year: FY 2010

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Feb.2012	Nov.2012	Feb.2012	Nov.2012	Feb.2012	Nov.2012
Ao(1)	3x3	*no treatment*	76.2	73.4	43.2	67.3	1.9	3.4

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Feb.2012	Nov.2012	Feb.2012	Nov.2012	Feb.2012	Nov.2012
Ao(1)	6x6	Line mound	57.3	49.3	26.5	33.4	<0.5	0.8
Bg(1)	3x3	*no treatment*	69.5	69.4	33.1	46.2	<0.5	2.7
Bs(4)	6x6	Spot mound	32.6-49.3	29.2-48.6	18.3-20.8	25.9-31.7	<0.5	2.2-3.3
Sa(3)	6x6	*no treatment*	27.8-34.0	27.8-34.0	52.4-56.2	133.9-160	<0.5	3.8-6.4
Ml(2)	6x6	Spot mound	0.7-8.7	0.7-6.1	26.8-29.5	38.9-44.1	<0.5	0.8-0.9
Ml(6)	6x6	Line mound	6.9-54.2	dead-36.1	29.9-41.7	dead-57.3	<0.5	dead-1.1

Note1: Ao: *Avicennia officinalis, Bg: Bruguiera gymnorhizza Sa: Sonneratia apetala Ml: Melaleuca leucadendron*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Nov.2012)

Source: JET, January 2013

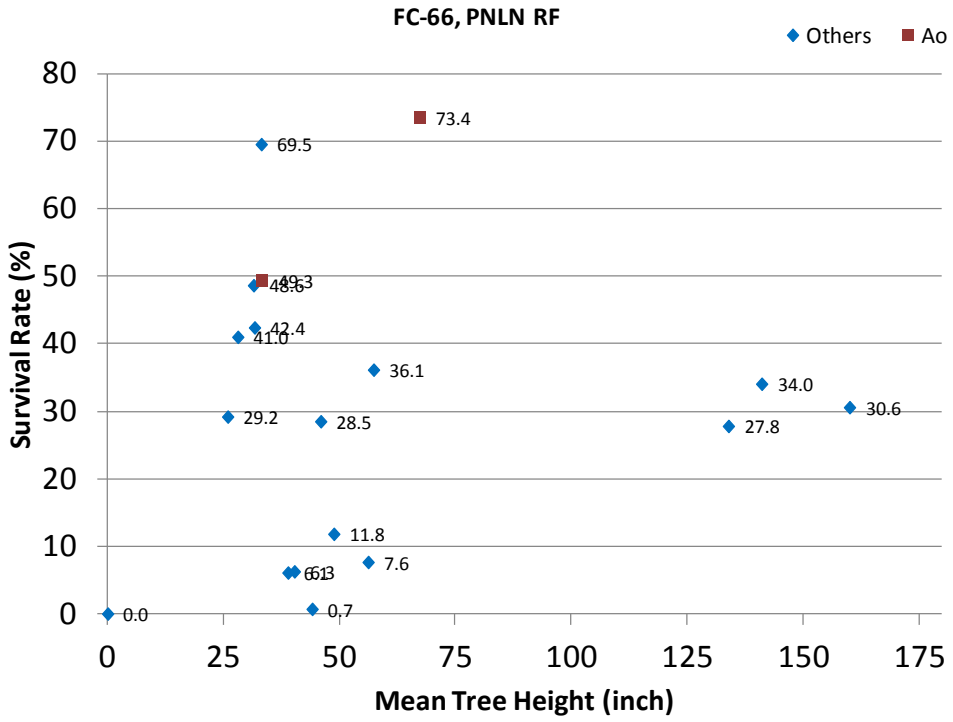


Figure1-6 Monitoring Result of PNLN FC-66 (Mean Height and Survival Rate)

6. 7 KADK FC-36 (Planted year: FY2008)

In the ARP FC-36 of KADK RF, it aimed to confirm growth performance of *Avicennia alba*, *Avicennia officinalis*, *Bruguiera sexangula* and effectiveness of mound treatment for *Melaleuca leucadendron*. Because of time limitation of the first monitoring survey period, it was postponed to August 2012. The results of ARP monitoring are summarized in **Table1-12** and **Figure1-7.**

1) *Avicennia alba* had the highest survival rate (75%) with 6'x6' spacing.

2) One of *Avicennia officinalis* plot had slow growth performance compared with other two plots.

3) One of *Bruguiera sexangula* plantation plot with 6'x6' spacing had good growth performance and high survival rate (nearly70%) compared with other plots, because land condition might be different.

4) *Melaleuca leucadendron* survived with mound treatment in this area, but it seems growing slower compared with other ARP sites.

Table1-12 Summary of ARP Monitoring Results in KADK FC-36

Planted Year: FY 2008

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
				Aug.2012		Aug.2012		Aug.2012
Aa(1)	6x6	*No treatment*		75.0		35.8		
Ao(2)	6x6	*No treatment*		33.3-68.8		22.8-38.0		
Bs(2)	3x3	*No treatment*		25.0-33.3		12.3-16.8		
Bs(2)	6x6	*No treatment*		25.0-69.4		17.5-29.9		
Ml(2)	6x6	Mound		12.5-58.7		26.8-27.6		

Note1: Aa: *Avicennia alba* Ao: *Avicennia officinalis, Bs: Bruguiera sexangula Ml: Melaleuca leucadendron*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Aug.2012)

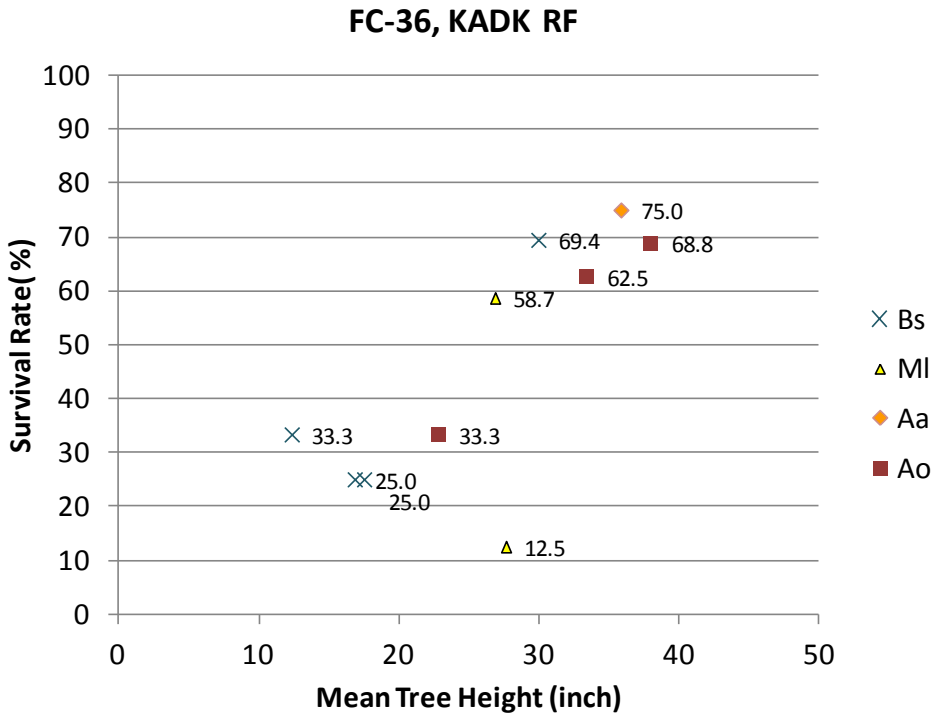


Figure1-7 Monitoring Result of KADN FC-36 (Mean Height and Survival Rate)

6. 8 KADK FC-39 (Planted year: FY2009)

In the ARP FC-39 of KADK RF, it aimed to confirm growth performance of *Avicennia marina*, *Bruguiera sexangula* , *Ceriops decandra* , *Heritiera fomes*, *Albizzia lucid* and *Melaleuca leucadendron* with spacing in 3'x3'. Because of time limitation of the first monitoring survey period, it was

postponed to August 2012. The results of ARP monitoring are summarized in **Table1-13** and **Figure1-8**.

1) *Avicennia marina* and *Bruguiera sexangula* had good survival rate (more than 60%) compared with other species.

2) *Heritiera fomes* and *Albizzia lucid*a had low survival rate (under 5%) compared with other species.

3) *Melaleuca leucadendron* had low survival rate (10%-1%), but survived *Melaleuca leucadendron* trees were growing well with averaged 88 inch in height.

Table1-13 Summary of ARP Monitoring Results in KADK FC-39

Planted Year: FY 2009

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
				Aug.2012		Aug.2012		Aug.2012
Am(2)	3x3	*No treatment*		72.8-76.9		51.9-53.6		1.6-1.8
Bs(1)	3x3	*No treatment*		63.3		44.4		2.9
Cd(2)	3x3	*No treatment*		30.4-47.1		19.9-21.0		0.8-1.2
Hf(1)	3x3	*No treatment*		3.1		24.6		0.8
Al(2)	3x3	*No treatment*		0.7-10.7		27.8-32.4		1.0-1.3
Ml(1)	3x3	Mound		0.7		88.4		2.9

Note1: Am: *Avicennia marina Bs: Bruguiera sexangula Cd: Ceriops decandra Hf: Heritiera fomes, Al: Albizzia lucida Ml: Melaleuca leucadendron*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Aug.2012)

Source: JET, January 2013

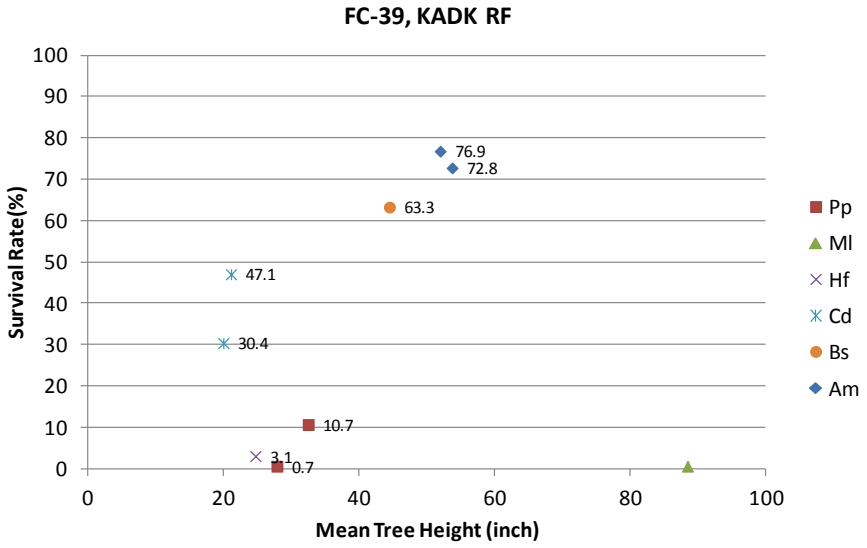


Figure1-8 Monitoring Result of PNLN FC-66 (Mean Height and Survival Rate)

6. 9 KADK FC-62 (Planted year: FY2011)

In the ARP FC-62 of KADK RF, it aimed to compare growth performance between *Avicennia officinalis, Aegiceras corniculatum, Bruguiera sexangula, Casuarina equisetifolia, Ceriops decandra* , *Excoecaria agallocha, Sonneratia apetala, Sonneratia caseolaris* and *Melaleuca leucadendron* with 3'x3'spacing and 6'x6'spacing. The ploughing treatment was also introduced in the ARP site. The results of ARP monitoring are summarized in **Table1-14** and

Figure 1-9

1) For *Aegiceras corniculatum*, there was no significant difference in growth between ploughing and no ploughing treatments.

2) Plough might support growth of *Avicennia officinalis*, because Survival rate is lower than no ploughing site.

3) *Bruguiera sexangula* had no differences between plough and no plough, but mound treatment had low survival rate less than 40%.

4) *Casuarina equisetifolia* has High survival rate with Mound. Low survival rate under 50% without treatment.

5) *Ceriops decandra* has low survival rate without ploughing. *Ceriops decandra* kept high survival rate more than 60% with ploughing.

6) *Excoecaria agallocha* without ploughing had high survival rate of 80% and above

7) *Melaleuca leucadendron* with mound treatment had 40% more better survival rate than without mound. Mound seems very effective for *Melaleuca leucadendron* in survival rate (more than 80%), but growth of tree is lower than other area. Survival rate is more than 50% with ploughing.

8) *Sonneratia apetala* with ploughing had maintained relatively high survival rate (60%) during two monitoring periods. of 70%, growth of tree is higher than no plough area. In no plough treatment, *Sonneratia apetala* had high survival rate of 90% above in first monitoring but all died by the time of second monitoring. Reasons are not identified yet..

9) *Sonneratia caseolaris* had good survival rate of more than 60%, tree growth in no mound treatment was also better than mound treatment Mound is not recommended for *Sonneratia caseolaris*.

Table1-14 Summary of ARP Monitoring Results in KADK FC-62

Planted Year: FY 2011

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Feb.2012	Dec.2012	Feb.2012	Dec.2012	Feb.2012	Dec.2012
Ac(1)	3x3	Plough	95.0	74.4	12.9	22.2	<0.5	0.6
Ac(1)	3x3	*No plough*	97.5	88.4	12.5	22.1	<0.5	0.7
Ao(3)	6x6	Plough	66.7-72.2	38.9-52.8	27.6-31.3	35.5-38.5	<0.5	0.8-1.1
Ao(4)	6x6	*No plough*	30.6-58.3	all dead	23.3-31.5	all dead	<0.5	all dead
Bs(3)	6x6	*No plough*	27.8-50.0	13.9-33.3	25.6-28.5	28.6-31.4	<0.5	0.5-0.8
Bs(5)	6x6	Plough	36.1-58.3	dead-22.2	26.3-29.4	dead-31.2	<0.5	dead-0.5
Bs(2)	3x3	Mound	18.2-31.4	4.1-10.7	22.4-23.6	25.2-29.7	<0.5	0.5-0.6
Ce(1)	3x3	Mound	81.0	46.3	22.6	112.7	<0.5	2.3
Ce(1)	3x3	*No plough*	41.3	5.8	21.0	50.1	<0.5	0.7
Cd(1)	3x3	Mound	63.6	10.7	14.6	31.3	<0.5	0.5
Cd(1)	3x3	Plough	71.9	5.0	14.8	32.0	<0.5	0.5
Cd(1)	3x3	Plough	80.2	32.2	13.3	14.8	<0.5	0.5
Ea(2)	3x3	*No plough*	80.2-91.7	53.7-76.0	12.1-15.1	15.1-20.1	<0.5	0.5-0.6
Ea(1)	3x3	Plough	67.8	54.5	14.3	15.6	<0.5	0.5
Ml(1)	3x3	*No Mound*	48.8	38.0	27.0	62.0	<0.5	1.3
Ml(2)	3x3	Mound	82.6-95.9	82.6-96.7	20.9-30.0	79.1-91.3	<0.5	1.4-1.5
Ml(1)	6x6	Plough	58.3	58.3	23.5	46.6	<0.5	1.2
Ml(1)	6x6	*No plough*	52.8	5.6	26.5	41.4	<0.5	0.8
Sa(1)	3x3	Plough	76.9	62.0	18.3-19.8	28.1-29.0	<0.5	1.4-1.5
Sa(3)	3x3	*No plough*	91.7-98.3	all dead	20.4-26.6	all dead	<0.5	all dead
Sc(2)	6x6	*No plough*	61.1-75.0	19.4-58.3	17.6-20.0	34.6-36.3	<0.5	1.4-1.5
Sc(1)	3x3	Mound	19.0	0.8	11.1	38.4	<0.5	2.0

Note1: Ac: *Aegiceras corniculatum Ao: Avicennia officinalis Bs: Bruguiera sexangula Ce: Casuarina equisetifolia Cd: Ceriops decandra Ea: Excoecaria agallocha Ml: Melaleuca leucadendron Sa: Sonneratia alba Sc: Sonneratia caseolaris*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Dec.2012)

Source: JET, January 2013

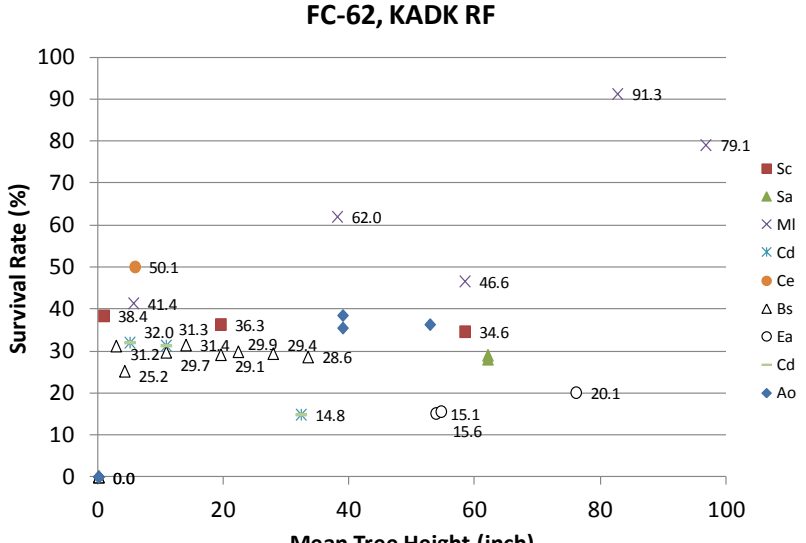


Figure 1-9 Monitoring Result of KADK FC-62 (Mean Height and Survival Rate)

6. 10 KADK FC-63 (Planted year: FY2010)

In the ARP FC-63 of KADK RF, it aimed spacing trials (3'x3', 6'x6', 9'x9' and 12'x12') for *Aegiceras corniculatum*, *Avicennia officinalis*, *Bruguiera sexangula*, *Ceriops decandra*, *Heritiera fomes*, *Melaleuca leucadendron* , *Pongamia pinnata* and *Sonneratia caseolaris*. The results of ARP monitoring are summarized in **Table1-15** and **Figure1-10**.

1) *Aegiceras corniculatum* had more than 60 % of survival rate. No big difference between 6x6 and 9x9 for *Aegiceras corniculatum*.

2) *Avicennia officinalis* had high survival rate and tree growth with 3'x3' and 6'x6', but 9'x9' was not effective for *Avicennia officinalis* in this area. 12' x 12' had the highest survival rate and tree growth compared with other spacing.

3) *Bruguiera sexangula* had low survival rate (around 30%) and tree growth at 3'x3'spacing, but had better survival rates of 50 to 60% at 6'x6' and 9'x9'spacings.

4) *Ceriops decandra* fairly survived at all spacing but 6'x6' spacing had better height/girth growth compared to other spacing thus more recommendable for *Ceriops decandra*

5) *Heritiera fomes* with6'x6' had better tree height growth and survival rate, compared with 3'x3' and 9'x9'.

6) Three plots of *Melaleuca leucadendron* were recorded all dead, but remaining plots had high survival rate and tree growth.

7) *Pongamia pinnata* had more than 60 % of survival rate. It had better growth compared with PNLN FC60 and KADK FC-39.

8) *Sonneratia caseolaris* maintained good survival rate and growth at both 6'x6' and 9'x9' in this area.

Table1-15 Summary of ARP Monitoring Results in KADK FC-63

Planted Year: FY 2010

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Feb.2012	Dec.2012	Feb.2012	Dec.2012	Feb.2012	Dec.2012

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Feb.2012	Dec.2012	Feb.2012	Dec.2012	Feb.2012	Dec.2012
Ac(6)	6x6	-	69.4-98.1	66.7-98.1	24.7-39.4	34.2-51.8	<0.5	0.5-3.0
Ac(3)	9x9	-	60.0-85.0	60.0-75.0	25.3-27.0	36.7-41.1	<0.5	0.5-1.0
Ao(2)	3x3	-	65.3-75.2	64.5-66.1	38.4-43.2	49.5-58.5	<0.5	1.6-2.1
Ao(10)	6x6	-	75.0-91.7	75.0-91.7	25.2-55.1	29.1-84.1	<0.5	1.6-3.3
Ao(2)	9x9	-	30.0-45.0	30.0-45.0	36.1-36.6	50.9-52.2	<0.5	1.7-2.1
Ao(2)	12x12	-	83.3-100.0	75.0-100.0	41.3-47.9	51.3-56.0	<0.5	1.9-2.0
Bs(2)	3x3	-	30.6-30.8	19.8-22.5	22.5-26.3	25.3-32.0	<0.5	0.5-0.8
Bs(17)	6x6	-	22.2-75.0	0.0-77.8	19.5-28.1	0.0-34.9	<0.5	0.0-1.7
Bs(3)	9x9	-	50.0-60.0	0.0-5.0	25.1-26.6	0.0-24.0	<0.5	0.0-1.0
Cd(2)	3x3	-	39.7-60.3	34.7-47.9	16.0-17.2	18.1-22.4	<0.5	0.5-0.6
Cd(7)	6x6	-	25.0-83.3	13.9-83.3	13.6-27.0	16.4-36.6	<0.5	0.5-2.1
Cd(2)	9x9	-	45.0-60.0	15.0-35.0	14.3-14.9	20.7-20.8	<0.5	0.7-0.8
Cd(2)	12x12	-	50.0-66.7	33.3	13.2-13.6	14.1-15.6	<0.5	0.5
Hf(2)	3x3	-	52.9-57.9	31.4-33.1	17.8-18.1	18.2-19.4	<0.5	0.5
Hf(3)	6x6	-	50.0-91.7	0.0-91.7	17.9-26.3	0.0-16.8	<0.5	0.0-2.6
Hf(5)	9x9	-	40.0-75.0	35.0-55.0	20.9-21.0	26.4-28.9	<0.5	1.0-1.2
Ml(17)	6x6	-	0.0-77.8	0.0-62.9	36.4-58.4	0.0-61.6	<0.5	0.0-1.8
Pp(21)	6x6	-	63.9-97.2	41.7-88.9	18.0-48.3	20.2-51.8	<0.5	0.9-2.0
Sc(8)	6x6	-	61.1-88.9	47.2-83.3	38.3-43.3	60.1-71.5	<0.5	2.6-3.7
Sc(4)	9x9	-	50.0-80.0	45.0-80.0	34.2-49.1	40.9-62.8	<0.5	0.6-2.5

Note1: Ac: *Aegiceras corniculatum Ao: Avicennia officinalis Bs: Bruguiera sexangula Cd:Ceriops decandra Hf: Heritiera fomes Ml: Melaleuca leucadendron Pp: Pongamia pinnata Sc: Sonneratia caseolaris*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Dec.2012)

Source: JET, January 2013

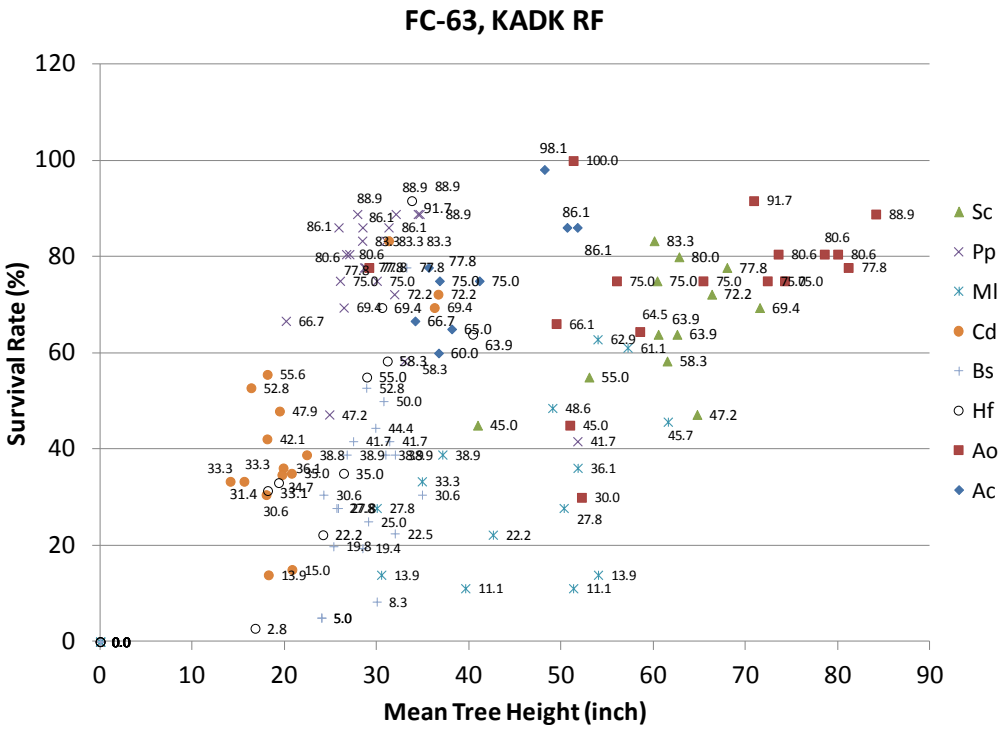


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Figure1-10 Monitoring Result of KADK FC-63 (Mean Height and Survival Rate)

6. 11 PNDY FC-64 (Planted year: FY2009)

In the Pyindaye Reserved Forest, location of monitoring plots were totally different between January 2012 and January2013 because of GPS data recorded in January 2012 had errors. It cannot be compared monitoring results between in Jan.2012 and in Jan.2013 in **Table 1-16**.

In the ARP FC-64 of PNDY RF, it aimed to confirm growth performance of *Avicennia marina*, *Bruguiera sexangula* , *Ceriops decandra* , *Excoecaria agallocha* and natural regeneration. The results of ARP monitoring are summarized in **Table1-16** and **Figure1-11**.

1) The survival rate (lower than 40%) was lower than KADK FC-39 (planted 2009,monitored August 2012, 3'x3'). It seemed that weeding treatment was not necessary *Avicennia marina* plantation in this area.

2) Weeding had positive effect for *Bruguiera sexangula* in this area compared with no-treatment area.

3) *Ceriops decandra* with weeding kept good survival rate of more than 60% in this area.

4) *Excoecaria agallocha* had good growth performance with weeding treatment.

Table1-16 Summary of ARP Monitoring Results in PNDY FC-64

Planted Year: FY 2009

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Jan.2013	Jan.2012	Jan.2013	Jan.2012	Jan.2013
Am(2)	6x6	Weeding	38.9-41.7	36.1-38.9	56.9-59.0	74.8-93.7	<0.5	3.6-4.0
Bs(2)	6x6	Weeding	58.3-80.6	58.3-69.4	41.2-80.3	62.3-71.0	<0.5	3.1
Bs(1)	6x6	No weeding	44.4	-	45.8	-	<0.5	-
Cd(2)	6x6	Weeding	61.1-69.4	55.6	28.0-69.4	35.3-39.1	<0.5	2.2-2.6
Ea(3)	-	Natural Regeneration	96.5-100.0	93.7-97.0	170.2-214.2	180.3-222.8	4.5-5.8	5.5-6.3
Ea/Hf(1)	-	Natural Regeneration	100.0	100.0	186.4-196.3	199.6	4.8-5.1	5.9

Note1: Am: *Avicennia marina Bs: Bruguiera sexangula Cd:Ceriops decandra Ea; Excoecaria agallocha Hf: Heritiera fomes*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Jan.2013)

Source: JET, January 2013

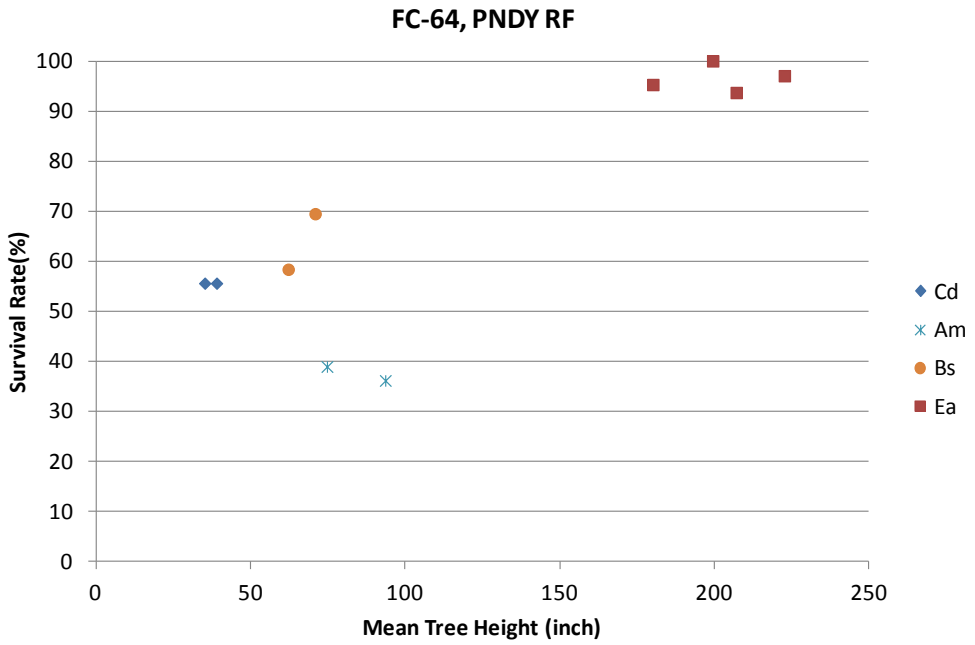


Figure1-11 Monitoring Result of PNDY FC-64 (Mean Height and Survival Rate)

6. 12 PNDY FC-65 (Planted year: FY2010)

In the ARP FC-65 of PNDY RF, implemented spacing trial and ploughing treatment for *Avicennia officinalis*, *Avicennia marina* and *Ceriops decandra*. The results of ARP monitoring are summarized in **Table1-17**and **Figure1-12**.

1) *Avicennia marina* had positive effect of ploughing, but almost all the monitoring plot without ploughing also had medium – high survival rate and growth performance of tree height/girth in this area.

2) Almost all the monitoring plots of *Ceriops decandra* had keep high survival rate(more than 60%) in Jan.2013.

Table1-17 Summary of ARP Monitoring Results in PNDY FC-65

Planted Year: FY 2010

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Jan.2013	Jan.2012	Jan.2013	Jan.2012	Jan.2013
Am(2)	3x3	Plough	80.2-90.9	76.0-90.1	39.1-44.8	52.5-75.9	<0.5	1.8-2.3
Am(2)	6x6	*No treatment*	20.0-91.4	-	27.1-50.4	-	<0.5	-
Am(2)	6x6	Plough	52.8-94.4	50.0-94.4	35.6-44.5	68.9-102.9	<0.5	2.7-3.4
Am(2)	9x9	Plough	80.0-95.0	80.0-95.0	37.4-42.5	63.0-90.2	<0.5	2.8-3.2

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Jan.2013	Jan.2012	Jan.2013	Jan.2012	Jan.2013
Am(2)	12x12	Plough	68.8-75.0	68.8-75.0	34.6-36.7	51.6-54.8	<0.5	2.6-2.8
Am(2)	3x3	No plough	66.1-100.0	61.2-74.4	34.6-37.3	74.1-83.2	<0.5	2.4-2.8
Am(2)	9x9	No plough	41.7-90.0	41.7-65.0	28.3-41.1	33.3-48.6	<0.5	1.7-2.3
Am(2)	12x12	No plough	75.0-93.8	59.8-76.7	34.9-45.7	93.8	<0.5	2.6-3.1
Ao(2)	6x6	*No treatment*	68.6-82.9	68.6-77.1	35.9-38.4	43.0-45.0	<0.5	3.0-3.7
Ao/ Am(2)	6x6	No plough	63.9-91.7	63.9-83.3	37.8-55.2	72.8-91.0	<0.5	4.6-5.1
Bs(2)	6x6	*No treatment*	25.7-65.7	22.9-62.9	18.8-23.1	28.8-29.1	<0.5	2.3-2.8
Cd(2)	6x6	*No treatment*	51.4-77.1	68.6-77.1	15.8-18.7	24.4-24.7	<0.5	1.2-1.4
Cd(2)	6x6	Plough	72.2-97.2	66.7-97.2	18.9-20.8	27.1-31.3	<0.5	2.0-2.4
Cd(2)	9x9	Plough	75.0-90.0	70.0-85.0	16.4-18.2	28.1-32.0	<0.5	2.0
Cd(2)	12x12	Plough	62.5-75.0	56.3-75.0	16.3-17.7	23.7-25.1	<0.5	2.0-2.2
Cd(2)	3x3	No plough	85.1-100.0	75.2-86.0	17.5-19.6	26.2-27.6	<0.5	1.6-1.7
Cd(2)	6x6	No plough	61.1-83.3	75.0-83.3	16.8-19.9	26.1-26.6	<0.5	1.7-1.8
Cd(2)	9x9	No plough	75.0-95.0	75.0-90.0	15.0-20.0	21.8-24.3	<0.5	1.5-2.2
Cd(2)	12x12	No plough	81.3-100.0	81.3-100	15.9-19.3	27.8-28.1	<0.5	1.9-2.3

Note1: Am: *Avicennia marina* *Ao: Avicennia officinalis Bs: Bruguiera sexangula Cd:Ceriops decandra*

Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Jan.2013)

Source: JET, January 2013

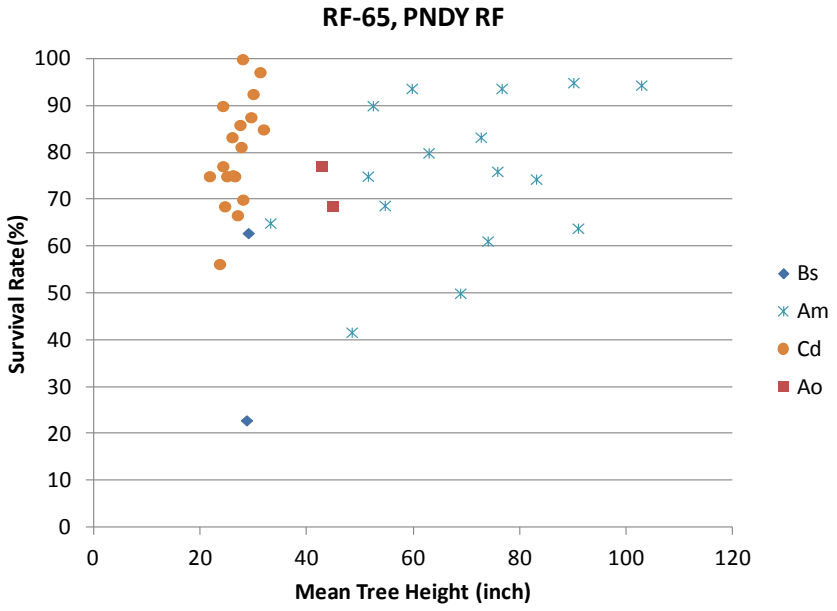


Figure1-12 Monitoring Result of PNDY FC-65 (Mean Height and Survival Rate)

6. 13 PNDY FC-66 (Planted year: FY2011)

In the ARP FC-66 of PNDY RF, it aimed to confirm effectiveness of ploughing treatment for *Avicennia alba*, *Avicennia marina*, *Bruguiera sexangula*, *Ceriops decandra*, *Excoecaria agallocha*, *Ceriops decandra*, *Melaleuca leucadendron*, *Nypa fruticans*, *Pongamia pinnata* and *Xylocarpus moluccensis* with 6'x6' spacing. The results of ARP monitoring are summarized in **Table1-18** and **Figure1-13.**

1) *Avicennia alba*, *Melaleuca leucadendron* and *Pongamia pinnata* had not been survived in this area just after planting. It might be insufficient of ground condition (especially ground level) for these species in this area.

2) *Avicennia marina*, *Bruguiera sexangula* and *Ceriops decandra* had positive effects of ploughing because it could keep high survival rate (more than 60%) until Jan.2013.

Table1-18 Summary of ARP Monitoring Results in PNDY FC-66

Planted Year: FY 2011

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Jan.2013	Jan.2012	Jan.2013	Jan.2012	Jan.2013
Aa(-)	-	All dead						
Am(3)	6x6	Plough	88.9-100.0	72.2-100	15.4-25.8	29.4-46.6	<0.5	0.5-1.6
Am(5)	6x6	No plough	72.2-88.9	36.1-88.9	18.6-27.8	22.1-36.8	<0.5	0.5-1.3
Bs(3)	6x6	*No treatment*	50.0-61.1	30.6-44.4	20.9-21.2	26.8-29.8	<0.5	0.8-1.6
Bs(2)	6x6	No plough	80.6-91.7	75.0-77.8	18.2-18.5	23.7-25.5	<0.5	0.9
Bs(2)	6x6	Plough	83.3-91.7	80.6-88.9	15.5-16.6	21.9-22.4	<0.5	0.5
Bs(1)	6x6	Mound	63.9	58.3	21.3	31.7	<0.5	1.4
Cd*(2)	6x6	*No treatment*	88.9-97.2	80.6-88.9	14.1-15.1	18-20.1	<0.5	0.5-0.7
Cd(1)	6x6	Mound	97.2	72.2	9.4	16.2	<0.5	0.5
Cd(2)	6x6	Plough	86.1-91.7	77.8	6.7-7.2	14.8-15.6	<0.5	0.5
Cd(1)	6x6	No plough	72.2	41.7	8.1	11.9	<0.5	0.5
Ea(3)	6x6	*No treatment*	91.7-100.0	50.0-100	11.8-12.6	30.8-32.5	<0.5	0.5-0.9
Ea(1)	6x6	Mound	63.9	58.3	8.9	30.7	<0.5	1.0
Ea(3)	6x6	No plough	77.8-100.0	77.8-94.4	9.7-12.2	22.5-25.3	<0.5	0.5-0.6
Ea(1)	6x6	Plough	80.6	75.0	9.5	25.6	<0.5	1.2
Lr(1)	6x6	*No treatment*	97.2	86.1-97.2	10.8-11.7	29.0-40.3	<0.5	0.5
Lr(1)	6x6	Mound	97.2	100	11.9	43.4	<0.5	0.5
Ml(-)	-	All dead	All dead		All dead		All dead	

Sp.	Spacing (ft x ft)	Treatment Type	Survival rate (%)		Mean Height (inch)		Mean Girth (inch)	
			Jan.2012	Jan.2013	Jan.2012	Jan.2013	Jan.2012	Jan.2013
Ny(3)	6x6	*No treatment*	63.9-72.2	61.1-66.7	18.2-19.1	28.6-41.7	<0.5	0.5
Pp(-)	-	All dead	All dead		All dead		All dead	
Xm(3)	6x6	*No treatment*	86.1-91.7	30.6-47.2	30.0-30.1	35.2-45.8	<0.5	0.5-1.0
Xm(1)	6x6	Mound	83.3	61.1	26.6	43.1	<0.5	0.9

*One plot all planted seedlings were dead.

Note1: Aa: *Avicennia alba* Am: *Avicennia marina* *Bs:Bruguiera sexangula Cd:Ceriops decandra Ea:Excoecaria agallocha Lr Lumnitzera racemosa: Ml:Melaleuca leucadendron Ny:Nypa fruticans Pp:Pongamia pinnata Xm:Xylocarpus moluccensis*
Note2: () is number of monitoring plots of each species by treatment based on the latest summary record (Jan.2013)

Source: JET, January 2013

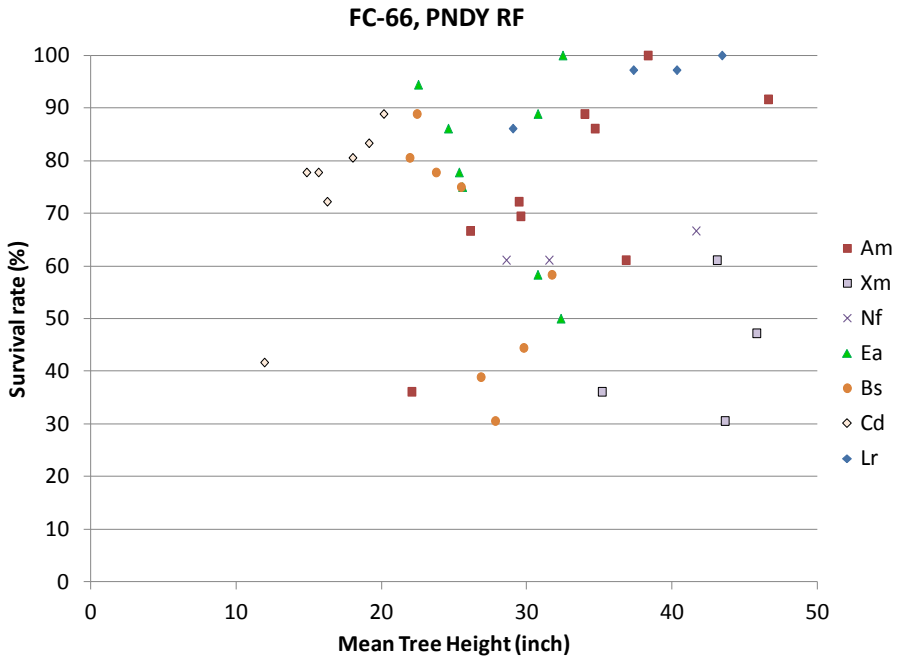


Figure1-13 Monitoring Result of PNDY FC-66 (Mean Height and Survival Rate)

7. Lessons learned

7.1 Findings from Species Trial

Relationships between mangrove species and their adaptable/ favorable habitats in terms of ground levels and tidal inundations were not fully possible to confirm during the project. However, based on results of the species trials, observations of past plantation activities and empirical experience of FD and its personnel, it is reasonable to say that species – site matching in the delta has general tendency as per indicated in the following table. Species indicated in the table shall be considered to be introduced in FD and CF plantation sites in the delta reflecting site conditions as well as plantation

objectives. (**Table1 1-19**).In case of production purposes in the delta, it is recommended to plant species indicated in **Table1 1-20**. For non- mangrove species (*Casuarina equisetifolia* , *Melaleuca leucadendron*, etc.), it is necessary to consider the high ground level sites without tidal inundation for better survival and growth.

Table1 1-19 Probably Adaptable Mangrove Species

No. of days of tidal inundation per month during dry season	**Probably Adaptable Mangrove Species**	
all high tides (at least 20days /month)	High saline water *Kandelia candle,* *Avicennia alba,* *Avicennia marina,* *Sonneratia apetala,* *Aegiceras corniculatum*	Low saline water *Kandelia candle,* *Nypa fruticans,* *Rhizophora apiculata,* *Sonneratia apetala,* *Sonneratia caseolaris,* *Avicennia officinalis*
medium high tides/every start of spring tides (10-19 days/month)	*Nypa fruticans,* *Rhizophora apiculata,* *Sonneratia qriffithii,* *Sonneratia alba,* *Ceriops decandra,* *Bruguiera gymnorhizza,* *Bruguiera sexangula,* *Avicennia officinalis,* *Aegiceras corniculatum*	*Brownlowia tersa,* *Ceriops decandra,* *Bruguiera gymnorhizza,* *Aegiceras corniculatum,* *Avicennia officinalis,* *Heritiera fomes* *Rhizophora apiculata*
every normal high tides/mid spring tides (3-9 days/month)	*Ceriops decandra, Bruguiera spp, Heritiera fomes, Amoora cucullata, Xylocarpus granatum,* *Xylocarpus mollucensis, Aegilitis rotundifolia,* *Avicennia officinalis,*	
every spring high tides (at least 2days/month)	*Heritiera fomes, Xylocarpus mollucensis,* *Xylocarpus granatum, Excoecaria agallocha,* *Amoora cucullata, Phoenix paludosa*	
4 times in dry season by equinoctial abnormal high tides	*Phoenix paludosa, Cynometra ramiflora,* *Hibiscus tiliaceus, Clerodendrum inerme,* *Lumnitzera racemosa, Myet-kha grass* *(Heritiera fomes, Excoecaria agallocha)*	
only flooded by rain water during rainy season	*Phoenix paludosa, Hibiscus tiliaceus* *and non-mangrove species (Melaleuca leucadendron, Casuarina equisetifolia)*	

Table1 1-20 Probably Applicable Mangrove Species for Production Purpose

Main Purpose of Plantation	Mangrove Species
Firewood , Charcoal, poles, post	Sonneratia apetala, Avicennia officinalis , Rhizophora apiculata, Bruguiera sexangula, Bruguiera gymnorhizza, Xylocarpus mollucensis, Heritiera fomes, Excoecaria agallocha, Lumnitzera racemosa, Rhizophora apiculata, Ceriops decandra, Cynometra ramiflora
Nypa thatch/juice	Nypa fruticans
Log/Timber	Avicennia officinalis, Sonneratia apetala, Intsia bijuga, Ceriops decandra, Bruguiera sexangula, Xylocarpus granatum, Rhizophora apiculata and Heritiera fomes

7.2 Findings from Spacing Trial

Possible spacing of each mangrove species are summarized in **Table1 1-21**).

Table1 1-21 Findings of Spacing Treatment

Spacing	Possible Species	Remarks
1'x1'	*Avicennia officinalis* can grow in 1'x1' but the survival rate was low.	In some locations/ species, may be possible for firewood (biomass) production but yet to be confirmed.
3'x3'	*Avicennia marina* and *Bruguiera gymnorhizza* can grow well.	Species other than *Avicennia marina* and *Bruguiera gymnorhizza* are not clarified the effect of 3'x3' spacing, need to be confirmed more.
6'x6'	*Avicennia officinalis, Excoecaria agallocha , Ceriops decandra, Heritiera fomes, Sonneratia caseolaris, Aegiceras corniculatum, Bruguiera sexangula, Avicennia marina*	This is standard tree spacing in the delta. Most of tree species show certain growth in this spacing. This spacing widely used from empirical experience.
9'x9'	*Avicennia officinalis, Sonneratia caseolaris, Avicennia marina, Ceriops decandra*	Depends on objectives but it is recommendable especially for achieving higher survival rate and growth of planted trees than 6' x 6'.
12'x12'	*Avicennia officinalis, Avicennia marina* and *Ceriops decandra* have positive effects of 12'x12' interval.	In this spacing, it seems to be that seedlings are more prone to damages from tidal waves and strong winds. Therefore, application of this spacing shall be limited to locations with less prone to waves/winds, suitable species. Depends on objectives, it is advisable that denser stands can be thinned to this spacing after the first initial years of plantation establishment.

7.3 Findings from Land Treatment Trail

Effectiveness of ploughing and weeding vary in mangrove species, spacing and site conditions. Therefore, it was not fully possible to identify tendencies of these treatments from the trials in the project. Mound treatment for non-mangrove species has positive effect for its survival rate in the delta (**Table1 1-22**).

Table1 1-22 Possible Treatment for Non-Mangrove Species

Non-mangrove Species	Possible Treatment
Casuarina equisetifolia	Mound treatment is preferred for *Casuarina equisetifolia* plantation in the delta. However, the effect of mound treatment is limited in low ground sites where tidal level exceeds the mound level.
Melaleuca leucadendron	Mound treatment is preferred for *Melaleuca leucadendron* plantation. Line mound is more effective than spot mound for tree growth and its survival. However, the effect of mound treatment is limited in low ground sites where tidal level exceeds the mound level.

7.4 Issues

1) The findings of growth performance of mangrove and non-mangrove species in ARPs were limited because the project could only monitor initial few years after the plantation establishment..

2) Ground level identifications and maintaining constant ground level for respective treatment areas were not fully possible, thus some trial results may have highly influenced by various differences in site conditions (within plots and also among plots).

3) In the ARP, information for the causes of tree's death was not fully recorded during the monitoring survey. To assess the effectiveness of trials as well as growth performance, not only quantitative data but qualitative data shall be timely recorded and analyzed, it is necessary to check not only height and girth of tree but also tree condition.

4) To confirm the growth performance of species trial, it is necessary to conduct regular monitoring in the ARP after the project.

8. Recommendations

1) Introduce Systematic Monitoring Procedure and Monitoring Format:

Through ARP, monitoring procedure and format were developed. To assess growth performance in plantation sites, it is necessary to confirm not only height and girth of tree but also tree condition. It needs to record more details of tree conditions using "remarks" column in the monitoring sheet.

1) Continue Monitoring in the ARP:

Results of ARP monitoring only cover tree growth of initial stage of plantation. To analyze more detail effect of each trial, it is recommend selecting accessible, well-maintained plots and continuing the monitoring after the project.

2) Frequency of Monitoring Activity:

It is recommended that monitoring to be conducted every dry season (November – March) since this period is easier for access to sites and can also confirm the survival /growth after the planting (rainy) season.

3) Technology Transfer among FD staffs

The monitoring skill should be shared and transferred continually among the FD staff through ARP monitoring as well as other FD plantation activity after the project.

Volume 2

Measurement Techniques for Mangrove Management in the Ayeyawady Delta

1. Introduction

Through the Action Research Plantation (ARP) in the project, following measurement activities (**Table2-1**) had been conducted by the project in the field. It aimed to find applicable measurement techniques for proper forest management conducted by FD staff in the delta.

Table2-1 Tested Measurement Techniques in Project

	Measurement techniques	Information
1	Tidal level measurement	To determine "Mean Sea Water Level (MSWL" in ARP sites, the tidal level measurement was conducted during project period at four Community Forestry Extension Center Nurseries (CFECNs).
2	Ground level measurement at Bench mark of ARP	To identify "absolute ground level" of ARP site using differences of tidal level between CFECNs and benchmarks nearby ARPs. Therefore, at least two concrete benchmark posts have been installed at ARP Sites.
3	Ground level measurement in ARP Sites	To identify "absolute ground level" inside ARP sites, the ground level measurement from each benchmark were conducted.
4	Soil condition survey	To analyze relationship between soil condition and growth of existing mangrove species, EC and Ph were measured in the project site.
5	Salinity measurement	To identify water salinity in the delta, portable refractor for water salinity is introduced to FD Township.

2. Tidal Level Measurement

2.1 Background and Objectives

The tidal level condition highly determines ground level as well as adaptable habitats for major mangrove species. Growth of tree and its survival has high relationship with water volume and soil/ water salinity. It means understanding tidal level is one of the most important factors for selecting sites and identifying species for plantation of mangrove/non-mangrove species in the delta.

For identification of suitable plantation sites in the delta, one should know the ground level by existing information. However, existing topographic maps do not have detail elevation data and not appropriate for identifying tidal levels as well as ground levels.

As a part of Action Research Plantation (ARP) activities, the project conducted simple tidal level measurement in the project sites to confirm averaged tidal level as reference of ground level.

2.2 Location of Measurement Points

Tidal level measurement was conducted at four (4) Community Forestry Extension Center and Nursery (CFECN) in each reserved forest (Figure 2-1).

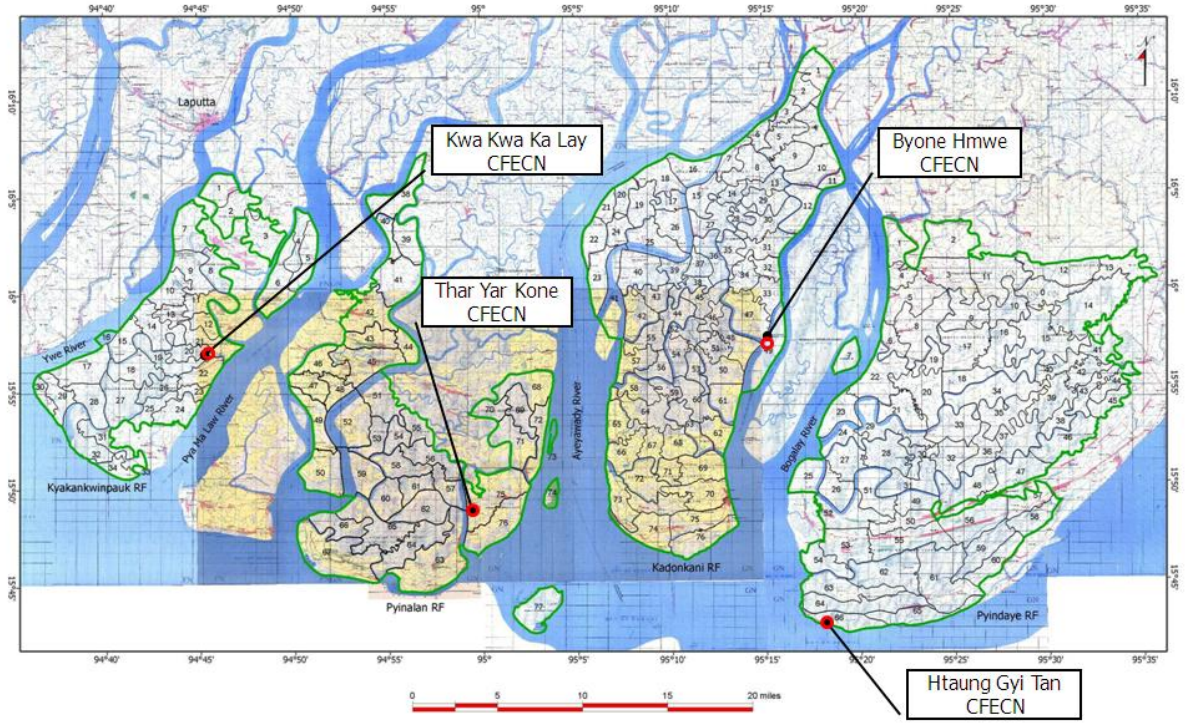


Figure2-1 Location of Tidal Level Measurement Points in the Ayeyawady delta

2.3 Measurement Periods

The project conducted tidal level measurements in four CFECNs from 2010 to 2012 as follows (**Table2-2**).

Table2-2 Measurement Period of tidal level in CFECNs

Name of CFECN	Starting date for monitoring	Ending date for monitoring	Duration (numbers of day)	Remarks
Kwa Kwa Ka Lay(KKKL)	17-Jul-2011	25-Aug-2011	40 days	Rainy season
	20-Feb-2012	10-Mar-2012	20 days	Dry season*
	20-Mar-2010	20-Apr-2010	31days	Dry season
Thar Yar Kone(TYK)	19-Jul-2011	25-Aug-2011	38 days	Rainy season
	20-Mar-2010	20-Apr-2010	31days	Dry season
Byone Hmwe(BYM)	23-Jul-2011	24-Aug-2011	33 days	Rainy season
	20-Mar-2010	20-Apr-2010	31days	Dry season
Htaung Gyi Tan(TGT)	21-Jul-2011	24-Aug-2011	35 days	Rainy season
	20-Mar-2010	20-Apr-2010	31days	Dry season

**The tidal measurement in February 2012, KKKL aims at corresponding of previous measurement records only.*

Source: JET, January 2013

2.4 Measurement Method

1) Necessary materials

The project installed temporally bamboo pole as tidal gauge nearby each CFECN. The pole is around 22 feet in height and 4 inch in girth (**Figure2-2**).

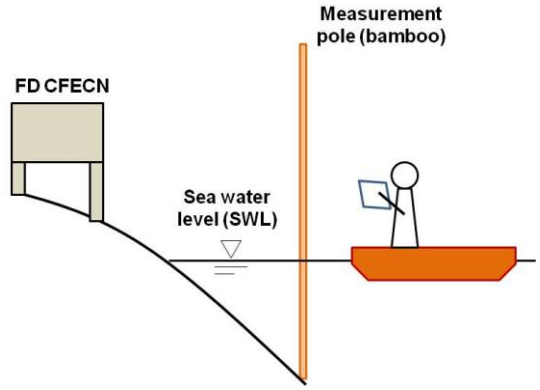


Illustration of Tidal Level Measurement pole

Temporally Measurement Pole in Kwa Kwa Ka Lay CFECN, Laputta T/S

Source: JET, January 2013

Figure2-2 Installation of Measurement Pole for Tidal Level

2) Record Interval and Record Format

For define averaged tidal level in each gauge, hourly tidal level has been collected by three persons who are assigned for the measurement work with eight (8) hours rotation. Record format of tidal level measurement in the project is indicated in **Attachment 2-1**.

2.5 Results

The averaged tidal level in four CFECNs is shown below (**Table 2-3**). And some of gauge positions changed because of tidal waves and other reasons during the rainy season measurements. After checking the measurement results, the project adapted averaged tidal levels of dry season measurement (Feb – April) in KKKL CFECN as base reference for further tidal / ground level measurement in the project area. Tidal level record in KKKL CFECN which was applied for further ground level measurement are attached in **Attachment 2-2.**

Table 2-3 Result of tidal level measurement in CFECNs

Name of CFECN	Starting date for monitoring	Ending date for monitoring	Duration (numbers of day)	Average Tidal level (unit: inch/cm)
Kwa Kwa Ka Lay(KKKL)	17-Jul-2011	25-Aug-2011	40 days	43.4/110
	20-Feb-2012	10-Mar-2012	20 days	34.7/88*
	20-Mar-2010	20-Apr-2010	31days	48.0/122
Thar Yar Kone(TYK)	19-Jul-2011	25-Aug-2011	38 days	58.7/149
	20-Mar-2010	20-Apr-2010	31days	78.3/199
Byone Hmwe(BYM)	23-Jul-2011	24-Aug-2011	33 days	54.8/139
	20-Mar-2010	20-Apr-2010	31days	92.1/234

Htaung Gyi Tan(TGT)	21-Jul-2011	24-Aug-2011	35 days	52.2/133
	20-Mar-2010	20-Apr-2010	31days	44.9/114

**The tidal measurement in February 2012, KKKL aims at corresponding of previous measurement records only.*

Source: JET, January 2013

2.6 Findings and Issues

1) Normally, it is required to measure tidal level for long terms at regular interval to estimate "Mean Sea Water Level of measurement site. Since the measurements were only conducted for one month or so with somewhat simple and robust methods, the data is to be only utilized for ARP and other plantation activities to serve as indicative basis for tidal/ ground level information.

2) Temporally tidal gauges in four CFECNs were broken or washed away by tidal after the measurement. However, link with benchmark posts at each CFECNs as well as major benchmarks within project areas were made with tidal gauge. Therefore, ground level information, though indicative can be referred from the respective benchmarks in the area.

2.7 Recommendations

If FD needs ground level information in scheduled plantation sites without benchmarks or far away from benchmarks, it is recommended to measure tidal level again using permanent tidal gauge.

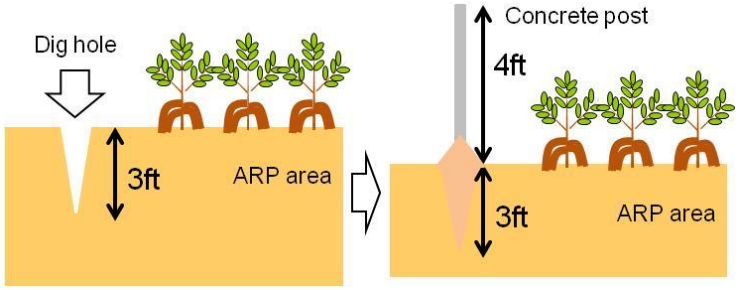
3. Ground Level Measurement between CFECNs and Benchmark Post

3.1 Objectives

The ground level measurement at Benchmark (BM) posts which were established near plantation sites aimed to define absolute ground level corresponding with CFECN averaged tidal level. When the absolute tidal fixed in each BM, it is easy to confirm ground level in each plantation site.
A series of ground level measurement techniques were applied in the project to determine ground levels a well a suitable area for plantation.

3.2 Benchmark Posts Installation

BM post is made from concrete and the size of BM post is 7 feet in height. Installation method of BM and photo are described in below. Posts were painted RF name, Forest Compartment number and Serial number by red.



Installation of installation of Benchmark Post

Installed Benchmark post

Source: JET, January 2013

Figure 2-3 Image of Benchmark Post Installation

3.3 Location of Benchmark Posts

The project installed BMs in some Forest Compartments (FC) nearby ARP, CF area and existing FD plantation area. Total number of BMs and its location is shown in **Table 2-4** and **Figure 2-4**.

Table 2-4 List of Benchmark Post in ARP, CF and FD Plantation Area

Reserved forest	Number of Benchmark			
	ARP area	CF area	FD plantation	Total
KKKP	9	7	4	20
PNLN	7	25	16	48
KADK	11	0	0	11
PNDY	8	5	0	13
Total	36	37	20	93

Source: JET, January 2013

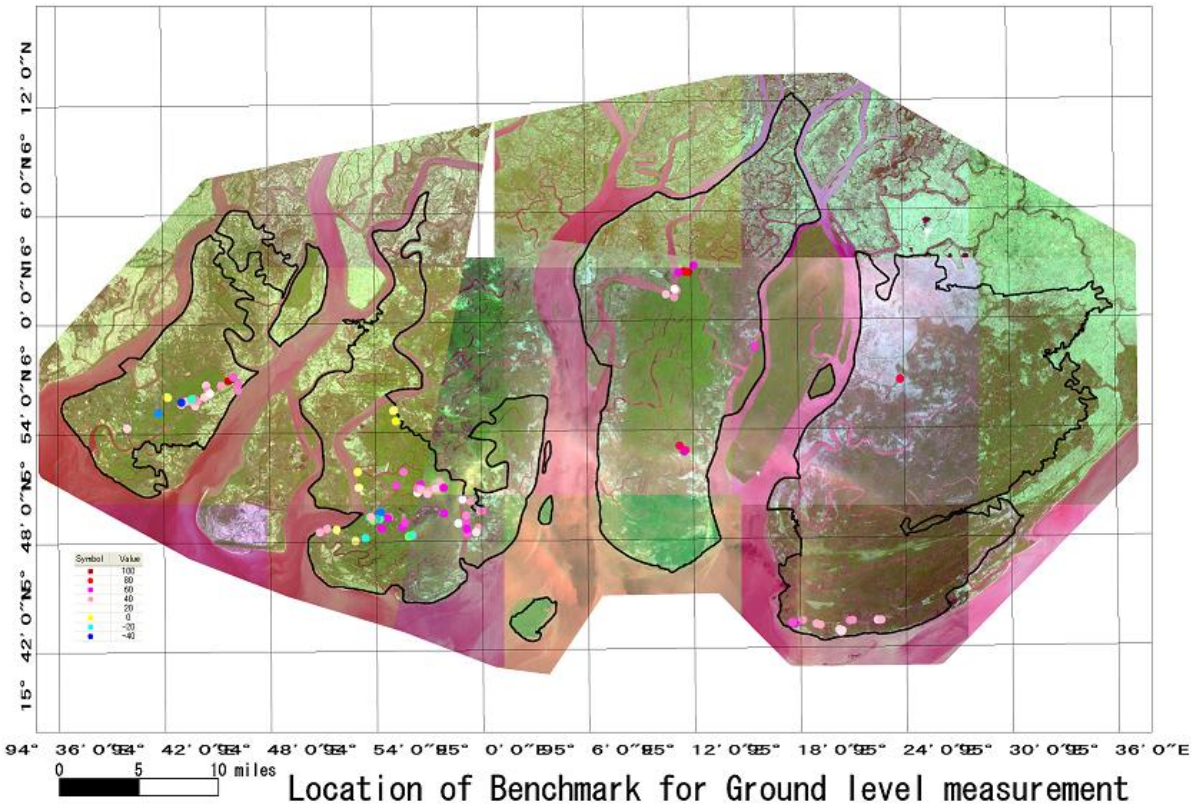
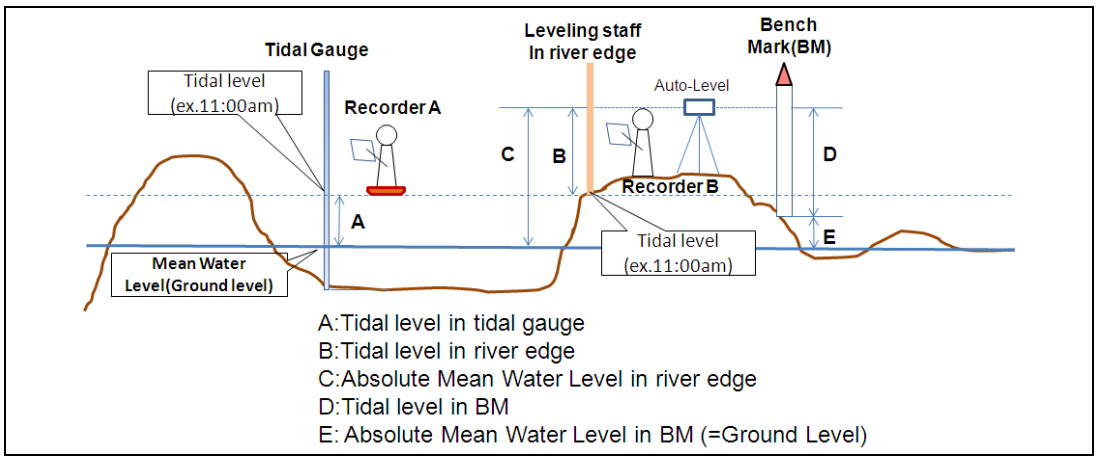


Figure 2-4 Location of Benchmarks in Project Area

3.4 Measurement Method between Tidal Gauge of CFECN KKKL and Benchmark Posts

To calculate absolute ground level at BMs, it is necessary to link ground level between tidal gauge of CFECN and each BM at same time. One surveyor stayed at tidal gauge of CFECN KKKL to measure tidal level. Other surveyors visit to BMs and measured tidal level and ground level at the same time as tidal measurement at tidal gauge (**Figure 2-5)**.



Source: JET, January 2013

Figure 2-5 Image of Ground Level Measurement between Tidal Gauge and Benchmark

3.5 Results

The project measured differences of ground level between CFECN KKKL and all BMs in ARP, CF Area and FD Plantation Area. Absolute ground level in each BM is calculated based on averaged water level in CFECN KKKL **(Attachment 2-3)**.

3.6 Findings and Issues

It is necessary to maintain BM posts through regular monitoring activity. During the project implementation, JET found that one BM was destroyed by local people for taking out steel rebar from the post. In some locations local people did not notice the purpose and importance of BM.

The BM has been marked measurement line at root of BM with color paint but description of absolute ground level in inch were not indicated at actual BM posts yet.

3.7 Recommendations

If FD continues to utilize BMs installed in the project, it is recommend to maintain it especially from damages and theft .

Based on the measurement results during the project, ground level information should be also indicated on BM posts for easy confirmation and reference.

For selecting proper location and ground condition of mangrove trees in the delta, understanding the tidal level is one of the fundamental factors. It is recommended that FD to utilize installed BMsas reference of ground level.

4. Ground Level Measurement in ARP

4.1 Objectives

Ground level measurement in ARP aimed to confirm suitable ground level by tree species.

4.2 Location of Ground Level Measurement Points in ARP

The project conduced ground level measurements with auto-level. Measurement points/ interval depend on the characteristics of site geography, and summarized in **Table 2-5**.

Table 2-5 List of Ground Level Measurement Points in ARP

Sr.	Township	Reserved Forest	FC	ARP area (acre)	Planted year	Ground level Measurement point	Month/Year
1	Laputta	KKKP	17	25	2011	13	Nov.2012
2	〃	KKKP	19	120	2010	18	Nov.2012

Sr.	Township	Reserved Forest	FC	ARP area (acre)	Planted year	Ground level Measurement point	Month/Year
3	〃	KKKP	26	250	2009	26	Nov.2012
4	〃	PNLN	60	250	2009	18	Nov.2012
5	〃	PNLN	66	120	2010	23	Nov.2012
6	Bogalay	KADK	62	25	2011	27	Jan.2013
7	〃	KADK	63	80	2010	*	*
8	〃	KADK	36	212	2008	7	Dec.2012
9	〃	KADK	39	200	2009	8	Dec.2012
10	Pyar Pon	PNDY	66	25	2011	48	Feb.2013
11	〃	PNDY	64	200	2009	12	Feb.2013
12	〃	PNDY	65	80	2010	44	Feb.2013

Note: Ground level measurement of ARP FC-63 in KADK RF was not finished cased by appearance of elephants nearby the ARP*

Source: JET, February 2013

4.3 Measurement Method

The basic procedure of ground level measurement in ARP is shown below;

1) Select the nearest benchmark post from target area.

2) Decide number and location of required measurement point on maps as per treatment area. Basic, interval for measurement was set every 200 feet and also points taken for major landmarks.

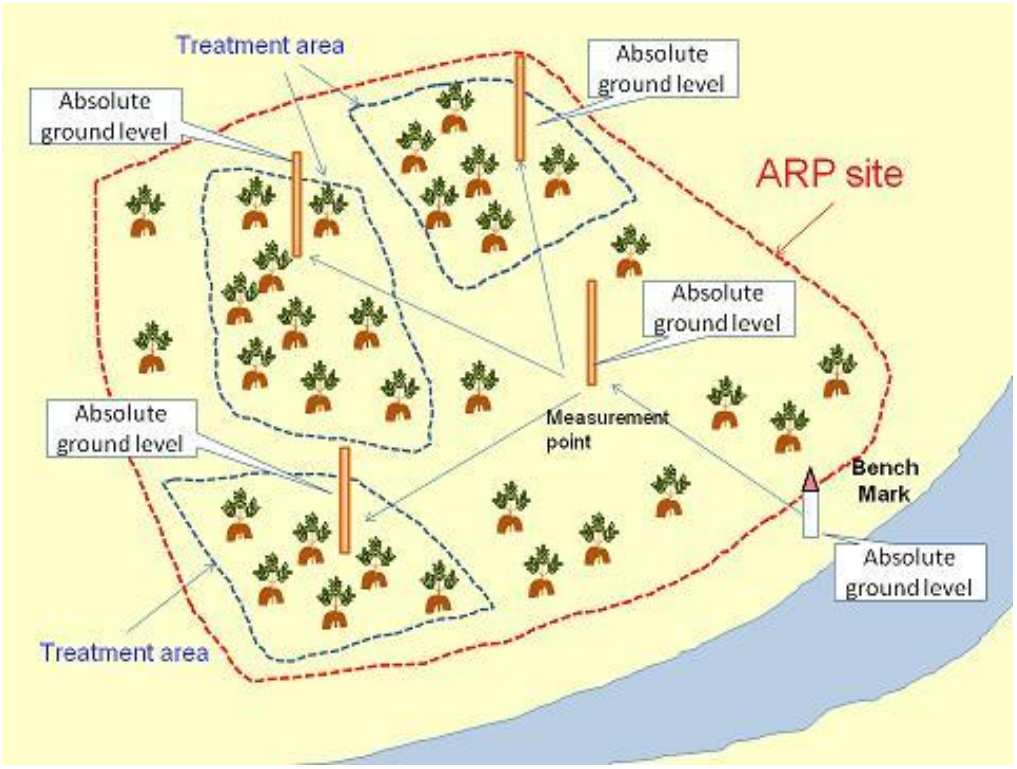
3) From the benchmark, start measurement every 200 feet from benchmark to treatment area.

4) Record difference of ground level between the benchmark and measurement points. The record format is described in **Attachment 2-4.**

5) After survey, all data should be encoded into Computer and calculate ground level in all measurement points from Benchmark.

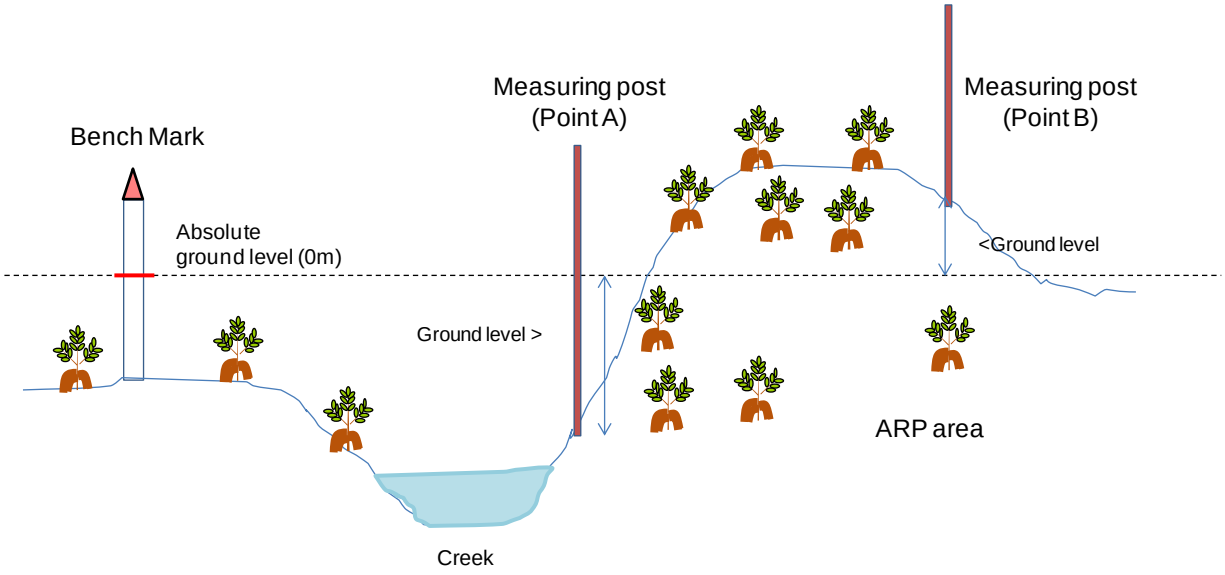
6) Using results of absolute ground level of Benchmark which calculated in previous chapter, the absolute ground level should be defined in each measurement.

7) The image of ground level measurement is shown in **Figure 2-6** and **Figure 2-7**. Necessary equipment of ground level measurement are indicated in **Figure 2-7**



Source: JET, January 2013

Figure 2-6 Image of Ground Level Measurement in ARP (Plane Figure)



Source: JET, January 2013

Figure 2-7 Image of Ground Level Measurement (Cross Section)

 GPS	 Auto-level
 Leveling Staff	 Measurement tape

Figure 2-7 Measuring Instruments

4.4 Results

The survey records are attached in **Attachment 2-5**. To make distinction of ground level among ARPs, expedient ground level category was prepared **(Table 2-6)**. The summary of result of ground level survey is shown below **(Table 2-7)**.

Table 2-6 Expedient Ground Level Categories in ARPs

Ground level from KKKL Tidal Gage	I	II	III
	More than 46 inch	0 – Less than 46 inch (same as 1.5 feet)	Less than 0 inch

Table 2-7 Summary of Ground Level by Reserved Forest

RF	FC	Averaged Ground Level		Ground level Category
		(inch)	(cm)	
KKKP	17	29.4	74.7	I
KKKP	19-1	34.8	88.4	I
KKKP	19-2	4.5	11.4	II
KKKP	26-1	32.6	82.8	I
KKKP	26-2	7	17.8	II
PNLN	60-1	27.4	69.6	I
PNLN	60-2	25	63.5	I
PNLN	66-1	34.2	86.9	I
PNLN	66-2	35.4	89.9	I
KADK	36-1	0.8	2.0	II
KADK	36-2	6.4	16.3	II
KADK	39	34.7	88.1	I

RF	FC	Averaged Ground Level		Ground level Category
		(inch)	(cm)	
KADK	62-1	-32.3	-82.0	III
KADK	62-2	-23.7	-60.2	III
KADK	63	-	-	-
PNDY	64-2	18.2	46.2	II
PNDY	64-3	26.4	67.1	II
PNDY	65-1	15.3	38.9	II
PNDY	65-2	15.5	39.4	II
PNDY	66	22.0	55.9	II

Note; KADK FC-63 is not measured ground level because of appearance of elephant in the ARP.
Note: 1 inch =2.54c m

1) KKKP Reserved Forest, Laputta

In FC-17, there are no big differences of ground level within ARP site between 27 inches and 31 inches (the range is around 10cm) In FC-19, range of ground level is 61 inches (around 156cm) from -3.7 to 57.7. In FC-26, some of measurement points are found as under the averaged ground level it means lower ground area of ARP. The range is 102 inches (around 260 cm) from -46.1 to 55.7 inches.

2) PNLN Reserved Forest, Laputta

In FC-60, almost all the measurement points are under averaged ground level at KKKL tidal gate. It seems flat and wet area because the range of ground level is only 9.8 inches (around 25cm) from -31.8 to -22 inches except BMs

3) KADK Reserved Forest, Bogalay

In FC-36, 39 and 62, the ground level is totally different according to the result of survey, especially it was found FC-62 located lowest ground level (III) among ARPs.

4) PNDY Reserved Forest, Pyar Pon

In PNDY RF, ground level of APRs is categorized into II.

4.5 Findings and Issues

Absolute ground levels were calculated using result of tidal level measurement in KKKL CFECN, Laputta and ground level measurement of each benchmark at sites. The project got good experiences and knowledge from ground level measurement activity.

4.6 Recommendations

1) It is necessary to further confirm correlations between ground level and dominant species in the delta based on the result of ground level measurement.

2) The results of ground level measurement can be utilized as one of the criteria for site selection and species selection for future plantation.

3) The measurement techniques should be share among FD staffs and keep all records of ground level measurement as reference.

5. Soil Conditions Survey

5.1 Background and Objectives

Soil condition is one of the main factors for growth performance of mangrove species in delta. The purpose of soil condition survey was to define suitable soil condition for each mangrove tree species and to transfer survey techniques to FD staff.

The project conducted soil survey to collect information of soil condition in candidate area for Action Research Plantation (ARP).

5.2 Location of Survey Area

Soil condition survey had been conducted at five ARP sites as follows. The project collected soil samples from 445 points in this survey **(Table 2-8)**.

Table 2-8 List of Sampling Points of Soil Condition Survey

Township	RF	FC	Number of Sampling points	GPS points
LPT	KKKP	26	82	76
LPT	PNLN	60	51	38
BGL	KADK	39	91	1
BGL	KADK	36	64	4
PYP	PNDY	64	157	No data
Total	-	-	445	-

Source: JET, January 2013

5.3 Survey Methods

Contents of soil survey are EC, pHh and water volume which are expectably effected to tree growth in the delta.

5.4 Results

Results of soil condition survey are summarized in **Table 2-9**. Because of different numbers of sample points in each RF, it cannot compare directly among plots. However, according to the summarized data, Kadonkani (KADK) Reserved Forest FC-36/FC-39 compared with other areas. EC value is lower, and Ph/water volume is higher than other RFs as indicated in **Figure 2-8.**

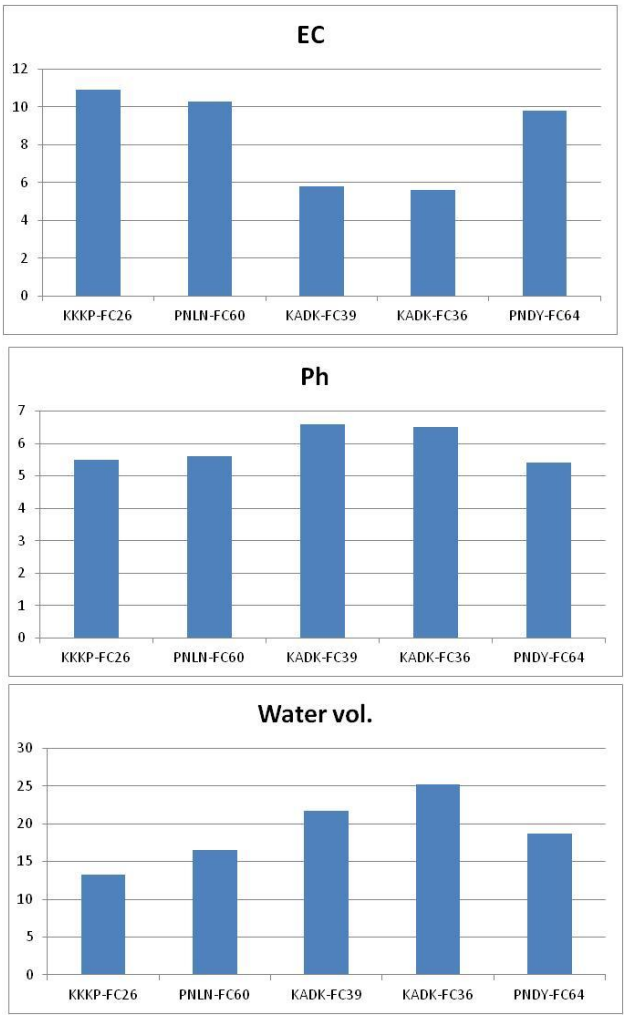
All records of the survey are attached this report in **Attachment2-6.**

Table 2-9 Summary of Soil Condition Survey

Township	RF	FC	Number of Sampling points	EC	Ph	Water Volume
LPT	KKKP	26	82	Ave:10.9 Min:3.4 Max:16.2	Ave:5.5 Min:4.0 Max:6.4	Ave:13.3 Min:1.0 Max:26.6
LPT	PNLN	60	51	Ave: 10.3 Min:6.0 Max:16.4	Ave: 5.6 Min:4.5 Max:6.3	Ave: 16.5 Min:10.5 Max:28.5
BGL	KADK	39	91	Ave:5.8 Min:3.0 Max:7.9	Ave:6.6 Min:4.5 Max:7.5	Ave:21.7 Min:15.4 Max:31.5
BGL	KADK	36	64	Ave: 5.6 Min:1.4 Max:8.0	Ave: 6.5 Min:4.5 Max:8.0	Ave: 25.2 Min:15.7 Max:32.7
PYP	PNDY	64 plot1	60	Ave:9.8 Min:5.0 Max:13.1	Ave:5.4 Min:- Max:7.0	Ave:18.7 Min:8.8 Max:28.0
PYP	PNDY	64 plot2	37	No data	No data	Ave:22.3 Min:14.2 Max:32.7
PYP	PNDY	64 plot3	60	No data	No data	Ave:18.6 Min:8.9 Max:27.8
Total	-	-	445	-	-	-

Note: PNDY FC-64 consists of three sites (1) is Deris, (2) is Dalbergia and (3) is Acanth.

Source: JET, January 2013



Source: JET, January 2013

Figure 2-8 Averaged value of EC, Ph and Water volume of Soil Condition in ARP

5.5 Findings and Issues

1) FC-36 and FC-39 in KADK RF has totally different characteristics on EC value, Ph value and water volume in delta. Especially, EC value in FC-36 and FC-39 seems almost half value compare with other sites.

2) Difference of water volume of soil might be depending on ground level, timing of tidal inundation and weather condition in the sample points.

3) Correlations between growths of trees and soil parameters (Ph, EC and water contents) were not clear based on results of survey in sample area.

Volume 3

Seedling Production Techniques for Mangrove Management in the Ayeyawady Delta

1. Introduction

During the project period, the JICA Expert Team (JET) summarized individual characteristics, usage and seedling production methods for major species based on the project activity and existing nursery records.

2. Objectives

This volume aims to promote improvement of seedling production techniques for mangrove and non-mangrove species.

3. Target Mangrove and Non-Mangrove Species

3.1 Mangrove and Non-Mangrove Species in Action Research Plantation

Through Action Research Plantation (ARP), following mangrove and non-mangrove species were introduced (**Table 3-1** and **Table 3-2)**.

Table 3-1 Mangrove Species in ARP

No.	Scientific Name	Local Name	Township/ Reserved Forest			
			LPT KKKP	LPT PNLN	BGL KADN	PYP PYDY
1	*Aegiceras corniculatum*	Ye Kaya			✔	
2	*Amoora cucullata*	Pantha Kha				
3	*Avicennia alba*	Thame Kyet Tet		✔	✔	
4	*Avicennia marina*	Thame Phyu		✔	✔	✔
5	*Avicennia officinalis*	Thame Gyi	✔	✔	✔	✔
6	*Bruguiera gymnorhizza*	Byu u talone	✔	✔		
7	*Bruguiera sexangula*	Byu shwewah	✔	✔	✔	✔
8	*Ceriops decandra*	Madama			✔	✔
9	*Excoecaria agallocha*	Thayaw	✔	✔	✔	✔
10	*Heritiera fomes*	Kanazo (kone)	✔	✔	✔	
11	*Lumnitzera racemosa*	Pyan Shar, Aikemathwe		✔		✔
12	*Kandelia candel*	Byu Baingdaung-she	✔			
13	*Nypa fruticans*	Dani				✔
14	*Pongamia pinnata*	Thinwin pyu		✔	✔	✔
15	*Rhizophora apiculata*	Byuchidauk (apo)	✔			
16	*Rhizophora mucronata*	Byuchidauk (ama)				
17	*Sonneratia apetala*	Kanbala	✔	✔	✔	
18	*Sonneratia caseolaris*	Lamu			✔	
19	*Sonneratia griffithii*	Laba				

No.	Scientific Name	Local Name	Township/ Reserved Forest			
			LPT KKKP	LPT PNLN	BGL KADN	PYP PYDY
20	*Xylocarpus moluccensis*	Pinle on	✔	✔		✔

Source: JET, January 2013, Summary of Monitoring Record

Table 3-2 Non-Mangrove species in ARP

No.	Scientific Name	Local Name	Township/ Nursery Center			
			LPT KKKP	LPT PNLN	BGL KADN	PYP PYDY
1	*Casuarina equisetifolia*	Pinlaikavie, Kabwi	✔		✔	
2	*Melaleuca leucadendron*	Malarluca		✔	✔	✔

Source: JET, January 2013, Summary of Monitoring Record

3.2 Characteristics of Mangrove and Non-Mangrove Species

As a part of ARP activities, characteristics of each mangrove and non-mangrove species including ecological information are collected and compiled as a "Mangrove and Non-Mangrove Species Handbook" in **Attachment 3-1**. Following contents are described in the handbook (**Table 3-3**).

Table 3-3 Contents of Mangrove and Non-Mangrove Species Handbook

	Main Contents
1	Code
2	Date (of data collecting)
3	Scientific name
4	Common name
5	Local name
6	Photos and descriptions (Tree images, Seeds/Fruits, Seedlings, Leaves, Flowers)
7	Sowing Method
8	Seedling Raising Method
9	Characteristics, usage
10	Nursery Calendar

Source: JET, January 2013

3.3 Usage of Mangrove and Non-Mangrove Species in Delta

Table 3-4 shows the summary of major usages of mangrove/non-mangrove species in the delta.

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Table 3-4 Usage of Mangrove and Non-Mangrove Species

No.	**Scientific Name**	**Major Usage of Tree in the Delta**					
		Medicine	**Food**	**Firewood**	**Charcoal**	**Pole**	**Others**
1	*Aegiceras corniculatum*			+	+		
2	*Amoora cucullata*			+	+		

No.	Scientific Name	Major Usage of Tree in the Delta					
		Medicine	**Food**	**Firewood**	**Charcoal**	**Pole**	**Others**
3	*Avicennia alba*	Leaf	Fruit	+	+	+	
4	*Avicennia marina*	Leaf	Fruit	+	+	+	
5	*Avicennia officinalis*	Leaf	Fruit	+	+	+	
6	*Bruguiera gymnorhizza*			+	+	+	
7	*Bruguiera sexangula*			+	+	+	
8	*Ceriops decandra*	Bark		+	+	+	
9	*Excoecaria agallocha*	Hard wood		+		+	
10	*Heritiera fomes*			+	+	+	
11	*Lumnitzera racemosa*			+	+	+	
12	*Kandelia candel*			+	+	+	
13	*Nypa fruticans*	Resin	Fruit				Thatch
14	*Rhizophora apiculata*			+	+	+	
15	*Rhizophora mucronata*			+	+	+	
16	*Sonneratia apetala*		Fruit	+	+	+	
17	*Sonneratia caseolaris*			+		+	
18	*Sonneratia griffithii*			+		+	
19	*Xylocarpus moluccensis*	Fruit		+	+	+	
20	*Heritiera littoralis*			+	+	+	
21	*Phoenix paludosa*		Shoot	+		+	
22	*Acacia magnum*			+		+	
23	*Melaleuca leucadendron*					+	

Note: + means stem and branch of tree.
Source I: JET, January 2013

5. Nursing Information and Applicable Seedling Standards

Based on findings from the project area, **Table 3-5** shows the summary of nursing information of major species and their applicable standards of potted seedlings.

The information indicated in the table is mainly collected at Tar Yar Kone CFECN in Pyinalan Reserved Forest, Laputta. According to the locality, there might be slightly difference for seed collection time and other nursing information at other locations in delta (**Attachment 3-2**). Also seedling standards can be adjusted based on seedling requirements/objectives. It is advisable for persons in charge of seedling production to confirm the specifications of the seedlings in their areas when starting to produce the seedlings at the nursery.

Table 3-5 Summary of Seedling Production Calendar

No	Scientific Name	Local Name	Seed collection time	Proper Nursing Period	Planting Time	Average Diameter	Average Height
			month	Months	month	inch	ft
1	*Aegialitis rotundifolia*	Sar Thar	June-July	13	June-July	0.1-0.2	1-1.5
2	*Aegiceras corniculatum*	Ye Kaya	June-July	13	June-July	0.1-0.2	1
3	*Avicennia alba*	Thame Kyet Tet	Sep	*10-11*	*June-July*	0.2-0.3	1-1.5
4	*Avicennia marina*	Thame Phyu	Sep	10-11	June-July	0.2-0.3	1-1.5
5	*Avicennia officinalis*	Thame Gyi	Sep	10-11	June-July	0.2-0.3	1-1.5
6	*Bruguiera cylindrical*	Hnan Byu	Jan-Feb	*5*	June-July	0.1-0.2	1
7	*Bruguiera gymnorhizza*	Byu u talone	June-Dec	8-13	June-July	0.2-0.3	1-1.5
8	*Bruguiera parviflora*	Byu War Kyaing Laing	June	*12-13?*	*June-July*	0.1-0.2	1
9	*Bruguiera sexangula*	Byu shwewah	*?*		June-July	0.2	1-1.5
10	*Ceriops decandra*	Madama	March-April	15	June-July	0.1-0.2	1
11	*Cynometra ramiflora*	Myin Ka	Jan-Feb	5	June-July	0.1-0.2	1
12	*Excoecaria agallocha*	Thayaw	July-Aug	12	June-July	0.1-0.2	1
13	*Heritiera fomes*	Kanazo (kone)	July	12	June-July	0.2-0.3	1-1.5
14	*Heritiera littoralis*	Kanazo (gyi)	Sep-Oct	*9*	*June-July*	0.2-0.3	1-1.5
15	*Hibiscus tiliaceus*	Tha Man Shaw	July	12-13	June-July	0.1-0.2	1
16	*Kandelia candel*	Byu Baingdaung-she	Aug-Sep	10	June-July	0.2-0.3	1.5-2
17	*Lumnitzera racemosa*	Pyan Shar, Aikemathwe	Sep	10-11	June-July	0.1-0.2	1
18	*Nypa fruticans*	Dani	June			-	1-1.5
19	*Phoenix paludosa*	Thin Paung	June	13-14	June-July	-	1
20	*Rhizophora apiculata*	Byuchidauk (apo)	May	12	June-July	0.2-0.3	1.5-2
21	*Rhizophora mucronata*	Byuchidauk (ama)	May	12	June-July	0.2-0.3	1.5-2
22	*Sonneratia Alba*	LaMe	Aug-Sep	10	June-July	0.1-0.2	1-1.5
23	*Sonneratia apetala*	Kanbala	July-Aug	12	June-July	0.1-0.2	1-1.5
24	*Sonneratia caseolaris*	Lamu	July-Aug	*12*	*June-July*	0.1-0.2	1-1.5
25	*Sonneratia griffithii*	Laba	Mar-Apirl	*3*	June-July	0.1-0.2	1-1.5
26	*Xylocarpus granatum*	Pin Lei Ohn	May	*2-3*	June-July	0.2-0.3	1.5-2.5
27	*Xylocarpus moluccensis*	Kya Na	July-Aug	12	June-July	0.2-0.3	1.5-2.5

Source: Nursery records in TYK, JICA Study Team, 2004

6. Findings and Issues

Up until compilation of this report, recordings of seedling production were rather weak in existing practices. The regular monitoring of seedling production in nurseries is important to maintain appropriate quality as well as quantity of required seedlings. To find necessary contents of Nursery record, current situation of each CFECN were confirmed by JET/FD (**Attachment 3-3)**.

7. Recommendations

For systematic recording of necessary information, following records/formats shall be utilized.

1) Seedling Production Plan/Monitoring Record

Total number of seedlings to be produced by nurseries shall be defined based on the Seedling Production Plan of respective FD Township. Following format shall be utilized at the planning stage as well as monitoring (**Table 3-6**).

Table 3-6 Seedling Production Plan/Monitoring Record

Species Name	Plan		Monitoring (1) (Date:)			Monitoring (2) (Date:)		Final Count	
	No. of Seedling	Type of Seedling	Nursery Pond/Bed	No. of Seedling	Type of Seedling	No. of Seedling	Type of Seedling	No. of Seedling	Type of Seedling
Total									

4) Seedling Distribution Plan

To summarize demands of seedlings in on-going activities such as CF and FD plantations, it is suggested that seedling distribution plan be prepared using following format (**Table 3-7**).

Table 3-7 Seedling Distribution Plan Format

No.	Place to be distributed	Objective	Species Name	Type of Seedlings	Number of Seedlings	
					Distribution	Planting
	Total					

5) Seedling Distribution Record

It needs to record actual number of distributed seedlings using this format. Based on differences of number of seedlings between the plan and actual record, FD staff can prepare practical seedling production plan in next year (**Table 3-8**).

Table 3-8 Seedling Distribution Record Format

No	Target Village	Target Area	Distributed Date	Species A			Total
				Number	Type of seedling	Size(height/diameter)	

Total							

Volume 4

Survey on Damages and Recovery Process of Mangrove Tree Species after the Cyclone Nargis in the Ayeyawady Delta

1. Introduction

Mangrove forests in the Ayeyawady Delta forms unique ecosystems consisting of precious fauna and flora, and provide several services and benefits to the rural communities as well. Livelihoods of the people in this area largely benefit from and depend upon Mangrove ecosystem as a whole.

Very unfortunately, the cyclone *Nargis* hit this area in May 2008. It caused huge loss of human life in the communities and devastating damages on mangrove forests as well. Since then, rehabilitation of the forests became an urgent issue to be addressed in order to recover the whole ecosystem and the socioeconomic activities of the communities to the conditions before the hit of the cyclone.

As a first step to address the issues above, the JICA Expert Team (JET) launched two types of the survey targeting the damaged mangrove forests locates in the project area. The first survey was conducted with the aim to grasp the degree of damages given to the mangrove forests (Tree Damage Survey) and another survey was to monitor the regeneration and the growth of the damaged trees after being hit by the cyclone (Recovery Monitoring Survey).

This report summarizes the findings and presents some lessons learned during these surveys (here after refer to as "the Survey)". The major findings and lessons are expected to contribute in providing the basis for more field-based knowledge/techniques to develop more disaster-tolerant mangrove forests in the delta area.

2. Objectives

Objectives of the Survey were to grasp the nature of the cyclone damages on the major mangrove tree species in the delta area and to understand the key features of the regeneration and growth of trees after the cyclone damages.

3. Methodology

3.1 Tree Damage Survey

3.1.1 Target Area and Basic Method of Collecting Data/Information

Because the accesses to the damaged mangrove forests were extremely difficult and the sanitary conditions were largely deteriorated soon after the cyclone, the damaged tree survey did not set up the specific target area/plots in the forest. Instead it collected data/information through interviews to the FD staffs assigned in the target Reserved Forests of the Project such as Kyakankwinpauk (KKKP), Pyinalan (PNLN), Kadonkani (KADK) and Pyindaye (PNDY). The data/information given by the staffs are based on the latest conditions of mangrove trees in the forest at the time of the survey.

3.1.2 Criteria to Evaluate the Degree of Damages to Mangrove Trees

The survey team lead by JET conducted interview to the FD staffs in the Reserved Forests such as KKKP, PNLN, KADK and PNDY. At the interview, the FD staffs were given questions on the degree of damages to the trees and requested to rank the species according to the nature and extent of damages. Areas to describe the damages which were indicated by the survey team are (1) branches, (2) leaves, (3) leaves color, and (4) root system. In order to do the assessment of the damages in each area, three criteria were further introduced such as "slightly damaged", "heavily damaged" and "severely damaged". These criteria were elaborated by the descriptions as shown in **Table 4.1**.

Table 4.1 Areas and Criteria to Evaluate Damages of Mangrove Trees

Area	Slightly damaged	Heavily damaged	Severely damaged
Branch damage	A few (not a major part) small branches are broken	Half of branches are broken	More than 80 % of branches are broken
Leaves damage	Less than half of leaves are lost	Half of leaves are lost	More than 80 % of leaves are lost
Leaves color	A part of leaves' colors are changed	Changes of leaves' color are clearly observed	Leaves' colors are totally changed
Root condition	A few small roots are broken	Half of roots are broken	More than 80 % of roots are broken
Overall condition	Good growth. No or a little damage is observed	Damage is clearly observed	Growth is very bad and recovery may be impossible.

3.2 Recovery Monitoring Survey (RMS)

3.2.1 Target Area and Basic Method of Collecting Data/Information

Same as the tree damage survey, the Recovery Monitoring Survey (RMS) set up its sample plots in the selected compartments in the four Reserved Forests presented in **Chapter 3.1**. It added one more RF as a target which is Meinmahala RF maintained as the Wildlife Sanctuary as indicated in **Table 4.2** and **Figure 4.1**.

These plots were selected to cover the mangrove species dominated in those areas as many as possible. The species are *Amoorra cucullata* (Amo), *Avicennia officinalis* (Ao), *Barringtonia spp.* (Ba), *Bruguiera gymnorhizza* (Bg), *Bruguiera sexangula* (Bs), *Ceriops decandra* (Cd), *Cerbera manghas* (Cm), *Cynometra ramiflora* (Cr), (Cspe), (Dspa), *Excoecaria agallocha* (Ea), *Heritiera fomes* (Hf), *Intsia bijuga* (Ib), *Pongamia pinnata* (Pp), and *Sonneratia apetala* (Sa).

After the monitoring sites were selected by Forest Department (FD) with the consideration of the damaged conditions by the cyclone, regular monitoring in the plots were implemented by FD staff in charge of respective RFs under the technical supports by JET.

Table 4.2 Outline of Target Area

No.	Reserved Forest	Target FC	Number of Plot	Major Species in Target Area
1	Kyakankwinpauk	FC-20	3	Ao, Bg, Ea, Sa
2	Pyinalan	FC-61	3	Ea
3	Kadonkani	FC-49	3	Amo, Bs, Cr, Dspa, Ea, Hf, Ib

No.	Reserved Forest	Target FC	Number of Plot	Major Species in Target Area
4	Meinmahla (Wildlife Sanctuary)	FC-1	6	Ac, Ba, Cd, Cm, Cspe, Fa, Hf, Pp
5	Pyindaye	FC-60	3	Ea, Hf

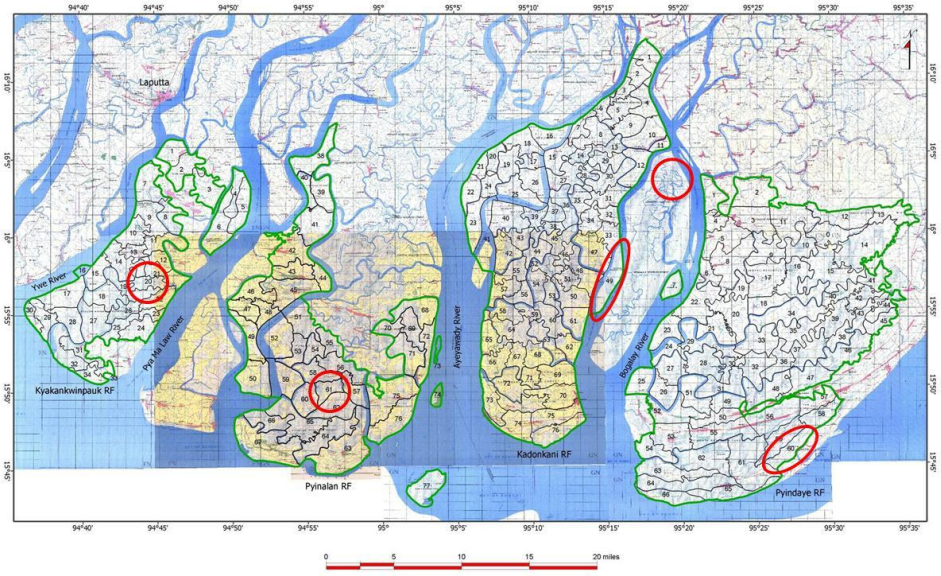


Figure 4.1 Target Forest Compartments for RMS in the Delta

3.2.2 Design of Sample Plot and Collection of Data

(1) Removal of Debris through NFIO

Through extensive survey in the target area, several factors were considered to affect the recovery process of the damaged trees. Among them, debris left over after the cyclone were supposed to be significant to the nature and process of the recovery. Huge mounds of debris in the field could hinder the recovery and natural regeneration of the damaged trees. Hence Natural Forest Improvement Operation (NFIO) was introduced as control experiment. Two types of plots were set up in the field, which are "the plot with NFIO-debris removal" and "the plot without NFIO- no operation" as illustrated in **Figure 4.2**.

(2) Location of RMS Plot

Experiences of the cyclone *Nargis* proved that the function of mangrove forests to prevent/mitigate damages of disaster varied according to their distances from the creek/river. Mangroves which are located close to the water are expected to be with higher capacity of reducing the damages compared to those located inland from the creek/river. In this sense their natural recovery process should be monitored in several locations with different distances from the water surface. Accordingly the survey plots were designed and placed in the target RFs as illustrated in **Figure 4.2**. Three levels of distances were set with technical options of with/without NFIO. The levels were defined by the professional judgment of the FD staffs who have worked for years in the target area.

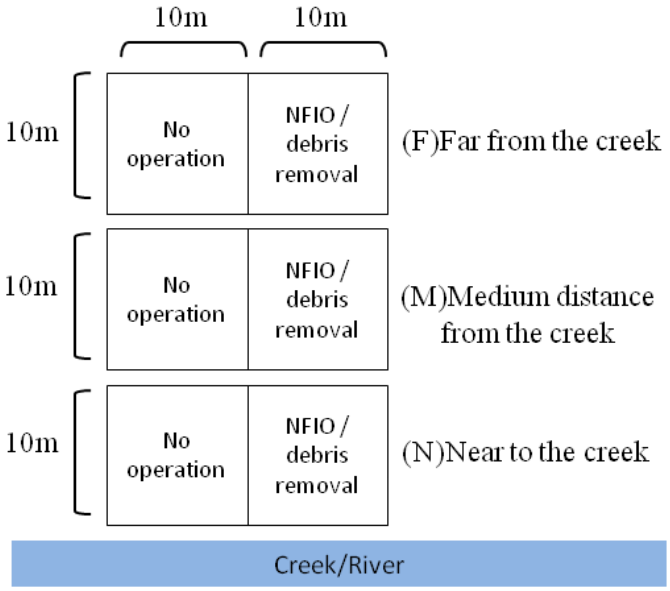


Figure 4.2 Diagram of RMS plot

(3) Monitoring Period and Timing

First measurement was conducted in August 2008, which was three months after the hit of cyclone as shown in **Table 4.3**. The total period was set to be two and half year which extended until December 2010. The interval of monitoring was initially supposed to be two to three months. However, because of man-power resources among the FD staffs were not always available to conduct the regular monitoring during the period. Moreover the natural forests identified in the sample plots were sometimes disturbed by illegal cutting, encroachment and other physical damages brought about during the monitoring period[1]. As a result the timing of monitoring became irregularly and in some cases the bulk of the target trees for measurement were removed or damaged largely, which made it extremely difficult to keep the consistency of measurement of target trees and quantitative ground of the data to be recorded.

Therefore, as is indicated in **Table 4.3** the frequency of monitoring became to be largely different and inconsistent with the initial design and policy of the monitoring. This report describes the results of the monitoring based on the data recorded in the field under the said conditions though they are limited in their quantity and consistency in timing of record between the RFs.

[1] Unanticipated problems which critically affected the results of the survey are summarized in Chapter 4.2 of this report.

Table 4.3 Outline of RMS Area

Distance from creek	KKKP			PNLN			KADK			Meinmahla			PNDY		
Distance from creek	Far	Mid	Near	Far	Mid	Near	Far	Mid	Near	Far	Mid	Near	Far	Mid	Near
Aug 2008	x	x	x				x	x	x				x	X	x
Sep 2008															
Nov 2008															
Feb 2009	x	x	x						x						
Aug 2009	x						x	x					x		
Nov 2009	x	x	x	x	x	x	x	x	X				x	X	
Dec 2010	x	x	x		x				x				x	X	

(4) Measurement of Trees in the Plot

At the monitoring, the height of the target trees were measured and recorded in the survey sheet. As mentioned above, some of the target trees were cut down and removed from the site or damaged while they were alive in the site. The trees removed from the plot were automatically excluded from the target of measurement[2] while the damaged trees which were still in the plot continued to be a target of measurement. In such a case they showed minus growth of "growth below zero". Details are described in the results of the survey.

4. Results

4.1 Result of Tree Damage Survey

Information was collected at the interview to the FD staffs in each RF. As a first step of encoding data, damages on every part of the tree were described and assessed using the identified criteria such as "slightly", "heavily" and "severely" as indicated in **Table 4.1** in **Chapter 3.1.2** of this report. Then the results of assessment were further processed in tree species wise and all species were ranked according to the degree of damages got in the cyclone. The overall results are shown in **Table 4.4**.

The figures in the table show that the range and degree of the damages varies with the species. It has not been investigated and clarified yet that such differences could be attributed mainly to the nature of the tree itself or to other factors such as location of the forest, distances from waterside, and any other natural conditions which might affect the degree of damages. Total ranking was done based on the information provided by the FD staffs in charge of the target RF.

Total ranking in the table show that *Avicennia officinalis* (Ao) is most damaged species among all,

[2] Removal of target trees by illegal cutting took place in PNLN, KDKN and PNDY though they are different in degree of removal.

which are followed by *Sonneratia apetala* (Sa), *Bruguiera sexangula* (Bs) and *Sonneratia caseolaris* (Sc) as the second, third and fourth damaged trees. Ao is most popular tree species used in the mangrove plantation. The reason why it was worst damaged is thought that most of Ao were still young trees which were less than 10 years after the planting at the time of the cyclone and not resistant enough to the natural impacts brought about by the cyclone.

Meanwhile *Nypa fruticans* (Nf) is least damaged species, which is followed by *Pongamia pinnata* (Pp) *Instia bijuga* (Ib) and *Rhizophora mucronata* (Rm) as the second, third and fourth less damaged species. Nf is one of the most popular and traditional species introduced by the community. It seems somehow contradictory that such a popular species distributing in the waterside got least damages among all. One of the reasons is thought to be the shape of Nf. It does not have hard stem/trunk or branches like other tree species hence it could parry the impacts of high tide and strong winds of the cyclone.

Table 4.4 Ranking of Trees according to the Degree of Damages

Species	Uprooted/ Felled Down	Broken Main Trunk	Broken Primary Branches	Broken Secondary Branches	Lost Canopy /Leaves	Total ranking
A. officinalis	1st	2nd	1st	2nd	3rd	1st
S. apetala	2nd	1st	2nd	1st	9th	2nd
S. caseolaris	4th	10th	4th	7th	11th	4th
H. fomes	6th	7th	13th	9th	7th	7th
A. marina	5th	9th	11th	6th	12th	9th
E. agallocha	3rd	8th	14th	10th	8th	8th
A. corniculatum	9th	14th	6th	8th	13th	11th
S. griffithi	11th	13th	5th	12th	14th	12th
B. sexangula	8th	5th	9th	3rd	5th	3rd
B. gymnorrhiza	10th	6th	10th	4th	6th	5th
C. decandra	12th	11th	12th	5th	4th	10th
P .paludosa	7th	-	-	-	2nd	13th
A. cucullata	13th	12th	15th	11th	16th	6th
R. mucronata	-	-	7th	16th	15th	18th
K. candle	-	-	3rd	13th	19th	16th
X. grnatum	-	-	-	14th	17th	14th
X. mollucensis	-	-	-	15th	18th	15th
R. apiculata	-	-	8th	17th	10th	17th
Nypa fruticans	-	-	-	-	1st	21st
Instia bijuga	-	-	-	18th	20th	19th
P. pinnata	-	-	-	19th	21st	20th

4.2 Result of Recovery Monitoring Survey

As described in **Chapter 3.2.2. (3)** of this report, the monitoring in the survey was largely affected by the availability of FD staff who could engage in it. Because of their limitation "as usual" the monitoring was not exactly conducted as planned in terms of maintaining the sample plots and constantly measuring and recording the target trees, which caused to some degree insufficient basis to describe the precise correlation of the nature of tree damages/recovery and some key factors affecting to its process. The monitoring in the survey was also critically disturbed by the expanded illegal activities such as cutting trees and encroachment in the target RFs. After the cyclone in 2008 these kinds of hazardous activities were accelerated to expand in the natural forests in the FRs which were in the past well protected by the FD.

With these limitations, data recorded in the monitoring was encoded and put into the preliminary analysis, which are described in the following parts of the report. All monitoring records of RMS are attached in **Attachment 4.**

(1) Overall Summary

Overall summary of status of tree recovery are summarized in **Table 4.5**.

Tree leaves have been recovered in the most of the species as of March 2009 while there are differences in the status of flowering, fruiting and regeneration, which is considered to be related to the physiological characteristics of each species. Detailed findings are described in the following sections.

Table 4.5 Ranking of Tree Species by Degree of Recovery in Leaf, Flower, Fruits and

Regeneration

Species	Re-Leaf (%)		Flowering (A,M,S)		Fruiting (A,M,S)		Regeneration (A,M,S)	
	Oct. 08	Mar. 09	Oct. 08	Mar. 09	Oct. 08	Mar. 09	Oct. 08	Mar. 09
Barringtonia spp	>50	100	S	Off	S	Off	S	S
P. paludosa	>25	>85	Off	S	Off	M	S	M
K. candle	>25	>85	None	S	None	S	None	S
A. corniculatum	>25	>85	Off	S	Off	S	None	S
C. decandra	>25	>85	None	S	None	S	None	S
C. ramiflora	>25	<85	Off	S	Off	S	None	S
B. sexangula	>25	<85	None	S	None	S	None	S
B. gymnorrhiza	>25	<85	None	S	None	S	None	S
S. grifithii	>50	100	S	Off	None	S	None	S
S. caseolaris	>50	100	S	Off	None	S	None	S
P. pinnata	>50	100	Off	S	Off	S	None	S
C. manghas	>50	100	S	S	S	S	S	S
Instia bijuga	>25	>85	Off	S	Off	S	None	S
Nypa fruticans	>50	100	S	S	S	M	S	M
E. agallocha	>50	100	None	Off	None	Off	None	None
S. apetala	>50	100	None	Off	None	Off	None	None
A. cucullata	>25	>85	None	Off	None	Off	None	None
A. officinalis	<25	<85	None	Off	None	Off	None	None
Heritiera fomes	<25	<85	Off	None	Off	None	None	None
R. mucronata	<25	<75	None	None	None	None	None	None
R. apiculata	<25	<75	None	None	None	None	None	None
X. granatum	<10	<75	Off	None	Off	None	None	None
A. marina	<10	<75	Off	None	Off	None	None	None
Legend:								

(2) Kyakankwinpauk RF (FC-20)

The summary of RMS results of KKKP FC-20 is indicated in **Table 4.6** and **Figure 4.3**. There are only three species (Ao ,Sa and Bg) identified within the sample plots. From August 2008 to December 2010, no positive effects were found in NFIO site which removes debris from its ground. In "Middle distance from creek", growth rate of Sa without NFIO is higher than with NFIO. Growth rate of Ao in "Middle from creek" are almost same both with and without NFIO.

According to the comparison of these species, Sa is growing faster than other species. Regarding Bg, it is difficult to find any trend of effectiveness of NFIO in this area because of limited survey data.

Table 4.6 Result of RMS in KKKP FC-20

Spp. (*)	Distance from Creek		Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Aug-'08	Feb-'09	Nov-'09	Dec-'10	From Aug-2008 to Dec-2010 (for 28 months)	
Ao(16)	Far	NFIO	98.6	112.9	124.1	138.9	40.4	1.4
Ao(14)		-	109.6	132.6	164.0	218.0	60.5	3.9
Sa(4)	Middle	NFIO	137.7	181.8	229.3	312.0	174.4	6.2
Sa(5)		-	123.7	154.1	207.3	315.2	191.5	6.8
Ao(8)		NFIO	109.6	132.6	164.0	218.0	108.4	3.9
Ao(3)		-	98.2	125.5	158.8	206.4	108.2	3.9
Ao(33)	Near	NFIO	114.9	126.9	135.7	155.9	41.0	1.5
Ao(24)		-	99.1	115.7	129.6	166.3	67.2	2.4
Bg(4)		NFIO	110.3	110.3	112.7	137.4	27.1	1.0

Remarks:(*) is total number of monitored trees. Not including dead tree and cutting tree.

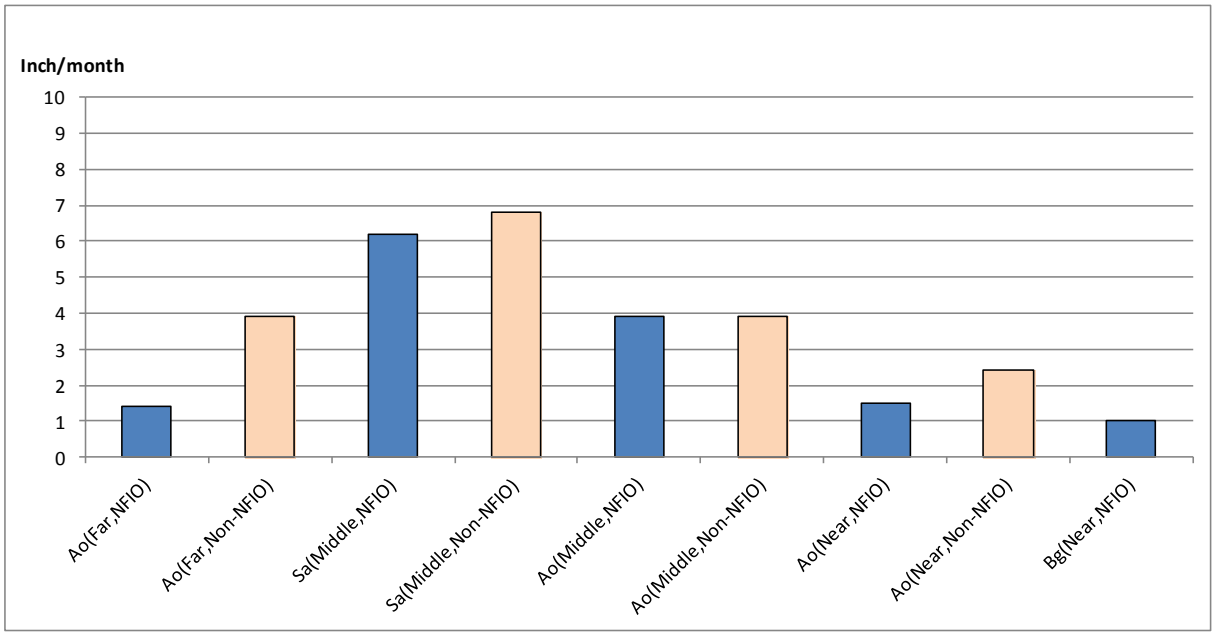
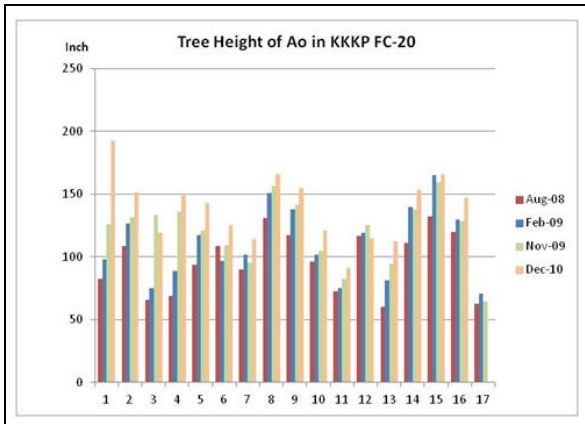


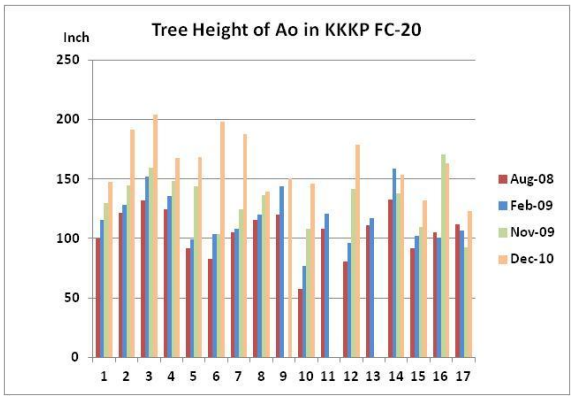
Figure 4.3 Growth of each Species with/without NFIO in KKKP FC-20

Some of the measured Ao achieved sudden growth in non-NFIO site during the period of November

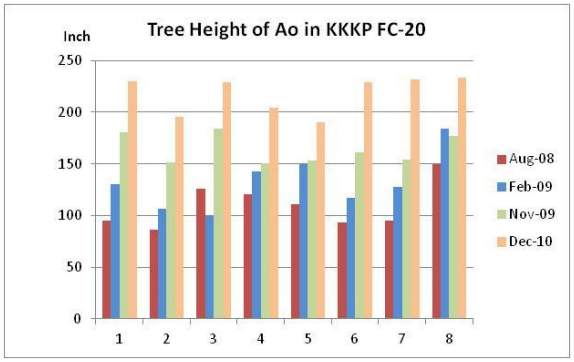
2009 and December 2010 while those in the middle distanced sites attained constant growth during the whole survey period. Similar to the case in far distance plots, most of the trees measured in the near distance plots achieved sudden large growth during 2009 and 2010. The reasons of these sudden growths were not identified in the survey.



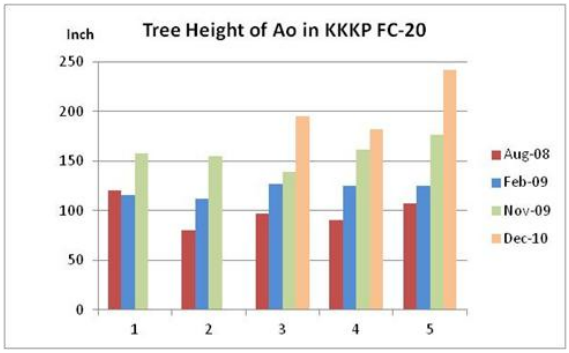
NFIO(Far from Creek)



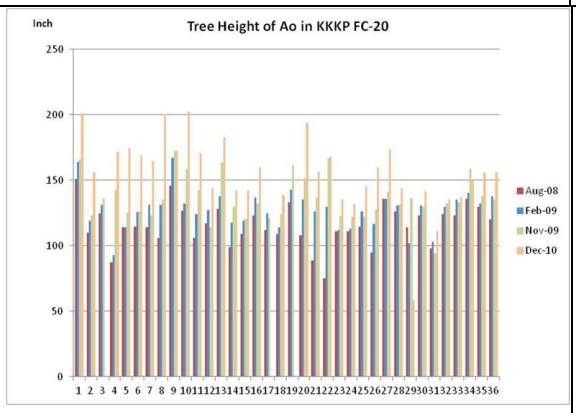
Non-NFIO(Far from Creek)



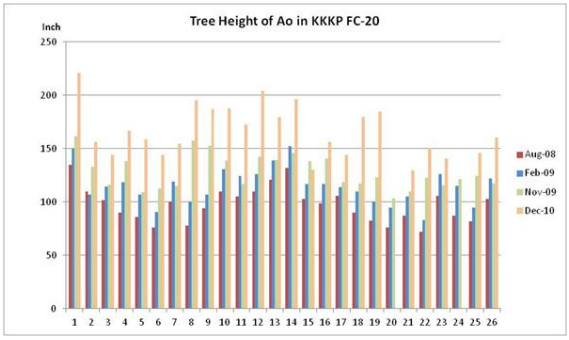
NFIO(Middle from Creek)



Non-NFIO(Middle from Creek)



NFIO(Near from Creek)



Non-NFIO(Near from Creek)

Figure 4.4 Height of Ao in FC-20 of KKKP RF

(3) Pyinalan RF (FC-61)

Only one species (Ea) in "middle distance from creek" monitored within the sample plots in **Table 23**

and **Figure 4.5**. Ea without NFIO showed "growth below zero". Detailed data showed five trees out of seven experienced "growth below zero" during the survey period. Same as this, detailed data in the figures below show three out of eight trees with NFIO also showed "growth below zero" in the said period. However, because other five trees achieved good positive growth, the average becomes above zero.

The reason of "growth below zero" is unknown. It is considered that some unexpected physical damages brought about to those trees caused these phenomena though they cannot be exactly specified.

Table 23 Result of RMS in PNLN FC-61

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)		Growth(inch)	Growth Rate (inch/month)
			Nov-'09	Dec-'10	From Nov.2009 to Dec-2010 (for 13 months)	
Ea(8)	Middle	NFIO	239.6	272.2	32.6	2.5
Ea(7)		-	245.1	237.3	-7.8	-0.6

Remarks:(*) is total number of monitored trees. Not including dead tree and cutting tree.

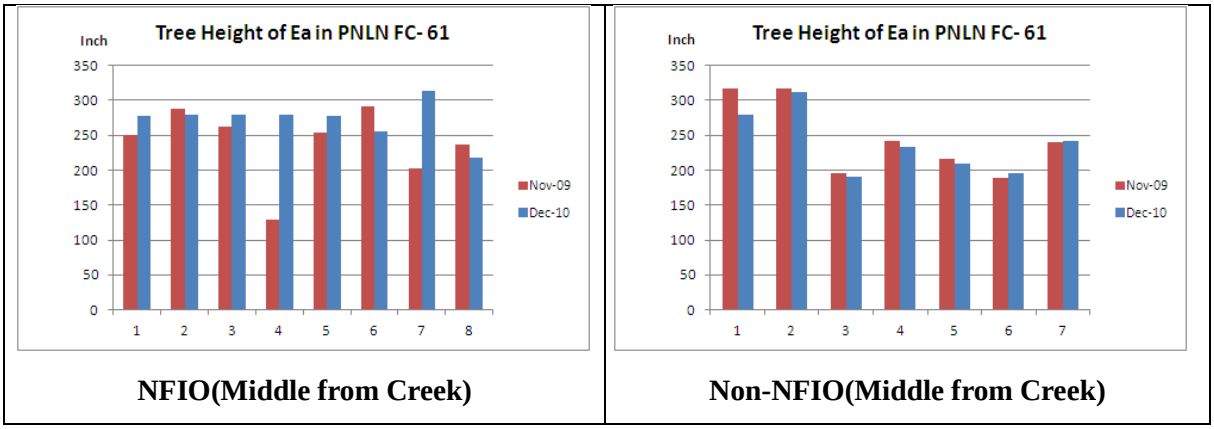


Figure 4.5 Tree Height of Target Trees in RMS(PNLN FC-61)

(5) Kadonkani RF (FC-49)

In KADK FC-49, there are seven species identified within the sample plots. However, only for Ea and Hf, it was possible to assess the effectiveness of NFIO. According to the summary of the results (**Table 4.8 ,Figure 4.6** and **Figure 4.7**), the growth of Hf with NFIO was outstanding in middle distance and showed different levels of growth in far and near distance. Growth rate of Ea in the Kadonkani FC-46(0 to 1.3 inch/month) was lower than PNLN FC-61(2.5inch/month) from August 2008 to August 2009.

Table 24 Result of RMS in KADK FC-49

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Aug-08	Aug-'09	Nov-'09	Dec-'10	From Nov.2009 to Dec-2010 (for 13 months)	
Ea(9)	Far	NFIO	189.1	194.3	-	-	5.2	0.4

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Aug-08	Aug-'09	Nov-'09	Dec-'10	From Nov.2009 to Dec-2010 (for 13 months)	
Ea(4)		-	232.2	232.2	-	-	0	0
Hf(4)		NFIO	102.0	112.2	-	-	10.2	0.8
Cr(5)		NFIO	88.1	98.2	-	-	10.1	0.8
Ib(5)		NFIO	105.1	114.5	-	-	9.4	0.7
Dspa(4)		-	111.0	114.6	-	-	3.9	0.3
Ea(12)	Middle	NFIO	302.3	319.1	-	-	16.8	1.3
Ea(12)		-	239.5	254.5	-	-	15.0	1.2
Hf(16)		NFIO	229.5	234.3	-	-	4.8	0.4
Hf(5)		-	221.0	262.8	-	-	41.8	3.2
Amo(4)		NFIO	204.0	220.4	-	-	16.4	1.3
Hf(15)	Near	NFIO	449.1	458.3	-	-	9.2	0.7
Hf(6)		NFIO	-	-	318.2	377.3	59.1	4.5
Hf(12)		-	-	-	438.9	407.3	-31.6	-2.4
Amo(5)		NFIO	276.0	285.5	-	-	9.5	0.7
Amo(6)		-	-	-	216.5	231.5	15.0	1.2
Cr(5)		-	-	-	211.4	-6.1	-6.1	-0.5
Bs(4)		-	-	-	162.6	191.8	29.2	2.2

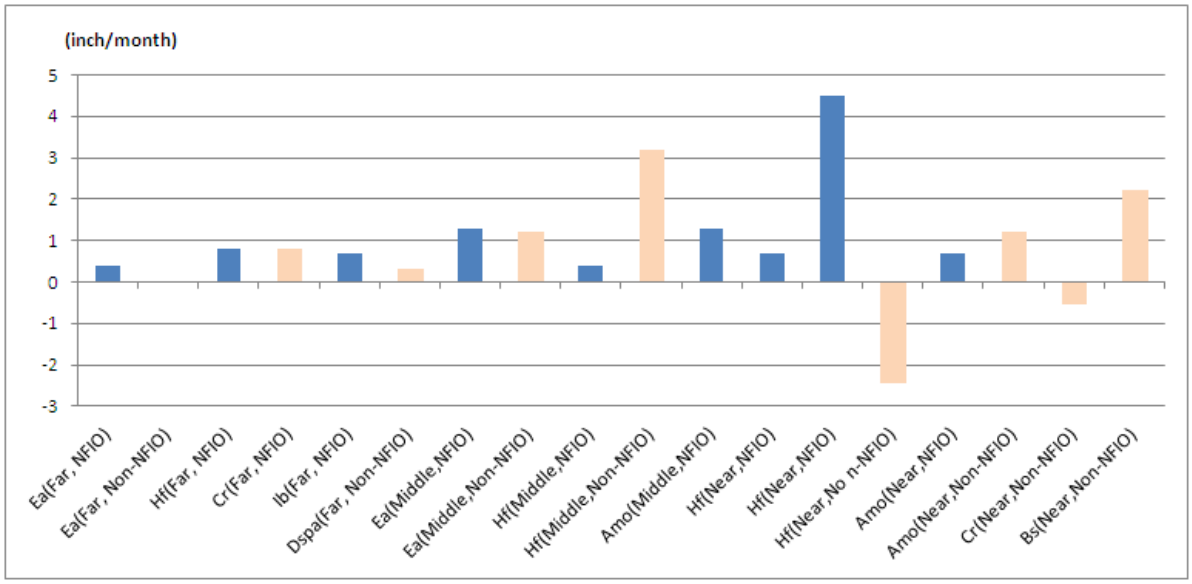
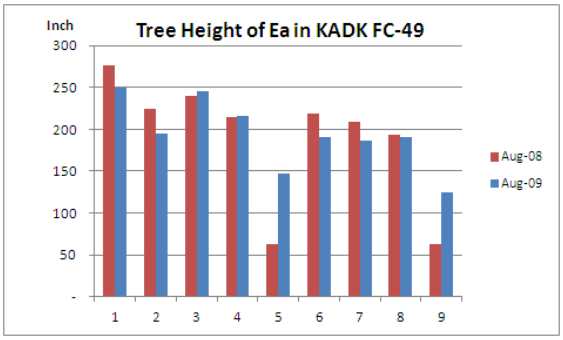
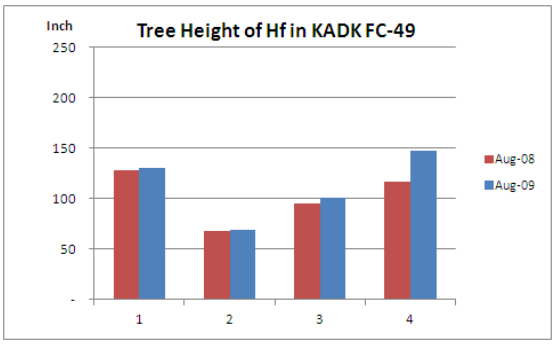
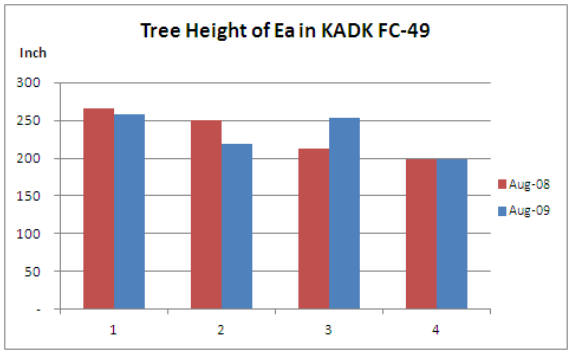


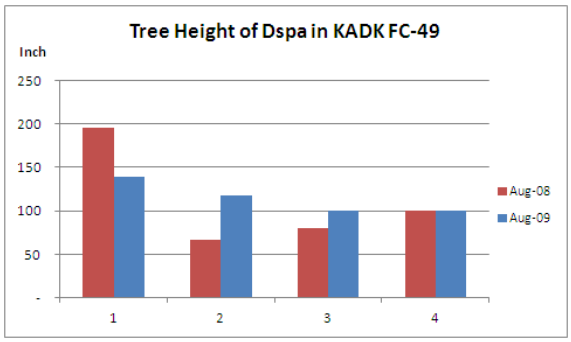
Figure 4.6 Tree Height of Target Trees in RMS(KADK FC-49)



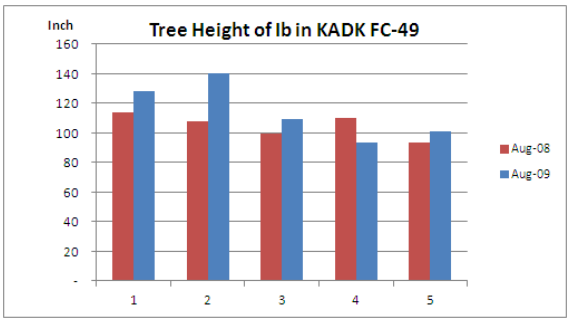


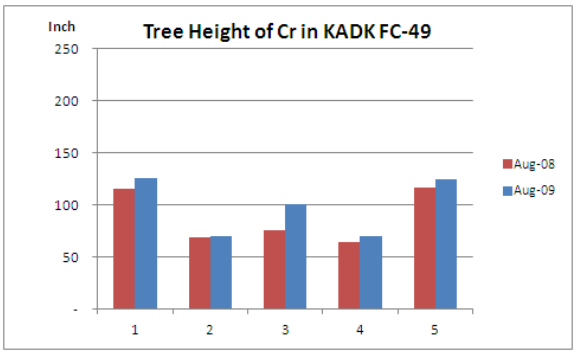
NFIO(Far from Creek)



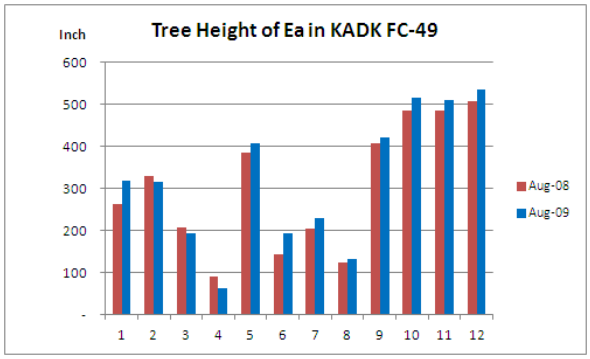


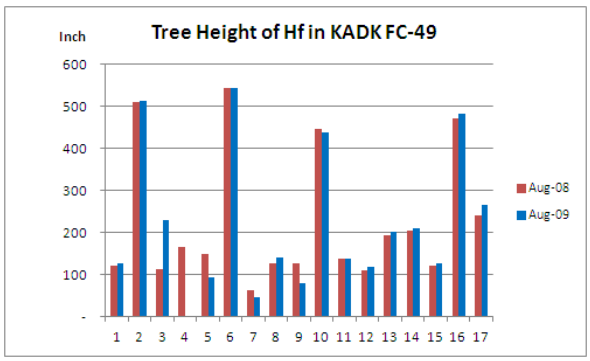
Non-NFIO(Far from Creek)

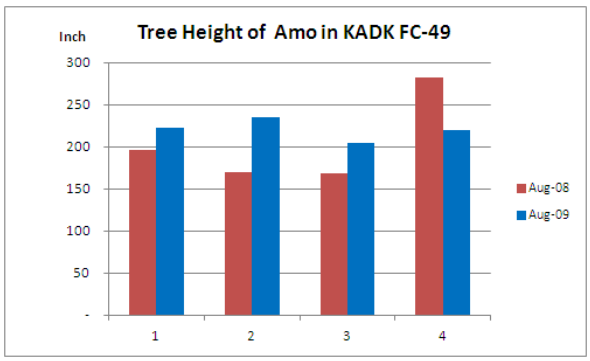




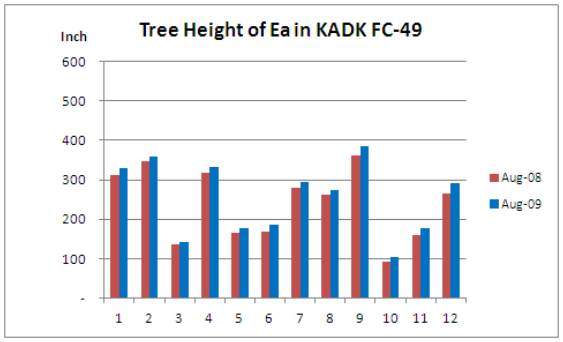
NFIO(Far from Creek)

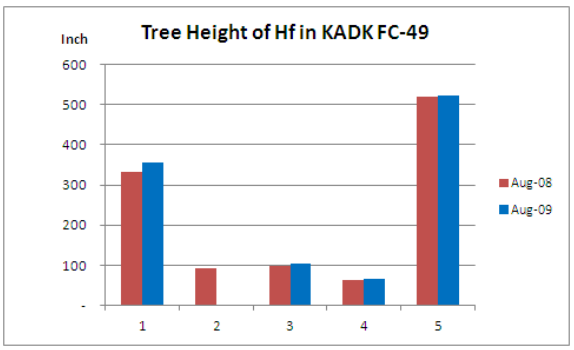






NFIO(Middle from Creek)





Non-NFIO(Middle from Creek)

Figure 4.7 Tree Height of Target Trees in RMS(KADK FC-49)

(6) Meinmahla（FC-1）

Even in Meinmahla RF which was declared as a Wildlife Sanctuary, illegal cuttings were found during the survey period. Only few numbers of remaining trees were monitored. Ea seemed good growing and growth of Pp as a fast growing species was not so high compared with Ea in middle distance from the creek.

Table 4.9 Result of RMS in Meinmahla FC-1: Inside Reserved Forest (Area-I)

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Sep.'08	Nov.'08	Aug.'09	Dec-'10	From Sep'08 – Aug.'09	(for 11months)
Ba(3)	Far	No Info.	159.2	162.8	173.6	-	14.4	1.3
Ea(3)			264.4	265.2	319.2	-	54.8	5.0
Cd(3)	Middle		121.6	126.0	116.4	-	-5.2	-0.5
Pp(5)			152.2	157.2	-	-	5.1(only for 3months)	0.5
Ea(3)			340.8	348.8	377.2	-	36.4	3.3
Ba(4)	Near		113.7	119.1	134.1	-	20.4	1.9
Ac(5)			195.1	202.6	160.3	-	-34.8	-3.2
Cd(3)			101.2	108.0	109.2	-	8.0	0.7
Cspe(4)			128.1	132.0	141.6	-	13.5	1.2
Hf(6)			133.4	139.2	157.2	-	23.8	2.2

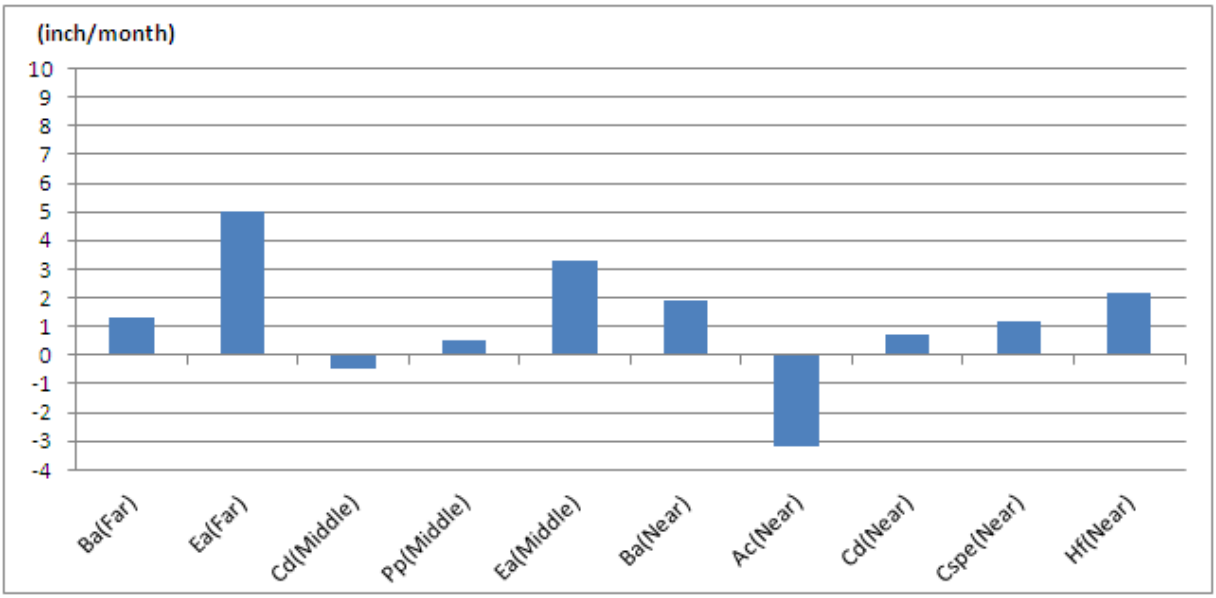
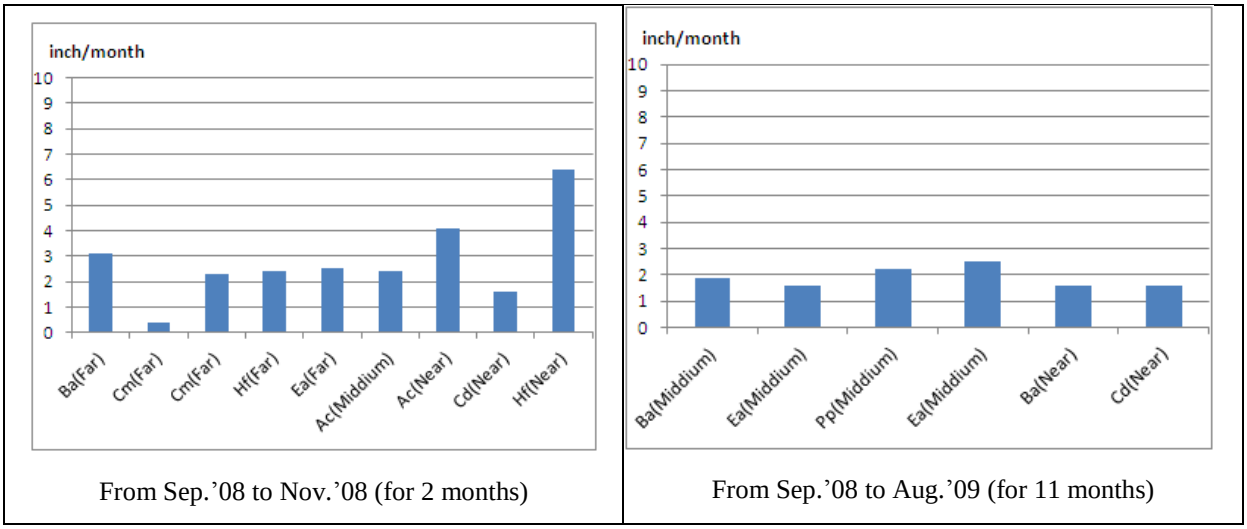


Figure 4.8 Tree Height of Target Trees in RMS (Meinmahla FC-1, Area-I)

Table 4.10 Result of RMS in Meinmahla FC-1: Western Side (Area-II)

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Sep.'08	Nov.'08	Aug.'09	Nov.'09	From Sep.'08 to Nov.'08	
Ba(8)	Far	No Info.	177.2	183.3			6.2	3.1
Cm(7)			150.2	151.0			0.9	0.4
Cm(16)			145.9	150.5			4.7	2.3
Hf(3)			173.6	180.8			7.2	2.4

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Sep.'08	Nov.'08	Aug.'09	Nov.'09	From Sep.'08 to Nov.'08	
Ea(14)			300.9	306.0			5.1	2.5
Ba(4)	Middle		196.8	198.9	217.2		20.4(for 11months)	1.9
Ac(6)			190.0	194.8			4.8	2.4
Ea(6)			251.2	259.2	269.2		18.0(for 11months)	1.6
Pp(8)			146.9	155.9	171.3		24.4(for 11months)	2.2
Ea(8)			342.8	345.6	370.7		27.9(for 11months)	2.5
Ba(3)	Near		206.8	210.0	224.0		17.2(for 11months)	1.6
Ac(13)			207.2	215.4			8.1	4.1
Cd(7)			103.9	107.1			3.3	1.6
Cd(4)			151.8	150.9	169.4		17.6(for 11months)	1.6
Hf(12)			153.7	166.5			12.8	6.4



From Sep.'08 to Nov.'08 (for 2 months)

From Sep.'08 to Aug.'09 (for 11 months)

Figure 4.9 Tree Height of Target Trees in RMS (Meinmahla FC-1, Area-II)

(7) Pyindaye RF (FC-60)

In this RF, trees without NFIO showed better growth than those with NFIO. This tendency is clearer in Hf in medium location. However, Ea without NFIO in far location shows little growth. The reason is unknown.

Table 4.11 Result of RMS in Pyindaye RF (FC-60)

Spp. (*)	Distance from Creek	NFIO	Mean Height (inch)				Growth(inch)	Growth Rate (inch/month)
			Aug.'08	Aug.'09	Nov-'09	Dec-'10	From Nov.2009 to Dec-2010 (for 13 months)	
Ea(27)	Far	NFIO			167.5	198.8	31.3	2.4

Ea(7)		-			166.4	169.1	2.7	0.2
Hf(7)	Middle	NFIO			124.0	150.9	26.8	2.1
Hf(4)		-		106.6	135.9		25.3	8.4
Ea(3)		-		110.6	122.6		16.0	5.3

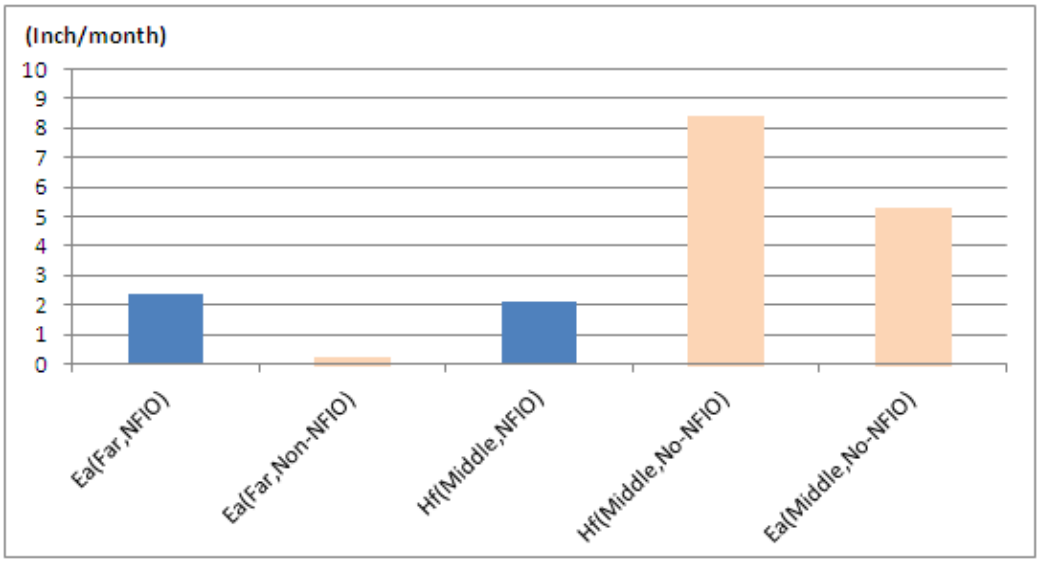
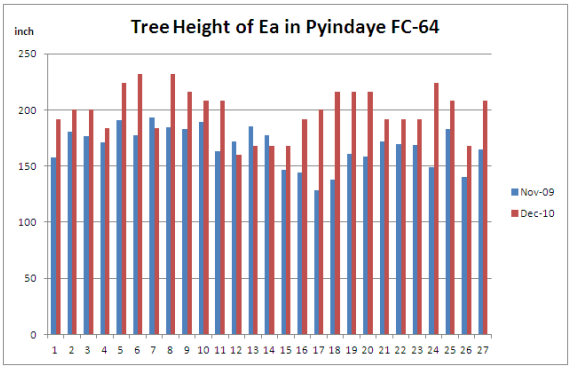
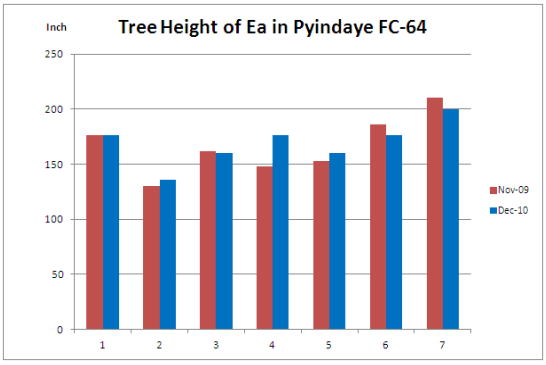


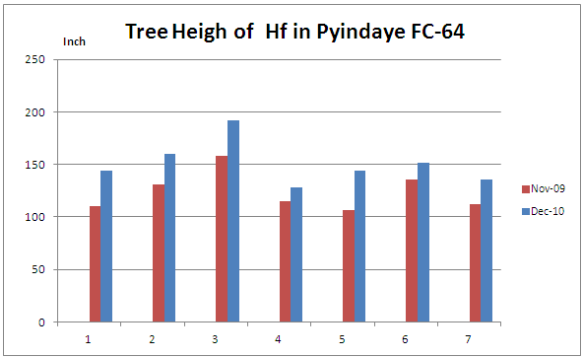
Figure 4.10 Tree Height of Target Trees in RM (PNDY FC-60)



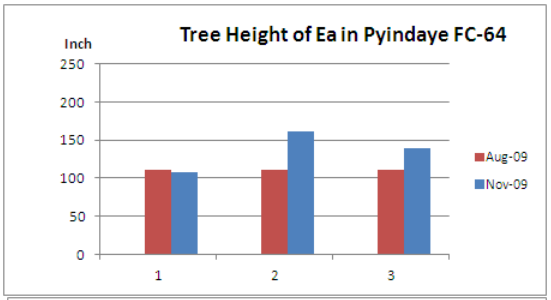
NFIO(Far from Creek)



Non-NFIO(Far from Creek)



NFIO(Middle from Creek)



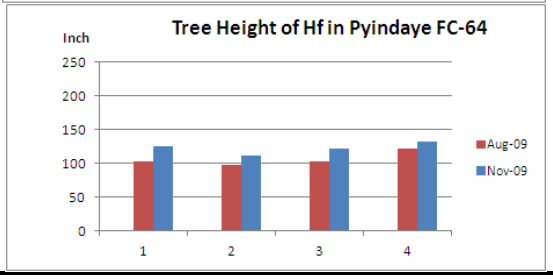


Figure 4.11 Tree Height of Target Trees in RMS (PNDY FC-60)

5. Summary of the Findings

5.1 Recovery from the Damages and Correlation with The Factors

The survey tried to find out the correlation between the tree growth and the several conditions which might affect the recovery of trees. The overall results are summarized in **Table 4.12.** Removal of debris in the NFIO operation did not give positive effects in tree growth. Trees without debris removal achieved better growth in KKKP and PNLN RFs while there were no significant differences in removal/non-removal debris in the rest of the RFs. Location factor has also limited effects in tree recovery. Trees in medium distance in KKKP showed better growth compared to others in near and far distances from the creek/river. There were not clear correlations between those factors in other RFs.

As indicted in the column of "Tree species" some tree species showed better recovery in KADK and Meinmahla RFs. Hf in KADK achieved quick recovery and showed better growth in medium and near distances while Ea in Meinmahla achieved better growth in far and medium distances. Factors which gave such differences in their recovery and quick growth need to be investigated by the continuous monitoring.

Table 4.12 Correlations of Tree Growth with the Factors set in the Survey

Forest Reserve / Factors	With/ without NFIO	Location	Tree species
KKKP	Yes	Yes	No
PNLN	Yes	No	No
KADK	No	No	Yes
Meinmahla	No	No	Yes
PNDY	No	No	No

5.2 Species Characteristics against Damages Given by the Cyclone

From the survey conducted soon after the cyclone *Nargis*, the different levels of damages and recovery were detected among the species. *Pongamia pinnata* (Pp), *Xylocarpus spp*, *Bruguiera gymnorhizza* (Bg), *Avicennia marina* (Am), *Rhizophora apiculata* (Ra), *Nypa fruticans* (Nf), *Intsia bijuga* (Ib), *Amoora cucullata* (Amo) and *Ceriops decandra (Cd)* were found to be resistant against the damages such as strong wind and extreme high tides brought by the cyclone. *Avicennia officinalis* (Ao) which is one of the most popular species in plantation was heavily damaged in all parts of its body hence does not seem to be tolerant against such damages. The recovery process of Ao was also found to be slower than other major species.

These findings give the FD significant implications for species selection in future planting plan which aims to develop plantation more tolerant to the disasters by the cyclone. Currently Ao is one of the most popular species to be used in mangrove plantation at the Ayeyawady delta. It is also fast growing with appropriate site selection, which has supported to develop the plantation in shorter period. However, the survey revealed that Ao is less tolerant against the damages of cyclone than other species. One of the reasons could be attributed to the fact that most of those damaged trees were still young

after being planted at the time of cyclone therefore they were more vulnerable to the damages. Accordingly, in response to the findings of the survey, the location and scale of planting of Ao should be reconsidered in the future to develop more disaster tolerant plantation against the cyclone.

Table 4.13 and **Table 4.14** summarize degree of the damages and status of recovery of major mangrove species used in plantation. These data will provide more practical basis in selecting and applying the tree species when FD plans to develop the seedling production.

Table 4.13 Degree of Damage by Species as of October 2008

Species	Spp.	Severely damaged	Heavily damaged	Slightly damaged
Pongamia pinnata	Pp			X
Heritiera fomes	Hf		X	
Excoecaria agallocha	Ea	X		
Ceriops decandra	Cd		X	
Avicennia officinalis	Ao	X		
Bruguiera gymnorrhiza	Bg		X	
Sonneratia apetala	Sa	X		
Rhizophora apiculata	Ra		X	
Nypa fruticans	Nf		X	

Table 4.14 Status of Recovery by Species as of October 2008

Species	Spp.	Fast (50%)	Moderate (30%)	Slow (10%)
Pongamia pinnata	Pp	X		
Heritiera fomes	Hf		X	
Excoecaria agallocha	Ea	X		
Ceriops decandra	Cd		X	
Avicennia officinalis	Ao			X
Bruguiera gymnorrhiza	Bg		X	
Sonneratia apetala	Sa	X		
Rhizophora apiculata	Ra		X	
Nypa fruticans	Nf	X		

5.3 Illegal Cutting: Unforeseeable Problem Arising during the Survey in Relation to Mangrove Conservation and Management

After the cyclone *Nargis*, illegal activities such as cutting, making charcoal and encroachment to open new farms drastically expanded into the reserved forests in many parts of the Ayeyawady delta. Behind the scene, severe shortage of timber/fuel woods for domestic and commercial uses and the temporarily limited way of income after the cyclone are considered to accelerate those trends causing the degradation of mangrove forest and its ecosystems as a whole. What is the worst among them was the encroachment by the farmers to develop paddy fields in the areas where previously were well protected by FD,. It converted the natural mangrove forest completely into the paddy, which is commonly irreversible land use change in the delta area.

As in the case of this survey, these human activities in the natural forest are critically affecting the rehabilitation and conservation of the mangroves. Together with this, the managerial capacities of the FD in the frontline of the delta area seemed to be weakened further after the cyclone. The nursery facilities and field stations of FD and the human resources as well were tremendously damaged by the cyclone, which resulted in declining the control of FD over illegal activities and the capacity of

monitoring and managing the mangrove forests regularly.

6. Recommendations

6.1 Improvement of Mangrove Forest to be More Disaster Tolerant and Recoverable agains the Natural Damages

In response to the findings of the survey, FD is recommended to reconsider the species selection and seedling producing plan at the nursery. More disaster tolerant and fast growing tree species should be widely adapted to develop the plantation. Less tolerant and slow recovering species need to be more considered in their selection of plantation sites and maintenance thereafter.

It is also recommended that FD shall continue further the monitoring of recovering process of mangrove and find out the more exact suitability of tree species to the specific geographical and other natural conditions in the RFs. Such kind of field-based forestry knowledge/technologies is to be continuously improved and all kinds of key findings in the fields need to be fed back to the stage of planning of operations in the nursery and at the sites.

6.2 Enhancement of Participatory Approaches in Conserving the Mangrove Forests for Disaster Prevention and Reduction of Illegal Activities

Approaches to the social aspects are also one of the keys to strengthen the stability of mangrove forests and its conservation. Community members regardless those who are involved in CF or not should be involved more in developing disaster tolerant mangrove and should be in compliance with the current legal laws and regulations to conserve the mangrove. In this sense, the capacity of FD need to be further strengthened at all levels, especially in the frontline stations to be able to collaborate with the communities in the mangrove management. Participatory approaches or collaborative management in the mangrove is to be disseminated to the community and practiced by the FD staffs and the people so as to achieve the goals of sustainable management of the FRs in the delta area.

6.3 Enhancement of Managerial Capacities of FD as the Firm Basis of Sustainable Forests Management in the Delta Area

As a conclusion of this report, it is pointed that basic capacity of FD should be strengthened to address the issues as described above. Regular monitoring and maintenances should be conducted at appropriate timing. Planning of seedlings producing, distribution and planting in the fields need to be continuously improved by incorporating various experiences in the past including the disaster of cyclone. All kinds of resources necessary to complete this continuous process are requested to be allocated properly all the time by the FD or the supporting organizations other than FD.

Volume 5
Mapping Techniques for Mangrove Management in the Ayeyawady Delta

1 Introduction

Forest Department (FD) has a responsibility to manage Reserved Forest (RF) area The map is one of the most important information to i) grasp locations and boundaries of target areas, and ii) identify current situation of mangrove forest and other land use in RFs. When FD selects area and conducts management activities, FD needs to prepare base maps, however it was difficult to prepare map timely because of the limitation survey and mapping instruments at beginning of the project.

Therefore, JICA Expert Team (JET) provides some of mapping techniques and equipments to FD . This volume summarizes practical mapping procedures of Community Forestry (CF) management map, land use map and hazard map based on the project accomplishment.

2 Mapping Items

It is desirable to introduce following items for field survey and mapping activity (**Table.5-1**)

Table 5-1 List of Items for Mapping

	Items	Remarks
1	Potable GPS	Based on the GPS point data, it is possible to make outer boundary of target area and calculate area on the computer. GPS manual is attached this report.
2	Computer with GIS software	Recent map information is provided as digital data (satellite image, GPS data). A set of computer system and free GIS software should be installed into all FD township office.
3	Laminator machine	Laminated map is required for field trip because of high humidity in the delta.
4	Color Printer/Color plotter	Color contents of map provide user friendly information.

3 Mapping for Community Forestry (CF) Management

To prepare CF mapping, FD township officers are required support villagers who have interest to introduce CF to conduct field survey to allocate CF target area with GPS. Based on the GPS points, FD can trace the points to make outer boundary of CF area in their computer (A GIS free software is attached with portable GPS). At township level, FD can calculate approximate area using the GPS points and provide hard copy maps to villagers.

As the first step of CF in accordance with the Community Forestry Instruction, candidates of CF user group (CFUG) members are supposed to prepare CF management plan for getting a CF certification. The project supported six (6) CFUGs to prepare and submit CF management plans attached with location map, stock map and management map (refer **Figure 5-1, Figure 5-2 and Figure 5-3**). Topographic maps were used as base map, but satellite images were also applied based on necessity and availabilities of topographic maps.

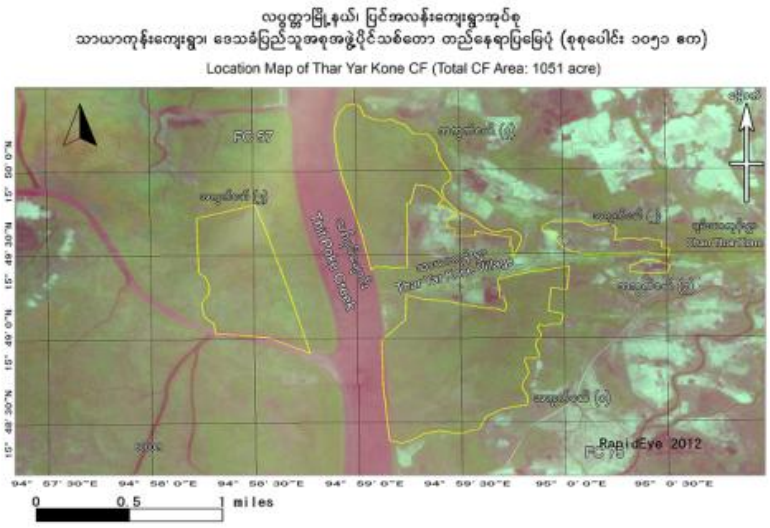


Figure 5-1 Sample Image of CF Location Map in TYK CFUG

Figure 5-2 Sample Image of CF Management Map in TGT CFUG

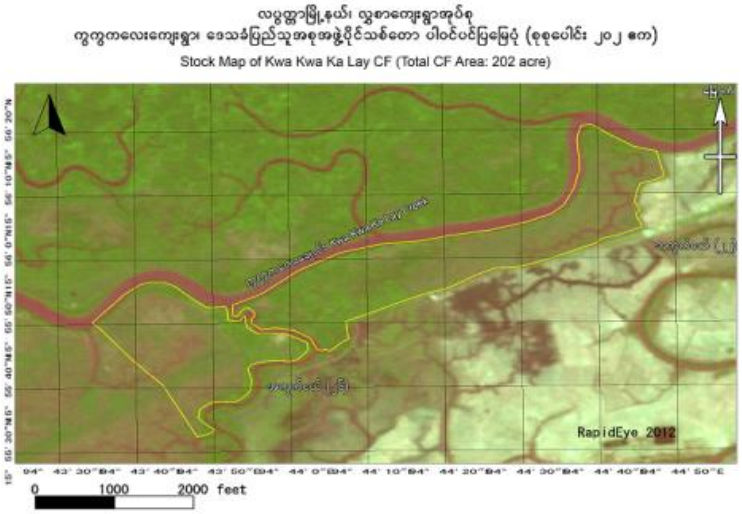


Figure 5-3 Sample Image of CF Stock Map in KKKL CFUG

4 Mapping for FD Plantation

In the project, twelve (12) Action Research Plantation (ARP) sites in total were established. Sketches of ARP were prepared during preparatory and planting stages, but it is difficult to confirm actual boundaries of ARP sites then after. Therefore, the project recorded corners of all monitoring plots by GPS., At sites, wooden stakes with plot numbers were installed at all corners of monitoring plots.

Finally, APR maps consist of outer boundaries of ARP site and points of individual monitoring plots were prepared based on GPS records. The ARP signboard with ARP map has been installed in each ARP site in February 2013. The ARP maps and GPS records shall be utilized for further ARP monitoring after the project (**Figure 5-4 and Figure 5-5**).

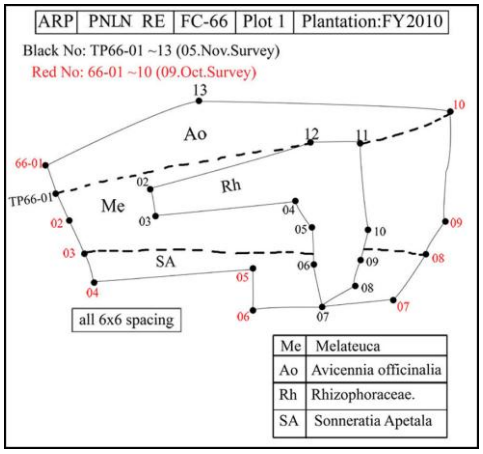


Figure5-4 Sample Image of ARP Sketch in FC-66, PNLN RF

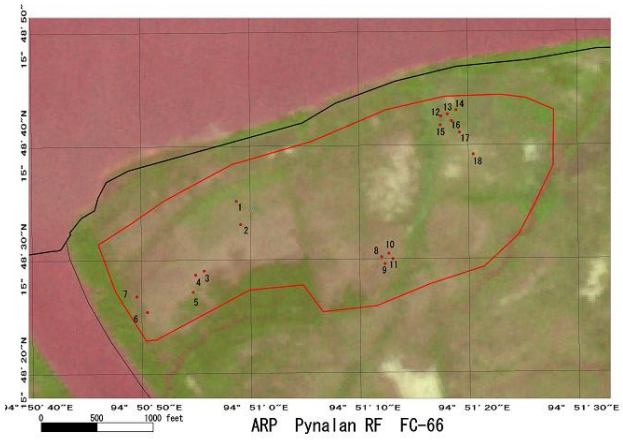


Figure 5-5 Sample Image of ARP Map in FC-66, PNLN RF

5 Land Use Mapping

The land use mapping is a part of project's Output 4 activity which aims to support coordinate mechanism for sustainable land use management among FD and relevant stakeholders in the Delta.

The land use map has been prepared and updated by JET and FD GIS section, Nay Pyi Taw in FY2007, FY2009 and FY2012(**Table 5-3)**. The types of satellite images were different depend on the year and season due to availabilities of satellite images. It is necessary to select appropriate method of image analysis depend on the characteristics of the obtained images. In FY2012, the project updated land use category in the delta and re-compared land use change during the project. The latest land use category is shown in **Table 5-4,** and **Figure 5-6**.

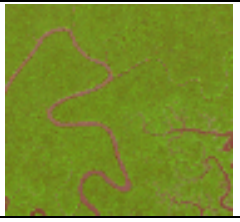
From 2007 to 2012, the project identified tendency of Land use change as distribution of each land use class and its area in the delta(**Table 5-4, Table 5-5)**. In the project area, urban(settlement) area with home garden /dani are increasing from 2007 to 2012. There are difference of Mangrove area between 2009 and 2012. One of the possible reason is Cyclone Nargis on May 2008, but also smog and cloud noises in the satellite images might have affected under/over estimate of vegetation area.

The flow of mapping procedure in 2007, 2009 and 2012 are shown in **Figure 5-7 and Figure 5-8**.

Table 5-2 List of Satellite Image for Land Use Mapping

	Satellite image	Year	Resolution	Method
1	Landsat ETM+	2007	30m	Automatically classification
2	ALOS AVNIR	2009	10m	Automatically classification
3	Rapid Eye	2012(Jan-April)	5m	Automatically classification and Image interpretation

Table 5-3 Land Use Category in 2012

Code	Category	Definition	Sample Image
1	Mangrove Forest	Distributed center of Reserved Forests and riverbank in the delta.	

Code	Category	Definition	Sample Image
2	Mixed Vegetation	Consists of sparse mangrove forest, bush, grass and part of green paddy and crops. ,	
3	Agriculture land (dry)	Bare land with artificial shape.	
4	Agriculture land (wet)	Vegetation with artificial shape.	
5	Home Garden and Dani	Characteristic texture of vegetation cover and distributed surrounding of urban area.	
6	Shrimp pond / salt pan	Shrimp pond and salt pan has artificial shape with water surface or bare land nearby big river in the delta.	
7	Urban	Settlements are classified into urban area.	
8	Sand	It distributed costal area.	
9	Wet land	It has similar refraction of water surface and is distributed in the land.	
10	Water	It consists sea, river and creek	

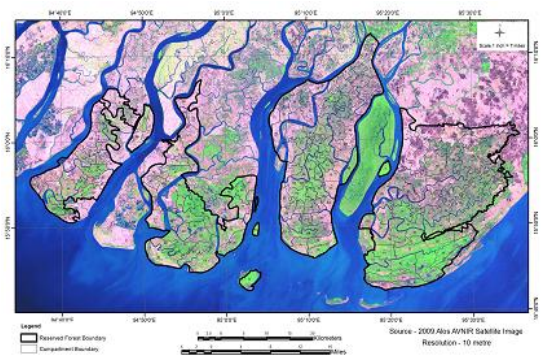
Table 5-4 Land Use Change

No.	Class Name	2007 Area ha (acre)	%	2009 Area ha (acre)	%	2012 Area ha (acre)	%
1	Mangrove	53,933 (133,267)	25	46,767 (115,560)	22	51,193 (126,495)	25
2	Mixed Vegetation	21,104 (52,147)	10	21,991 (54,339)	10	38,569 (95,303)	18
3	Agriculture dry	103,895 (256,721)	49	114,660 (283,321)	54	49,398 (122,061)	23
4	Agriculture wet					41,310 (102,075)	19
5	Home Garden & Dani	469 (1,159)	0	1,289 (3,185)	1	1,957 (4,836)	1
6	Salt Pan/Shrimp Pond	769 (1,900)	0	4,351 (10,751)	2	3,245 (8,018)	1
7	Urban	270 (667)	0	972 (2,402)	1	1,632 (4,032)	1
8	Sand	29 (72)	0	1,007 (2,488)	1	481 (1,189)	0
9	Wetland	15,025 (37,126)	7	5,288 (13,066)	2	4,313 (10,656)	2
10	Water /Unclassified	17,760 (43,884)	8	16,929 (41,831)	8	21,157 (52,277)	10
	Total	**213,254 (526,943)**	**100**	**213,254 (526,943)**	**100**	**213,254 (526,943)**	**100**

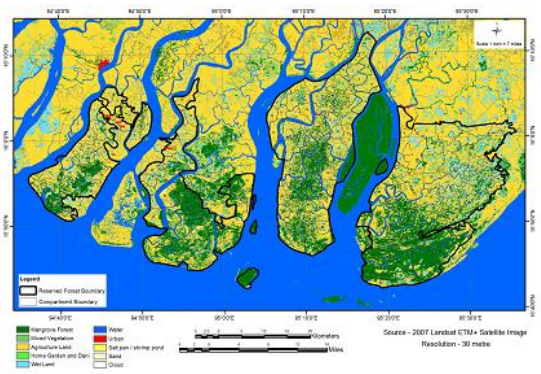
Table 5-5 Change of Mangrove Forest in each Reserved Forest

Reserved Forest (Township)	Total Area (acre)	Mangrove In 2007 Ha (acre)	%*	Mangrove In 2009 Ha (acre)	%*	Mangrove In 2012 Ha (acre)	%*
Kyakankwinpauk (Laputta)	28,486 (70,387)	4,730 (11,688)	17	3,873 (9,570)	14	4, 310 (10,650)	15
Pyinalan (Laputta)	41,881 (103,485)	13,458 (33,254)	32	11,585 (28,626)	28	10,942 (27,037)	26
Kadonkani (Bogalay)	64,521 (159,428)	13,574 (33,574)	21	11,625 (28,725)	18	14,551 (35,955)	23
Pyindaye(Pyar Pon, Bogalay)	78,368 (193,643)	22,171 (54,784)	28	19,683 (48,636)	25	21,390 (52,853)	27
Total area	213,254 (526,943)	53,933 (133,267)	25	46,767 (115,560)	22	51,193 (126,495)	24

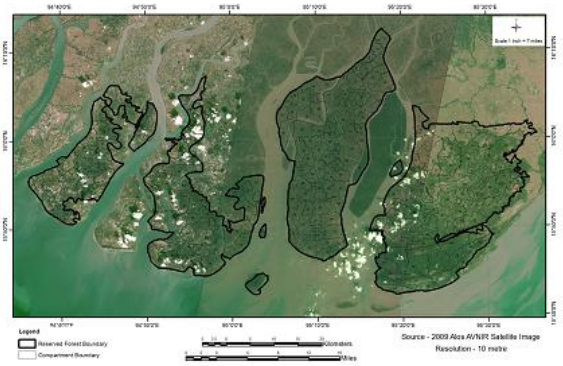
*Note: * is percentage of mangrove area in each Reserved Forest.*



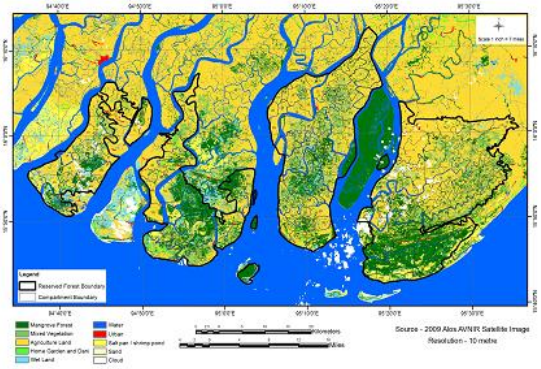
Satellite image (Landsat 2007)



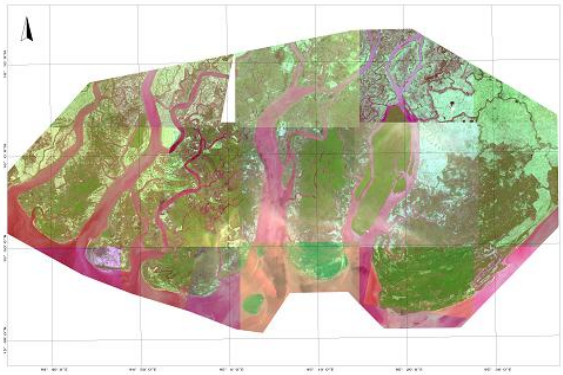
Land Use Map 2007



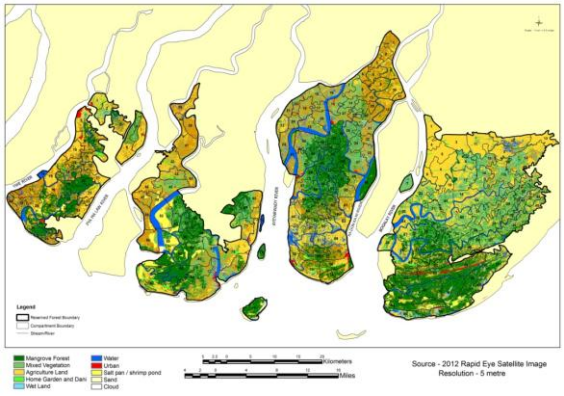
Satellite image (ALOS 2009)



Land Use Map 2009



Satellite image (Rapid Eye 2012)



Land Use Map 2012

Figure 5-6 Satellite Image and Land Use Map (2007,2009 and 2012)

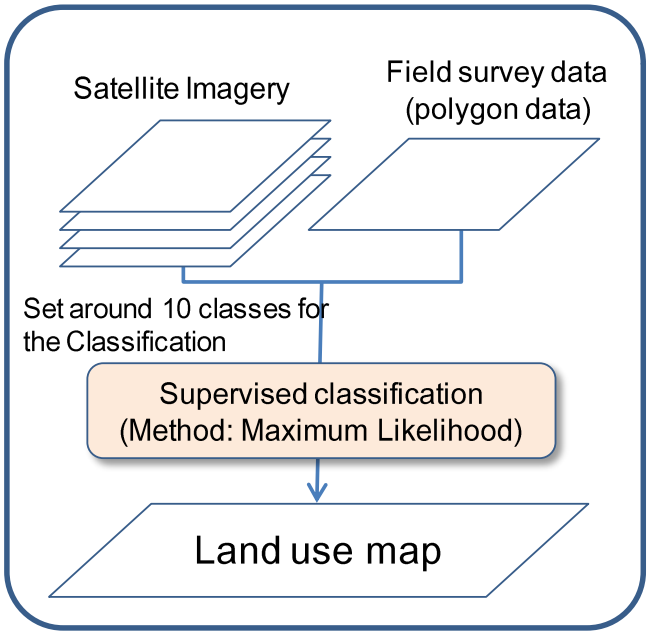


Figure 5-7 Procedure of Satellite Image Analysis in 2007 and 2009

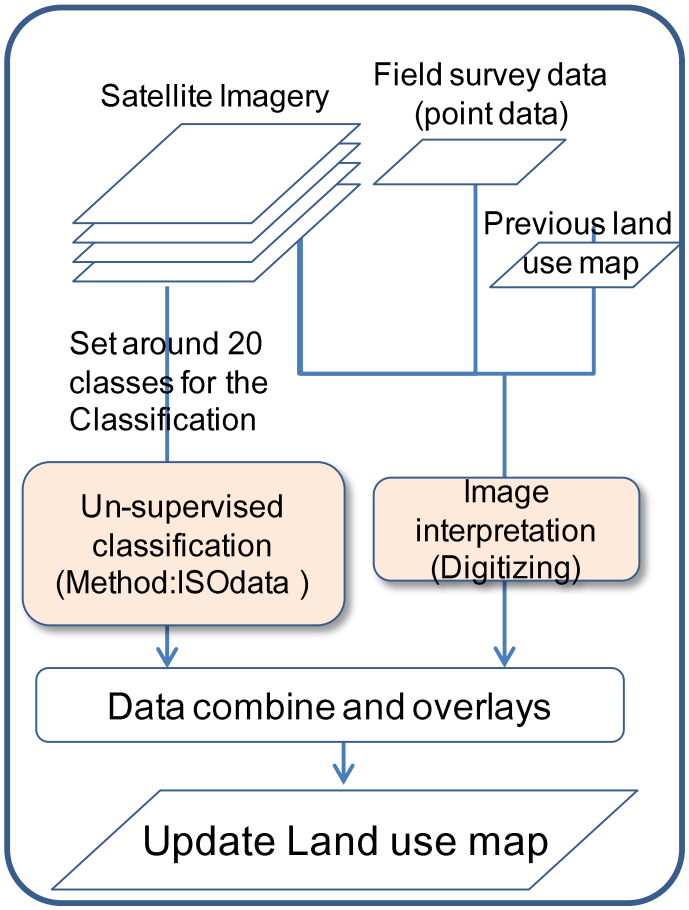


Figure 5-8 Procedure of Satellite Image Analysis in 2012

6 Hazard Mapping

1) Hazard Map 2009

After the Cyclone Nargis, JET and FD GIS section prepared Hazard Map based on the results of rapid damage survey and satellite image analysis (**Figure 5-9 and Figure 5-10**). Detail procedure and results of Hazard Map 2009 were reported in project's Interim Report. Final image of Hazard Map 2009 is shown below. It consists of two categories and resolution of the image is 500mx500m.

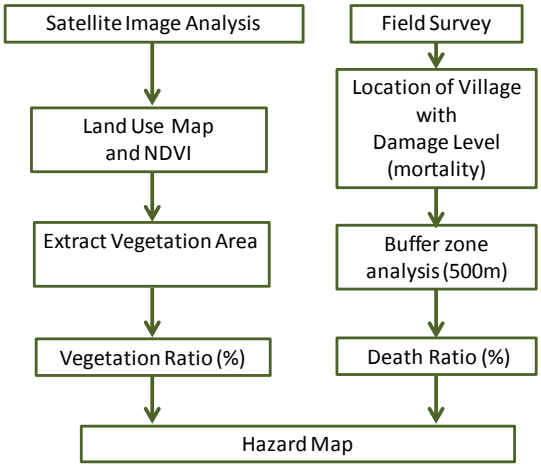
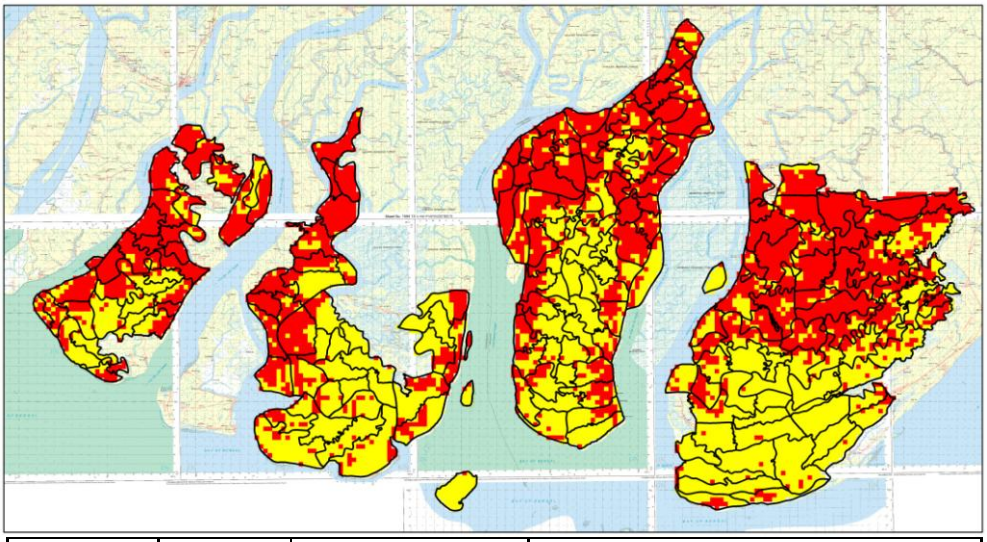


Figure 5-9 Procedure of Hazard Map 2009



Color	Level	Vegetation Ratio *1	Death Ratio (Water Level 2m (6 ft)) *2
	Level 1	<= 10%	22%
	Level 2	> 10%	12%

*Note: *1 Only 10% of vegetation ratio can be identified as the threshold level statistically*
*Note:*2 Death ratio in 2m water level in constant is the average death ratio for the surveyed villages, in which are categorized in each Level (Level 1 and Level 2).*

Figure 5-10 Hazard Map 2009

2) Updated Hazard Map 2013

In 2012, the land use map has been updated using latest satellite image. There are some land use changes from 2009 to 2012. Mangrove vegetation decreased and also social conditions might have been changed after the cyclone. To reflect actual situation, JET and FD GIS section updated Hazard map in 2013. It introduced new procedure and methodology for updating hazard map as follows(**Figure 5-11, Table5-6, Table 5-7 and Figure 5-12**) .

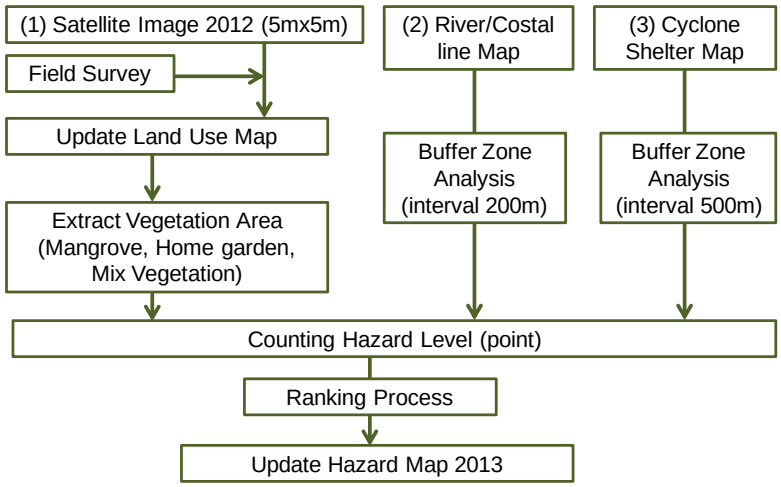


Figure 5-11 Procedure of Hazard Map 2013

Table 5-6 Change of Mangrove Forest in each Reserved Forest

Hazard level (point)		Independent Criteria (5m resolution)		
		Land Use Map	Distance from River/Creek	Distance from Cyclone Shelter
High Risk	4	Other category	0m-200m	More than 1,500m
	3	Mix Vegetation	201-400m	1,001-1,500m
	2	Home garden/Dani	401-600m	501-1,000m
Low Risk	1	Mangrove	600m	0m-500m

Table 5-7 Change of Mangrove Forest in each Reserved Forest

Hazard Ranking	Definition (when cyclone comes)	Total point
High Dangerous	Escape from river/creek and find thick Mangrove tree to hold as well as possible.	10-12
Dangerous	Flee into safety area where far from river and surrounding Mangrove forest.	7-9

Less Dangerous	Stay cyclone shelter or nearby Mangrove forest	4-6
Relatively safety	Stay house or cyclone shelter.	3

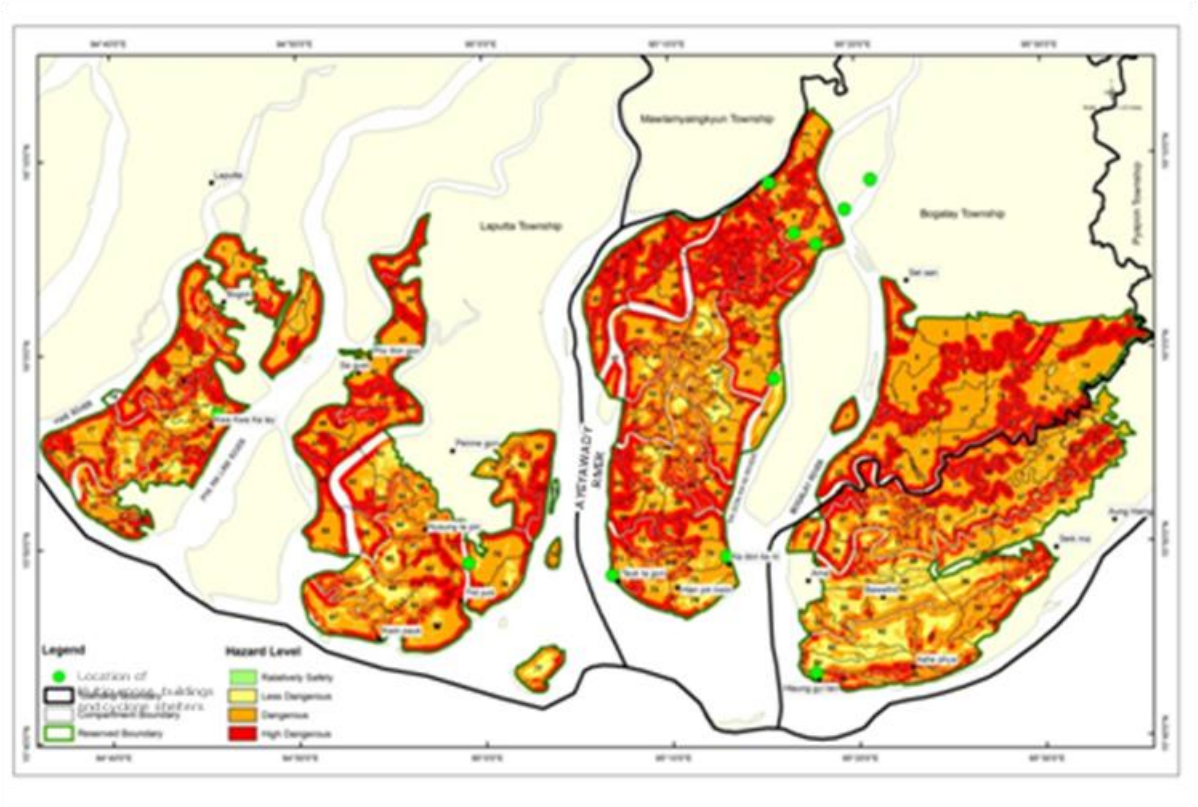


Figure 5-12 Hazard Map 2013

7 Findings and Issues

1) CF mapping and ARP plantation

FD staffs in township offices are participated in field survey for CF mapping and especially leant technical procedure of GPS survey in the field..

2) Land use mapping

-Update Land use map provides useful information for planning for mangrove management in the delta.

-Consideration of following issues for updates land use map in the future.

-Need more technical supports for developing map procedure of different type of satellite image.

-Need coordination between FD and stakeholders for discussing land use management in the delta.

-Limitation of budget for purchasing satellite image, field work and mapping for update maps.

3) Hazard mapping

-Simple method, criteria and visible information is required for well understanding for people in the delta.

-Map accuracy depends on land use map through using Satellite image analysis.

-Need to add information for updating Hazard Map in the future(Ex. Village population, other facility for disaster prevention).

8 Recommendations

1) For Community Forestry

-FD staff in township offices should support mapping activity and introduce mapping skills to CFUG member continually after the project end. .

-It needs to allocate budget for maintenance of mapping items and mapping activities in the field and office

2) FD plantation Activity

-It should conduct regular monitoring work in FD plantation area including ARP. Stakes of monitoring plot should be maintained or replaced every monitoring period

-It needs to allocate budget for maintenance of mapping items and mapping activities in the field and office

3) Land Use Management

-Forest Department has a responsibility to monitor current status of mangrove in four Reserved Forests using available satellite image.

-It is recommended to update land use map regularly to identify land use change for conservation of mangrove area every two years,

-For update the land use map, it is necessary to allocate budget for mapping and field survey.

4) Disaster Prevention

-It should considered “user friendly information” in hazard map.

-Sharing Hazard Map information between stakeholders in the delta is recommended.

-FD GIS section should update Hazard Map with latest information in the future if needed.

Attachment 1-1: Inventory of Action Research Plantation (ARP)

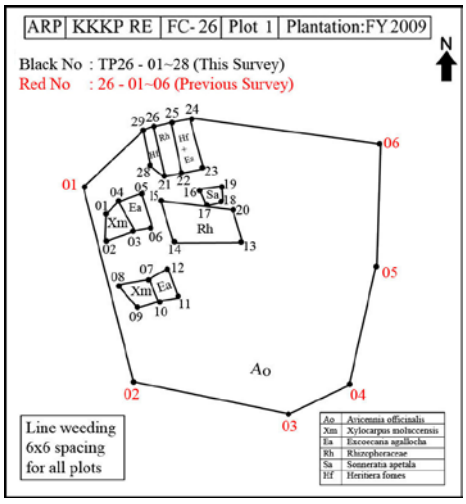
List of ARP Site

Reserved Forest(Township)	Sr.	Forest Compartment	Planting year	ARP reported area (acre)
Kyakankwinpauk (Laputta)	1	FC-26	FY2009	250
	2	FC-19	FY2010	120
	3	FC-17	FY2011	25
Pyinalan (Laputta)	4	FC-60	FY2009	250
	5	FC-66	FY2010	120
Kadonkani (Bogalay)	6	FC-36	FY2008	212
	7	FC-39	FY2009	200
	8	FC-63	FY2010	80
	9	FC-62	FY2011	25
Pyindaye (Bogalay, Pyar Pon)	10	FC-64	FY2009	200
	11	FC-65	FY2010	80
	12	FC-66	FY2011	25
TOTAL	-	-	-	1,587

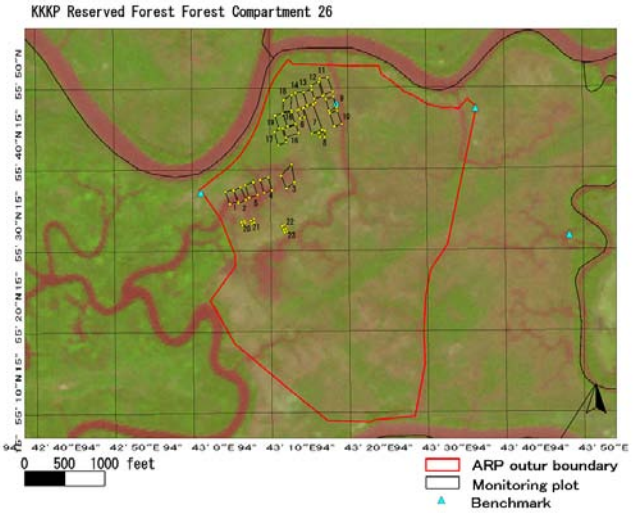
Source: JET, January2013

1: ARP (KKKP, FC-26)

Township	Laputta(LPT)
Reserved Forest	Kyakankwinpauk(KKKP)
Forest Compartment	FC-26
ARP reported area(area)	250 acre
Planted year	FY2009
Target Monitoring plots/trees	23 plots / 9,805 trees
Monitoring records	1st: Dec. 2011, 2nd:Nov.2012
2. Target operations	Line weeding(LT-2) , Spacing 6x6 (feet)
3. Target Species (confirmed by Monitoring)	Seven(7) species: *Avicennia officinalis(Ao), Bruguiera sexangula(Bs), Xylocarpus moluccensis(Sm), Excoecaria agallocha (Ea), Sonneratia Apetala(Sa), Heritiera fomes (Hf), Rhizophora apiculata (Ra)*



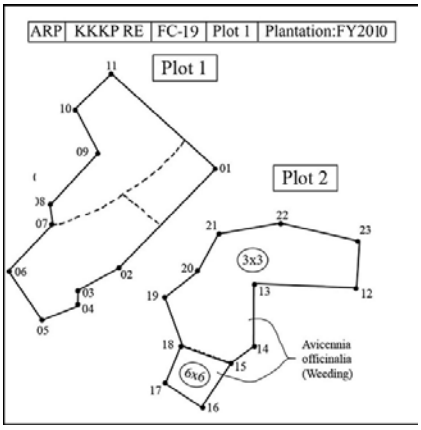
Sketch of ARP FC-26, KKKP RF

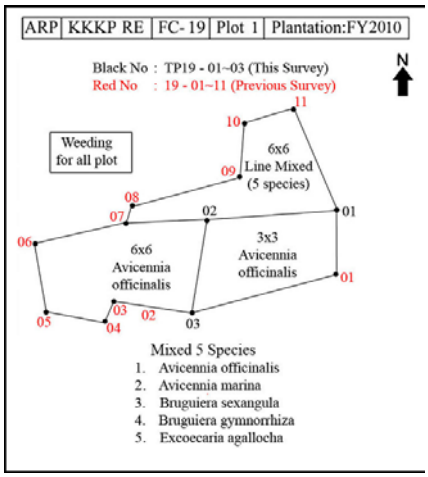


ARP map of FC-26, KKKP RF
(Base Map: Rapid Eye Image 2012)

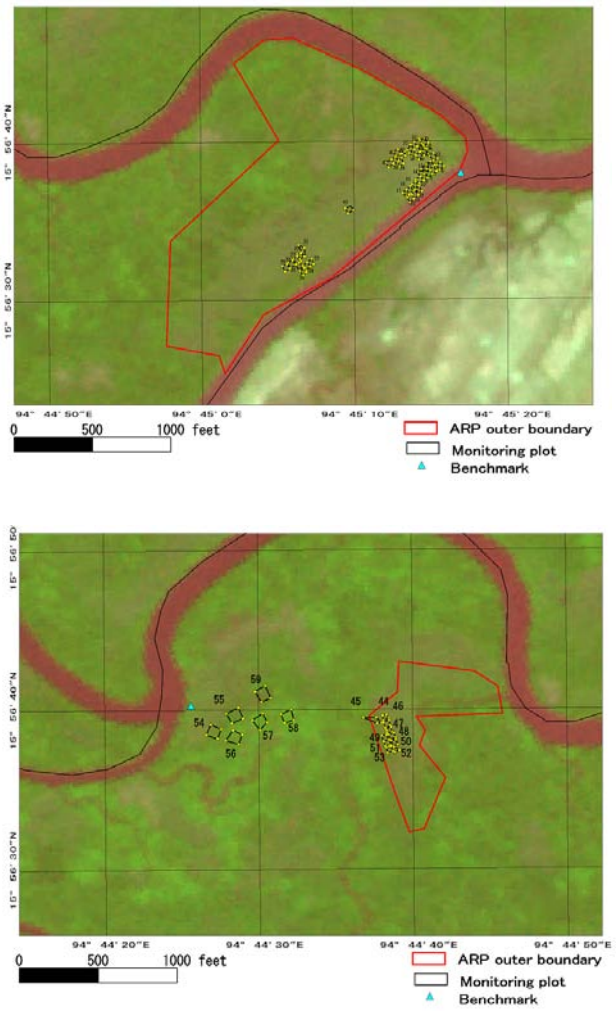
2: ARP (KKKP, FC-19)

Township	Laputta(LPT)
Reserved Forest	Kyakankwinpauk(KKKP)
Forest Compartment	FC-19
ARP reported area(area)	120
Planted year	FY2010
Target Monitoring plots/trees	59 plots / 4,208 trees
Monitoring records	1st: Dec 2012, 2nd: Nov 2012
2. Target operations	Weeding
3. Target Species (confirmed by Monitoring)	*Avicennia officinalis (Ao)and Natural Regeneration (Ac,Cd,Hf,Ea,Ac,Sg)*





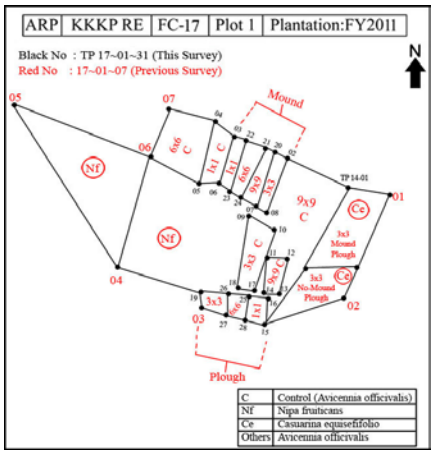
Sketch of ARP FC-19, KKKP RF



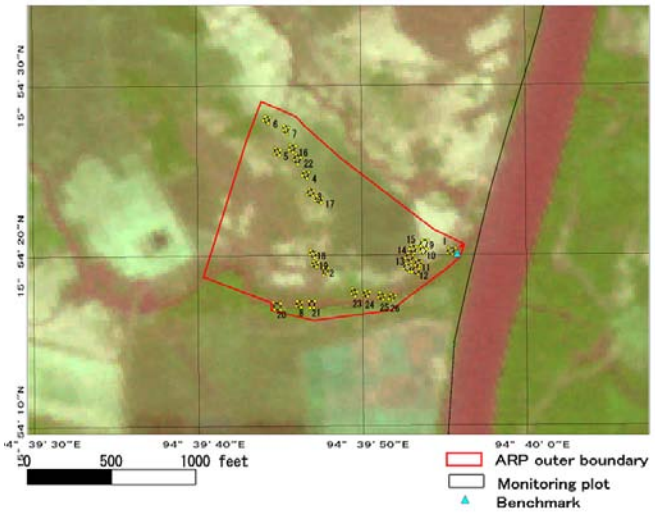
ARP map of FC-19, KKKP RF
(Base Map: Rapid Eye Image 2012)

3: ARP (KKKP, FC-17)

Township	Laputta(LPT)
Reserved Forest	Kyakankwinpauk(KKKP)
Forest Compartment	FC-17
ARP reported area(area)	25
Planted year	FY2011
Target Monitoring plots/trees	26 plots / 4,310 trees
Monitoring records	1st:Jan 2012 , 2nd: Dec 2012
2. Target operations	Mound, Plough
3. Target Species (confirmed by Monitoring)	2species: *Avicennia officinalis (Ao) and Casuarina equisetifolia (Ce)*



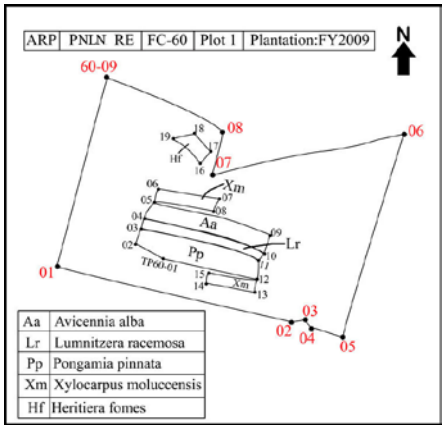
Sketch of ARP FC-17, KKKP RF



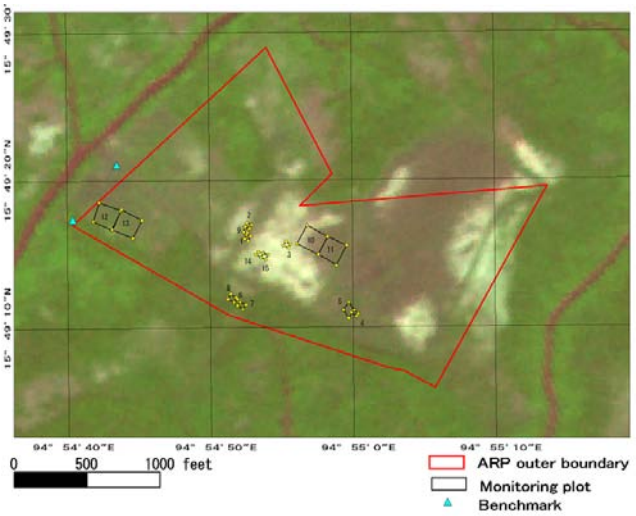
ARP map of FC-17, KKKP RF
(Base Map: Rapid Eye Image 2012)

4: ARP (PNLN, FC-60)

Township	Laputta(LPT)
Reserved Forest	Pyinalan (PNLN)
Forest Compartment	FC-60
ARP reported area(area)	250
Planted year	FY2009
Target Monitoring plots/trees	15 plots / 2,944 trees
Monitoring records	1st: Feb 2012, 2nd: Nov 2012
2. Target operations	No operation
3. Target Species (confirmed by Monitoring)	7 species: *Avicennia officinalis (Ao),Xylocarpus moluccensis(Xm),Lumnitzera racemosa(Lr),Excoecaria agallocha(Ea),Heritiera fomes (Hf),Avicennia alba(Aa),Avicennia marina(Am)*



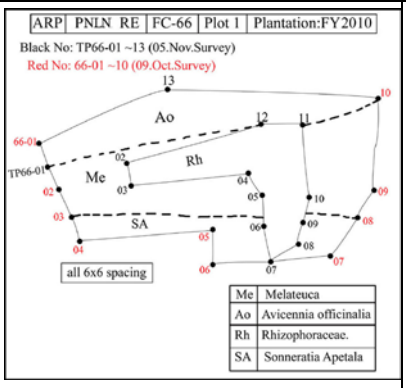
Sketch of ARP FC-60, KKKP RF



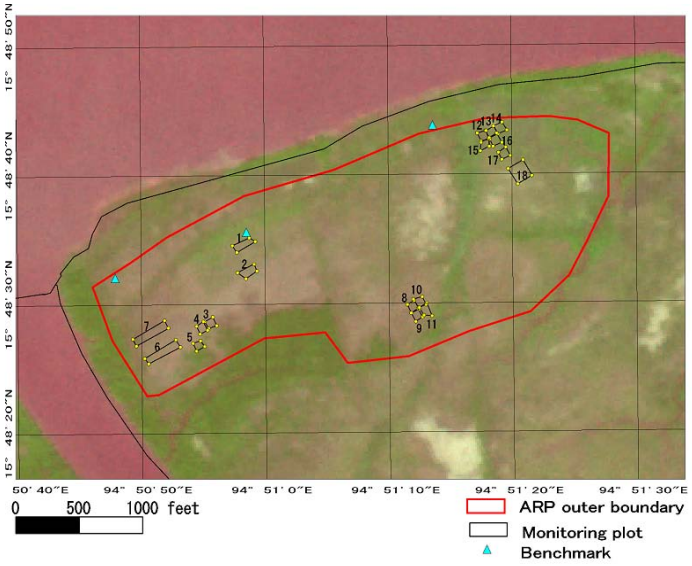
ARP map of FC-60, KKKP RF
(Base Map: Rapid Eye Image 2012)

5: ARP (PNLN, FC-66)

Township	Laputta(LPT)
Reserved Forest	Pyinalan (PNLN)
Forest Compartment(area)	FC-66
ARP reported area	120
Planted year	FY2010
Target Monitoring plots/trees	18 plots / 5,444 trees
Monitoring records	1st: Jan 2012, 2nd: Nov 2012
2. Target operations	Spot/Line mound
3. Target Species (confirmed by Monitoring)	4 species: *Avicennia officinails(Ao),Melaleuca leucsdendron(Mi),Sonneratia apetala(Sa),Bruguiera gymnorrhiza(Bg)*



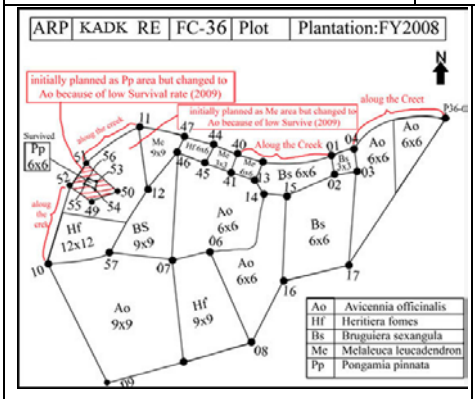
Sketch of ARP FC-66, PNLN RF



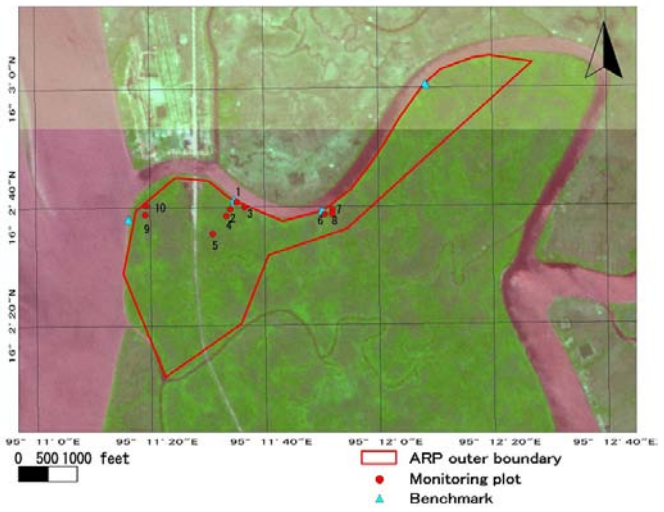
ARP map of FC-66, PNLN RF
(Base Map: Rapid Eye Image 2012)

6: ARP (KADK, FC-36)

Township	Bogalay(BGL)
Reserved Forest	Kadonkani (KADK)
Forest Compartment	FC-36
ARP reported area(area)	212
Planted year	FY2008
Target Monitoring plots/trees	10 plots / 2,674trees
Monitoring records	1st: July 2010, 2nd: Aug 2012
2. Target operations	Mound
3. Target Species (confirmed by Monitoring)	4 species: *Avicennia officinails(Ao),Bruguiera sexangula (Bs),Avicennia alba(Aa),Melaleuca leucadendron(Ml)*



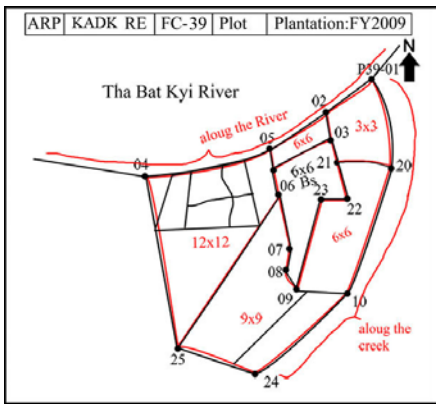
Sketch of ARP FC-36, KADK RF



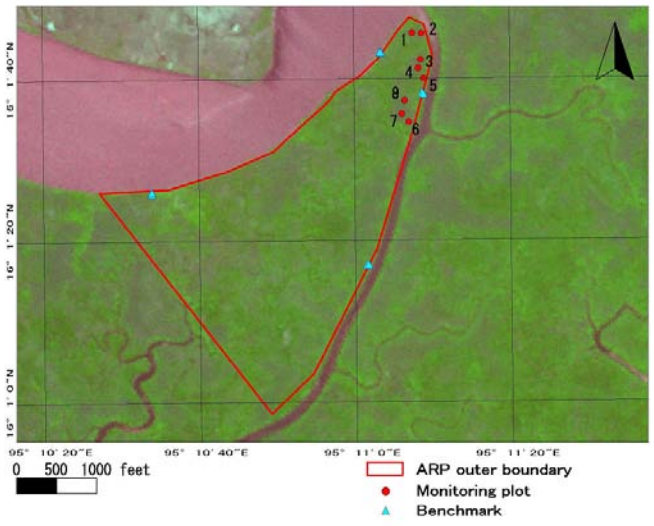
ARP map of FC-36, KADK RF
(Base Map: Rapid Eye Image 2012)

7: ARP (KADK, FC-39)

Township	Bogalay(BGL)
Reserved Forest	Kadonkani (KADK)
Forest Compartment	FC-39
ARP reported area(area)	200
Planted year	FY2009
Target Monitoring plots/trees	9 plots / 7,713 trees
Monitoring records	1st:July 2010, 2nd:Aug 2012
2. Target operations	Mound
3. Target Species (confirmed by Monitoring)	6 species: *Avicennia marina(Ao),Bruguiera sexangula (Bs),Heritirea fomes (Hf),Melaleuca leucadendron (Ml) ,Ceriops decandra(Cd),Pomgamia pinnata(Pp)*



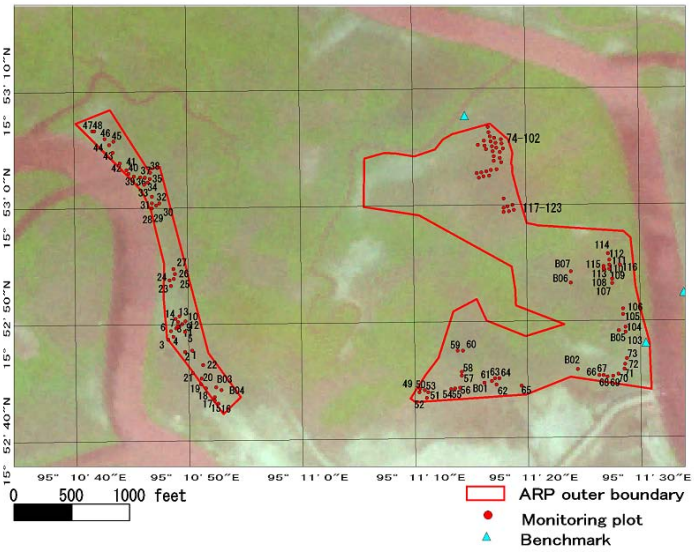
Sketch of ARP FC-39, KADK RF



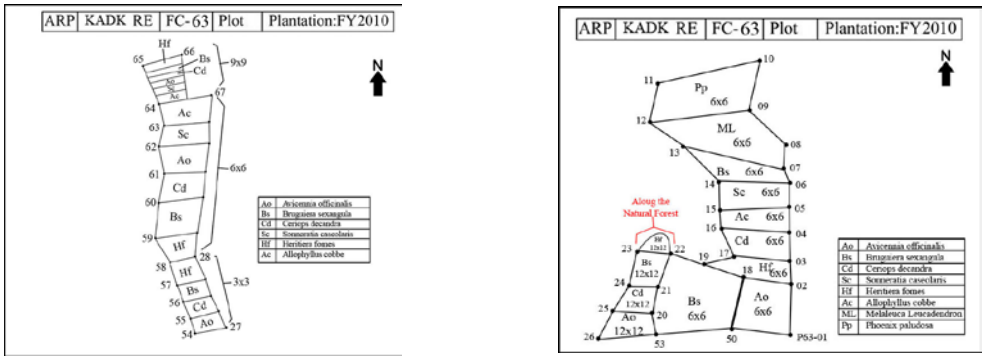
ARP map of FC-39, KADK RF
(Base Map: Rapid Eye Image 2012)

8: ARP (KADK, FC-63)

Township	Bogalay(BGL)
Reserved Forest	Kadonkani (KADK)
Forest Compartment	FC-63
ARP reported area(area)	80
Planted year	FY2010
Target Monitoring plots/trees	133 plots / 5,315 trees
Monitoring records	1st: Feb2012, 2nd: Dec 2012
2. Target operations	No operations
3. Target Species (confirmed by Monitoring)	8 species: :*Bruguiera sexangula (Bs),Heritirea fomes (Hf),Melaleuca leucadendron (Ml) ,Ceriops decandra (Cd),Pomgamia pinnata(Pp), Avicennia officinails (Ao) ,Aegiceras corniculatum (Ac),Sonneratia caseolaris (Sc)*



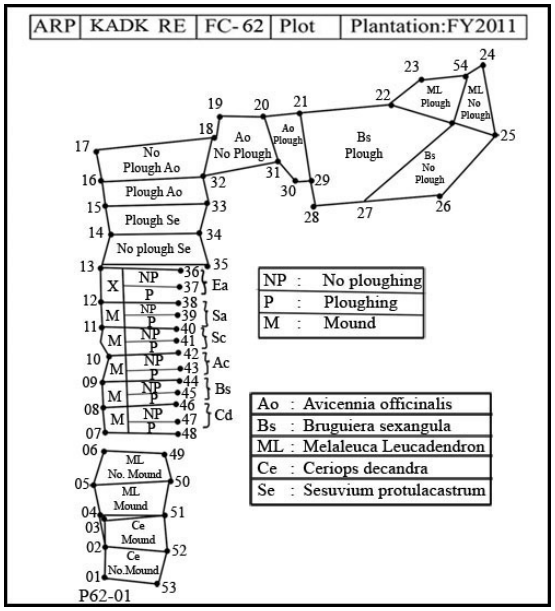
ARP map of FC-63, KADK RF(Base Map: Rapid Eye Image 2012)



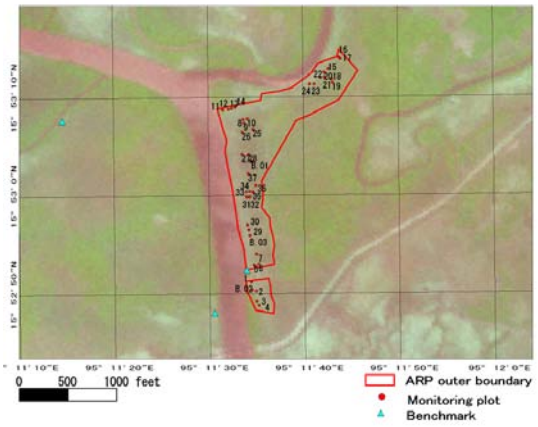
Sketch of ARP FC-63, KADK RF

9: ARP (KADK, FC-62)

Township	Bogalay(BGL)
Reserved Forest	Kadonkani (KADK)
Forest Compartment	FC-62
ARP reported area(area)	25
Planted year	FY2011
Target Monitoring plots/trees	37 plots / 5,426trees
Monitoring records	1st: Feb 2012, 2nd: Dec 2012
2. Target operations	Mound,Plough
3. Target Species (confirmed by Monitoring)	9 species: *Bruguiera sexangula (Bs),Heritirea fomes (Hf),Melaleuca leucadendron (Ml) ,Ceriops decandra (Cd) ,Casuarina equisetifolia (Ce), Avicennia officinalis (Ao) ,Aegiceras corniculatum (Ac),Sonneratia caseolaris (Sc),Excoecaria agallocha (Ea)*



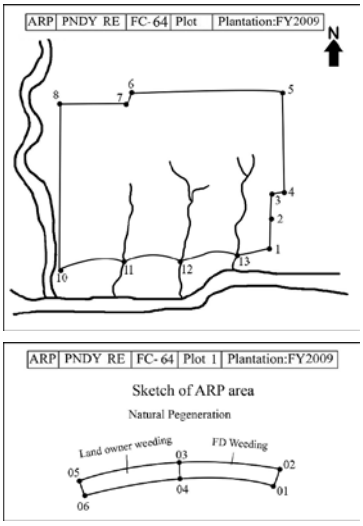
Sketch of ARP FC-62, KADK RF



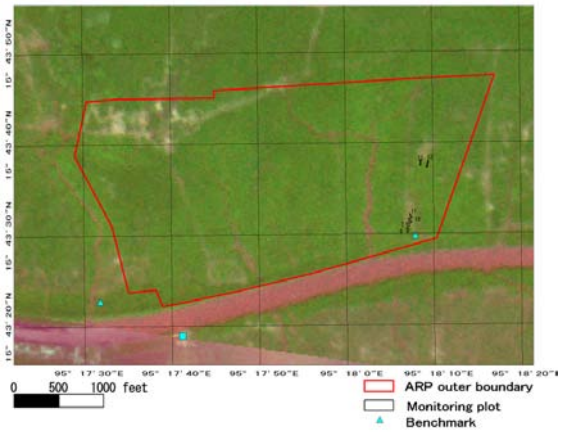
ARP map of FC-62, KADK RF
(Base Map: Rapid Eye Image 2012)

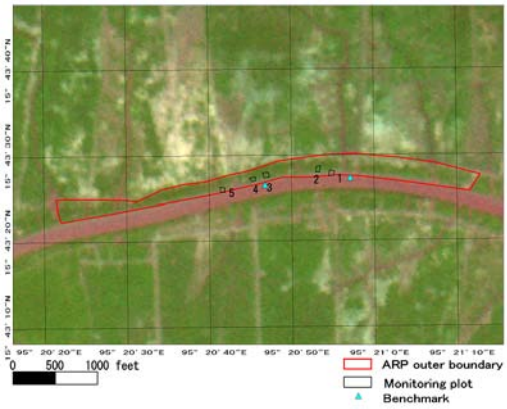
10: ARP (PNDY, FC-64)

Township	Pya Pon(PYP)
Reserved Forest	Pyindaye (PNDY)
Forest Compartment	FC-64
ARP reported area(area)	200
Planted year	FY2009
Target Monitoring plots/trees	16 plots / 1,233trees
Monitoring records	1st: Jan 2012, 2nd: Jan 2013
2. Target operations	weeding
3. Target Species (confirmed by Monitoring)	6species: *Excoecaria agallocha (Ea),Bruguiera sexangula (Bs),Heritirea fomes (Hf),Ceriops decandra (Cd), Avicennia marina (Am),Natural Regeneration.*



Sketch of ARP FC-64, PNDY RF

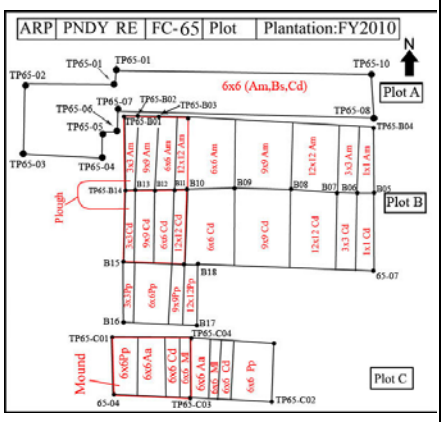




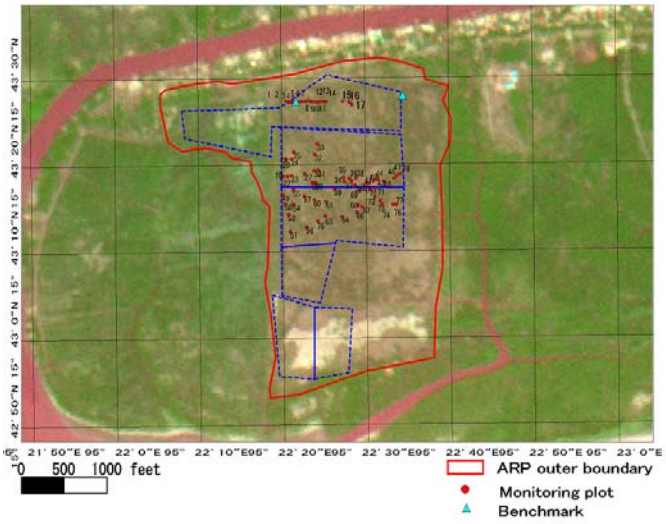
ARP map of FC-64, PNDY RF
(Base Map: Rapid Eye Image 2012)

11: ARP (PNDY, FC-65)

Township	Pya Pon(PYP)
Reserved Forest	Pyindaye (PNDY)
Forest Compartment	FC-65
ARP reported area(area)	80
Planted year	FY2010
Target Monitoring plots/trees	78 plots/ 3,929 trees
Monitoring records	1st: Jan 2012, 2nd: Jan 2013
2. Target operations	Ploughing
3. Target Species (confirmed by Monitoring)	4 species: *Avicennia officinalis (Ao),Avicennia marina (Am),Ceriops decandra (Cd),Bruguiera sexangula (Bs).*



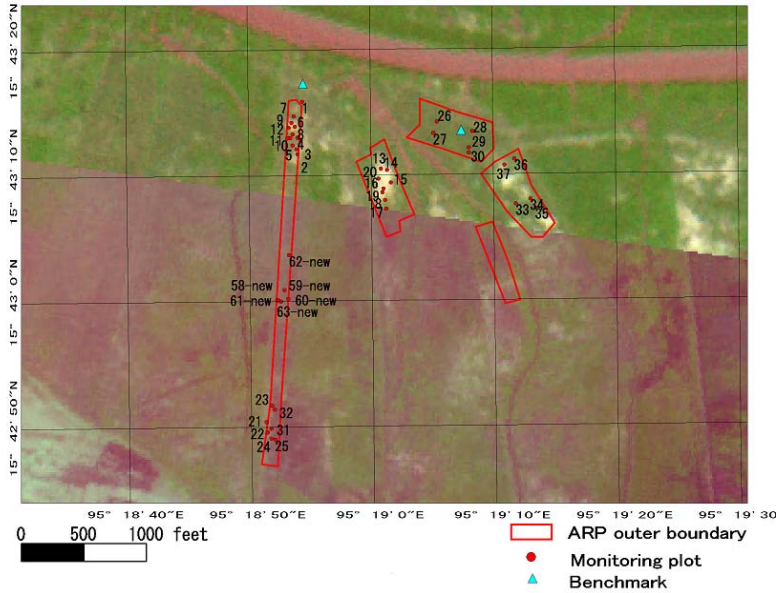
Sketch of ARP FC-65, PNDY RF



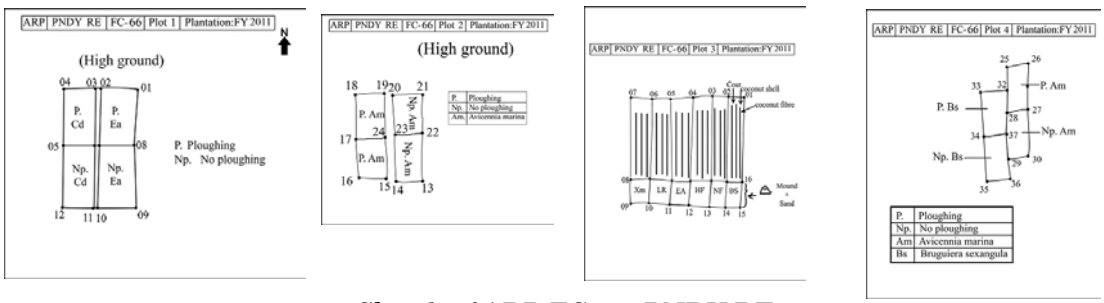
ARP map of FC-65, PNDY RF
(Base Map: Rapid Eye Image 2012)

12: ARP (PNDY, FC-66)

Township	Pya Pon(PYP)
Reserved Forest	Pyindaye (PNDY)
Forest Compartment	FC-66
ARP reported area(area)	19
Planted year	FY2011
Target Monitoring plots/trees	57 plots / 1,548trees
Monitoring records	1st: Jan 2012, 2nd: Jan 2013
2. Target operations	Mound, Ploughing
3. Target Species (confirmed by Monitoring)	9 species: *Bruguiera sexangular (Bs),Nypa fruticans (Nf),Ceriops decandra (Cd),Excoecaria agallocha (Ea),Lumnitzera racemosa (Lr),Xylocarpus moluccensis (Xm),Avicennia marina (Am),Pongamia pinnata (Pp),Melaleuca leucadendron*



ARP map of FC-66, PNDY RF(Base Map: Rapid Eye Image 2012)



Sketch of ARP FC-66, PNDY RF

Attachment-1-2: Record Format of ARP Monitoring

Township _____

Reserved Forest _____

FC No. _____

Plantation Year _____

Treatment type _____

Treatment Area (A) _____ acre

No.	tape No.	Species	Height (ft)	Girth (inch)	Survival (Yes/No)	Remarks
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						

Note: Girth is actually measured for tree with girth above 1 inch.
Tree which were judge to have girth less than 1 inch is recorded as 0.5 inch.

Plot Sketch

Summary

Treatment Type	
Monitoring Plot Size	
Monitoring Date	
Number of Planted Tree	
Number of Live Tree	
Number of Dead Tree	
Survival Rate (%)	
Mean Height (inch)	
Mean Girth (inch)	

GPS Point

		Latitude		Longtidue		
	Degree					
1						
2						
3						
4						

Attachment 1-3: Summary Record of ARP Monitoring Results

(Full contents in CD)

List of Contents

Attachment 1-4: Record of ARP Monitoring Results

(Full contents in CD)

List of Contents

Attachment 2-1: Record Format of Tidal Level Measurement

Tidal Level Measurement Record

Location (Name of site)

Monitoring period: from (DD/MM/YYYY)

to (DD/MM/YYYY)

Total ( ) days

Date	Time	Tide level (cm)	Remarks

Attachment 2-2: Tidal Level Measurement in KKKL Tidal Gage

Record of Tidal Level Measurement in KKKL Tidal Gage

Date_time	KKKL_Tide_cm
2012/2/20 0:00	54
2012/2/20 1:00	31
2012/2/20 2:00	27
2012/2/20 3:00	18
2012/2/20 4:00	11
2012/2/20 5:00	5
2012/2/20 6:00	12
2012/2/20 7:00	27
2012/2/20 8:00	42
2012/2/20 9:00	50
2012/2/20 10:00	56
2012/2/20 11:00	58
2012/2/20 12:00	52
2012/2/20 13:00	40
2012/2/20 14:00	27
2012/2/20 15:00	17
2012/2/20 16:00	10
2012/2/20 17:00	5
2012/2/20 18:00	14
2012/2/20 19:00	29
2012/2/20 20:00	46
2012/2/20 21:00	61
2012/2/20 22:00	67
2012/2/20 23:00	70
2012/2/21 0:00	68
2012/2/21 1:00	52
2012/2/21 2:00	37
2012/2/21 3:00	22
2012/2/21 4:00	12
2012/2/21 5:00	3
2012/2/21 6:00	4
2012/2/21 7:00	17
2012/2/21 8:00	33
2012/2/21 9:00	46
2012/2/21 10:00	55
2012/2/21 11:00	62
2012/2/21 12:00	64
2012/2/21 13:00	52
2012/2/21 14:00	38
2012/2/21 15:00	24
2012/2/21 16:00	13
2012/2/21 17:00	6
2012/2/21 18:00	3
2012/2/21 19:00	19
2012/2/21 20:00	35
2012/2/21 21:00	52
2012/2/21 22:00	63
2012/2/21 23:00	69
2012/2/22 0:00	71
2012/2/22 1:00	64
2012/2/22 2:00	43
2012/2/22 3:00	30
2012/2/22 4:00	17
2012/2/22 5:00	3
2012/2/22 6:00	0
2012/2/22 7:00	5
2012/2/22 8:00	23
2012/2/22 9:00	40
2012/2/22 10:00	51
2012/2/22 11:00	60
2012/2/22 12:00	66
2012/2/22 13:00	61
2012/2/22 14:00	44
2012/2/22 15:00	31
2012/2/22 16:00	17
2012/2/22 17:00	8
2012/2/22 18:00	0
2012/2/22 19:00	6
2012/2/22 20:00	24
2012/2/22 21:00	42
2012/2/22 22:00	58
2012/2/22 23:00	66
2012/2/23 0:00	72
2012/2/23 1:00	70
2012/2/23 2:00	56
2012/2/23 3:00	36
2012/2/23 4:00	21
2012/2/23 5:00	7
2012/2/23 6:00	0
2012/2/23 7:00	0
2012/2/23 8:00	14
2012/2/23 9:00	33
2012/2/23 10:00	49
2012/2/23 11:00	59
2012/2/23 12:00	68
2012/2/23 13:00	69
2012/2/23 14:00	57
2012/2/23 15:00	47
2012/2/23 16:00	25
2012/2/23 17:00	13
2012/2/23 18:00	4
2012/2/23 19:00	0
2012/2/23 20:00	17
2012/2/23 21:00	33
2012/2/23 22:00	56
2012/2/23 23:00	60
2012/2/24 0:00	67
2012/2/24 1:00	71
2012/2/24 2:00	63
2012/2/24 3:00	42

Date_time	KKKL_Tide_cm
2012/2/24 4:00	30
2012/2/24 5:00	13
2012/2/24 6:00	0
2012/2/24 7:00	0
2012/2/24 8:00	4
2012/2/24 9:00	25
2012/2/24 10:00	42
2012/2/24 11:00	54
2012/2/24 12:00	63
2012/2/24 13:00	69
2012/2/24 14:00	65
2012/2/24 15:00	42
2012/2/24 16:00	33
2012/2/24 17:00	18
2012/2/24 18:00	8
2012/2/24 19:00	0
2012/2/24 20:00	11
2012/2/24 21:00	27
2012/2/24 22:00	31
2012/2/24 23:00	55
2012/2/25 0:00	61
2012/2/25 1:00	68
2012/2/25 2:00	67
2012/2/25 3:00	49
2012/2/25 4:00	34
2012/2/25 5:00	22
2012/2/25 6:00	9
2012/2/25 7:00	0
2012/2/25 8:00	0
2012/2/25 9:00	17
2012/2/25 10:00	36
2012/2/25 11:00	51
2012/2/25 12:00	60
2012/2/25 13:00	68
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2012/2/25 16:00	40
2012/2/25 17:00	25
2012/2/25 18:00	12
2012/2/25 19:00	6
2012/2/25 20:00	0
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2012/2/25 22:00	24
2012/2/25 23:00	48
2012/2/26 0:00	54
2012/2/26 1:00	61
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2012/2/26 4:00	33
2012/2/26 5:00	24
2012/2/26 6:00	10
2012/2/26 7:00	5
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2012/2/26 18:00	19
2012/2/26 19:00	11
2012/2/26 20:00	6
2012/2/26 21:00	13
2012/2/26 22:00	20
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2012/2/27 0:00	47
2012/2/27 1:00	59
2012/2/27 2:00	63
2012/2/27 3:00	56
2012/2/27 4:00	43
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2012/2/27 6:00	16
2012/2/27 7:00	9
2012/2/27 8:00	2
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2012/2/27 10:00	23
2012/2/27 11:00	41
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2012/2/27 15:00	62
2012/2/27 16:00	49
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2012/2/28 2:00	58
2012/2/28 3:00	56
2012/2/28 4:00	45
2012/2/28 5:00	35
2012/2/28 6:00	26
2012/2/28 7:00	13

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2012/3/3 4:00	34
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2012/3/3 6:00	38
2012/3/3 7:00	36
2012/3/3 8:00	33
2012/3/3 9:00	30
2012/3/3 10:00	26
2012/3/3 11:00	22

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2012/3/3 15:00	29
2012/3/3 16:00	37
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2012/3/7 1:00	39
2012/3/7 2:00	20
2012/3/7 3:00	14
2012/3/7 4:00	5
2012/3/7 5:00	0
2012/3/7 6:00	4
2012/3/7 7:00	22
2012/3/7 8:00	42
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Date_time	KKKL_Tide_cm
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2012/3/8 2:00	37
2012/3/8 3:00	22
2012/3/8 4:00	8
2012/3/8 5:00	1
2012/3/8 6:00	0
2012/3/8 7:00	12
2012/3/8 8:00	32
2012/3/8 9:00	49
2012/3/8 10:00	60
2012/3/8 11:00	69
2012/3/8 12:00	73
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2012/3/8 14:00	42
2012/3/8 15:00	22
2012/3/8 16:00	14
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2012/3/8 18:00	0
2012/3/8 19:00	12
2012/3/8 20:00	33
2012/3/8 21:00	52
2012/3/8 22:00	64
2012/3/8 23:00	73
2012/3/9 0:00	78
2012/3/9 1:00	62
2012/3/9 2:00	43
2012/3/9 3:00	31
2012/3/9 4:00	14
2012/3/9 5:00	3
2012/3/9 6:00	0
2012/3/9 7:00	0
2012/3/9 8:00	19
2012/3/9 9:00	40
2012/3/9 10:00	55
2012/3/9 11:00	68
2012/3/9 12:00	77
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2012/3/9 14:00	60
2012/3/9 15:00	37
2012/3/9 16:00	22
2012/3/9 17:00	4
2012/3/9 18:00	0
2012/3/9 19:00	0
2012/3/9 20:00	11
2012/3/9 21:00	40
2012/3/9 22:00	56
2012/3/9 23:00	68
2012/3/10 0:00	78
2012/3/10 1:00	78
2012/3/10 2:00	66
2012/3/10 3:00	40
2012/3/10 4:00	24
2012/3/10 5:00	10
2012/3/10 6:00	3
2012/3/10 7:00	0
2012/3/10 8:00	4
2012/3/10 9:00	31
2012/3/10 10:00	51
2012/3/10 11:00	55
2012/3/10 12:00	79
2012/3/10 13:00	82
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2012/3/10 17:00	5
2012/3/10 18:00	0
2012/3/10 19:00	0
2012/3/10 20:00	6
2012/3/10 21:00	29
2012/3/10 22:00	46
2012/3/10 23:00	60

Attachment2-3 Ground Level of ARP Benchmarks

Ground Level of ARP Benchmarks

Absolute Ground Level of ARP Bench Marks

Date of Measurement: 8-May-12
Starting Time:

Location: RF: KKKP
FC: 17

Sr.	Point	A BS (From Water	B FS	C BM Height from water suface	D KKKL Tidal Level	E Mean Sea Water Level	F Height of KKKL guage from	G Absolute Ground Level for	Time	Date	Coordinates by GPS Longitude (East)	Latitude (North)	Remarks
1	ARP-KKKP-17 BM	72	73.4	-1.4	73	43.4	29.6	28.2	11:00	8-May-12	E94 39 55.8	N15 54 20.1	Finished

Date of Measurement: 8-May-12
Starting Time:

Location: RF: KKKP
FC: 19

Sr.	Point	BS (From Water	FS	BM Height from water suface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS Longitude (East)	Latitude (North)	Remarks
1	ARP-KKKP-19 BM-1	56.4	52.3	4.1	79	43.4	35.6	39.7	14:12	8-May-12	E94 45 17.0	N15 56 38.0	Finished
2	ARP-KKKP-19 BM-2	59.0	51.4	7.7	67	43.4	23.6	31.3	15:00	8-May-12	E94 44 25.6	N15 56 40.3	
3	ARP-KKKP-19 BM-3	84.7	50.4	34.3	50	43.4	6.6	40.9	15:50	8-May-12	E94 44 31.4	N15 56 22.2	Finished
4	ARP-KKKP-19 BM-4	97.2	49.9	47.3	34	43.4	-9.4	37.9	16:28	8-May-12	E94 44 36.1	N15 56 09.8	

Date of Measurement: 9-May-12
Starting Time:

Location: RF: KKKP
FC: 26

Sr.	Point	BS (From Water	FS	BM Height from water suface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS Longitude (East)	Latitude (North)	Remarks
1	ARP-KKKP-26 BM-1	56.9	60.5	-3.6	77	43.4	33.6	30	14:59	9-May-12	E94 43 01.1	N15 55 37.2	Finished
2	ARP-KKKP-26 BM-2	56.4	54	2.4	69	43.4	25.6	28	15:29	9-May-12	E94 43 36.3	N15 55 47.4	
3	ARP-KKKP-26 BM-3	67.7	50.9	16.8	56	43.4	12.6	29.4	16:12	9-May-12	E94 43 48.2	N15 55 31.8	
4	ARP-KKKP-26 BM-4	81.1	47.0	34.1	41	43.4	-2.4	31.7	10:28	10-May-12	E94 43 18.5	N15 55 48.1	Finished

Date of Measurement: 12-May-12
Starting Time:

Location: RF: PYNLN
FC: 60

Sr.	Point	BS (From Water Edge)	FS	BM Height from water suface (inch)	KKKL Tidal Level (inch)	Mean Sea Water Level (inch)	Height of KKKL guage from MSWL (inch)	Absolute Ground Level for BM (inch)	Time	Date	Coordinates by GPS Longitude (East)	Latitude (North)	Remarks
2	ARP-PYNLN-60 BM-1	63.6	43.4	20.2	66	43.4	22.6	42.8	14:58	12-May-12	E94 54 43.5	N15 49 21.1	
2	ARP-PYNLN-60 BM-2	106.3	22.6	83.8	19	43.4	-24.4	59.4	15:52	20-May-12	E94 54 39.6	N15 49 17.9	
3	ARP-PYNLN-60 BM-3	135.4	44.4	91.0	10	43.4	-33.4	57.6	17:43	20-May-12	E94 55 39.7	N15 49 02.6	
4	ARP-PYNLN-60 BM-4	124.8	41.3	83.5	12	43.4	-31.4	52.1	18:02	20-May-12	E94 55 30.7	N15 48 47.7	

Date of Measurement: 13-May-12
Starting Time:

Location: RF: PYNLN
FC: 66

Sr.	Point	BS (From Water Edge)	FS	BM Height from water suface (inch)	KKKL Tidal Level (inch)	Mean Sea Water Level (inch)	Height of KKKL guage from MSWL (inch)	Absolute Ground Level for BM (inch)	Time	Date	Coordinates by GPS Longitude (East)	Latitude (North)	Remarks
1	ARP-PYNLN-66 BM-1	107.5	38.9	68.6	25	43.4	-18.4	50.2	9:47	13-May-12	E94 50 58.5	N15 48 35.6	
2	ARP-PYNLN-66 BM-2	62.4	38.9	23.5	56	43.4	12.6	36.1	16:59	13-May-12	E94 50 47.9	N15 48 32.1	
3	ARP-PYNLN-66 BM-3	55.4	33.8	21.6	58	43.4	14.6	36.2	18:06	14-May-12	E94 51 13.6	N15 48 43.8	

Date of Measurement: 25-May-12
Starting Time:
Location: RF: KADK
FC: 36

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-KADK-36 BM-1	114	33.8	80.2	47	43.4	3.6	83.8	10:00	25-May-12	E95 11 34.7	N16 02 41.1	
2	ARP-KADK-36 BM-2	105.8	37.7	68.2	54	43.4	10.6	78.8	10:30	25-May-12	E95 11 50.4	N16 02 39.1	
3	ARP-KADK-36 BM-3	79.4	34.6	44.9	59	43.4	15.6	60.5	11:00	25-May-12	E95 12 08.5	N16 03 00.4	
4	ARP-KADK-36 BM-4	84.2	44.9	39.4	65	43.4	21.6	61.0	11:30	25-May-12	E95 11 16.3	N16 02 38.0	

Date of Measurement: 25-May-12
Starting Time:
Location: RF: KADK
FC: 39

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-KADK-39 BM-1	47.3	41.0	6.2	78	43.4	34.6	40.8	13:30	25-May-12	E95 11 08.7	N16 01 38.3	
2	ARP-KADK-39 BM-2	46.1	40.6	5.5	79	43.4	35.6	41.1	14:00	25-May-12	E95 11 01.5	N16 01 17.0	
3	ARP-KADK-39 BM-3	27.6	41.5	-13.9	78	43.4	34.6	20.7	14:25	25-May-12	E95 11 03.5	N16 01 43.2	
4	ARP-KADK-39 BM-4	39.1	38.2	1.0	75	43.4	31.6	32.6	14:47	25-May-12	E95 10 33.9	N16 01 25.9	

Date of Measurement: 25-May-12
Starting Time:
Location: RF: KADK
FC: 62

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-KADK-62 BM-1	130.3	41.5	88.8	21	43.4	-22.4	66.4	9:06	25-May-12	E95 11 33.9	N15 52 52.4	

Date of Measurement: 25-May-12
Starting Time:
Location: RF: KADK
FC: 63

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-KADK-63 BM-1	122.8	33.8	88.9	27	43.4	-16.4	72.5	9:35	25-May-12	E95 11 14.6	N15 53 07.7	
2	ARP-KADK-63 BM-2	112.8	37.2	75.6	34	43.4	-9.4	66.2	9:55	25-May-12	E95 11 30.5	N15 52 48.1	

Date of Measurement: 28-May-12
Starting Time:
Location: RF: PYNDY
FC: 64

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-PYNDY-64 BM-1	56.4	34.6	21.8	65	43.4	21.6	43.4	14:15	28-May-12	E95 20 46.8	N15 43 26.5	
2	ARP-PYNDY-64 BM-2	58.6	39.4	19.2	66	43.4	22.6	41.8	14:35	28-May-12	E95 20 57.1	N15 43 27.3	
3	ARP-PYNDY-64 BM-3	49.0	36	13.0	71	43.4	27.6	40.6	16:15	28-May-12	E95 18 07.9	N15 43 29.8	
4	ARP-PYNDY-64 BM-4	65.0	50.9	14.2	69	43.4	25.6	39.8	16:41	28-May-12	E95 17 31.8	N15 43 22.8	

Date of Measurement: 28-May-12
Starting Time:
Location: RF: PYNDY
FC: 65

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-PYNDY-65 BM-1	52.6	38.6	13.92	59	43.4	15.6	29.5	13:45	28-May-12	E95 22 21.7	N15 43 27.3	
2	ARP-PYNDY-65 BM-2	55.0	38.2	16.8	63	43.4	19.6	36.4	13:17	28-May-12	E95 22 34.5	N15 43 27.9	

Date of Measurement: 28-May-12
Starting Time:
Location: RF: PYNDY
FC: 66

Sr.	Point	BS (From Water	FS	BM Height from water surface	KKKL Tidal Level	Mean Sea Water Level	Height of KKKL guage from	Absolute Ground Level for	Time	Date	Coordinates by GPS		Remarks
											Longitude (East)	Latitude (North)	
1	ARP-PYNDY-66 BM-1	52.1	39.1	13.0	68	43.4	24.6	37.6	15:06	28-May-12	E95 19 07.4	N15 43 13.5	
2	ARP-PYNDY-66 BM-2	50.9	40.6	10.3	70	43.4	26.6	36.9	15:36	28-May-12	E95 18 54.5	N15 43 17.3	

Attachment 2-4: Record Format of Ground Level Measurement in BM

Measurement of Ground Level Sheet

Township/ R.F :
F.C No. :
Weather :

Date:
Surveyor I :
Surveyor II:

Sr.	Point Name(Station)	Backsight (feet/inch)	Foresight (feet/inch)	Coordinates by GPS							Turning Degree	Species	Plot No.	Remarks
				Longitude (East)			Lattitude (North)							
				D	M	S	D	M	S					

Attachment2-5 Record of Ground Level Measurement in Measurement Points

(Full Contents in CD)

List of Contents

Folder name	Sub folder name	File name
KKKP	Calculation Data	KKKP-FC-17-GL-Absolute.xlsx
		KKKP-FC-19-GL-Absolute.xlsx
		KKKP-FC-26-GL-Absolute.xlsx
	Encoding Data	KKKP_FC_17_GL_Encord.xls
		KKKP_FC_19_GL_Encord.xls
		KKKP_FC_26_GL_Encord.xls
PNLN	Calculation Data	PLNLN_FC60_GL_Absolute
		PPYNLN_FC66_GL_Absolute
	Encoding Data	PNLN_FC 60_GL_Encord
		PNLN_FC 66_GL_Encord
KADK	Calculation Data	KADK_FC_ 62_GL_Absolute
		KADK_FC_ 36_GL_Absolute
		KADK_FC_ 39_GL_Absolute
	Encoding Data	KADK _FC62_GL Encord
		KADK_FC_36_GL_Encord
		KADK_FC_39_GL_Encord
PNDY	Calculation Data	PNDY_FC64_GL_Absolute
		PNDY_FC65_GL_Absolute
		PNDY_FC66_GL_Absolute
	Encoding Data	PNDY_FC64_GL_Encord
		PNDY_FC65_GL_Encord
		PNDY_FC66_GL_Encord

Attachment2-6 Record of Soil Survey

(Full Contents in CD)

List of Contents

Attachment 3-1: Mangrove and Non-Mangrove Species Hand Book

List of Contents

Mangrove Tree List

Non-Mangrove Tree List

Attachment 3-2 : Nursery Information

(All Contents in CD)

List of Contents(CD)

Attachment 3-2 Nursery Information.xls

Attachment 3-3 : Current Condition of CFECNs (FY2012)

Current Condition of the CFECN (FY2012)

Recording Date: Oct 23, 2012

1. Name of CFECN:[TGT] Interviewee: U Thein Min Soe
2. Total Number of Nursery ponds[5] Nursery ponds
3. Planting Conditions

Ponds	Species Name	Planting Condition	Total Number of Seedlings	Period of sowing seeds
1	*Avicennia officinalis* *Avicennia marina*	(1. Pot) 2. Bare	22,200 (Mix*)	September
1	*Avicennia officinalis* *Avicennia marina*	1. Pot (2. Bare)	50,000 (Mix*)	September
2	None	1. Pot 2. Bare	-	-
3	*Avicennia officinalis* *Avicennia marina*	(1. Pot) 2. Bare	12,800 (Mix*)	September
3	*Bruguiera sexangula*	(1. Pot) 2. Bare	35,200	
3	*Bruguiera gymnorhiza*	(1. Pot) 2. Bare	16,000	
4	*Avicennia officinalis* *Avicennia marina*	(1. Pot) 2. Bare	78,062 (Ao:Am=1:9)	
5	None	1. Pot 2. Bare	-	-

Mix*:When FD purchases mangrove seeds from local communities, it is difficult to classify seeds *by species(Avicennia officinalis and Avicennia marina)* because of similar figure. Therefore, FD nurses mixed seeds in the same nursery bed.

4. Photo

TGT CFECN

Nursery No.2

Pot Seedlings

Left side: bare, Right side: pot

Date: Oct 23, 2012

1. Name of CFECN:[KKKL] Interviewee: U Hla Myint
2. Total Number of Nursery ponds:[6] Nursery ponds
3. Planting Conditions

Ponds	Species Name	Planting Condition	Total Number of Seedlings	Period of sowing seeds
1	*Bruguiera sexangula*	(1. Pot) 2. Bare	40,000	August -September
2	(Preparing BS)	1. Pot 2. Bare	(50,000)	-
3	(Preparing BS)	1. Pot 2. Bare	(50,000)	-
4	*Avicennia officinalis*	(1. Pot) 2. Bare	40,000	August -September
5	*Avicennia officinalis*	1. Pot (2. Bare)	50,000	August -September
6	None	1. Pot 2. Bare	-	-

Date: Oct 23, 2012

1. Name of CFECN:[TYK] Interviewee: U Hla Myint
2. Total Number of Nursery ponds[8] Nursfry ponds
3. Planting Conditions

Ponds	Species Name	Planting Condition	Total Number of Seedlings	Period of sowing seeds
1	*Avicennia officinalis*	1. Pot (2. Bare)	150,000	August
2	*Avicennia officinalis*	(1. Pot) 2. Bare	90,000	August
3	*Rhizophora mucronata*	(1. Pot) 2. Bare	90,000	August
4	*Avicennia officinalis*	(1. Pot) 2. Bare	90,000	August
5	*Sonneratia apetala*	1. Pot (2. Bare)	15,000	September
6	*Ceriops decandra*	(1. Pot) 2. Bare	75,000	May
7	*Avicennia officinalis*	(1. Pot) 2. Bare	90,000	August
8	*Avicennia officinalis*	1. Pot (2. Bare)	150,000	August

Current Condition of the CFECN (FY2012)

Date: 10-DEC-2012

1. Name of CFECN:[BYM] Interviewee:
2. Total Number of Nursery ponds:[10] Nursery ponds
3. Planting Conditions

Ponds	Species Name	Planting Condition	Total Number of Seedlings	Period of sowing seeds
1	*Sonneratia apetala*	(1. Pot) 2. Bare	20,000	Aug 2012
1	*Ceriops decandra*	(1. Pot) 2. Bare	22,000	Mar 2012
1	*Aegiceras corniculatum*	(1. Pot) 2. Bare	6,000	Jul 2012
1	*Sonneratia caseolaris*	(1. Pot) 2. Bare	20,000	Aug 2012
1	*Avicennia officinalis*	(1. Pot) 2. Bare	80,000	Sep 2012
	Sub-total		148,000	
2	*Bruguiera sexangula*	(1. Pot) 2. Bare	25,000	Apr 2012
2	*Aegiceras corniculatum*	(1. Pot) 2. Bare	10,000	Jul 2012
2	*Avicennia officinalis*	(1. Pot) 2. Bare	87,000	Sep 2012
	Sub-total		122,000	
3	*Heritiera*	(1. Pot) 2. Bare	7,000	Aug 2012
3	*Sonneratia apetala*	(1. Pot) 2. Bare	21,000	Aug 2012
3	*Bruguiera sexangula*	(1. Pot) 2. Bare	21,000	Apr 2012
3	*Ceriops decandra*	(1. Pot) 2. Bare	21,000	Mar 2012
3	*Aegiceras corniculatum*	(1. Pot) 2. Bare	21,000	Jul 2012
3	*Sonneratia caseolaris*	(1. Pot) 2. Bare	20,000	Aug 2012
3	*Avicennia officinalis*	(1. Pot) 2. Bare	60,000	Sep 2012
3	*Avicennia alba*	(1. Pot) 2. Bare	21,000	Sep 2012
3	*Excoecaria agallocha*	(1. Pot) 2. Bare	10,500	Aug 2012
	Sub-total		202,500	
4	Ceriops decandra	(1. Pot) 2. Bare	12,000	Mar 2012
4	Avicennia officinalis	(1. Pot) 2. Bare	50,000	Sep 2012
	Total		62,000	
5	Blank	1. Pot 2. Bare		
6	Avicennia officinalis	1. Pot (2. Bare)	100,000	Sep 2012
7	Avicennia officinalis	1. Pot (2. Bare)	130,000	Sep 2012
8	Avicennia officinalis	1. Pot (2. Bare)	150,000	Sep 2012
9	Sonneratia caseolaris	1. Pot (2. Bare)	170,000	Aug 2012
10	Avicennia officinalis	1. Pot (2. Bare)	170,000	Sep 2012
	Total Seedlings	Potted	534,500	(4 ponds)
		Bare	720,000	(5 ponds)

Pond no.	Size of the ponds	No. of seedlings bed
1	185' x 112'	74
2	182' x 108'	52
3	135' x 98'	58
4	117' x 95'	30
6	49' x 43'	
7	145' x 18'	
8	119' x 27'	
9	87' x 41'	
10	135' x 27'	

Attachment4 Monitoring Record of RMS

(Full Contents in CD)

List of Contents

	File name
1	RMS_KKKP.xls
2	RMS_Pyinalan.xls
3	RMS_KDKN.xls
4	RMS_Meinmahla .xls
5	RMS_PNDY.xls