Papua New Guinea
Forest Authority

CAPACITY DEVELOPMENT PROJECT FOR OPERATIONALIZATION OF PNG FOREST RESOURCE INFORMATION MANAGEMENT SYSTEM FOR ADDRESSING CLIMATE CHANGE

FINAL REPORT
(Main)

September 2019

JAPAN INTERNATIONAL COOPERATION AGENCY

KOKUSAI KOGYO CO., LTD.

GE
JR
19-044

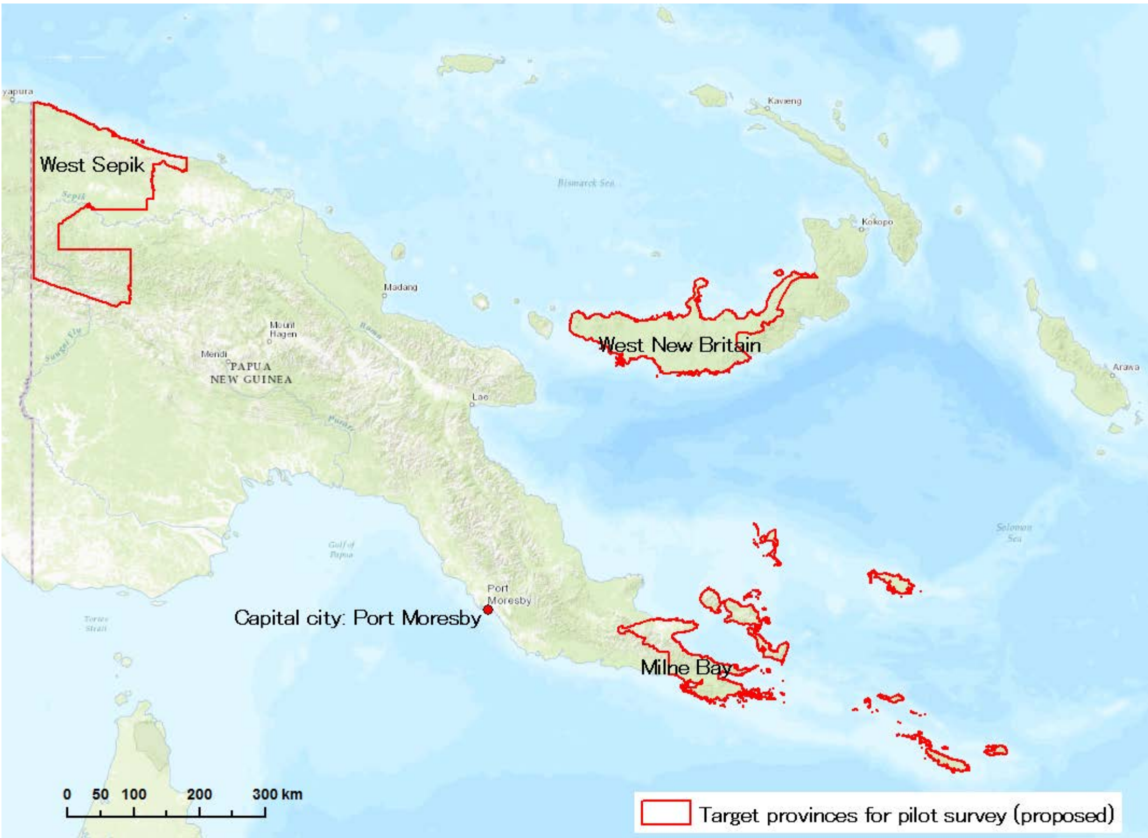
Project Area Map

Independent State of Papua New Guinea

Area: 462,840 km2 (Ministry of Foreign Affairs of Japan)

Population: 7,619,321 (2015, World Bank)

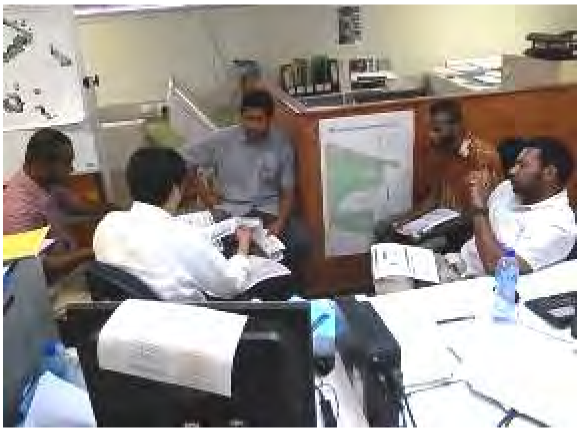
GNI per capita: 2,240 USD (2014, World Bank)



Introductory Photos: Status of Local Activities

August 2014 – September 2019

1st JCC (September, 2014)



Explanation to modify forest information (November, 2014)

Discussion of forest planning issues (November, 2014)

COP20 event organized by JICA-Peru office at climate change *feria*: case example of PNG forest conservation monitoring (December, 2014)

Interview with local staff in Milne Bay Province (February, 2015)

GIS demonstration at area office (May, 2015)

Introductory Photos: Status of Local Activities

August 2014 – September 2019

Logging road (width: 30-50 m) (May, 2015)

Condition of crown (after 2 years of selective logging) (May, 2015)

Discussion with staff at Milne Bay-area office (August, 2015)

Debriefing session during training in Japan at PNGFA HQ (September, 2015)

Explanation and Discussion of PINFORM at FRI (October, 2015)

Presentation by Mr. Gamoga at COP21 Japan Pavilion (December, 2015)

Introductory Photos: Status of Local Activities

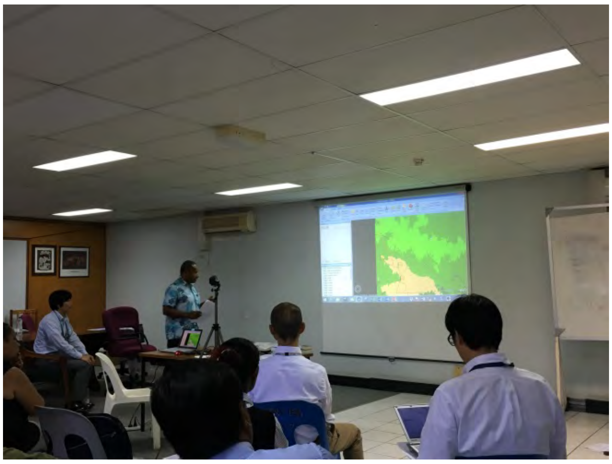
August 2014 – September 2019

Group discussion at the Project workshop (June, 2016)

Discussion about outputs, issues, and plans for future (February, 2017)

Preparation of logging road information (May, 2017)

Demonstration and discussion of utilization of LAN-Map (May, 2017)



Project workshop (August, 2017)

OJT on development of forest degradation driver (August, 2017)

Introductory Photos: Status of Local Activities

August 2014 – September 2019

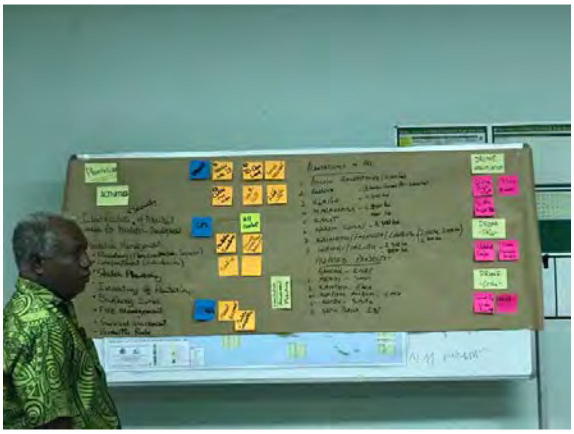
PNGFA internal Project debriefing session (November, 2017)

Visit to logging site (November, 2017)

Visit to logging site (November, 2017)

Land change simulation training (May, 2018)

Drone operational training at plantation site (June, 2018)



Discussion about possibility of drone utilization (June, 2018)

Introductory Photos: Status of Local Activities

August 2014 – September 2019

Training of forest monitoring by drone (February, 2019)

Discussion of drone utilization for forest monitoring (March, 2019)

Drone donation ceremony (March, 2019)

Report and discussion of FRL (May, 2019)

Project final seminar (July, 2019)

Project final seminar (documents developed in the Project activities) (July, 2019)

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Annexes

Annex 52: Presentation Material for MRV-TWG

List of Figures and Tables

Tables

Figures

Abbreviations

AAC	Annual Allowable Cut
ACQ Branch	Acquisition Branch
AD	Activity Data
ALOS	Advanced Land Observing Satellite
ALOS-2	Advanced Land Observing Satellite 2
ALP	Annual Logging Plan
BAU	Business as Usual
C/P	Counterpart
CCBS	Climate, Community & Biodiversity Standard
CCDA	PNG Climate Change and Development Authority
CDM	Clean Development Mechanism
CEPA	Conservation and Environment Protection Authority
CfRN	Coalition for Rainforest Nations
CLASLite	The Carnegie Landsat Analysis System Lite
COP	Conference of the Parties
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
DSM	Digital Surface Model
DSS	Decision Support System
EF	Emission Factors
ELE	Extracted Log Emissions
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCA	Forest Clearance Authority
FCPF	Forest Carbon Partnership Facility
FDD	Forest Development Directorate
FIMS	Forest Inventory Mapping System
FIPS	Forest Inventory Processing System
FLEGT	Forest Law Enforcement, Governance and Trade
FMA	Forest Management Agreement
FMU	Forest Management Units
FMU	Forest Mapping Unit
FMU	Forest Monitoring Unit
FPPD	Forest Policy & Planning Directorate
FREL	Forest Reference Emission Level
FRI	Forest Research Institute
FRL	Forest Reference Level
FSD	Field Services Directorate
FWP	Forest Working Plan
GCF	Green Climate Fund
GeoSAR	Geosynchronous Synthetic Aperture Radar
GHG	Green House Gases
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit

GPS	Global Positioning System
HCS	High Carbon Stock
HCVF	High Conservation Value Forests
HQ	Headquarters
ICT Branch	Information & Communication Technology Branch
ILG	Incorporated Land Group
I&M Branch	Inventory & Mapping Branch
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
ITTO	International Tropical Timber Organization
JAXA	Japan Aerospace eXploration Agency
JCC	Joint Coordinating Committee
JCM	Joint Crediting Mechanism
JICA	Japan International Cooperation Agency
JJ-FAST	JICA-JAXA Forest Early Warning System in the Tropics
LAN	Local Area Network
LANDSAT	Land Satellite
LCoP	Logging Code of Practice
LDF	Logging Damage Factor
LEAF	Lowering Emissions in Asia's Forests
LFA	Local Forest Area
LIF	Logging Infrastructure Factor
LULUCF	Land Use, Land Use Change and Forestry
MRA	Mineral Resource Authority
MRV	Measurement, Reporting and Verification
NAS	Network Attached Storage
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NFI	National Forest Inventory
NFP	National Forest Plan
NFRIMS	National Forest Resource Information Management System
NGO	Non-Governmental Organizations
NRS	National REDD+ Strategy
NSO	National Statistical Office
OCCD	Office of Climate Change and Development
OJT	On-the-Job Training
PAD	Project Allocations Directorate
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PaMs	Policies and Measures
PDM	Project Design Matrix
PFP	Provincial Forest Plan
PINFORM	PNG/ITTO Natural Forest Model
PMCP	Planning, Monitoring and Control Procedure
PNG	Papua New Guinea
PNGFA	PNG Forest Authority
PNG-FRIMS	PNG-Forest Resource Information Management System
PNGRIS	PNG Resource Information System

PRA	Participatory Rural Appraisal
PSP	Permanent Sample Plots
R/D	Record of Discussions
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
REL	Reference Emission Level
RESTEC	Remote Sensing Technology Center of Japan
RFIP	REDD+ Finance Investment Plan
RIL	Reduced Impact Logging
RS	Remote Sensing
SAR	Synthetic Aperture Radar
SABL	Special Agriculture and Business Leases
SFM	Sustainable Forest Management
SRTM	Shuttle Radar Topography Mission
TA	Technical Assessment
TLS	Timber Legality Standard
TLVS	Timber Legality Verification System
TRP	Timber Rights Purchase
TWG	Technical Working Group
UAV	Unmanned Aerial Vehicle
UN-REDD	The United Nations Collaborative Programme on REDD
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPNG	University of Papua New Guinea
USAID	United States Agency for International Development
VCS	Verified Carbon Standard
VM	Volume Method

Abbreviations of Papua New Guinea Province

CEN	Central
NCD	National Capital District
ORO	Oro
MIL	Milne Bay
GUL	Gulf
WES	Western
MOR	Morobe
MAD	Madang
ESK, ESP	East Sepik
WSK, WSP	West Sepik
SIM	Chimbu
ENG	Enga
EHY, EHP	Eastern Highlands
SHY, SHP	Southern Highlands
HLA	Hela
WHY, WHP	Western Highlands
JWK, JIW	Jiwaka
WNB	West New Britain

ENB	East New Britain
MAN	Manus
NIR, NIL	New Ireland
ARB	Autonomous Region of Bougainville

Currency Equivalents

As of September 2019

USD 1.00 = JPY 106.27

USD 1.00 = PGK 3.33

Chapter 1. Outline of the Project

1.1 Background of the Project

Papua New Guinea (hereinafter referred to as "PNG") contains some of the largest areas of tropical rainforest in the world. The tropical rainforest plays an important role for PNG in many aspects, contributing to the national economy through timber exports and rich biodiversity, and in recent years the tropical rainforest's potential to contribute to the mitigation of climate change has been discussed. On the other hand, the areas of forests in PNG decreased from 82% to 71% between 1972 and 2002[1], and deforestation and forest degradation are serious problems.

To address these problems, the Japan International Cooperation Agency (hereinafter referred to as "JICA") and PNG Forest Authority (hereinafter referred to as "PNGFA") implemented a three-year Technical Cooperation Project entitled "The Capacity Development on Forest Resource Monitoring for Addressing Climate Change in Papua New Guinea" (hereinafter referred to as "T/C") starting in March 2011, together with a Japanese Grant Aid Programme since 2010. The outputs of the T/C and Grant Aid Programme include an improved Nation-wide Forest Base Map and National Forest Resource Information Management System (hereinafter referred to as "NFRIMS") based on a Geographic Information System (GIS) system which enables the officers of PNGFA and other relevant government agencies to grasp the newest information concerning forest coverage, timber volume, and other information which had previously not been updated for a long period.

Although the T/C and the Grant Aid Programme provided immense support and assistance to PNGFA for attaining basic institutional capacity, there were several issues to be addressed, including the improvement of the following: capacity to update and manage forest coverage and stocks in a timely manner; efficiently utilize the forest monitoring system; and institutional reporting mechanisms and technical capacity for REDD+ reporting. To address these issues, the expansion and enhancement of NFRIMS must be developed so that it may serve as information infrastructure for systems used by PNGFA, allowing them to carry out their planning and works.

Against this background, in accordance with the Record of Discussions (R/D) signed and exchanged by JICA and the Government of PNG, a technical cooperation project entitled "Capacity Development Project for Operationalization of PNG Forest Resource Information Management System for Addressing Climate Change" (hereinafter referred to as "the Project") was implemented as a five-year project between August 2014 and August 2019, with PNGFA as the counterpart (C/P). Two long-term experts, a chief advisor, who was in charge of forest administration and climate change, and an expert in charge of forest planning and project coordination, were dispatched to PNG for the period between August 2014 and August 2019.

[1] Global Forest Resources Assessment 2010 Country Report, Papua New Guinea

Kokusai Kogyo Co., Ltd. contracted with JICA to supply short-term experts to participate in the Project on August 29, 2014. In this report, the outputs of the Project are summarized with a focus on the activities implemented by the short-term experts of Kokusai Kogyo Co., Ltd.

1.2 Purpose and Goal of the Project

The Project aimed to achieve the Project purpose through the implementation of Project activities in collaboration with the C/P and in cooperation with the long-term experts. The overall goal, Project purpose, outputs and activities of the Project are listed as follows. The Project Design Matrix (PDM) of the Project is shown in Annex 41.

(1) Overall Goal

Forests in PNG are conserved and managed in a sustainable manner, while at the same time, mitigation and adaptation measures against climate change are promoted.

(2) Project Purpose

Capacity of the PNGFA to continuously update forest information and to fully operationalize and utilize PNG Forest Resource Information Management System (hereinafter referred to as "PNG-FRIMS")[2] for promoting sustainable forest management and for addressing climate change is enhanced.

(3) Outputs

1: PNG-FRIMS is expanded and enhanced.

2: The national forest plan, provincial forest plans, forest management plans and their monitoring system are improved through steady operation of PNG-FRIMS.

3: Forest information for addressing REDD+ is prepared.

(4) Activities

[For Output 1]

Among the following activities, the short-term expert team provides technical assistance to the long-term experts in activities 1-1, 1-4 and 1-6; manages activities 1-2, 1-3 and 1-5 while obtaining advice from the long-term experts; and conducts activities 1-7, 1-8, 1-9 and 1-10 by themselves.

1-1. Examine and identify information to be added and integrated to PNG-FRIMS.

1-2. Lay out a basic design for expansion and enhancement of PNG-FRIMS.

1-3. Examine the approach of updating the forest base map.

1-3-1. Lay out a basic design for the method of detecting forest area changes with remote sensing technology.

[2] The designation of NFRIMS was changed to PNG-FRIMS in the preparatory survey for the Project.

1-3-2. Process and analyze the remote sensing data combining with ground truth on a trial basis.

1-3-3. Identify necessary additional information from other sources.

1-3-4. Develop the manual on updating the forest base map.

1-3-5. Update the forest base map for the forest area change detected in the pilot area(s) identified in activity 2-2-1.

1-4. Examine the method of developing and updating information on growing stock.

1-4-1. Examine the method for defining a new set of the forest management units in PNG-FRIMS based on the historical record of logging operation and vegetation type.

1-4-2. Examine the possibilities of integrating PINFORM (PNG International Tropical Timber Organization Natural Forest Model) into PNG-FRIMS.

1-4-3. Design and develop the database for calculating and recording harvested timber and timber growth on the basis of the activities 1-4-1 and 1-4-2.

1-5. Examine the method of reflecting the ground sample plot information on forest resources in the activities 1-3 and 1-4.

1-6. Examine the method, if necessary, of preparing information other than that described in the activities 1-3 and 1-4.

1-7. Develop a prototype of upgraded PNG-FRIMS based on the activities 1-1 to 1-6.

1-8. Operate the prototype on a trial basis and finalize PNG-FRIMS.

1-9. Develop a work manual of the PNG-FRIMS operation including field data collection.

1-10. Conduct trainings for keeping and improving the technical levels of PNGFA and other collaborators, particularly on remote sensing, GIS and database management necessary for the PNG-FRIMS operation.

[For Output 2]

Based on a review of the current status of the forest planning system in PNG by the long-term experts, the short-term expert team provides technical assistance to the long-term experts in activities 2-2 and 2-3.

2-2. Experiment a series of the operations of forest management plans; evaluation, advice, approval (or preparation) and monitoring by utilizing PNG-FRIMS, in the pilot area(s).

2-2-2. Examine the usage of PNG-FRIMS in the evaluation, advice, approval (or preparation) and monitoring of forest management plans.

2-2-3. Conduct a series of the operations of forest management plans through hands-on training for PNGFA officers in the evaluation, advice, approval (or preparation) and monitoring of forest management plans.

2-2-4. Determine how to utilize PNG-FRIMS in a series of the operations of forest management plans on the basis of the result of the activity 2-2-3.

2-3. Hold training workshops for PNGFA officers and other collaborators to disseminate the results from the pilot area(s).

[For Output 3]

Among the following activities, the Project team will manage activity 3-3 while obtaining advice from the long-term experts and provides technical assistance to the long-term experts in activities 3-4, 3-6 and 3-7.

3-3. Consider how to utilize PNG-FRIMS in the calculation of the forest reference emission level and forest reference level (FREL / FRL).

3-4. Identify the information which the PNGFA is able to provide, regarding necessary forest resource information for REDD+ activities, through the use of the PNG-FRIMS.

3-6. Provide technical input to committees established by the PNG Government relating to climate change as needed.

3-7. Conduct training for keeping up and improving the technical levels of PNGFA and other collaborators on measurement and reporting of forest carbon emissions and removals and FREL / FRL.

(5) Project Target Group

Target Group: Staff of PNG Forest Authority (PNGFA)

(6) Project Target Areas

Target Areas: The whole of PNG; pilot areas relevant to the Project including West New Britain Province, Milne Bay Province and West Sepik Province have been selected. Since logging projects in Milne Bay Province are not operated anymore during the Project, West Sepik Province has been selected for the reason that there are several sites which are relatively-easy to access and have logging projects in operation.

1.3 Work Flow and Input

1.3.1 Flow Chart of the Project

The flow chart of the Project is shown in Figure 1.3-1.

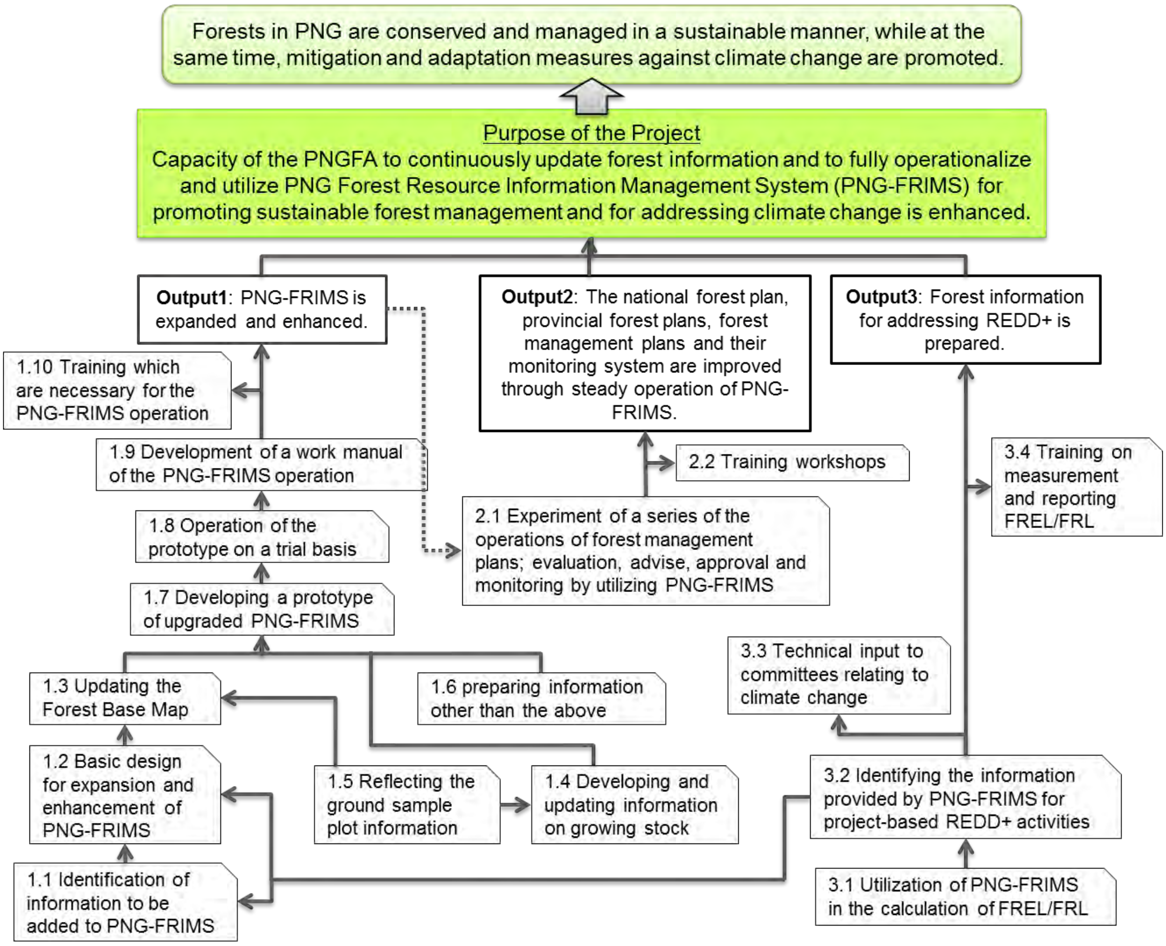
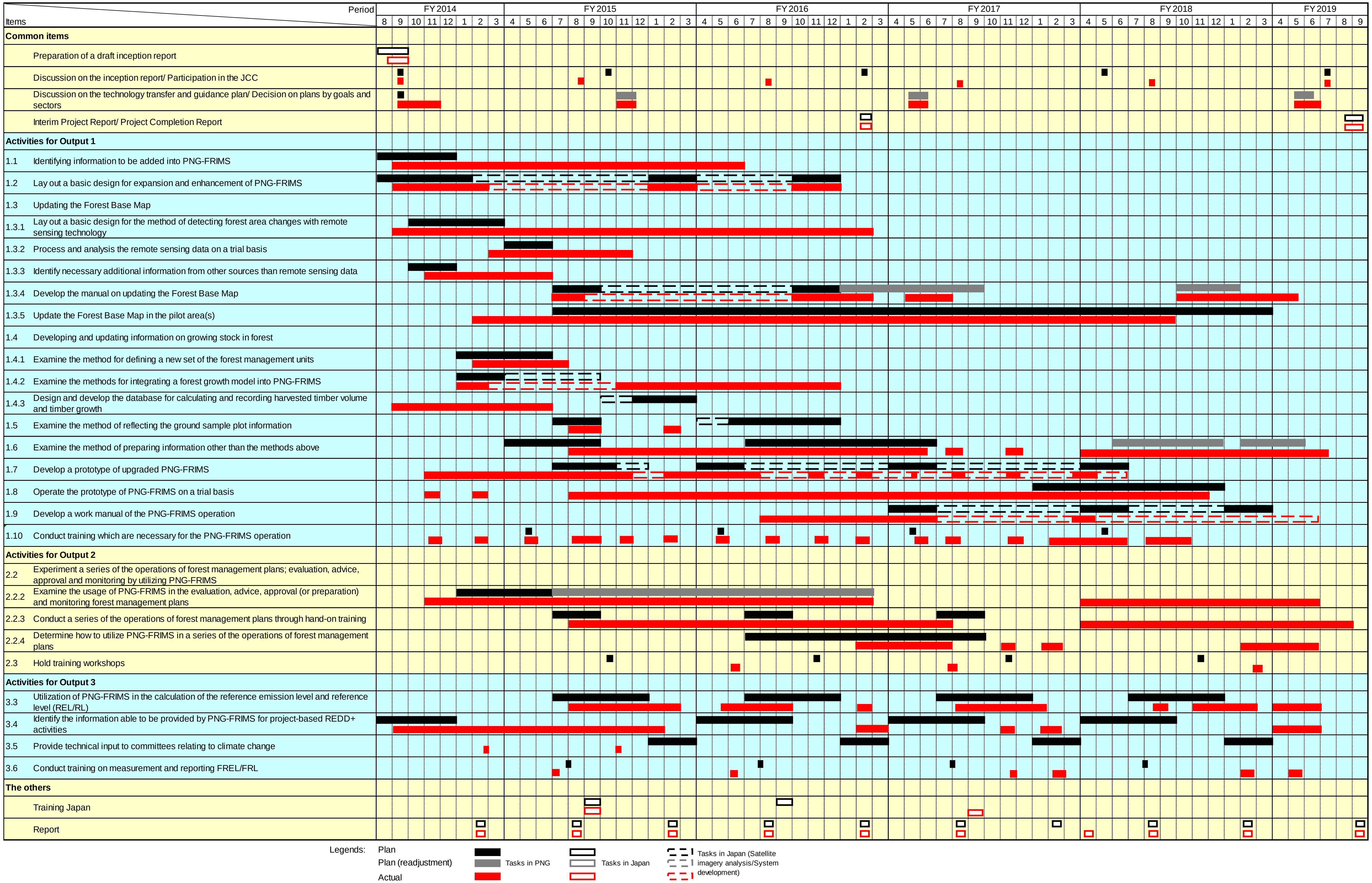


Figure 1.3-1 Implementation Flow of the Project

1.3.2 Implementation Flow of the Project

The correlation table for Project activities and achievements is shown in Table 1.3-1.

Table 1.3-1 Correlation Table for Project Activities and Achievements



1.3.3 Short-term Expert Assignment

The short-term expert assignments are shown in Table 1.3-1.

Table 1.3-1 Short-term Expert Assignments

Short-term experts (FY 2014 – 2016)

	Duty	Name	Grading	FY2014								FY2015												FY2016											
				8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Work in PNG	Team leader /Forest remote sensing 1 /Forest GIS 1	Masamichi HARAGUCHI	4		15			12	8	(8)	8							12				7						8						7	
	Sub-Team leader /Forest remote sensing 2 /Forest GIS 2	Ayako OCHI	3		22		29			22			22			29			29			15				22		22			22			22	
	Forest database 1	Yasuyuki OKADA	3		22		22			22			22			22			15			22				22		22				22		12	
	Forest database 2 /Database management	Takahiro KOIDE	4		22		29			29			29			36			36			16			22			22			36			29	
	REDD+ project planning assistance	Stéphane SALIM	3		15		15			8			29			15				15						22								16	
	Forest database 3	Hirokazu TAKAHASHI	4																																
Work in Japan	Team leader /Forest remote sensing 1 /Forest GIS 1	Masamichi HARAGUCHI	4	2																															
	Sub-Team leader /Forest remote sensing 2 /Forest GIS 2	Ayako OCHI	3			12		7	7		2	2		1	5	3	4	1		1			1							1					
	Forest database 1	Yasuyuki OKADA	3			8		8	3		3	3		3			1	2			1	2	3				1	1	1	1		1			1
	Forest database 2 /Database management	Takahiro KOIDE	4	4																															
	REDD+ project planning assistance	Stéphane SALIM	3																																
	Forest database 3	Hirokazu TAKAHASHI	4																																
	Satellite imagery analysis 1	Yoko HIROSE	3					3			1	1	3	2	2	2	1.5	1				1													
	Satellite imagery analysis 2	Noritoshi KAMAGATA	4								1	2	3	2	6	4	3	2		1				2											
	Requirement definition /System designing 1	Osamu OCHIAI	3						2	2	2	2	1	1	1					2	2		2		1										
	Requirement definition /System designing 2	Junichi OZAKI	4						2	2	2	2	4	2	2	2			4	3	8	4	6	4	2	2	2	1	1			1	2		
	Training in Japan 1	Yasuyuki OKADA	3														12																		
	Training in Japan 2	Takahiro KOIDE	4														12																		
	Training in Japan 3	Ayako OCHI	3																																
Reports, etc.	Report				▲ Ic/R					▲ P/R1						▲ P/R2						▲ P/R3						▲ P/R4						▲ I/R	
	JCC/Workshop				▲ JCC1											▲ JCC2			▲ WS									▲ JCC3							

Legend: ■ : Work in PNG　▨ : Burden borne by KKC
□ : Work in Japan

Short-term experts (FY 2017 – 2019)

	Duty	Name	Grading	FY2017												FY2018												FY2019						Man Manth	
				4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	PNG	Japan
Work in PNG	Team leader /Forest remote sensing 1 /Forest GIS 1	Masamichi HARAGUCHI	4					8			6		12							7		1			6						16			4.43	
	Sub-Team leader /Forest remote sensing 2 /Forest GIS 2	Ayako OCHI	3		22			22			29							22		14	7						21	10			21			14.13	
	Forest database 1	Yasuyuki OKADA	3		8			22			22					22					16													10.50	
	Forest database 2 /Database management	Takahiro KOIDE	4		25			22			26						19					20									15			14.43	
	REDD+ project planning assistance	Stéphane SALIM	3								11			22												22			12					6.73	
	Forest database 3	Hirokazu TAKAHASHI	4															22				20				22			19		5 5			3.10	
																																		53.33	
Work in Japan	Team leader /Forest remote sensing 1 /Forest GIS 1	Masamichi HARAGUCHI	4																																0.10
	Sub-Team leader /Forest remote sensing 2 /Forest GIS 2	Ayako OCHI	3	1						1		1		1	2	2	1																		2.80
	Forest database 1	Yasuyuki OKADA	3		2	1				1		1	2		1	1	3	1																	2.80
	Forest database 2 /Database management	Takahiro KOIDE	4																																0.20
	REDD+ project planning assistance	Stéphane SALIM	3																																0.00
	Forest database 3	Hirokazu TAKAHASHI	4																																0.00
	Satellite imagery analysis 1	Yoko HIROSE	3											1																					0.93
	Satellite imagery analysis 2	Noritoshi KAMAGATA	4		1								0.5			1																			1.43
	Requirement definition /System designing 1	Osamu OCHIAI	3	1		1									1	1																			1.10
	Requirement definition /System designing 2	Junichi OZAKI	4		1					1			1	2	1																				3.20
	Training in Japan 1	Yasuyuki OKADA	3																																0.60
	Training in Japan 2	Takahiro KOIDE	4																																0.60
	Training in Japan 3	Ayako OCHI	3						24																										1.20
																																			14.95
Reports, etc.	Report							P/R5								P/R6				P/R7						P/R8							F/R	53.33	14.95
	JCC/Workshop							JCC4												JCC5			WS								JCC6			68.28	

Development of Database / Software (FY 2014 – 2016)

	Duty	Name	Grading	FY2014								FY2015												FY2016											
				8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
Development of Database/Software	Database architecture 1	Ayako OCHI	SE 1							2	1	1	2	4	5						2				7	4			5		3	4	5		2
	Database architecture 2	Zenichi CHIBA	SE 2								1	1	8	11	10	8		2	2				1	4	6	7			3	5	5	5	4		
	Database architecture 3	Taira NAKANISHI	SE 2												5		1		2	2			3	10	13			1	6	7	5	5.5	4		2
	Database architecture 4	Takahiro KOIDE	PG								6	7	1	2			2	10		4	3				6		2.5	1	1	0.5					
	Database architecture 5	Michiko MASUNAGA	PG																					6	12	9	12	9	7	8	2	3		2	3
	System engineer 1	Yasuyuki OKADA	SE 1												8	3	1	1	2	7			1	5	4	3	2	2	2		2	2.5			1
	System engineer 2	Keiji YANADA	SE 1													1		6	6	5.5	5	10	2					4	2			3			2
	Programmer 1	Gakumin KATO	SE 2													3	3		9	10	8	8	9	8		4	4		3						1
	Programmer 2	Eita HORISHITA	SE 2													3	3		11	7	7	7	13	3	1			2	5	5	5	2	1	1	

Legend: ☐ : Work in Japan

Development of Database / Software (FY 2017 – 2019)

	Duty	Name	Grading	FY2017												FY2018												FY2019						Man Manth	
				4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	PNG	Japan
Development of Database/Software	Database architecture 1	Ayako OCHI	SE 1		7	3	2		2	1							2		3	5	2	1	5	8	6	6	1		1						5.10
	Database architecture 2	Zenichi CHIBA	SE 2	4.5	1	4	1		2	5	5	3					2	9	5	5	6	3	4	3	2.5	3			1						7.60
	Database architecture 3	Taira NAKANISHI	SE 2			10		1	8	5				1	4			7	5	7	5	5	3.5	4											6.60
	Database architecture 4	Takahiro KOIDE	PG	2	1		1	1									3		4	9		1	2	3											3.65
	Database architecture 5	Michiko MASUNAGA	PG	3	1	4	2										1	1	2	5	7	2	3	1		2									5.35
	System engineer 1	Yasuyuki OKADA	SE 1			1				1		1		2	2	1	13	7	3	8	4	5	4	3											5.08
	System engineer 2	Keiji YANADA	SE 1									1	3	1	2		10	2		4				2											3.58
	Programmer 1	Gakumin KATO	SE 2	4	3							2	3	7			3	13	13		9	12	8	4	3										7.70
	Programmer 2	Eita HORISHITA	SE 2							1	4			5			11	3	15	11															6.30
																																			50.95

1.3.4 Operating Costs

Operating costs are shown in Table 1.1-2.

Table 1.1-2 Operating Costs

	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Total
Employee	1,681,679	1,316,998	43,198	255,454	1,852,391	2,852,736	8,002,456
Vehicle	2,111,233	2,340,915	2,095,381	1,882,846	2,514,810	774,289	11,719,474
Equipment maintenance	7,406,272	0	0	0	0	0	7,406,272
Expendable	63,777	346,659	15,597	0	163,493	960,954	1,550,480
Travel and Transport	52,499	148,944	0	0	107,934	54,044	363,421
Communication and	174,273	106,113	89,184	109,129	69,289	54,137	602,125
Documentation	24,000	9,500	0	0	120,988	1,346,128	1,500,616
Miscellaneous	3,708,090	12,000	0	0	1,736,112	0	5,456,202
Total	15,221,823	4,281,129	2,243,360	2,247,429	6,565,017	6,042,288	36,601,046

1.3.5 Equipment Provided

A list of equipment and goods provided is shown in Table 1.1-3.

Table 1.1-3 List of Equipment and Goods Provided

JFY	Item	Specification, Model	Quantity	Purchase Price	Currency	In Japanese Yen	Date of Purchase	Location	Current State	Financial Category
2014	Mobile internet modem	HUAWEI WIFI	1	208	PGK	8,915	2014/8/31	PNGFA HQ	Being used	Expendable
2014	External HDD	Toshiba USB Portable HDD 2TB Y32PPC4ATXR6	1	570	PGK	25,790	2014/10/23	PNGFA HQ	Being used	Expendable
2014	ArcGIS licens and maintenance services	ArcGIS for Server Enterprise Standard, maintenace service for ArcGIS for Desktop Basic CU primary、 ArcGIS for Desktop Basic CU secondary、 ArcGIS for Desktop Advanced CU primary、 ArcGIS for Desktop Advanced CU secondary、 ArcGIS Spatial Analyst for Desktop CU primary,ArcGIS 3D Analyst for Desktop CU primary、 ArcGIS for Desktop Standard primary、 ArcGIS for Desktop Standard CU secondary.	1	6,672,320	JPY	6,672,320	2014/12/26	PNGFA HQ	Being used	Equipment maintenance
2014	ArcGIS licens and maintenance services	Maintenance services for ArcGIS Spatial Analyst for Desktop CU secondary, ArcGIS 3D Analyst for Desktop CU Secondary	3	733,952	JPY	733,952	2014/12/26	PNGFA HQ	Being used	Equipment maintenance
2014	Mobile internet modem	HUAWEI WIFI	1	249	PGK	11,887	2015/1/12	PNGFA HQ	Being used	Expendable
2014	PC software license (Land Change Modeler)	Land Change Modeler 2.0 General License	1	395	USD	47,590	2015/1/20	PNGFA HQ	Being used	Miscellaneous
2014	Mobile internet modem	HUAWEI WIFI	1	249	PGK	11,485	2015/2/9	PNGFA HQ	Being used	Expendable
2014	PC software license (ENVI)	ENVI Floating License for windows	1	1,240,000	JPY	1,240,000	2015/2/27	PNGFA HQ	Being used	Miscellaneous
2014	PC software license (SARscape)	SARscape Basic for Windows	1	2,400,000	JPY	2,400,000	2015/2/27	PNGFA HQ	Being used	Miscellaneous
2015	NAS (Network Access Storage)	QNAP TS-431 NAS Enclosure Seagate 4Tb SATA 3.5"HDD	1	4,065	PGK	190,282	2015/6/4	PNGFA HQ	Being used	Equipment
2015	External HDD (3TB)	IBM 1Tb 2.5" SAS HDD 81Y9690	5	6,150	PGK	287,881	2015/6/23	PNGFA HQ	Being used	Expendable
2015	USB hub	Shintaro USB3.0 PCI-e x Port Card-2 Ext and 1 Int	7	991	PGK	41,884	2015/11/19	PNGFA HQ	Being used	Expendable
2015	Mobile internet modem	HUAWEI WIFI	1	399	PGK	16,025	2016/2/1	PNGFA HQ	Being used	Expendable
2016	Mobile internet modem	HUAWEI WIFI	1	420	PGK	15,226	2016/5/16	PNGFA HQ	Being used	Expendable
2018	PC software license (Pix4D Mapper)	Pix4D Mapper	1	295,000	JPY	295,000	2018/6/15	PNGFA HQ	Being used	
2018	Tablet PC for Deones	SIM free tablet	1	38,380	JPY	38,380	2018/10/10	PNGFA HQ	Being used	Expendable
2018	Drone equipment	PA POWER SUPPLY SI#370 4460	1	750	PGK	25,937	2018/10/18	PNGFA HQ	Being used	Expendable
2018	Tablet holder for drone receiver	DOUPRO DJI Mavic 2 pro, Mavic 2 Zoom, DJI Spark, Mavic Air	4	11,200	JPY	11,200	2019/1/4	PNGFA HQ	Being used	Equipment
2018	Protector for Drone	DJI MA2P15(Mavic 2 Part15 Pro Gimbal Protector	4	7,408	JPY	7,408	2019/1/10	PNGFA HQ	Being used	Equipment
2018	Protector for Drone	DJI MA2P14(Mavic 2 Part14 Propeller Guard)	4	11,852	JPY	11,852	2019/1/10	PNGFA HQ	Being used	Equipment
2018	Tablet PC for Drones	Apple ipad mini 4	2	91,592	JPY	91,592	2019/1/10	PNGFA HQ	Being used	Expendable
2018	PC software license (Gspro Mapper)	DJI GS Pro,KLM/SHP File Import	2	11,112	JPY	11,112	2019/2/3	PNGFA HQ	Being used	Miscellaneous
2018	Drone set	DJI MAVIC 2 PRO, batteries and accessories	2	26,824	PGK	887,393	2019/2/11	PNGFA HQ	Being used	Equipment
2018	Laptop PC set	LAPTOP HP 450G5i7-8550U 256GB PROBOOK I5 8G W10P64&BACKPAC and Ms office	2	11,121	PGK	367,911	2019/2/11	PNGFA HQ	Being used	Equipment
2018	Hard case and key for drones	TOOL BOX MODULAR LOCKABLE TACTIX 6120421 371×304mm, PADLOCK 40mm LONG SHK FORTRESS MASTERLOCK FM1840DL	2	528	PGK	17,467	2019/2/11	PNGFA HQ	Being used	Equipment
2018	Drone adapter	3 Pin Adaptor	2	7	PGK	234	2019/2/12	PNGFA HQ	Being used	Equipment
2018	PC software license (Pix5D Mapper)	Pix4D Mapper	1	800,000	JPY	800,000	2019/3/20	PNGFA HQ	Being used	Miscellaneous
2018	Desktop PC set	Desktop-HP 800 Elite Desk G4 i7-8700, HP Pro Display P232 23"VGA DP TILT VESA, UPS 700VA/420W Brick 10A LCD Cyber Power and MS office.	1	9,422	PGK	315,732	2019/3/29	PNGFA HQ	Being used	Equipment
2019	HDD for NAS	Storage-Synology DiskStation DS918+4-Bay 3.5"Diskless 4GB 2xGbE 4GB Storage-Synology 4GB RAM fo2xGbE 4GB for DS718+DS218+DS918+DS418 Play Storage-Synology IronwoIf Pro 8TB 3.5" SATA3 7200RPM5Yr	5	9,814	PGK	330,759	2019/5/30	PNGFA HQ	Being used	Equipment

1.3.6 Local Sub-contracting

Local sub-contracting was utilized for the additional tasks related to Remote Sensing (RS) and GIS to expand and enhance PNG-FRIMS. TOR of sub-contracting is shown in Annex 42. Outputs are included in Annex 8 and Annex 25.

Contract: Consulting Service for Management and Analysis of Forest Resource Information

Contractor: Raro GeoSpatial Solutions

Period of the service: 18 May 2018 – 31 December 2018

Amount of contract: 248,774.00 PGK (8,511,000 JPY)

1.4 Project Operations

1.4.1 Joint Coordinating Committee

The Joint Coordinating Committee (JCC) met six times annually. The outputs, progress and challenges of the Project were explained to and discussed with the PNG side at the JCC meetings, and future Project plans were approved by JCC participants. An overview of JCC meetings is given in Table 1.4-1. The documents related to the JCC meetings, such as agendas, presentations and minutes of meetings are attached in Annex 43.

Table 1.4-1 Dates and Agenda of JCC Meetings

	Date	Items on the Agenda
1st	19th September 2014	- Review of the Project - Review on overall progress of the Project activities - Plan of operations and the annual work plan of the Project - Confirmation of schedule of next JCC meeting - Confirmation of Minutes of Agreement (MoA) on Mapping and GIS Data Sharing with relevant institutions
2nd	19th August 2015	- Review of overall progress and achievements of the Project activities - Plan of operation and the annual work plan of the Project - Suggestion of the number of provinces, which is not defined, for ‘objectively verifiable indicators’ for ‘Overall Goal’ in the PDM of the Project
3rd	25th August 2016	- Review of overall progress of the Project activities - Plan of operation and the annual work plan of the Project - Definition of the number of provinces for ‘objectively verifiable indicators’ for ‘Overall Goal’ in the PDM of the Project - Confirmation of how to deal with ‘FREL development’ in Project Activity 3.7.
4th	11th August 2017	- Review on overall progress of the Project activities - Plan of operation and the annual work plan of the Project - Confirmation of management of ICT items procured by JICA projects and Japanese Grant Aid
5th	8th August 2018	- Review of overall progress and achievements of the Project activities - Plan of operation and the annual work plan of the Project

		- Review of improvement of technical operations for forest planning system utilizing PNG-FRIMS - Review of improving efficiency of forest monitoring system utilizing RS techniques - Evaluation of GIS / Global Positioning System (GPS) training
6th	2nd August 2019	- Review of output and evaluation of the Project - Review of other issues for future (updating ICT items, management of data and information in PNG-FRIMS, and next Project application) - Report on the training in Japan by trainees

1.4.2 Technology Transfer

The plan of technology transfer and guidance for the C/P was discussed with the C/P and a Technology Transfer Plan describing a concrete plan for the guidance for each sector was drawn up in November 2014. In November 2015, the Technology Transfer Plan was reviewed in consideration of the progress of the Project and the results of the technology transfer implemented in the first year, and then the plan was updated as the second version (September 2015 version). The technology transfer policy, training content and achievements are summed up as Technology Transfer Plan and Achievements Final Report (July 2019 version) (Annex 44).

With the purpose of developing the advanced capacity of the C/P officers engaged in RS and forest GIS, two types of training in Japan were held twice during this Project, in 2015 and 2017. The training sessions were in the fields of database and RS / GIS. There were four trainees in each training, with three attending both training sessions, and five trainees in total. An overview of the training sessions in Japan is given in Table 1.4-2 and Table 1.4-3.

Table 1.4-2 First Training in Japan

Training	Database Training	RS / GIS Training
Trainee (Position)	Mr. LA'A Patrick Lionel Cartographer, Forest Policy and Planning Directorate, PNGFA Mr. SIGAMATA Jason Desktop / Network Technician, Information & Communication Technology (ICT) Branch, Corporate Services Directorate, PNGFA	Mr. ANTIKO Jehu Cartographer, Forest Policy and Planning Directorate, PNGFA Mr. PAKURE Charles Alfred Project Officer, Southern Project Allocation Directorate, PNGFA
Date	September 5, 2015 (arrival date) – September 19, 2015 (departure date)	
Program	Database	RS / GIS

<table>
<tr><td rowspan="5">First week</td><td>Mon</td><td colspan="2">- JICA briefing
- Introduction (logistics, schedule, training purpose, and forest monitoring)</td></tr>
<tr><td>Tue</td><td>- FIMS/FIPS setup and review (including installation of SQLServer / ArcServer)
- Review of forest data in PNG-FRIMS</td><td rowspan="3">- Basis of RS
- Procurement and preprocessing of RS data (LANDSAT imagery, Annual Greenest Pixel, Hansen data, PALSAR data, etc.)
- Basis of GIS
- Topographic analysis</td></tr>
<tr><td>Wed</td><td rowspan="3">- Introduction of ArcGIS for Server Web services
- Introduction of ArcGIS for Web Mapping API</td></tr>
<tr><td>Thu</td></tr>
<tr><td>Fri</td><td>- Practice of forest monitoring</td></tr>
<tr><td rowspan="5">Second week</td><td>Mon</td><td>- Review of first week training</td><td rowspan="3">- Basis and principle of RS (optical / Synthetic Aperture Radar (SAR))
- Land cover classification analysis using SAR</td></tr>
<tr><td>Tue</td><td rowspan="3">- Discussion of forest management issues and practical work (data editing and GIS application designing and construction)
- Report preparation</td></tr>
<tr><td>Wed</td></tr>
<tr><td>Thu</td><td>- Land cover change analysis using PALSAR-2
- Report preparation</td></tr>
<tr><td>Fri</td><td colspan="2">- Wrap-up presentations by trainees
- Introduction of JICA work for natural environment conservation
- Certificate conferment</td></tr>
</table>

Table 1.4-3 Second Training in Japan

<table>
<tr><td colspan="2">Trining</td><td>PNG Forest Resource Monitoring / Data Management Training</td></tr>
<tr><td colspan="2">Trainee (Position)</td><td>Mr. LA'A Patrick Lionel
Cartographer, Forest Policy and Planning Directorate, PNGFA
Mr. ANTIKO Jehu
Cartographer, Forest Policy and Planning Directorate, PNGFA
Ms. SUMAREKE Agnes Mone
Research Officer, Forest Research Institute (FRI)
Mr. PAKURE Charles Alfred
Project Officer, Southern Project Allocation Directorate, PNGFA</td></tr>
<tr><td colspan="2">Date</td><td>September 5, 2017 (arrival date) – September 16, 2017 (departure date)</td></tr>
<tr><td colspan="2">Program</td><td>PNG Forest Resource Monitoring / Data Management</td></tr>
<tr><td rowspan="3">First week</td><td>Tue</td><td>- JICA briefing
- Introduction (logistics, schedule and training purpose)
- Overview of forest resource monitoring</td></tr>
<tr><td>Wed</td><td>- Touring at Tsukuba Space Center
- Discussion with Japan Aerospace eXploration Agency (JAXA) related to JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST)</td></tr>
<tr><td>Thu
Fri</td><td>- Lecture of forest resource monitoring (Collect Earth, SEPAL, GLAD, JJ-FAST, and Unmanned Aerial Vehicle (UAV))
- Discussion of utilization possibility and challenges
- Preparation of action plan of forest resource monitoring</td></tr>
<tr><td rowspan="2">Second week</td><td>Sun</td><td>(Travel to Kyoto / Kyoto cultural visit / Travel to Kobe)</td></tr>
<tr><td>Mon</td><td>- Introduction to UAV
- Lecture of safety standard
- Lecture of flight simulator</td></tr>
</table>

	Tue Wed	- UAV inspection and maintenance training - Flight demo - Practical training (basic)
	Thu	- Practical training (advanced) (Return to Tokyo)
	Fri	- Preparation of presentation - Wrap-up presentations by trainees - Certificate conferment

In the first database training sessions, skills related mainly to the maintenance, utilization and application of PNG-FRIMS were learned. The RS / GIS training sessions were centered on the advanced technologies of Japan, such as advanced techniques for satellite imagery analysis. These skills are necessary for contributing to updating and operating PNG-FRIMS in the future. The details were reported in the final report on the acceptance of trainees (September 2015). Presentations by trainees about the report on the training in Japan are shown in Annex 45.

The objectives of the second training sessions were to learn a variety of the latest technologies related to PNG-FRIMS (drone[3], Collect Earth[4], Hansen data[5], Google Earth Engine[6], GLAD Alert[7], JJ-FAST[8], etc.) and to consider / discuss the methods and systems of the forest logging plan and forest monitoring for future work. The following is a list of the achievements that the trainees gained from the training.

- They were able to acquire knowledge of technology that can be used for forest resource monitoring at PNGFA by receiving an explanation of advanced technology
- They learned the basic operation of technology that could be used for forest resource monitoring by receiving advanced technology exercises
- They were able to discuss and propose concrete plans to utilize learned technology for the work of PNGFA

Through the trainees' experience of discussing how to utilize in their work the skills learned in the training, the expectation is that some proposals will be made to improve daily work by using available new technologies in the future.

1.4.3 Outputs of the Project

Technical cooperation outputs from the Project are shown in Table 1.4-4.

3 An uninhabited airborne vehicle (UAV) that enables autonomous aviation using on-board GPS and sensor.
4 A tool that enables data collection and analysis through Google Earth developed by FAO. As Google Earth, it can refer LANDSAT, Sentinel-2, imagery of DigitalGlobe, etc. with spatial resolution of between 15 m and 15 cm.
5 Planetary-scale annual forest loss/gain area data delivered by University of Maryland in the United States.
6 A cloud-based platform for browsing and analyzing a massive amount of satellite imagery information.
7 An alert system that is updated every eight days for tree cover loss using Google Earth Engine.
8 JICA-JAXA Forest Early Warning System for deforestation of tropical forest developed by JICA and JAXA.

Table 1.4-4 Technical Cooperation Outputs

Outputs	Annex No.	Indicators in PDM
Outputs related to PNG-FRIMS	Annex 1	Indicator 1.3, 1.4, 1.6
Manual on updating Forest Base Map	Annex 2	Indicator 1.1
Manual of PNG-FRIMS	Annex 3	Indicator 1.8
Estimated change of forest carbon stocks	Annex 4	-
Calculation of the forest reference emission level and forest reference level	Annex 5	Indicator 3.2

1.4.4 Dissemination of the Outcome and Public Relations

As part of activities related to the dissemination of the outcomes and public relations, the Project has created various tools to introduce these outcomes and latest information on the Project.

(1) JICA Project Introduction Website

The Project established a website (https://www.jica.go.jp/project/png/002/index.html (Japanese), https://www.jica.go.jp/png/english/activities/activity12.html (English) (accessed on 21 June 2019)) on the JICA homepage to disseminate news and leaflets on the Project. Twelve Project-related news articles have been posted on this website.

(2) Project Facebook Page

Under the initiative of the long-term experts, a Facebook page for the Project (https://www.facebook.com/jica.png.forest.monitoring/ (accessed on 21 June 2019)) is operated. More than 32 articles have been posted on the page in both Japanese and English. The total number of 'likes' is 1,135 and total number of followers is 1,140.

(3) Project Fact Sheet & Analytical Report

Series of Project Fact Sheets and Analytical Reports were created to introduce Project activities and PNG-FRIMS (Annex 6). The Analytical Reports are internal PNGFA materials, since their purpose is to introduce trial analyses implemented in the Project activities. They fulfilled the role of disseminating the outputs not only to the public but also internally within PNGFA. C/P officers were also able to deepen their understanding of PNG-FRIMS and the Analyses by creating the materials.

Table 1.4-5 Project Fact Sheet Series

No.	Title	Issue Date	Number of Copies
Fact Sheet No. 1	JICA-PNGFA Project Outline	Nov. 2014 (first ver.) Feb. 2018	500 copies

		(revised ver.)	
Fact Sheet No. 2	Papua New Guinea Forest Base Map 2012	Feb. 2018	300 copies
Fact Sheet No. 3	PNG-FRIMS	Feb. 2018	300 copies
Fact Sheet No. 4	Forest Monitoring Unit (FMU) in Papua New Guinea Forest Cover Map	Mar. 2019	300 copies
Fact Sheet No. 5	Constraints Data – Natural Condition Layers in the PNG-FRIMS	Mar. 2019	300 copies
Fact Sheet No. 6	Watershed and Catchment Data	Jun. 2019	300 copies
Fact Sheet No. 7	Digitized Road Information	Jun. 2019	300 copies
Fact Sheet No. 8	Forest Concession and Land Management Layers in PNG-FRIMS	Jun. 2019	300 copies
Fact Sheet No. 9	Forest Cover Map 2015	Jul. 2019	300 copies
Fact Sheet No. 10	Drone Applications in Sustainable Forestry Management and Monitoring in PNGFA	Jun. 2019	300 copies

Table 1.4-6 Project Analytical Report Series

No.	Title	Issued date	Number of Copies
Analytical Report No. 1	Analysis of Drivers of Deforestation and Forest Degradation in Papua New Guinea	Mar. 2019	30 copies
Analytical Report No. 2	Analysis of Future Forest Change Modeling in Papua New Guinea	May 2019	30 copies
Analytical Report No. 3	Potential in Papua New Guinea to Estimate Emissions from Forest Degradation Caused by Logging Based on Field Methods (using FRIMS)	Jul. 2019	30 copies

（4）Big-Book

The C/P requested the publication of a scientific report containing the Forest Base Map, one of the main outputs of this Project and the previous projects. Therefore, the accomplishment reports of the Project and the previous projects, with a focus on the Forest Base Map and PNG-FRIMS, were compiled as the ‘Papua New Guinea Forest Base-Map and Atlas’ and the ‘Papua New Guinea Forest Resource Information Management System (PNG-FRIMS)’ (commonly known as the ‘Big-Book’) by C/P officers with the support of the JICA expert team (Annex 7).

（5）Attendance at COP

The short-term expert team attended the Twentieth Session of the Conference of Parties to the United Nations Framework Convention on Climate Change (COP 20) and the 21st Session of the Conference of Parties to the United Nations Framework Convention on Climate Change (COP 21). The team supported governmental negotiations and gained a grasp of the trends in international discussions. Additionally, the team attended side events to publicize the results of the Project. Presentation materials from each event and reports on COP 20 and COP 21 are included in Annex 46.

1) COP 20

The short-term expert team attended COP 20 held in Lima, Peru between 1st and 12th December 2014 as a member of the PNG delegation. The team supported the governmental negotiations and gained a grasp of the trends in the international discussions. In addition, the team attended four side events regarding the activities of JICA and the United Nations Collaborative Programme (UN-REDD) and publicized the results of this Project and the preceding T/C.

(i) Climate Change Feria (JICA Peru): Report on Monitoring for Forest Conservation in PNG (2014/12/1)

Mr. Masamichi Haraguchi, the leader of the short-term expert team, gave a presentation entitled ‘Case Example: Papua New Guinea Forest Resource Information Management System for Forest Conservation and REDD+’ at the opening event of the Climate Change *Feria* sponsored by the National Forest Conservation Program for Climate Change Mitigation, Ministry of Environment, Peru and JICA Peru on the first day of COP 20.

At the event, forest management by communities in both India and the Philippines, the importance of peat land management in the Peruvian Amazon and the case study of PNG were reported. Even though the event was held in the evening on the first day of COP 20, there were more than 80 participants, with some having to stand. This was a good opportunity to publicize the work being done in PNG and the Project.

(ii) Measurement, Reporting and Verification (MRV) Event at the Indonesia Pavilion (Remote Sensing Technology Center of Japan (RESTEC) / JAXA / JICA): Readiness in MRV in PNG (2014/12/4)

Mr. Perry Malan, a senior cartographer / the leader of the team in PNGFA, gave a presentation entitled ‘Papua New Guinea Readiness of MRV and Possibility for REDD+/Joint Crediting Mechanism (JCM): Achievements & Challenges by Remote Sensing’, explaining the on-going utilization of RS technology in PNG.

In this presentation, the possibility of utilizing the Forest Base Map, National Forest Inventory (NFI) and airborne data for estimating carbon storage, which is one of the most important issues in the MRV sector, and method and possibility to use Advanced Land Observing Satellite (ALOS) / Phased Array type L-band Synthetic Aperture Radar (PALSAR) data as another hot topic on analysis of forest degradation were reported with current issues and future expectations.

(iii) Democratic Republic of Congo (DRC) side event (UN-REDD): Warsaw Framework & Progress in PNG (2014/12/6)

Ms. Rensie Panda, a negotiator in the Office of Climate Change and Development (OCCD) participated in this side event as one of the panelists with negotiators from Brazil, Peru and DRC, as well as the person in charge from the Green Climate Fund, to discuss the Warsaw Framework and progress in PNG.

The report given by Ms. Panda was discussed with the persons concerned in advance, based on the outcomes of the JICA Project and UN-REDD program being implemented, for which PNGFA was the main C/P. In addition, advice from the Coalition for Rainforest Nations (CfRN) was prepared for the presentation. The progress made while preparing for this report had significant meaning for the future plans and activities of the Project.

(iv) REDD+ in Asia-Pacific Region event at the Indonesia Pavilion (JICA): Collaboration with Multilateral Cooperation (2014/12/8)

Mr. Gewa Gamoga, of the REDD & Climate Change Branch in PNGFA, gave a presentation entitled 'Papua New Guinea (PNG) JICA's Support for Forest Management/REDD+: Case Example of Collaboration with Multilateral Cooperation', at an event on REDD+ in the Asia-Pacific Region, sponsored by the Ministry of Forestry in Indonesia with support from JICA.

In this presentation, the Forest Base Map and PNG-FRIMS developed in the JICA Project utilizing Japanese radar satellite (ALOS/PALSAR) were introduced. The on-going preparation for forest monitoring and MRV through close collaboration with NFI, supported by UN-REDD / the Food and Agriculture Organization of the United Nations (FAO), was also highlighted to appeal to the attendees.

2）COP 21

Continuing from attendance at COP 20 (Lima, Peru) in 2014, two C/P officers from PNGFA and a long-term chief advisor and expert on REDD+ project planning support participated in COP 21, which was held from 30th November to 13th December 2015 in Paris, France. They presented the results of the Project at the JICA-JAXA side event at COP 21 and collected the latest information related to REDD+ considering reflecting this information in PNG-FRIMS. In addition, the Paris Agreement and the Project activities and related items were analyzed and organized.

At the COP 21 side event, which was held on 1st December and called the 'JICA-JAXA Tropical Forest Change Detection System: Forest Governance Improvement Initiative', Mr. Gewa Gamoga, the manager of the REDD+ and Climate Change Branch, reported about the outcomes and challenges of the Project and then expressed expectations for forest monitoring in near real-time utilizing ALOS-2 as a representative example from developing countries.

(6) Other PR Activities

1) Project Debriefing Meeting

In the third year of the Project, the functions and database of PNG-FRIMS were enhanced and the C/P officers' capacity strengthened in various areas such as GIS, GPS, and the ability to manage and monitor field operations. Therefore, on 22nd November 2017, the Project debriefing meeting was held targeting managers and officers in a wide variety of departments concerned with the Project. The concept note and presentation documents of the meeting can be found in Annex 47. Through this meeting, the following things were achieved or were expected to be achieved.

- The Project outputs over three years are widely recognized by not only the officers engaged in Project work, but also by other officers of PNGFA.
- PNGFA officers can discuss concretely the use of PNG-FRIMS since they have detailed knowledge about the content of the results.
- The dissemination of work details and outputs implemented by the engaged officers can foster an understanding of the outputs to be achieved in the remaining term, as well as cooperation on the Project activities.

2) TLVS Workshop

The Project manager of the Project, Mr. Constin Bigol, had an opportunity to present an overview of PNG-FRIMS at a workshop on the PNG Timber Legality Verification System, which was held on 20-21 June 2018. The Project supported the preparation of the presentation materials (see Annex 48). In the workshop summary by Director, Dr. Ruth Turia, PNG-FRIMS was recognized as an important existing system to be utilized.

3) Coverage by CNN

In August 2018, PNGFA received coverage by CNN and had an opportunity to present an overview of PNG-FRIMS and forest monitoring done with drone technology. The Project gave support in the preparation of presentation materials. The video shot by CNN was used as a public relations video by the Ministry of Foreign Affairs of Japan (https://www.youtube.com/watch?v=SlWv9SRBzxY&t=1s (accessed on 15th December 2018)).

4) Project Final Seminar

On 18th July 2019, in order to report and disseminate the outputs of the Project, the final seminar of the Project was held targeting the officers in PNGFA HQ, Area Offices and relevant institutions. The agenda and presentations of the seminar are attached in Annex 49. In addition, documents, such as manuals, maps and posters to introduce the outputs or the Project, were displayed and a video, which introduces the Project activities, was screened. Through this seminar, the activities and outputs of the Project were disseminated both inside and outside PNGFA and the incentives regarding the need to continually update the data of PNG-FRIMS and to enhance the capacity of PNGFA were promoted.

Chapter 2. Achievements of the Project Activities

2.1 Activities for Output 1

2.1.1 Identifying Information to Be Added into PNG-FRIMS

（1）Study on Schema of Information to Be Added into PNG-FRIMS

The short-term expert team has organized forest information to be added into PNG-FRIMS as shown in the following table.

Table 2.1-1 Classification of Information to Be Added into PNG-FRIMS

Classification	Role
Forest Base Map （Vegetation）	Forest information which can be used to grasp the potential for forest resources and carbon emissions.
Logging	Forest information which can be used to grasp possible deforestation, forest degradation and secondary forest areas.
Constraints Area	Project area information which should be paid attention to in planning new logging or REDD+ projects.
Topography	Topographical information which can be an index to evaluate the validity of a logging project or a REDD+ project.

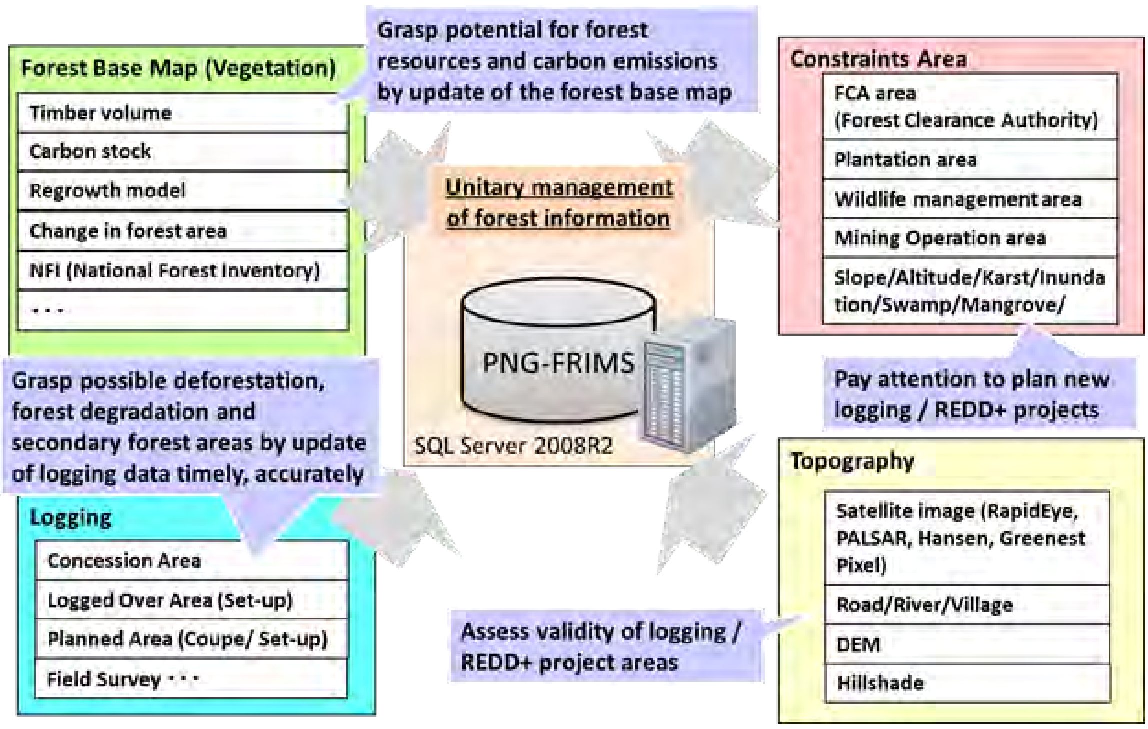


Figure 2.1-1 Schema of Information to Be Added into PNG-FRIMS

(2) Logging Concession

1) Quality Evaluation and Grasp of Issues on Logging Concession Data, and Data Entry and Revision

The JICA short-term expert evaluated the quality of logging concession data which the C/P uses in daily business, gaining a grasp of issues about the data and then entering and revising together with the C/P. Information about the logging concessions managed by PNGFA are as follows.

Table 2.1-2 Information about Logging Concessions Managed by Each Branch of PNGFA

Branch	Information about Logging Concessions
Inventory and Mapping (I&M) Branch (Cartographer Team)	Geographic information (map data) about the logging concessions stored in PNG-FRIMS. The logging concession information is divided into an operational area and a planned area. The map data includes the names of the logging concessions, area, purchase date and expiry date as attributes.
Acquisition Branch	List of TRPs (Timber Rights Purchase), LFAs (Local Forest Area) and FMAs (Forest Management Agreement) which are kinds of logging concessions in PNG. All logging concessions in operation and under planning are listed.
I&M Branch (Forest Plans Officer)	List of potential logging concession sites planned by each province, which appear in the National Forest Plan.

According to the C/P, the lists in the Acquisition Branch and I&M Branch (Forest Plans officer) of PNGFA provided more reliable logging concession information compared with the information stored in PNG-FRIMS. The short-term expert team assessed the quality of logging concession information in PNG-FRIMS compared with the lists and considered how to handle the inconsistencies between PNG-FRIMS and the lists with the C/P officers.

The points used for quality assessment of logging concession data (in accordance with international standards for geographical information, ISO 19113) are shown in the following table.

Table 2.1-3 Points Used for Quality Assessment of Logging Concession Data

Points Used for Quality Assessment	Explanation
Completeness	Presence and absence of shapes (boundaries) and their attributes
Positional accuracy	Accuracy of the position of boundaries
Temporal accuracy	Accuracy of the temporal attributes (purchase date & expiry date)
Thematic accuracy	Accuracy of the attributes except positional and temporal attributes

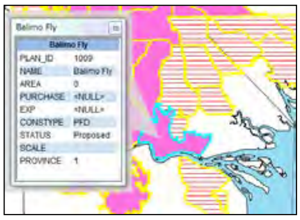
(i) Assessment of completeness and policies for modifying errors

The short-term expert team confirmed there were areas where logging concession data is missing and others where it is abundant in PNG-FRIMS compared with the lists in the Acquisition Branch and I&M Branch.

Examples of Excess data

FIMS has a following proposed polygon data, but There is no description on NFP.
Should we remove the polygon from FIMS database?

PLAN_ID	NAME	PURCHASE	EXP	CONSTYPE	STATUS	Area(ha)
1009	Balimo Fly			PFD	Proposed	237718



FIMS has three polygons of "Kamula Doso". But "Kamula Doso" is not split on the list of acquisition brunch. Should we merge the three polygons?

PLAN_ID	NAME	PURCHASE	EXP	CONSTYPE	STATUS	Area(ha)
1012	KAMULA DOSO Block 1	19/02/1998	18/02/2048	FMA	Proposed	268788
1013	KAMULA DOSO Block 2	19/02/1998	18/02/2048	FMA	Proposed	265909
1014	KAMULA DOSO Block 3	19/02/1998	18/02/2048	FMA	Proposed	257964

PROJECT NAME	PURCHASE DATE	EXPIRY DATE	TYPE	TERM	REMARKS	GROSS AREA (ha)
Kamula Doso	19/02/1998	18/02/2048	FMA	50	Cancelled	593,725

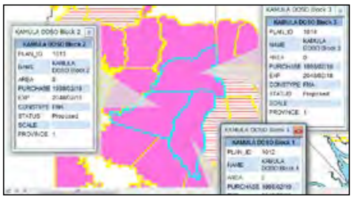


Figure 2.1-2 Examples of Surplus Logging Concession Information in PNG-FRIMS

Examples of Data absent

The table from acquisition brunch and NFP show the following concession areas in GULF.
But current FIMS database doesn't have the polygons.
Can we digitize the boundary of these concession areas?

PROJECT NAME	PURCHASE DATE	EXPIRY DATE	TYPE	TERM	REMARKS	GROSS AREA (ha)
Kikori Area A	31/10/1952	30/10/1992	TRP	40	Expired	1,741
Kikori Area B	2/12/1953	1/12/1993	TRP	40	Expired	1,255
Sirebi	16/12/1953	15/12/1993	TRP	40	Expired	891
Eia Creek	6/04/1955	5/04/1995	TRP	40	Expired	3,240
Tauri Meporo					Proposed	54,390
Sori Meporo					Proposed	86,422
Hekiko (Gulf)					Proposed	195,715

The table from acquisition brunch shows two project names about Iva and Inika.
Current FIMS data has not been split the polygon.
Should we split the polygon according to the table from acquisition brunch?

PLAN_ID	NAME	PURCHASE	EXP	CONSTYPE	STATUS	Area(ha)
3003	Iva Inika		28/03/1996	TRP	Concession	13376

PROJECT NAME	PURCHASE DATE	EXPIRY DATE	TYPE	TERM	REMARKS	GROSS AREA (ha)
Iva	1/01/1972	31/12/2011	TRP	40	Current	4,612
Inika	1/01/1972	31/12/2011	TRP	40	Current	8,851

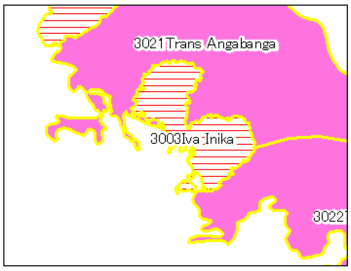


Figure 2.1-3 Example of Missing Logging Concession Information in PNG-FRIMS

Many expired logging concessions that appeared in the list in the Acquisition Branch were not in PNG-FRIMS as geological information (around 90 sites). When information on logging activity around an expired logging concession was requested, PNGFA could not judge whether it came under re-entry or not (re-entry is prohibited at present). Mapping an expired logging concession seems useful for judging re-entry matters efficiently. In addition, the information contributes to the consideration of methods for introducing a forest re-growth model and degraded forest information in PNG-FRIMS, which is within the scope of the Project.

The C/P suggested three policies to solve the expired logging concession issue:

(a) There may be paper maps of the concessions somewhere at PNGFA. Digital maps can be made from them.

(b) Make digital maps by asking the Regional and Provincial / Project Offices about locations.

(c) Check whether or not an expired logging concession was included in a new logging concession.

There are also inconsistencies between planned logging concessions in the National Forest Plan (NFP) and PNG-FRIMS. In particular, around 60 logging concessions in PNG-FRIMS were not on the list in the NFP. The logging concession data in PNG-FRIMS has been accumulated since the 1990's without sufficient review, meaning that the cancellation or consolidation of plans, etc. may not be reflected in PNG-FRIMS. The short-term expert team confirmed the knowledge of the officer in charge of NFP and referred to the Provincial Forest Plans (PFPs) to ensure consistency with the actual situation and decide to take appropriate steps.

(ii) Assessment of the positional accuracy and policies for modifying errors

To judge the positional accuracy of the logging concession data in PNG-FRIMS, the values in "Area" attributes were compared with the lists and issues were extracted.

Examples of Positional accuracy error

"Area" attribute in FIMS is calculated by New FIMS (ArcMap) automatically.
If you find a big difference in area figure between FIMS data and existing documents, it should be better to check that which is correct. When existing documents is correct, we need to fix the boundary of concession area.

PLAN_ID	NAME	PURCHASE	EXP	CONSTYPE	STATUS	Area(ha)
1002	Wawoi Guavi Block 1	14/08/1981	14/08/2021	TRP	Concession	108666

PROJECT NAME	PURCHASE DATE	EXPIRY DATE	TYPE	TERM	REMARKS	GROSS AREA (ha)
Wawoi Guavi Blk.1	14/08/1981	14/08/2021	TRP	40	Current	35,000

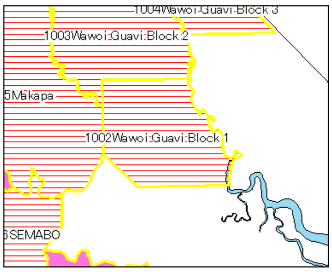


Figure 2.1-4 Example of Issues on Positional Accuracy of Logging Concession Information in PNG-FRIMS

The C/P suggested three causes of discrepancies in logging concession information among its sources:

1. Whether Forest Conservation Area was considered or not.
2. Issues with Incorporated Land Group (ILG) boundaries at the conclusion of the FMA.
3. Difference in the boundaries between the plans and the conclusion of the FMA (information in PNG-FRIMS is not updated).

The Project team considered how to handle each matter and decided to take appropriate steps through the use of PNG-FRIMS in cooperation with the officers at the Acquisition Branch and the officer in charge with NFP.

(iii) Assessment of the temporal accuracy and policies for modifying errors

The short-term expert team compared start and end dates of logging from logging concession data in PNG-FRIMS with the logging period in the list of the Acquisition Branch.

Examples of Temporal accuracy

There is a difference between FIMS data and existing documents. We have to confirm which date is correct to Acquisition branch.

PLAN_ID	NAME	PURCHASE	EXP	CONSTYPE	STATUS	Area(ha)
19041	Alimbit Anu	21/07/1989	20/07/2009	LFA	Concession	32548

PROJECT NAME	PURCHASE DATE	EXPIRY DATE	TYPE	TERM	REMARKS	GROSS AREA (ha)
Anu Alimbit	2/05/1989	N/A	LFA	N/A	Current	32,800

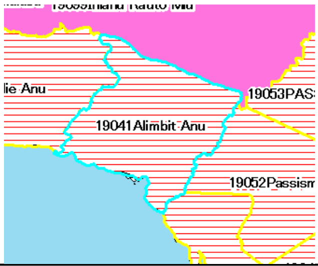


Figure 2.1-5 Example of Issues on Temporal Accuracy of Logging Concession Information in PNG-FRIMS

When a discrepancy between the two kinds of information was found, the team basically assumed that the temporal information on the list in the Acquisition Branch was correct and that the information in PNG-FRIMS was in need of correction. A discussion with the C/P revealed that the logging concession data in PNG-FRIMS contains several kinds of temporal information, such as planned start and end dates, actual start and end dates and the date on which the digital map was created. Considering the importance of estimating the extent of re-growth in a logging concession — as it is needed to decide whether to permit re-entry (for logging) to the concession — the actual end dates of previous logging activities is required.

(iv) Assessment of the thematic accuracy and policies for modifying errors

There was a discrepancy in the names of the logging concessions between PNG-FRIMS and the lists in the Acquisition Branch and the NFP.

Examples of Thematic accuracy error

There are a difference in name of concession area.
Which is correct? Should we use the name in existing documents?

PLAN_ID	NAME	PURCHASE	EXP	CONSTYPE	STATUS	Area(ha)
6009	YEMA GAIAPA	6/08/1991	5/08/2006	LFA	Concession	38321
6011	Collingwood Bay			FMA	Proposed	182412

PROJECT NAME	PURCHASE DATE	EXPIRY DATE	TYPE	TERM	REMARKS	GROSS AREA (ha)
Yema Gaepa	8/12/1989	N/A	LFA	N/A	Current	39,930
West Collingwood Bay					Proposed	182,727

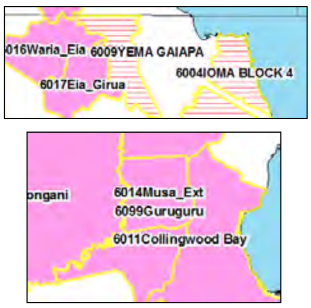


Figure 2.1-6 Example of Error in Thematic Accuracy of Logging Concession Information in PNG-FRIMS

Basically, the short-term expert team assumed that the thematic information on the lists in the Acquisition Branch and the NFP was correct and that the thematic information in PNG-FRIMS needed correction.

2）Updating Concession Area Data

The C/P updated the concession area database together with the short-term expert team according to the correction policy shown in 1) above. The C/P provided a couple of ideas, which are shown below, in the process of updating.

Table 2.1-4 Ideas Provided by the C/P in the Process of Updating

Ideas Provided by the C/P		Conclusion
1	Existing concession area data has the attribute “status” which is an index to identify whether PNGFA already obtained forest management rights (under FMA) or not. Concession areas for which forest management rights have been obtained have a value “concession” in the attribute “status”. Another value “proposed” means a proposed concession area. Regarding the concession area with the value “concession”, it is better to be able to identify whether the concession area is currently operational or expired based on the document which the Acquisition Branch manages.	A new attribute will be added to the concession area database to identify whether a given concession area is “currently operational” or “expired”. The attribute name will be “REMARKS”.
2	Sometimes a concession area under FMA has not allocated a timber permit to logging companies. It is better to be able to record exceptional circumstances.	A new attribute will be added to concession area database to record exceptional circumstances. The attribute name will be “REMARKS2”.

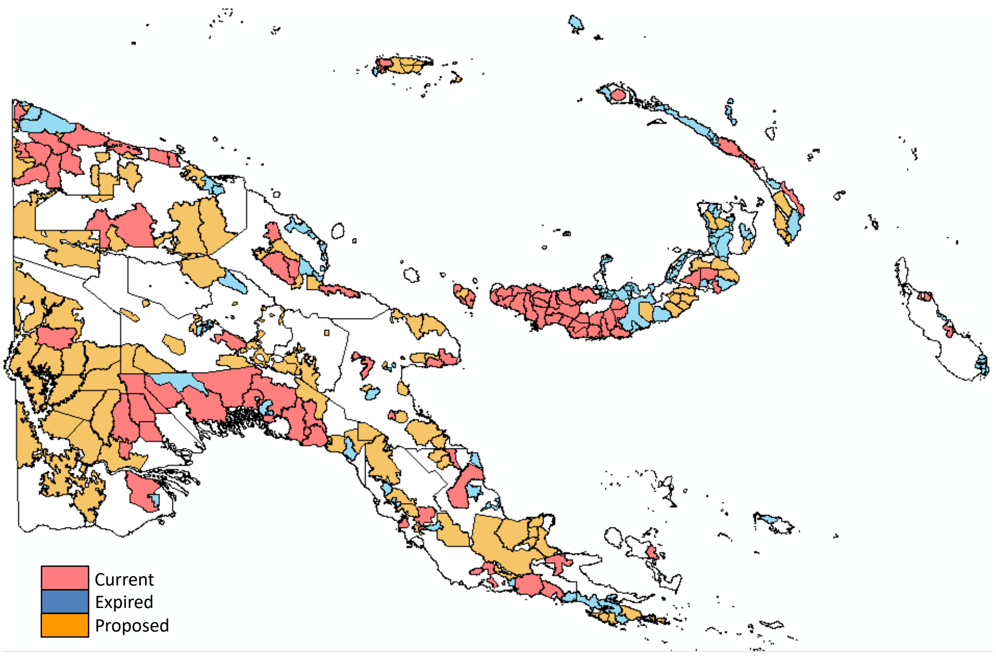


Figure 2.1-7 Concession Area Map Showing the Current Situation

There is an issue with the expired concession areas that do not have graphic (map) information in the database. The concession areas include areas which had expired before PNGFA started creating geospatial data. The Project team decided to take appropriate steps, including getting graphic (map) information, through the use of PNG-FRIMS.

(3) Harvesting History (Logged Over Area)

1) Understanding the Current Situation and the Issue of Logged Over Areas

The short-term expert team found several issues concerning the logged over areas through a study of the spatial relationship between “logged over area” and “concession area”.

Table 2.1-5 Issues Concerning Logged Over Areas

Type of Concession Area	Issues
Currently operational	There are concession areas which have no data entered about logged over areas. Confirmation of the contents of annual or five-year logging plans which are in possession by Project Allocation is required.
Expired	Expired concession boundaries usually overlap with the data on logged over areas. In addition, there are concession boundaries which have only partially entered data on logged over areas. Confirmation of the contents of annual or five-year logging plans which are in possession by Project Allocation is required.
Proposed	There are some proposed concession areas which overlap with the logged over areas. Confirmation of the actual situation of the concession areas is required.

Of particular note, the timing of updating this forest information is a few years behind the actual state of forests. Moreover, the forest information stored in PNG-FRIMS has not made a distinction between harvesting history and logging plan until now. Therefore, the current situation for updating forest information is going to be an obstacle to the realization of adequate forest monitoring. Accordingly, the JICA expert team discussed the solution to the issues together with the C/P officers, who are in charge of the harvesting history and logging plan, after verifying of the current workflow and reaching a common understanding about current processes.

As for the workflow in updating of logging information, issues with each process and future actions are shown in the following table. First, we focused on operations in the I&M Branch and examined them in detail.

Table 2.1-6 Analysis of Present State and Future Actions Regarding Updating of Logging Information

Step	Who	Current work	Issues (under study)	Current / Future actions
1	Logging Company	・Submit annual and 5-year logging plans with hard copy of maps to Projects.	・Possibility of submitting soft copy of maps ・Map layer format differs depending on companies	・Interview with several logging companies ・Study existing logging maps which PNGFA keeps
2	PAD Projects Branch	・Assess logging maps ・Update the catalog of logging maps every year	・FIMS map is not used well ・The catalog of logging maps is shared with cartographer team (for identifying the map to digitize) but slow due to skilled man power	・Share FIMS map through the Web browser map ・Examine a procedure for sending and receiving logging information
3	I&M (carto-grapher)	・Digitize logging maps which Projects Branch provides	・Logged area boundaries are not identified \`duration\` and \`meaningful boundary\` (set-up, coups…) ・Updating map is not timely	・Find the gap between maps on 'received by PAD' and 'entered to FIMS' ・Examine the appropriate data specification
4	PNGFA officers	・Has to ask cartographer team to output FIMS data and maps	・Accessibility to the map (Need to ask a cartographer to print the map)	・Share FIMS map through the Web browser map ・Study the usage of map for planning and monitoring

2）Design of Data Specification

The purpose of the logging information stored in PNG-FRIMS is to estimate forest volume at the national or provincial levels. The JICA expert team examined the expansion of existing data specification together with the C/P not only for an estimate of forest volume but also for appropriate forest management and monitoring. The requirements for data specification requested by the C/P are shown in the following table.

Table 2.1-7 Requirements for Harvesting History (Logged Over Area)

Layer	Attribute	Example of Value	Using Soft Copy	Digitize Manually
Logged-Over Set-Ups	PROJECT_NAME	East Fergusson TRP	✔	✔
	NAME	S10-11/12	✔	✔

Layer	Attribute	Example of Value	Using Soft Copy	Digitize Manually
	YEAR_OF_ALP	2010-2011	✔	✔
	DURATION	2010-2011	✔	✔
	Actual harvest volume			✔
	Related concession ID	5005	✔	
Planned Area Set-Ups	PROJECT_NAME	East Fergusson TRP	✔	
	NAME	S11-12/11	✔	
	YEAR_OF_ALP	2011-2012	✔	
	DURATION	2011-2012	✔	
	Related concession ID	5005	✔	
	Type	Planned / SetAside / Deferred / Contingency etc.	✔	
Annual working plan in Forest Working Plan	PROJECT_NAME	East Fergusson TRP	✔	✔
	NAME	Coup2	✔	✔
	YEAR_OF_ALP	2011-2012	✔	✔
	DURATION	2010-2015	✔	✔
	Related concession ID	5005	✔	✔

The difference in harvesting histories between the current data specification and improved data specification is shown in the following figure.

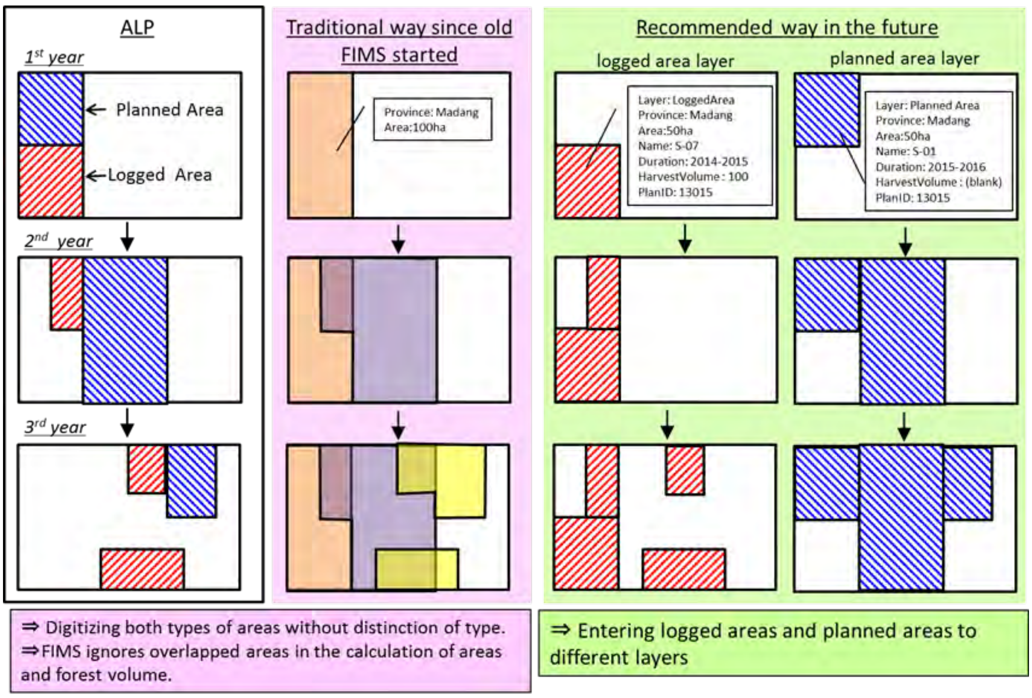


Figure 2.1-8 Storage of Harvesting History in PNG-FRIMS (Comparison of Old and New Ways)

The JICA expert team also suggested two ways to digitize the Set-Ups layer. The C/P decided to adopt 'Way 1' shown in the following figure since the Set-Ups layer can be linked with land owners and also can be used for more elaborate analysis.

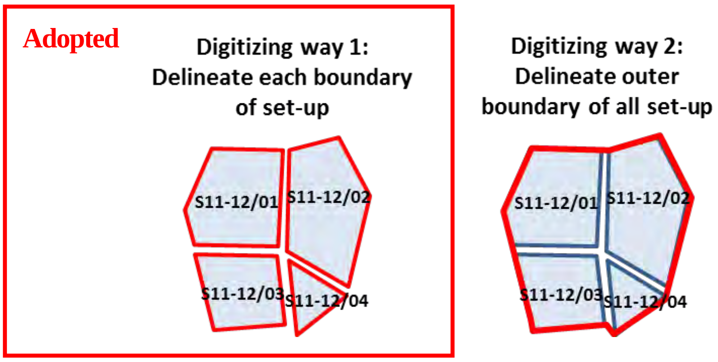


Figure 2.1-9 Possible Ways to Digitize Set-Ups Layer Boundary

3）Examine the Work Procedure Based on the New Data Specifications

As shown in 2) above, the data specification of logging information has become detailed. Therefore, there is reason for concern over increasing the cartographer team's amount of work. Accordingly, the C/P and the long-term expert proposed using soft copies with Annual Logging Plans (ALPs) and five-year logging plans, the submission of which is required of logging companies to PNGFA. This method can make it efficient to store more accurate logging information in PNG-FRIMS.

For the pilot sites of this Project, 'East Fergusson' in Milne Bay and 'Asengseng_Consolidated' and 'Aliavanu Block2' in West New Britain, the C/P and the JICA expert team attempted to work on data entry regarding harvest history and the logging plan by using the soft copies submitted by logging companies. Meanwhile, regarding the logging project, for which it is difficult to get a soft copy of the map, it was decided that the traditional method would be applied, that is, the digitization of paper maps for the data entry of logging information.

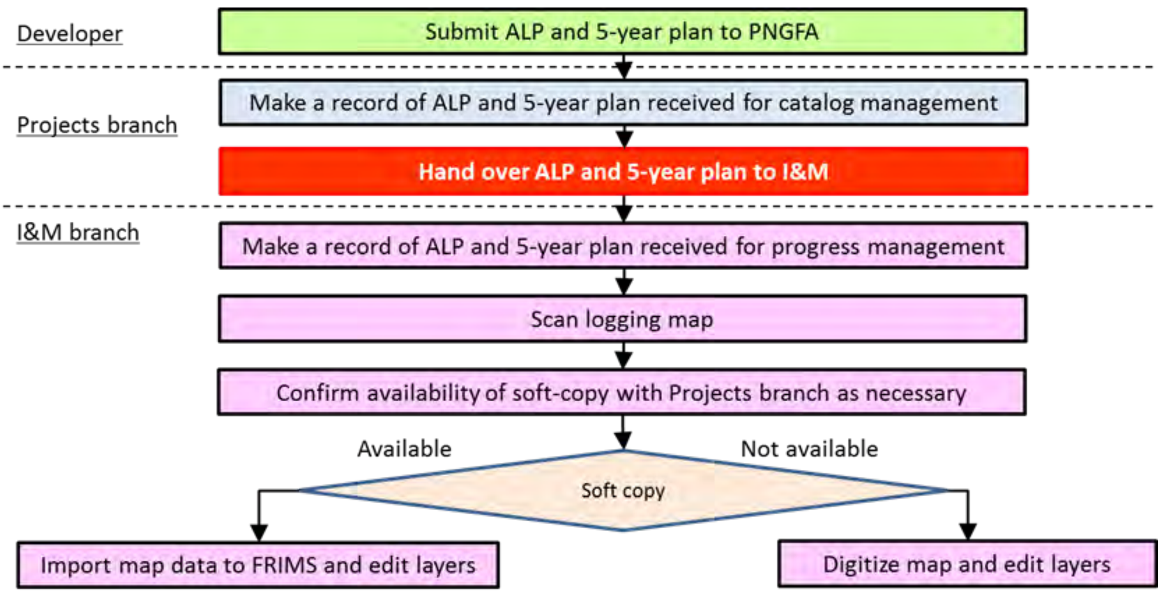


Figure 2.1-10 Work Procedure for Data Entry on Harvesting History

(4) Adding Forest Information from Forest Logging Plan

Up to the present, the C/P has used annual and five-year logging plans submitted by logging companies to add and update the harvesting history on PNG-FRIMS. The long-term expert team was responsible for arranging the new framework of acquiring soft copies of logging plans from logging companies. Therefore, the C/P and the short-term expert team examined the new forest information, aside from that for the harvesting history, included in the soft copies of logging plans.

Table 2.1-8 Possible Forest Information Added from Forest Logging Plan into PNG-FRIMS

Category	Possible Forest Information
Planning information	Inoperable Area
	Buffer zone
	Strip Line
Facility information	Bridge / Culvert
	Campsite
	Gravel Pit
	Log Landing
Topographic information	Road
	River / Stream
	Contour

The C/P added forest information on the pilot sites of the type shown in Table 2.1-8 into PNG-FRIMS.

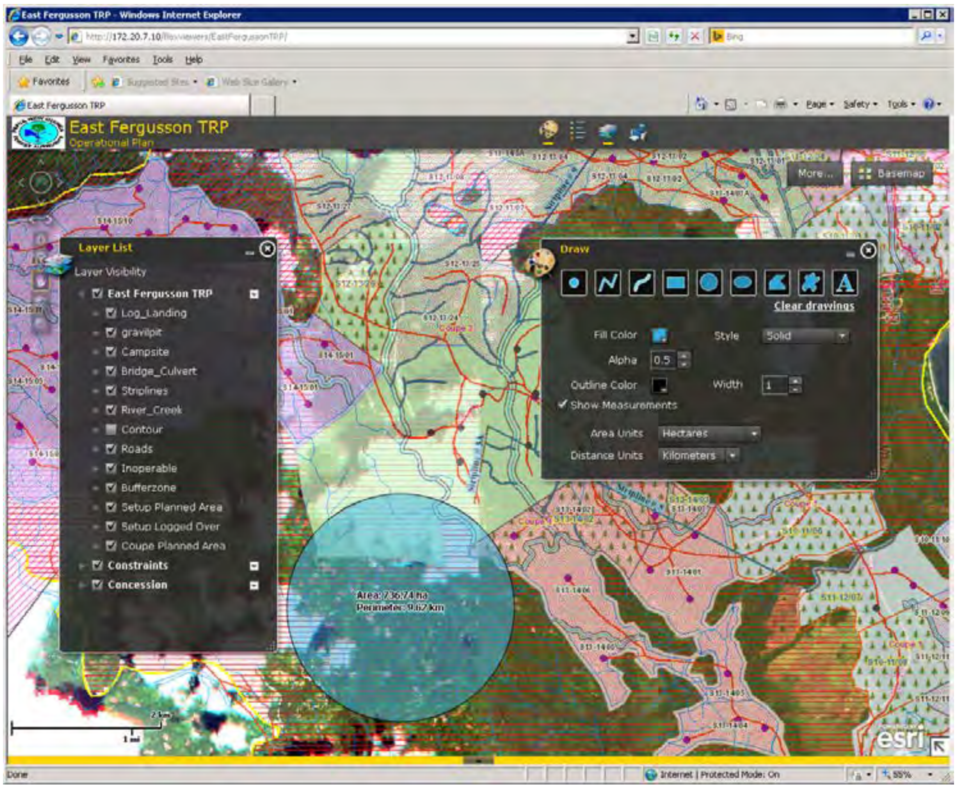


Figure 2.1-11 Result of Adding Forest Information Based on Forest Logging Plan

2.1.2 Lay out a Basic Design for Expansion and Enhancement of PNG-FRIMS

PNG-FRIMS is composed of several application functions, such as the Forest Inventory Mapping System (FIMS), Forest Inventory Processing System (FIPS) and LAN-Map (LAN Map BrowserWebBrowserMap). These functions share various kinds of forest information that is in the database of PNG-FRIMS. In addition, the forest information in the database can be directly utilized by general-purpose software such as ArcGIS for Desktop and Microsoft Access.

A brief overview of PNG-FRIMS was compiled in ‘Fact Sheet No. 3 PNG-FRIMS’ (Annex 6) for the dissemination of outputs.

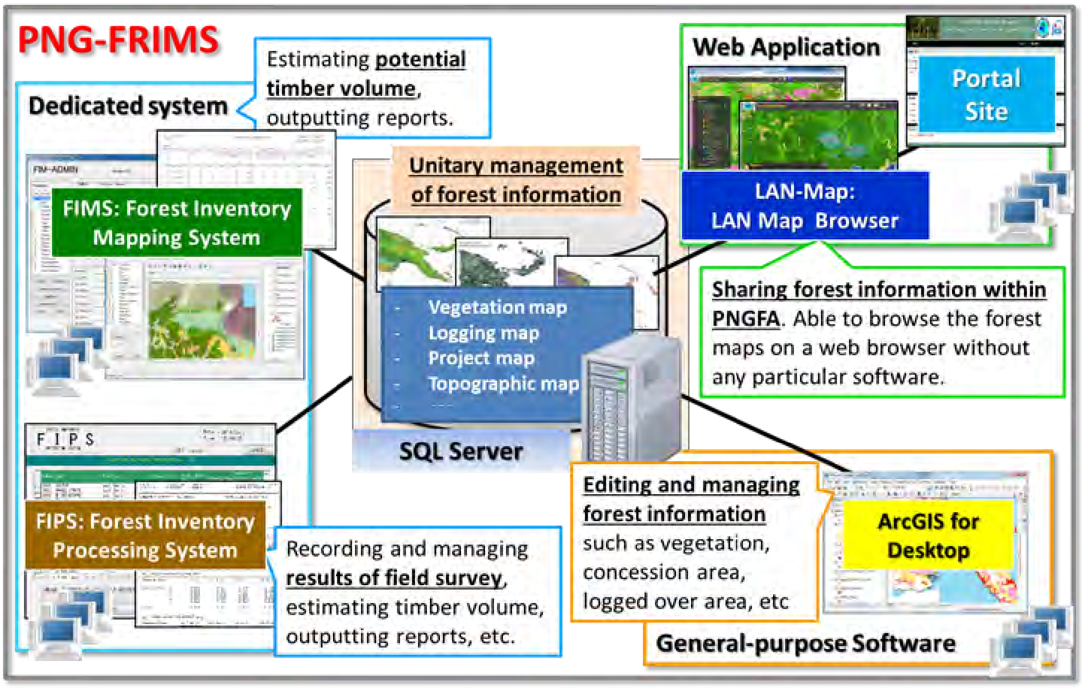


Figure 2.1-12 Structure of PNG-FRIMS

(1) Version Update for Compatibility with ArcGIS 10.2.2

The version of ArcGIS operated in PNGFA was updated from ver. 10.0 to ver. 10.2.2 (the newest version of that time) out of consideration for technical transfer efficiency. For the update, the JICA expert team carried out improvement design for the FIMS functions. The target functions are shown in the following table.

Table 2.1-9 Target Functions of Improvement Design

Function	Note
Map display function	Zoom in or out and move the display position, add or delete and edit geometry, print a map being displayed
Attribute edit function	Add, update or delete an attribute value

Analysis function	Recalculate forest volume and reflect the result on the province, concession, and proposed concession.
Data import function	Import and replace a layer

(2) Function to Support Assessment and Monitor Logging Operation Plans

The concept of the function to support assessment and monitor logging operation plans is shown in the following table. The short-term expert team developed the LAN-Map based on this concept.

Table 2.1-10 Concept of Function to Support Assessment and Monitor Logging Operation Plans

Goal	Function	Objectives	Outcomes
To make the procedure of assessing and monitoring logging operation plans more efficient	Shares and utilizes the forest information in PNG-FRIMS	- Overlay various kinds of forest information - Search location - Sketch map on web browser - Measure distance and extent - Print Maps	This function will help to assess logging plans.
			This function will make it easy to find encroachment logging and overlapping of project boundaries by easy access to PNG-FRIMS through a web browser.

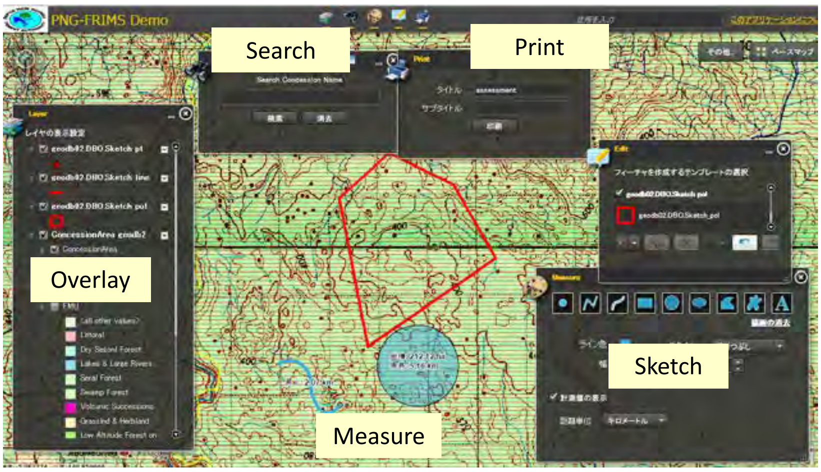


Figure 2.1-13 Function Design to Support Assessment and Monitor Logging Operation Plans

(3) Extension Functions of LAN-Map

The C/P and the short-term expert team examined solutions for issues familiar to the C/P by using the extension functions of the LAN-Map for improvements in daily business.

Table 2.1-11 Ideas on New Extension Functions of FRIMS-LAN

Goal	Function	Objectives	Outcomes
To manage JOB Request for map	Submits job requests, approves the request and reports the progress via web browser map.	- To record all job requests onto the PNG-FRIMS. - To count and analyze all job requests	- This application will be helpful for managing job request history. - This application will make it possible to record number of map.
To estimate forest volume of AOI	Enter the AOI and estimates forest volume at AOI via web browser map.	- To estimate forest volume for project planning officer (who is not familiar with GIS)	- This application will make it possible to estimate forest volume of AOI easily and efficiently (No need to use FIMS). - In the future, this application will become available for estimating carbon stock as well.

1）Job Request Function

First, the C/P and the short-term expert team started a job analysis about the current work flow for job requests. The results of the job analysis are shown in the following table. Clients need to fill out a request form for their requests when they ask the cartographer team to make maps that include forest information. The written request form is submitted to the cartographer team with the approval of the manager. However, there are some problems in this request process, such as the duplication of tasks or the misplacement of request forms, which makes daily business inefficient. Accordingly, the C/P mainly tried to improve the current processes through the unitary management of job request information on LAN-Map.

Table 2.1-12 Result of Job Analysis for Design of Job Request Function

Step	Person	Work/ task	Issues	Way to improve the issues
1	External client or Internal client	Request Maps Printing	・requests by same clients	・Minimize multiple tasks by checking the history on the web browser
2	I&M Branch	Accept the requests	・Request does not go to manager for approval	・Share requests on the web browser
3	I&M manager/ supervisor	Approve the request	・Request does not go to manager for approval	・Share requests on the web browser
4	Cartographer team	If map request, making and printing maps	・Misplace of request forms	・Registers all requests to JICA Server using Web browser map
5	Admin assistant	Filing request forms	・Keeping record with hardcopy, occupy a lot of space ・Keeping track of maps printout (How many maps, for which province, for which project) ・Need to count hardcopy	・Registers all requests to JICA Server using Web browser map
6	Finance Branch	Issue the Receipt for purchasing publications		

There are three actors with this function: the client, manager and cartographer. The data specifications were defined taking into account each of the actor's roles.

Table 2.1-13 Data Specification of Job Request Layer

Layer	Attribute	Client (Admin assistant)	Manager / Supervisor	Cartographer
Job request for maps	Requester	**Editable**	View	View
	Designation	**Editable**	View	View
	Office	**Editable**	View	View
	Contact	**Editable**	View	View
	Date	**Editable**	View	View
	Province	**Editable**	View	View
	Project	**Editable**	View	View
	JobRequestDescription	**Editable**	View	View
	Geometry	**Editable**	View	View
	ApprovalStatus	View	**Editable**	View
	StatusOfJobRequest	View	View	**Editable**
	Receipt	View	View	**Editable**

2）Forest Volume Estimate Function

The current FIMS is able to estimate forest volume. However, it can be only estimated by province or concession area; it is impossible to estimate forest volume for an area of interest. Therefore, the C/P examined developing functions which help users easily estimate forest volume. The results of job analysis done by the C/P are shown in the following table.

Table 2.1-14 Job Analysis Related to Forest Volume Estimation

Person	Work/ task	Issues	Way to improve the issues
Internal (Project allocation)	Provide and request Proposed and current boundaries	Current FIMS can calculate forest volume for entire concession but not AOI. They can not estimate the volume themselves. They rely on FIMS or Harvest volume from operational plan.	To provide the simple function for estimating volume through web browser map.

（4）Portal Site for LAN-Map

According to the introduction to LAN-Map, PNGFA officers can access several maps that include forest resource information any time via computers connected to the intranet inside PNGFA. However, forest information stored in PNG-FRIMS sometimes has confidential information that only specific officers are allowed to access. Therefore, the short-term expert team decided to develop a gateway to LAN-Map forest information by establishing a portal site that manages access privileges to forest information stored in PNG-FRIMS.

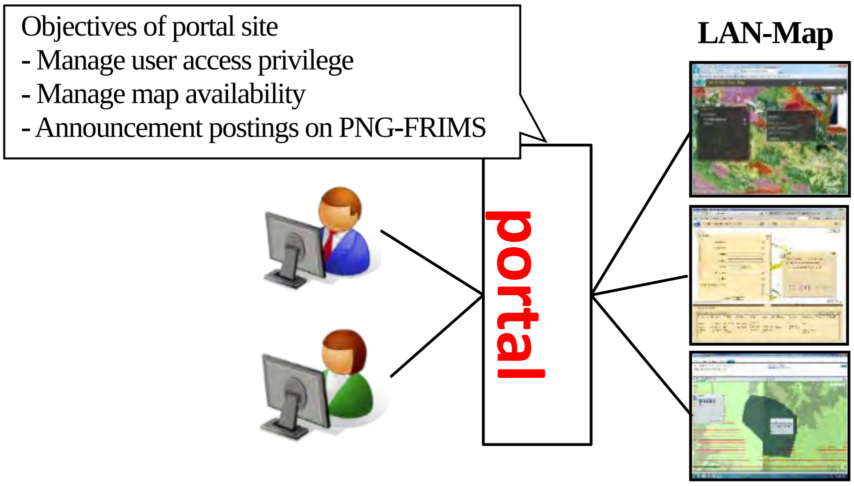


Figure 2.1-14 Role of the Portal Site

The functions of the portal site were designed as shown in the following table and figure.

Table 2.1-15 List of the Portal Site Functions

Category		Function		Summary
1	Common	1-1	Logout	Executes logout processing and returns to the login window.
		1-2	Log output	Outputs log file including users' access histories.
2	Login	2-1	Login	Logs into the portal site through inputting user ID and password. Controls map availability in accordance with the privilege of each group that the user belongs to.
		2-2	Group select	Selects a group if the user belongs to two or more groups.
3	Menu	3-1	News list	Shows the list of news.
		3-2	Map list	Shows the list of maps and links to them that the user can see.
4	Map	4-1	Map viewer	Shows a map published on LAN-Map.
		4-2	Article editor	Creates, updates and deletes articles.
		4-3	News viewer	Shows the list of news and its contents.
		4-4	Function linkage	Starts other functions from the map window.
5	System administration	5-1	User management	Shows the list of users, and creates, updates and deletes user information.
		5-2	Group list	Shows the list of groups, and creates, updates and deletes them.

Category		Function		Summary
		5-3	Map management	Edits the name of map and connects the name with URL.
		5-4	Group management	Defines the privilege of each group to access each map.
6	Map sharing	6-1	Map URL creation	Creates a URL for shared map with customized scale for a specific point of interest.

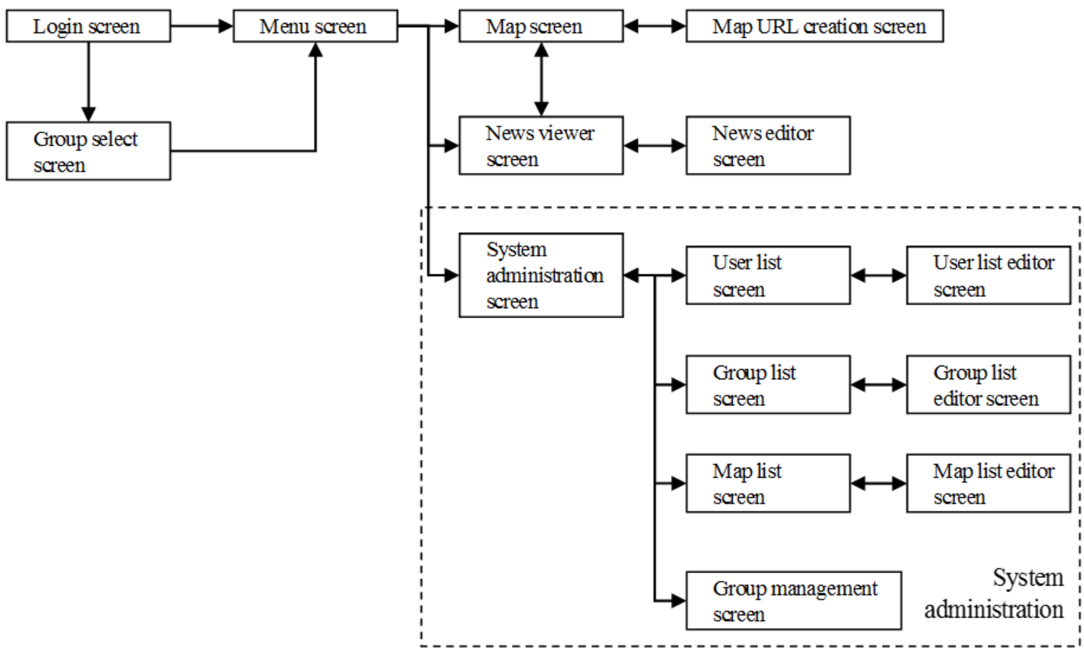


Figure 2.1-15 Screen Transition of Portal Site

Based on the above results, the portal site for LAN-Map was developed on a trial basis.

(5) Function to Estimate Timber Volumes Considering Forest Re-Growth

The function to estimate timber volume in the current FIMS is calculated by subtracting the annual amount of timber logged in logging concession areas. This calculation only takes into account decreases in total timber volume in the areas of interest. However, forest in the logged areas will in fact gradually regrow after logging. Therefore, the short-term expert team added a function to estimate timber volume in secondary forests utilizing a forest regrowth model developed in another activity of the Project.

1) Calculation Method of Forest Re-Growth

The JICA expert team discussed the forest re-growth calculation method with the C/P. The JICA expert team confirmed the functional requirements as follows.

Preconditions of the calculation method (*to be confirmed*)	
1	When a logged-over area is digitized in a concession area, FRIMS (FIMS) regards the volume of the logged-over area as zero.
2	The volume of the logged-over area will recover over the next 35 years linearly. * New FIMS can change the recovery period. The single period will be applied to whole country. Need to decide the recovery period before start improvement of new FIMS.

Example: Logging started in 2000 over the next 35 years.

2000	2001	2002	2003	2004	2005	2006
2007	2008	2009	2010	2011	2012	2013
2014	2015	2016	2017	2018	2019	2020
2021	2022	2023	2024	2025	2026	2027
2028	2029	2030	2031	2032	2033	2034

Recovery ratio as of 2035.

100%	97%	94%	91%	89%	86%	83%
80%	77%	74%	71%	69%	66%	63%
60%	57%	54%	51%	49%	46%	43%
40%	37%	34%	31%	29%	26%	23%
20%	17%	14%	11%	9%	6%	3%

Figure 2.1-16 Forest Re-Growth Calculation Method

The C/P and the JICA expert team agreed on the scenario about forest volume displayed in FIMS. The scenario is that forest volume recovery starts after each harvest year. For example, if the same amount of area were harvested and forest volume were reduced the same amount every year up to the expiry year, the graph of forest re-growth would be displayed as it is in the graph for Idea 2 shown in the following figure.

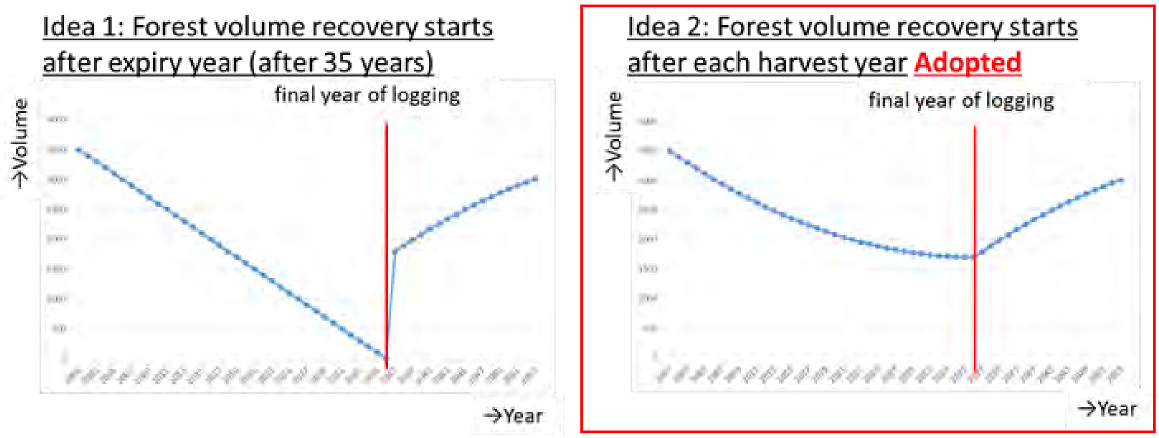


Figure 2.1-17 Scenario of the Re-Growth Volume Calculation

2）Issues on Data Which are Used for Calculation and Possible Solutions

Considering forest re-growth, there are several issues related to data stored in PNG-FRIMS for estimating forest volume. The JICA expert team discussed these issues with the C/P and possible solutions were confirmed as follows.

Table 2.1-16 Data Issues and Possible Solutions

Issues		Possible Solutions
Expired concession	Actual harvested areas are unclear.	Regard the whole area of expired concession as logged over area. The logged over area will be the concession boundary.
	Harvest year of logged over area stored in PNG-FRIMS is not clear.	FIMS assumes a constant logging rate during the contract of TRP. FIMS regards the logging year as the LFA contract expiry year.
Current operational concession	Actual harvested areas are unclear.	Collect past logging plans and digitize boundaries The target year is 2000 (at the least back to 2010) since calculation of values for in-country FREL / FRL verification can be used back to this time.
	Harvest year of logged over area stored in PNG-FRIMS is not clear.	Enter harvest year to logged over area layer using past logging plans.

2.1.3 Updating the Forest Base Map

In the preceding T/C, the Forest Base Map 2012 (ver. 1.0), which could be used as a base map of forest cover in PNG, was developed. In the Project, to utilize the Forest Base Map as a database in PNG-FRIMS and develop the method of updating the forest cover map for detecting forest area changes, the following activities were implemented:

(1) Basic design for detecting forest area changes with RS technology;
(2) Processing and analysis of the RS data on a trial basis to detect forest area changes;
(3) Identification of necessary additional information from sources other than RS;
(4) Development (based on the results of implementing the preceding three activities) of a manual on updating the forest base; and
(5) Updating the forest base map in the pilot areas.

(1) Basic Design for Detecting Forest Area Changes with Remote Sensing Technology

The team developed the basic design for detecting forest area changes, and then examined the issues related to the Forest Base Map ver. 1.0 that were pointed out in the preceding T/C, and considered other improvements to utilize the map in PNG-FRIMS.

The following issues were pointed out at the end of the preceding T/C:

(i) The quality and accuracy of the Forest Base Map developed in the preceding T/C had not yet been sufficiently evaluated.
(ii) Despite the lack of a quality and accuracy assessment of the map, issues related to distinguishing

what gets classified as Woodland / Savanna / Scrub, on extracting Swamp Forests and on demarcating Plain forest (P) and Hill forest (H) in Western Province were qualitatively revealed in the process of developing the Forest Base Map.

(iii) The classification categories used for the Forest Base Map are derived from the PNG Resource Information System (PNGRIS)[9], which does not contain secondary forest related information. It is necessary to discuss how to define secondary forest and examine how to develop the information and integrate it into PNG-FRIMS.

During the Project, first, the short-term expert team updated the Forest Base Map to address the issues pointed out in b) above, discussing strategies for how to solve the problems with the C/P. After that, the updated Forest Base Map was compared with the data of the pre-inventory survey for the NFI survey funded by UN-REDD / FAO. This was done to check the quality and accuracy of the Forest Base Map to identify issues related to it to be further addressed (coping with a) above). Among other improvements, the development of sub-vegetation type, the addition of useful new attributes, and the treatment of small studded islands, were also examined. The definition of secondary (degradation) forest and how to construct information (coping with c) above) was examined in 2.1.3（2）.

1）Basic Design for Detecting Forest Area Changes

To develop the method for monitoring forest area changes, forest cover maps are arranged at four stages: (i) revision of the Forest Base Map 2012; (ii) creation of past forest cover maps; (iii) creation of a forest cover map for 2015; and (iv) monitoring forest area changes after 2015. Along with these, the method and the system of future forest cover monitoring were examined. The design described in this section is linked with the technical examinations in 2.1.3（2）and 2.1.3（3）. The basic design is shown in this section; each examination of methods for creating forest cover maps is shown in each section.

(i) Revision of the Forest Base Map 2012

Work descriptions: Examine improvements made on the issues clarified in the preceding T/C and other improvements for the Forest Base Map 2012 (ver. 1.0) and revise the Forest Base Map 2012.

Target area: Whole of PNG

Output: The revised Forest Base Map 2012 (ver. 1.1) with forest degradation attributes

Objective / Impact: The accuracy of the revised Forest Base Map, which will be a base map for creating other forest cover maps, will be improved and be made practical for the Project. Forest degradation information arranged as attributes of the map will contribute to estimating forest resource volume and the forest management plan.

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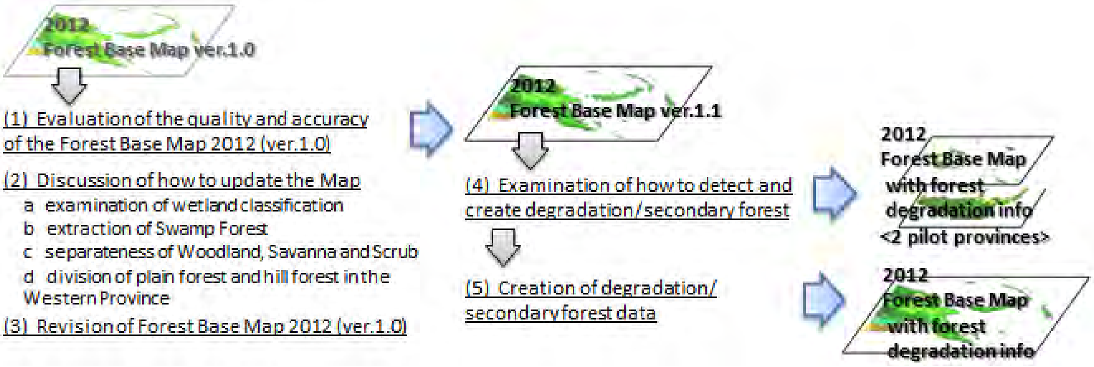
9 E.T. Hammermaster and J.C. Saunders, Forest resources and vegetation mapping of Papua New Guinea, PNGRIS Publication No. 4 (1995) The categories of the classification in the Forest Base Map are derived from this document which describes the classification of the vegetation in FIMS.

Work procedure:



(ii) Creation of past forest cover maps

Work descriptions: Create past forest cover maps for 2000 and 2005 from the revised Forest Base Map by utilizing LANDSAT imagery, etc. These years were chosen as a result of examination of utilizable data. Modify land use in the Forest Base Map and arrange data as a forest cover map for 2011, if certain kinds of land use that was not classified in the Forest Base Map — such as that of agricultural land — is detected by interpreting newly utilizable RS imagery from multiple years. Arrange forest degradation information for the past forest cover maps according to the method used in stage (i).

Target area: Pilot provinces (West New Britain Province, West Sepik Province)

Output: Past forest cover maps for 2000 and 2005, and a revised forest cover map for 2011 with forest degradation attributes for pilot provinces

Objective / Impact: Confirmation of past forest areas in multiple years will contribute to simulating forest changes and developing the reference emission level. Knowledge clarified in this stage such as detectable land changes from RS imagery, the tendency of forest changes in PNG, and technical issues, will be useful for examining the methods used in the following stages.

Work procedure:

(iii) Creation of forest cover map for 2015 (benchmark map)

Work descriptions: Develop a forest cover map for 2015 for the whole of PNG from the revised Forest Base Map by utilizing LANDSAT 8, etc. Arrange forest degradation information for the forest cover map for 2015 according to the method used in stage (i) and (ii).

Target area: Whole of PNG

Output: Forest cover map for 2015 with forest degradation attributes for the whole of PNG

Objective / Impact: The developed forest cover map, a benchmark map, could be the basis for monitoring the impact of REDD+ activities. The basic capacities for updating a future forest cover map for the whole of PNG will be developed in PNGFA. Routine work, as well as the system in PNGFA that is required to update the forest cover map, will be considered through this activity.

Work procedure:

(iv) Monitoring forest area changes after 2015

Work descriptions: Examine the methods and system in PNGFA for regular and high frequency monitoring of forest area changes in pilot areas using the latest technologies and methods used in stage (i) to (iii) as a reference.

Target area: Pilot areas

Output: Information about forest area changes between 2015 and 2019 for pilot areas

Objective / Impact: A suitable method and frequency of monitoring will be clarified; a monitoring system in PNGFA will be developed.

2) Classification among Woodland, Savanna and Scrub

In the preceding T/C, it was revealed that the thresholds for distinguishing for classification into Woodland, Savanna and Scrub are not robust even at PNGFA. It also turned out to be difficult to separate Savanna and Scrub utilizing analyzed satellite imagery (RapidEye). The extent of Savannas is limited by climatic and environmental conditions, and by fires caused by humans. On the other hand, Scrub is low-height forest composed of particular species. These differences in where each are likely to be located were used to determine the distribution of Savanna and Scrub in the Forest Base Map based on the FIMS map. Although Woodland was rather distinguished from Savanna and Scrub in analysis of satellite imagery, it was difficult to separate Savanna and Scrub, so consolidation of those classes was an option. In this Project, this matter was discussed with the C/P and it was decided that the classification based on the FIMS map would be kept, rather than consolidating the classifications, even though uncertainties regarding those remained.

3）Examining Methodology to Detect Wetland-Forest

An issue raised when developing the Forest Base Map ver. 1.0 at the end of the preceding T/C was that more precise land cover information on the FIMS map was simplified into rough information on the Forest Base Map, which lost some information, such as wetland information, from the FIMS map. Additionally, the accuracy of information about wetland distribution on the FIMS map was not satisfactory. The preceding T/C was expected to examine how to grasp the distribution of wetland, because this information is important for judging the possibility of forest operations and for reference in selecting candidate areas for activities to conserve their characteristic ecosystems. The short-term expert team examined the methodology for detecting wetland-forest utilizing RS data around April Salome in East Sepik Province, where the distribution of peatland, deeply related with existence of wetland forest, was investigated in detail (Figure 2.1-18).

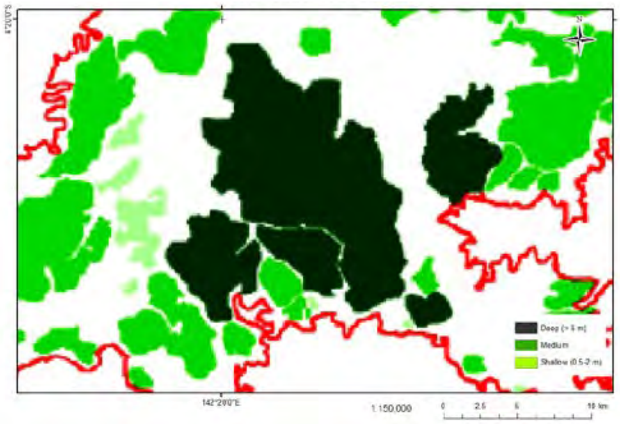


Figure 2.1-18 Distribution of Peatland around April Salome[10]

Geosynchronous Synthetic Aperture Radar (GeoSAR) data is airborne data utilizing P-band microwave to observe ground features. This data was expected to be used for effectively detecting wetland forest because P-band microwave, which has a relatively longer wavelength, can penetrate the crown of a forest and monitor the forest floor directly. However, using GeoSAR, it was not easy to distinguish wetland forest, which is likely to be distributed on peatland, and other forests (Figure 2.1-19, upper left image).

A false color composite of LANDSAT-8 (R: Band 6, G: Band5, B: Band 4) looked capable of helping estimate peat distribution (Figure 2.1-19, upper right). On the other hand, Normalized Difference Water Index (NDWI) calculated from LANDSAT-8 imagery was unable to show a significant difference between the inside and outside of peatland area (Figure 2.1-19, bottom image).

This suggests that digitizing work or object-based segmentation referring to LANDSAT-8 imagery is one of the options for detecting wetland forest using RS data. However, because a ground survey is necessary to

[10] Extracted from Pokana and Joseph (2013): Papua New Guinea’s status on peatland initiative

ensure the accuracy of the information, it is difficult to investigate the distribution of wetland forest targeting the whole of PNG. Practically speaking, updating the Forest Base Map to integrate wetland information by referring to information in FIMS should come first (refer to 2.1.3（1）6）). Moreover, the accuracy of the information should be enhanced locally as necessary, digitizing or using object-based segmentation of RS data such as LANDSAT-8 imagery and ground surveys.

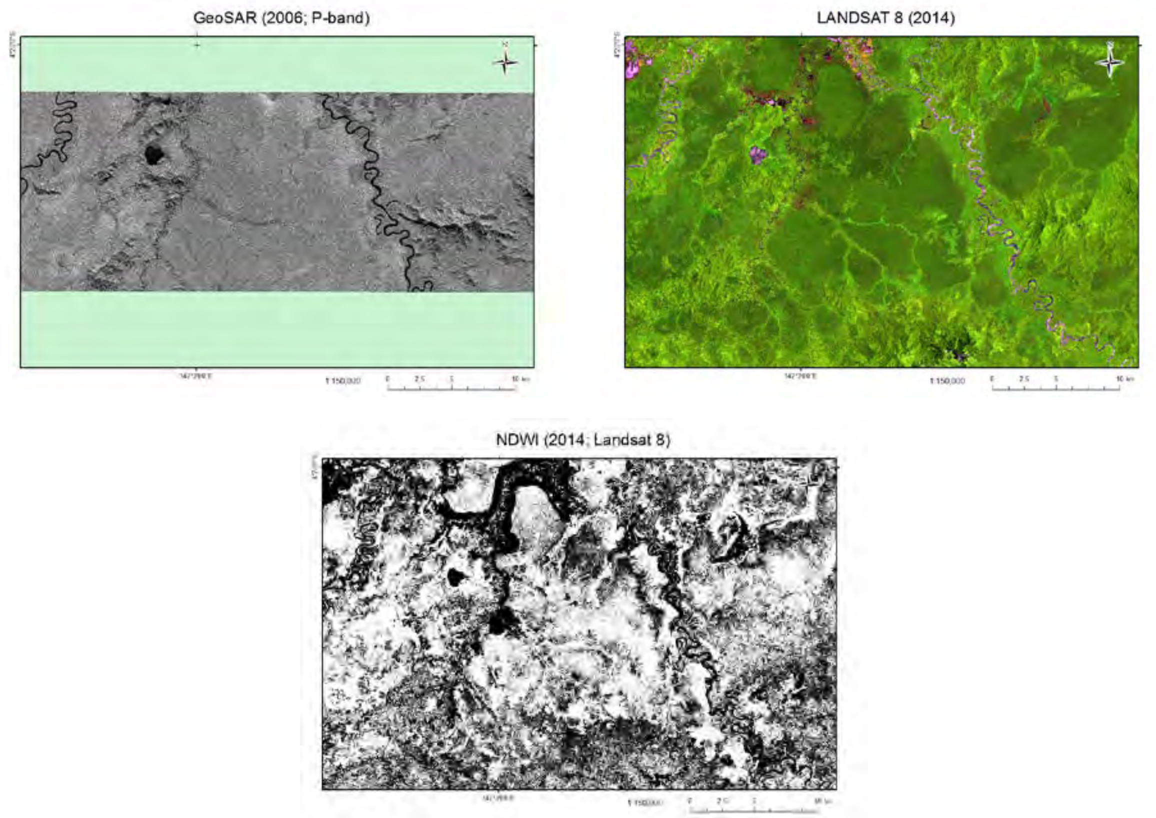


Figure 2.1-19 Imagery around April Salome; GeoSAR (upper left), LANDSAT-8 (upper right), NDWI (bottom)

4）Distinction between Plain Forest (P) and Hill Forest (H) in Western Province

In the preceding T/C, it was known that the distribution pattern in Low Altitude Forest on Plains and Fans (P) and Low Altitude Forest on Uplands (H) in the existing Forest Inventory Mapping System (FIMS) and the pattern on the new Forest Base Map were completely different (Figure 2.1-20). In this Project, the causes of this discrepancy were examined and the necessity of revision of the Forest Base Map was discussed (refer to Annex 13).

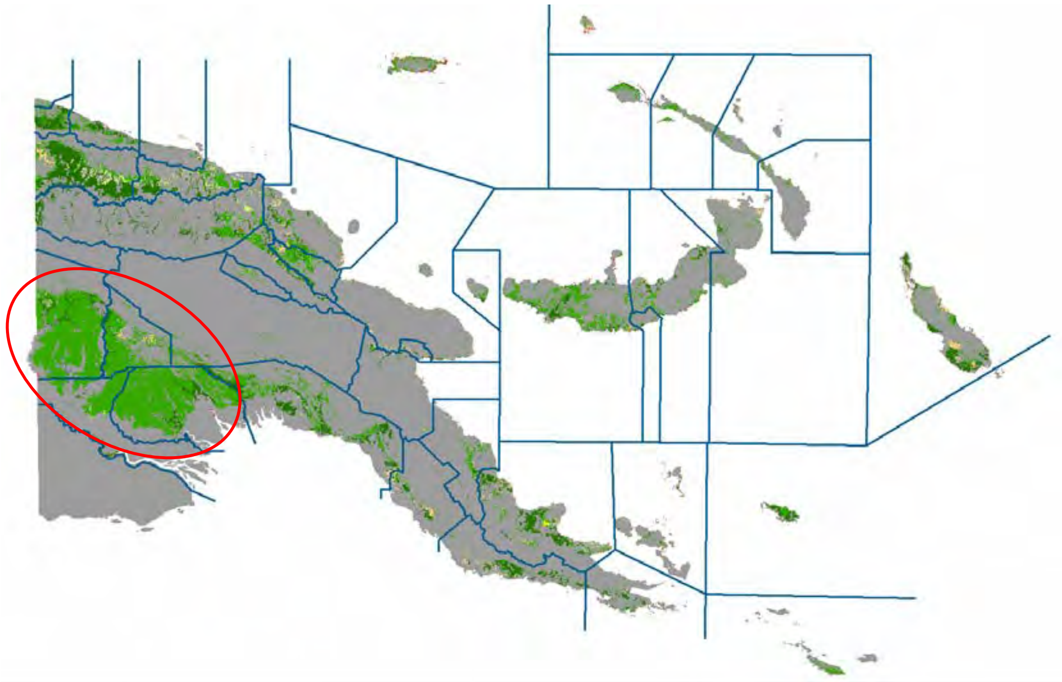


Figure 2.1-20 Comparison between Distribution Pattern in P Forest on the Forest Base Map and in Various Forest Types in the FIMS Map

The colored part of the map is the area where P forest is distributed on the Forest Base Map. The dark green part is P forest on both the Forest Base Map and the FIMS map and the light green part is P forest on the Forest Base Map and H forest on the FIMS map. The blue lines indicate the boundaries of each forest zone. The discrepancy between the Forest Base Map and the FIMS map is obvious in the four forest zones circled by a red line

As a result of the analysis, it was revealed that the relationship between the slopes of the forests and tree composition in this region was different from that in other regions in PNG. When the existing FIMS was made, P and H were distinguished from tree composition. In the preceding T/C, the Forest Base Map was developed from satellite imagery and it was not possible to distinguish the tree composition of the forests using this imagery. Comparing the distribution pattern in P and H in FIMS and the steepness of the polygons in the developing Forest Base Map, the Project team decided to define low altitude forest, which is located on slopes with a gradient less than 6º, as P, and the opposite — that is slopes with a gradient greater than 6° — as H. However, tree species composing H in other regions are distributed even in lower slope areas in this region. This might be the main reason why distributions in P and H are different between the Forest Base Map and the FIMS map for this region.

The short-term expert team suggested the following two options to PNGFA as policies for updating the Forest Base Map:

(i) That no change be made to the definition of P and H on the Forest Base Map (use 6º as the threshold)

(ii) That P be changed to H in the four forest zones around Western Province if the area was H on the FIMS map

The team recommended option (i) if PNGFA considers the slope information to be more important than the tree composition information. Otherwise option 2 was recommended.

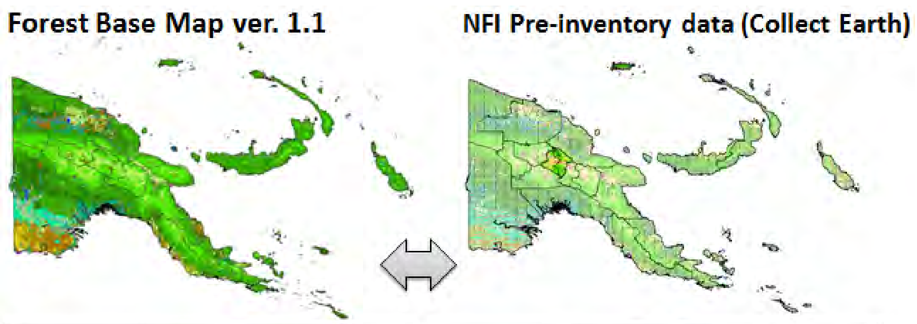
Mr. Constin Bigol, the head of the I&M Branch, PNGFA, which is the main C/P in this Project, and most of the other staff members, believed that slope information was more useful than tree composition information. This was despite the fact that there might be a relationship between tree composition information and flood plain distribution, which could be important information for logging operations. They also recognized that the current distribution pattern of each tree species in the zones was actually not clear, because most of the forests in the zones were disturbed after FIMS map development. As a result, the staff chose option (i) as their collective opinion.

The advantages of this choice is that the slope of a site in low altitude forest can be clearly understood from the vegetation code and that, moreover, the vegetation code will be easy to identify from the slopes in the future when non-forest polygons in low altitude areas change to forest polygons. On the other hand, tree species that are expected to exist on a site according to the vegetation code may not actually be there.

5) Quality and Accuracy Assessment of Forest Base Map ver. 1.1

The Forest Base Map ver. 1.0 was updated to ver. 1.1 after improvements on the issues mentioned above. The quality and accuracy of the Forest Base Map ver. 1.1 were assessed using an error matrix. These assessments should be done using ground truth data which is collected by appropriate sampling design. However, national level ground truth data of a statistically significant sample size were not available in PNG. Therefore, the accuracy assessment was implemented by comparing the land use class in the Forest Base Map with the land classification used in the NFI Pre-Inventory, collected using Collect Earth with support from UN-REDD / FAO, as reference data.

Figure 2.1-21 shows the characteristics of the Forest Base Map ver. 1.1 and NFI Pre-Inventory (Collect Earth). The correspondence of land use classes in the Forest Base Map and NFI Pre-Inventory is shown in Table 2.1-17 using Intergovernmental Panel on Climate Change (IPCC) land categories.



	Basemap	Sampling Point
Spatial Coverage	**Wall-to-wall by polygons** Segmentation < 1ha (100x100m)	**Sampling plots** Points every 4km x 4km 1ha unit with 25 check points
Satellite	Rapid Eye, ALOS/PALSAR	LANDSAT, Digital Globe, Rapid Eye, SPOT, etc.
Land cover class	21 classes including agricultural land and plantation	**class:**6 grouping categories; Forest, Grassland, Cropland, Wetland, Settlement, Other, with 54 detailed classes

Figure 2.1-21 Characteristics of the Forest Base Map ver. 1.1 and NFI Pre-Inventory

Table 2.1-17 Correspondence of Land Use Classes in the Forest Base Map and NFI Pre-Inventory

IPCC Category	Forest Base Map No	Code	Class	NFI Land use class
Forest	1	P	Low Altitude Forest on Plains and Fans	low_altitude_forest_on_plains and
	2	H	Low Altitude Forest on Uplands	low_altitude_forest_on_upland
	3	L	Lower Montane Forest	lower_montane_forest
	4	Mo	Montane Forest	montane_forest
	4	Mo	Montane Forest	montane_coniferous_forest
	5	D	Dry Seasonal Forest	dry_seasonal_forest
	6	B	Littoral Forest	littoral_forest
	7	Fri	Seral Forest	seral_forest
	8	Fsw	Swamp Forest	swamp_forest
	15	M	Mangrove	mangrove
	20	Qf	Forest Plantation	acacia_plantation
				balsa_plantation
				eucalyptus_plantation
				hoop_plantation
				klinki_plantation
				pine_plantation
				rubber_plantation
				teak_plantation
				terminalia_plantation
				undetermined_plantation
Woodland	9	W	Woodland	woodland
Savanna	10	Sa	Savanna	savanna
Scrub	11	Sc	Scrub	scrub
Grassland	12	G	Grassland and Herbland	herbland
				meadows
	13	Ga	Alpine grassland	alpine_grassland
	14	Gi	Subalpine grassland	-

IPCC Category	Forest Base Map No	Code	Class	NFI Land use class
Cropland	16	O	Agricultural Land Use	irrigated_perennial_crops
				non_irrigated_perennial_crops
				other_crop
				subsistence_agriculture
				subsistence_agriculture_not_sure
				subsistence_agriculture_permanent
				subsistence_agriculture_shifting
	21	Qa	Plantation other than forest plantation	palm_oil
				cocoa
				coconut
				coffee
				tea
Wetlands	-	-	-	freshwater_swamp
				lowland_freshwater_swamp
				montane_swamp
				saline_brackish_swamp
	17	E	Lakes and larger rivers	lake
				river
Other land	18	Z	Bare areas	barrein_soil
				land_slides
				rock
				sand_soil
Settlements	19	U	Larger urban centres	large_settlement
				infrastructure
				village
-	22	Es	Sea	sea
	-	-	-	clouds
	-	-	-	other_reason

Error matrices were shown using forest / non-forest categories, six land categories of IPCC, seven categories in the Savanna / Scrub class, eight categories in the Woodland class, and the most finely detailed land use categories. Furthermore, error matrices were created for each province and the results were considered with the C/P. Each error matrix is shown in Annex 16.

The accuracy of classification using forest / non-forest categories in PNG is shown in Table 2.1-18. The Overall Accuracy (O.A.) was 87%. The high accuracy obtained here may be because of the high percentage of forest area (around 70%) in PNG.

Table 2.1-18 Classification Accuracy Using Forest / Non-Forest Categories in PNG

		NFI			
		Forest	Non-forest	Total	U.A.
Map	Forest	18333	1545	19878	92%
	Non-forest	1612	3606	5218	69%
	Total	19945	5151	25096	
	P.A.	92%	70%		

O.A.	87%

P.A. = Producer's Accuracy
U.A. = User's Accuracy
O.A. = Overall Accuracy

The accuracy of classification using IPCC land categories in PNG is shown in Table 2.1-19. The O.A. was sufficiently high (83%). The accuracy of classification using all land use categories in PNG is shown in Table 2.1-20. The O.A. was 60%.

Table 2.1-19 Classification Accuracy Using IPCC Land Categories in PNG

			NFI							
			Forest	Non-forest						
			Forest	Grassland	Cropland	Wetlands	Other land	Settlements	Total	U.A.
Map	Forest	Forest	18333	323	719	415	6	82	19878	92%
	Non-forest	Grassland	491	802	179	303	7	20	1802	45%
		Cropland	1063	273	1541	47	2	174	3100	50%
		Wetlands	53	19	2	209		2	285	73%
		Other land	5	4		3	2	1	15	13%
		Settlements		1	1			14	16	88%
		Total	19945	1422	2442	977	17	293	25096	
		P.A.	92%	56%	63%	21%	12%	5%		

O.A.	83%

Table 2.1-20 Classification Accuracy Using All Land Use Categories in PNG

				NFI																					
				Forest													Grassland		Cropland		Wetlands	Other	Settlements	Total	U.A.
														Woodl	Savanna/Sc										
				P	H	L	Mo	D	B	Fri	Fsw	M	Qf	W	Sa	Sc	G	Ga/G	O	Qa	E	Z	U		
Map	Forest	P	Low Altitude Forest on Plain	2446	1138	4		40	21	70	309	31	16	65	9	18	41		184	26	80		31	4529	54%
		H	Low Altitude Forest on Uplar	1122	4820	109			9	47	18		4	17	6	17	41		225	21	23	4	22	6505	74%
		L	Lower Montane Forest		58	4208	74						2			16	56	18	165	7	6	1	13	4624	91%
		Mo	Montane Forest			19	186									6	2	26						239	78%
		D	Dry Seasonal Forest	121	8			207	1	5	47			65	3	3	13				7			480	43%
		B	Littoral Forest	8					6		3	1		7			1			1				27	22%
		Fri	Seral Forest	17	18	11			1	4	11	1		5			3		2	3	6			82	5%
		Fsw	Swamp Forest	297	38			48	6	22	314	11		90	15	11	33		13	1	116		6	1021	31%
		M	Mangrove	17				2	11	2	34	104		5	2		1		3	2	62		2	247	42%
		Qf	Forest Plantation	3	3	1			1				7	1		2	1	1	11	2				33	21%
	Woodland	W	Woodland	267	33	1		326	5	16	247	7		307	115	40	51		36	5	104		2	1562	20%
	Savanna /Scrub	Sa	Savanna	5	1	1		34			8	3		77	132	8	27		11		9	1	6	323	41%
		Sc	Scrub	2	1	1	1	33			3			58	85	11	8		1		2			206	5%
	Grassland	G	Grassland and Herbland	83	44	45		53	3	7	72	4	1	98	24	36	689	20	162	15	303	7	19	1685	41%
		Ga/G	Alpine grassland/Subalpine g			7	12									2	23	70	2				1	117	60%
	Cropland	O	Agricultural Land Use	225	299	363	4	7	12	16	45	6	7	21	9	24	233	30	1211	132	47	2	165	2858	42%
		Qa	Plantation other than forest	13	6				1		1		2			2	10		66	132			9	242	55%
	Wetlands	E	Lakes and larger rivers	13	18	3		2		4	6	3		1	2	1	19		2		209		2	285	73%
	Other land	Z	Bare areas	2	1	1										1	4				3	2	1	15	13%
	Settlements	U	Larger urban centres														1		1				14	16	88%
			Total	4641	6486	4774	277	752	77	193	1118	171	39	817	402	198	1257	165	2095	347	977	17	293	25096	
			P.A.	53%	74%	88%	67%	28%	8%	2%	28%	61%	18%	38%	33%	6%	55%	42%	58%	38%	21%	12%	5%		

O.A.	60%

Checking each class, although the User's Accuracy (U.A.) of Settlements was 88%, Producer's Accuracy (P.A.) was only 5%. This indicates that although classified Settlements were extracted with high accuracy on the Forest Base Map, only larger urban centers and large Settlements were extracted. This was different from the NFI Pre-Inventory, which included small village as Settlements. Additionally, the NFI Pre-Inventory might have extracted more Settlements because of hierarchical land use rules, which extract Settlements preferentially.

High U.A. (73%) and low P.A. (21%) were also indicated for Wetlands. This mismatch is considered to have been caused by the difference in land classification between the NFI Pre-Inventory and the Forest Base Map. For example, in the former, swamp is classified in Wetlands; on the other hand, in the latter, land covers related to swamp are not categorized in Wetlands; swamp woodland is categorized in Woodland (W), while swamp grassland is classified in Grassland and Herbland (G). In addition, the category of Wetlands in the NFI Pre-Inventory, which is defined by flooded areas, changes depending on the season in which satellite imagery was taken. These would make the P.A. of Wetlands in the Forest Base Map low.

Both the P.A. (2%) and U.A. (5%) for Seral Forest (Fri) were very low. Fri is usually distributed along rivers and the shape of the area is long and thin, so that extracting Fri, even by interpretating satellite imagery, is considered difficult.

Most of the Forest Plantation (Qf) and Plantation other than Forest (Qa) categories on the Forest Base Map were classified as Agricultural Land Use (O) in Collect Earth. It is assumed that Collect Earth might not fully extract Plantations.

Large parts of Woodland (W) in the Forest Base Map were classified as Dry Seasonal Forest (D) in Collect Earth. It is assumed that distinguishing W and D is difficult.

As a result of accuracy assessments of each province, the P.A. of Wetlands in Gulf Province was very low (8%). In this province, there are many winding rivers and wetlands. Although many swamps were extracted along the rivers by Collect Earth, they were not in the Forest Base Map.

The accuracy of Cropland extraction varied region by region. Although the accuracy (especially P.A.) of Cropland was high in Enga Province, Hela Province, Western Highlands Province and Jiwaka Province, that of Central Province, Western Province and West Sepik Province was low. Enga Province, Hela Province, Western Highlands Province and Jiwaka Province are located in the small Highland Region, so accessibility is good and there are a lot of Plantations (Qa and Qf). Because the scale of commercial agriculture in this region is quite large and plantation boundaries are straight with angular shapes, extracting Cropland in this region was easy. On the other hand, Central Province and Western Province are less accessible, while most of the agricultural fields are for subsistence agriculture and are scattered. Additionally, the natural vegetation is very thin because of the dry climate, so that it is difficult to distinguish grassland and fields used for shifting cultivation.

As a result of the accuracy assessment, there was clarification of the characteristics of the Forest Base

Map and its features as compared with Collect Earth, and of the status of classification and related issues. The following are points to consider in using the Forest Base Map:

- Because the Forest Base Map and Collect Earth have different development methods (how to read land use), the characteristics of their data are also different. The Forest Base Map has data covering the entire land use area and it reads the land use of a certain area size. On the other hand, Collect Earth reads the land use of a 1 ha site with 25 check points located on 4 km grid lattice points. As a result, even if some point were classified as "A" in Collect Earth, the polygon of the Forest Base Map containing that point might be classified as having a different land use. Additionally, Collect Earth employs land use hierarchical rules for classification.
- The Collect Earth data is not always correct because it is not ground truth data.
- There are differences in the definitions of classes between the Forest Base Map and Collect Earth. Those of the Forest Base Map are based on FRIMS / PNGRIS, which is compatible with IPCC standards. Under IPCC standards, Forests and Grasslands are classified first and Wetlands may be extracted from other areas. Thus, on the Forest Base Map, swamp forest (Fsw) would be classified as Forest, swamp woodland as Woodland and swamp grassland and herbaceous swamp as Grassland, but none of these would be classified as Wetlands. On the other hand, Collect Earth categories of fresh water swamp, lowland freshwater swamp, mountain swamp and saline brackish swamp would be included in such categories as Woodland, Grassland, Swamp Forest, and Mangrove (M) on the Forest Base Map.
- The Forest Base Map focused on forest cover and the NFI Pre-Inventory focused on land use cover.

6) Subdividing Codes of Land Cover

In the Forest Base Map developed in the preceding T/C, the number of land cover codes is limited to 21 types for several reasons such as limitation in interpretation using satellite imagery (Table 2.1-21). The number of land cover codes in the existing FIMS, however, is 63 types, including various useful classifications such as wetlands. Therefore, PNGFA requested that 21 land cover codes from the Forest Base Map be subdivided into more codes, to be as close to FIMS as possible. By subdividing the land cover codes it was also expected that the accuracy of forest timber volume estimations would increase. The short-term expert team subdivided the land cover codes of the Forest Base Map by referring to the land cover codes of the FIMS.

Looking at a polygon to compare the land cover codes of the Forest Base Map with those of the FIMS, if a land cover code of the former was the same as a generic category of the latter, then the FIMS land cover code would be used. For example, when the land cover code of a polygon was "H" (Low Altitude Forest on Uplands) in the Forest Base Map and "Hm" (Low Altitude Forest on Uplands – Medium crowned forest) in the FIMS, the land cover code in the Forest Base Map was replaced with “Hm”. On the other hand, when the land cover code in the Forest Base Map and a generic category of the land cover code in the FIMS in a polygon was different, the land cover code in the Forest Base Map was kept and “x” was attached on the code as a suffix. This is because the land cover codes in the FIMS cannot be used as a reference for subdividing the land cover code in the Forest Base Map in this polygon. For example, when the land cover code of a polygon was “H” (Low Altitude Forest on Uplands) in the Forest Base Map and “P” (Low Altitude Forest on Plains and Fans – small crowned forest) in the FIMS, the land cover code in the Forest Base Map was replaced with “Hx”. The detailed rule applied for the subdivision is shown in Annex 15.

Table 2.1-21 Comparison between Land Cover Code in Forest Base Map and in FIMS

Forest Base Map		FIMS	
P	Low Altitude Forest on Plains and Fans – below 1000 m	Pl	Large to medium crowned forest
		Po	Open forest
		Ps	Small crowned forest
H	Low Altitude Forest on Uplands – below 1000 m	Hl	Large crowned forest
		Hm	Medium crowned forest
		HmAr	Medium crowned forest with *Araucaria* common
		Hmd	Medium crowned forest depauperate/damaged forest
		Hme	Medium crowned forest with an even canopy
		Hs	Small crowned forest
		Hse	Small crowned forest with an even canopy
		HsAr	Small crowned forest with *Araucaria* common
		HsCa	Small crowned forest with *Castanopsis*
		HsCp	Small crowned forest with *Casuarina papuana*
		HsN	Small crowned forest with *Nothofagus*
		HsRt	Small crowned forest with *Rhus taitensis*
L	Lower Montane Forest – above 1000 m	L	Small crowned forest
		LAr	Small crowned forest with *Araucaria* common
		LN	Small crowned forest with *Nothofagus*
		Lc	Small crowned forest with conifers
		Ls	Very small crowned forest
		LsCp	Very small crowned forest with *Casuarina papuana*
		LsN	Very small crowned forest with *Nothofagus*
Mo	Montane Forest – above 3000 m	Mo	Very small crowned forest
D	Dry Seasonal Forest	D	Dry evergreen forest
B	Littoral Forest	B	Mixed forest
		BCe	Forest with *Casuarina equisetifolia*
		BMl	Forest with *Melaleuca leucadendron*
Fri	Seral Forest	Fri	Riverine mixed successions
		FriCg	Riverine successions with *Casuarina grandis*
		FriK	Riverine successions with *Eucalyptus deglupta*
		FriTb	Riverine successions with *Terminalia brassii*
		Fv	Volcanic successions
Fsw	Swamp Forest	Fsw	Mixed swamp forest
		FswC	Swamp forest with *Campnosperma*
		FswMl	Swamp forest with *Melaleuca leucadendron*
		FswTb	Swamp forest with *Terminalia brassii*
W	Woodland	W	Woodland
		Wri	Riverine successions dominated by woodland
		WriCg	Riverine successions with *Casuarina grandis* woodland
		Wv	Volcanic successions dominated by woodland
		Wsw	Swamp woodland
		WswMl	Swamp woodland with *Melaleuca leucadendron*
Sa	Savanna	Sa	Savanna
		Saf	Savanna with gallery forest
		SaMl	Savanna with *Melaleuca leucadendron*
Sc	Scrub	Sc	Scrub
		ScBc	Scrub with *Bambusa* and *Cyathea*
		Scv	Volcanic successions dominated by scrub
G	Grassland and Herbland	G	Grassland
		Gf	Grassland with some forest
		Gr	Grassland reverting to forest
		Grf	Grassland reverting to forest with some forest
		Gsw	Swamp grassland
		Gri	Riverine successions dominated by grass
		Gv	Volcanic successions dominated by grass
		Hsw	Herbaceous swamp
Ga	Alpine grassland – above 3200 m	Ga	Alpine grassland
Gi	Subalpine grassland – above 2500 m	Gi	Subalpine grassland
M	Mangrove	M	
O	Agricultural Land Use	O	Land use intensity classes 0-4 (low to very high)
E	Lakes and larger rivers	E	Lakes and larger rivers
Z	Bare areas	Z	Bare areas
U	Larger urban centres	U	Larger urban centres
Qa	Forest Plantation	–	–
Qf	Plantation other than forest plantation	–	–

7) Addition of New Attributes

Additional attributes which are thought of as useful for the Forest Base Map have been arranged.

New information shown in Table 2.1-22, which was thought of as useful for developing information on growing stock in forest and examination of the method for defining a new set of the forest management units in 2.1.4（1）, was arranged as attributes of the Forest Base Map. Forest cover gain / loss data published by Hansen, et al. of the University of Maryland[11], which was considered useful for developing deforestation and forest degradation information in 2.1.3（2）, was also arranged as a relational database for the Forest Base Map with consideration given to convenient operation and maintenance since Hansen data should be updated annually and its data size could be large.

Table 2.1-22 New Attributes Added to the Forest Base Map

Attribute	Data Description / Note
Sub-vegetation type	Sub-vegetation type arranged in 2.1.3（1）6） Implemented in relation to old FIMS vegetation class
Tree crown size	Determined from sub-vegetation type
Forest Zone	Digitized 'FOREST ZONES OF PAPUA NEW GUINEA' map[12]
Catchment (watershed)	Used catchment data created from GeoSAR DEM in the preceding T/C
Province	
Forest cover gain	Sum of forest gain area from 2000 to 2012 Arranged as relational database from Hansen data Plan to be updated annually
Forest cover loss	Sum of forest loss area from 2000 to 2014 Arranged as relational database from Hansen data Plan to be updated annually
Forest cover loss year	Forest loss area of each year from 2000 to 2014 Arranged as relational database from Hansen data Plan to be updated annually

8）Treatment of Small Studded Islands

The following points regarding small islands were identified as a result of comparing the Forest Base Map with other existing data such as province data from the 2011 Census published by National Statistical Office (NSO), old FIMS vegetation data, and province data from Geobook[13].

- Country boundaries between existing data have some differences, especially around small islands
- The Forest Base Map does not cover all small islands
- The Forest Base Map includes islands in Australian territory and Solomon Islands

[11] Hansen, Potapov, Moore, Hancher, et al., Global Forest Change 2000-2015, https://earthenginepartners.appspot.com/science-2013-global-forest (accessed on 03 April 2017)
[12] Accompany to E.T. Hammermaster and J.C. Saunders, Forest resources and vegetation mapping of Papua New Guinea, PNGRIS Publication No. 4 (1995)
[13] University of Papua New Guinea Remote Sensing Centre, PNG Geobook

The data conditions were understood by the C/P, and as a result of discussions with the C/P, ways to cope with the aforementioned points were decided as follows:

- The boundary of the Forest Base Map, which was created from RapidEye imagery, is be maintained, since other existing boundaries are not necessarily accurate
- Small islands which were not included in the Forest Base Map are not under the jurisdiction of PNGFA and there is no land use information on them, thus they were not newly created. Notes and explanation of small island data conditions were inserted in the metadata of the map
- Islands in Australian territory and Solomon Islands are maintained with “outsidePNG” description in the attribute table to indicate their territory

Details about contents and results of the discussion are shown in Annex 16.

（2）Processing and Analysis of the Remote Sensing Data on a Trial Basis

1）Examining RS Information Utilized for Identifying Secondary / Degraded Forest

The issue of grasping the distribution of secondary / degraded forest was raised at the end of the preceding T/C, so it was examined in this Project. Selective logging, collection of fuel wood, grazing in forests, gathering understory plants, fire, flooding, landslides, etc., are listed as factors of forest degradation and deforestation, which cause the formation of secondary forests. Subsistence agriculture and the construction of towns, roads, plantations, etc., are also critical reasons for deforestation. To specify places affected by forest degradation or deforestation, clarifying each driver is necessary to simulate change in forest biomass just after the damage has occurred and to simulate the process of forest regrowth. The short-term expert team collected RS data to understand this kind of information.

As for RS information, which can be utilized for both the detection of forest change and the identification of its drivers, optical satellite imagery is one option. Analyzing this kind of information along a time series, forest change and its drivers can be identified intuitively. Although this task will become easier as imagery resolution increases, high-resolution imagery entails higher costs. However, because Sentinel-2 imagery (spatial resolution: 10 m) is now freely available on the Internet, as is traditional LANDSAT imagery (spatial resolution: 30 m), it is easy to detect at least logging roads, even though direct detection of selective logging is still difficult. Cloud disturbance is one of the difficulties with technology using optical satellite imagery for monitoring the ground. As a lot of places, especially mountainous regions in PNG, are covered by clouds for almost the entire year, it is sometimes too difficult to monitor the ground conditions of such areas.

Radar satellite imagery is another option for monitoring forests. This information is not affected by clouds, so the ground situation can always be observed without any interruption. As this kind of imagery may not provide intuitive information like optical imagery does, it is first necessary to confirm what kind of ground features can be detected. As with optical imagery, the price of imagery increases as the resolution increases.

Imagery from PALSAR, Japanese Radar satellite, which is lower in resolution (25 m), can be obtained via website for free (http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm (accessed on 03 April 2017)).

Greenest Pixel, processed by Google Earth Engine (https://earthengine.google.com/ (accessed on 03 April 2017)) is one kind of information which takes good points from both optical and radar imagery. This information includes all the scenes in particular periods (of one year, for example) obtained by each LANDSAT satellite (#4, 5, 7, 8) or Sentinel-2 with the greenest pixel (30 m x 30 m for LANDSAT and 10 m x 10 m for Sentinel-2) on top, where 'the greenest pixel' means the pixel with the greatest Normalized Difference Vegetation Index (NDVI) value. The information shows cloud-less optical features on the ground (Figure 2.1-22).

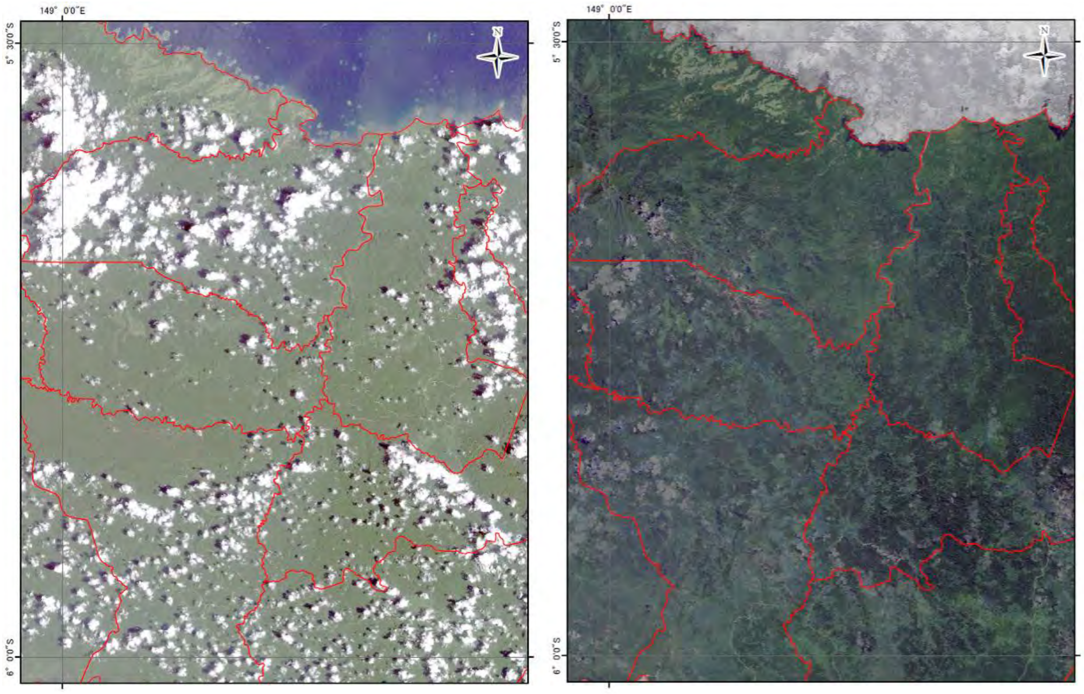


Figure 2.1-22 A Comparison of LANDSAT Imagery (Left) and LANDSAT Greenest Pixel (Right)

Greenest Pixel generated from Sentinel-2 images of the Aria Vanu Block 2 concession area and the surrounding area in West New Britain Province, one of the pilot sites of the Project, were analyzed (Figure 2.1-23). The first satellite of Sentinel-2 (a two-satellite constellation) was launched on 23rd June 2015. The second satellite was launched on 7th March 2017. As of 16th July 2016, when the analysis was implemented, the Sentinel-2 mission provide global coverage of the Earth's land surface every 10 days with one satellite. A total of seven satellite images of Aria Vanu Block 2 and the surrounding area were available for the use of the Project. Observation of the state of Aria Vanu Block 2 logging roads on Greenest Pixel revealed that clouds and haze on the images had not been removed completely and that areas of selective logging were not clearly identifiable, except at some log-skidding roads and at locations near logging roads. However, as an image of a certain area with very little cloud cover can be generated from twenty or so LANDSAT images of the area taken over a year. Considering all of these factors, it was thought that the Sentinel-2 imagery would become a powerful tool once it started operation with two satellites allowing frequent observations. The technology development in this Project proceeded using Greenest Pixel generated from LANDSAT imagery; however, the Project team noted that in future it can be replaced with Greenest Pixel generated from Sentinel-2 imagery.

There is another advantage to handling satellite imagery using Google Earth Engine. Because of the large sizes of Sentinel-2 images, some of which exceed 6 GB, it is very difficult to download and utilize them in a country with a poor Internet environment, such as PNG. However, the use of Google Earth Engine enables its users to use the Sentinel-2 images for reference purposes without downloading them and to download small portions of images that they require.

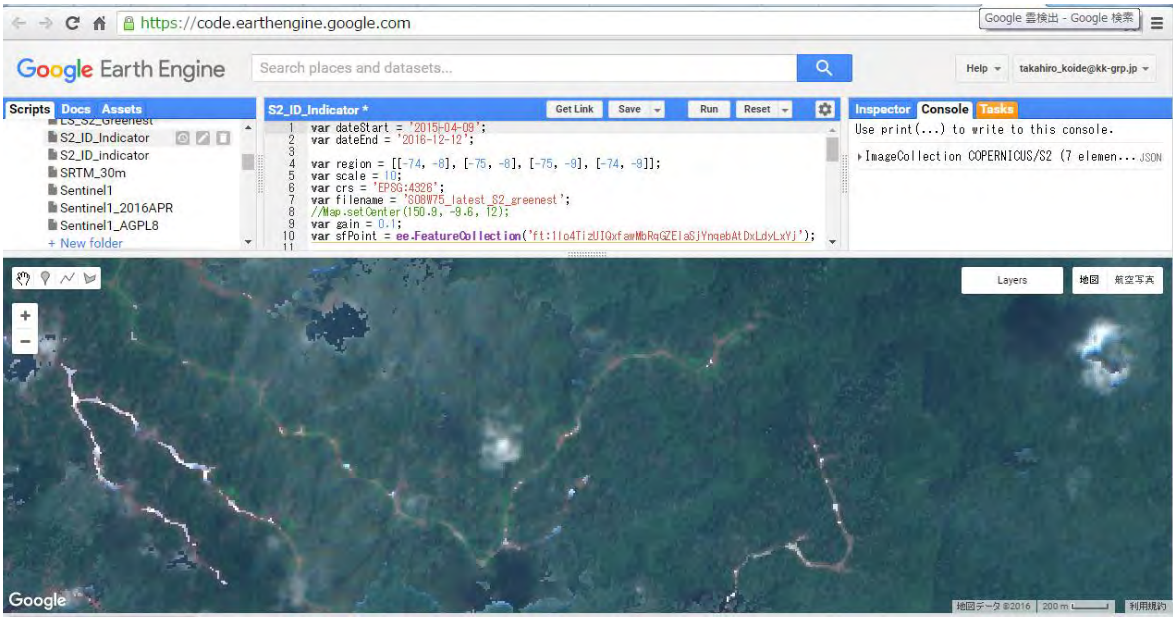


Figure 2.1-23 Logging Roads Seen on Greenest Pixel Generated from Sentinel-2 Images

Another set of information easily accessible with regard to forest degradation is a dataset of forest reduction developed by Professor Matthew C. Hansen of the University of Maryland, in the USA (https://earthenginepartners.appspot.com/science-2013-global-forest (accessed on 3rd April 2017)). This dataset shows yearly forest reduction between 2001 and 2013 based on an algorithm that detected areas where a decrease of vegetation taller than 5 m was occurring by utilizing imagery of LANDSAT 7 and LANDSAT 8 (Figure 2.1-24). It is necessary to utilize this dataset taking into account that type of vegetation (forest, grass, plantation, etc.) and the reason it has decreased is not considered in the dataset.

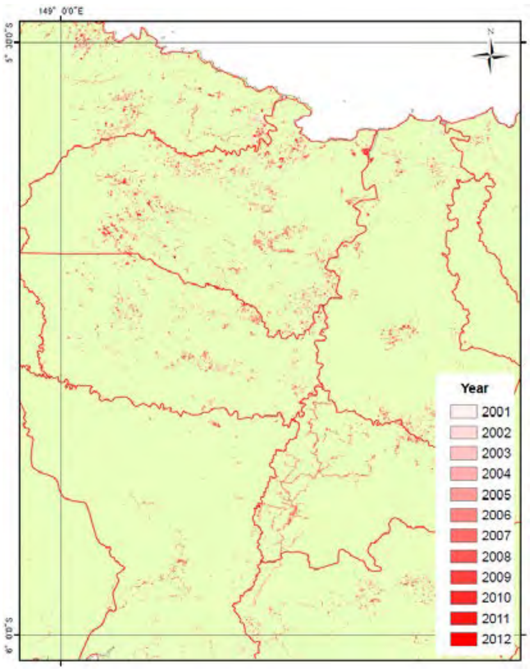


Figure 2.1-24 A View of Dataset Developed by Prof. Hansen's Team

In this Project, it is necessary to establish a sustainable system for PNGFA by identifying the type of information and the required frequency of data collection to update the forest cover map economically and efficiently. The short-term expert team collected all available RS data possible that could be applied for updating the forest cover map (Table 2.1-23) to examine how to detect forest degradation and deforestation caused by each driver (see to 2.1.3（2）2）). The LANDSAT Greenest Pixel was collected for some specific years and areas (Table 2.1-24).

Table 2.1-23 RS Dataset Collected in this Project

Sort of data	Resolution	Price	Procurement Method
RapidEye	5 m	High	Obtained in whole of PNG in the preceding T/C
PALSAR	10 m	Middle	Obtained in whole of PNG in the preceding T/C
PALSAR-2	10 m	Middle	Obtained only one imagery on the short-term expert team's expense
PALSAR	25 m	Free	Obtained in whole of PNG from a web site[14]
Greenest Pixel (LANDSAT)	30 m	Free	Obtained in whole of PNG from a web site
Greenest Pixel (Sentinel-2)	10 m	Free	Obtained only around Aria Vanu Block 2 from a web site
Hansen	30 m	Free	Obtained in whole of PNG from a web site

[14] Obtained for each year from 2007 to 2010

Table 2.1-24 Years and Areas in which LANDSAT Greenest Pixel Was Collected

Area	Years Greenest Pixel was Collected
Whole of PNG	1990, 2000, 2005, 2010, 2011,and 2014
Milne Bay Province	Every year from 1987 to 2014
West New Britain Province	1989, 1990, every year from 1999 to 2014

2) Trial Detection of Forest Degradation and Deforestation Using RS Data

As stated above, to identify points with forest degradation and deforestation that are causing the occurrence of secondary forest, it is necessary to distinguish each driver to simulate a decrease in the amount of forest carbon stock just after the disturbance has occurred, and to simulate recovery in the future. In this section, methodologies for detecting forest degradation and deforestation and identifying each driver utilizing available RS data were examined.

Selective logging is an important driver for forest degradation in PNG. The short-term expert team tried to detect the marks of this activity by utilizing RS data. Figure 2.1-25 compares two satellite views, RapidEye (5 m-resolution) and Greenest Pixel (30 m-resolution), of a selective logging site in Asengseng Consolidated FMA, in West New Britain Province. Although it is possible to confirm the marks of selective logging in the lower right part of the RapidEye imagery, it is not in Greenest Pixel. This is because the width of the skidding track is only 4 m and the area of one spot of canopy loss is, at most, the same as the size of a single crown of the fallen tree (Figure 2.1-26). Greenest Pixel with 30 m-resolution could not detect those marks. On the other hand, the logging road is easily detected by Greenest Pixel (Figure 2.1-25). Assuming selective logging was occurring within some distance from the logging road, it is possible to estimate the range of the logging site indirectly.

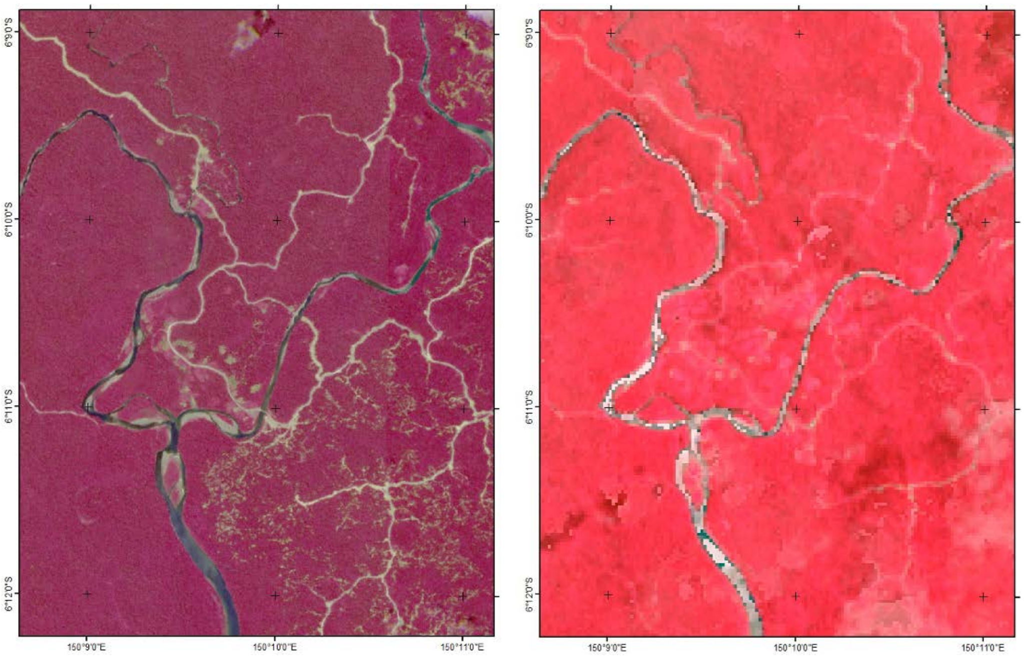


Figure 2.1-25 Satellite Views of a Selective Logging Site in Asengseng FMA 1

(Left) RapidEye (5 m-resolution). Year 2010; (Right) LANDSAT Greenest Pixel (30 m -resolution), Year 2014

Figure 2.1-26 Interior of a Forest Selectively Logged One Month Before
(Rottock Bay FMA, West New Britain Province)

(Left) Skidding track; (Right) Canopy of the forest

Although the resolution of PALSAR-2 imagery is relatively high (10 m), it is not possible to detect the marks of the selective logging (Figure 2.1-27 left). Even though the logging road is identified, it is not clear when compared with RapidEye imagery and Greenest Pixel. Hansen's dataset also cannot identify the marks of the logging, although a major logging road was apparently developed after the year 2001 (Figure 2.1-27 Right). Hansen's team states that their data set can detect a certain area of vegetation loss but cannot identify vegetation loss with small spot shapes such as with marks of selective logging.

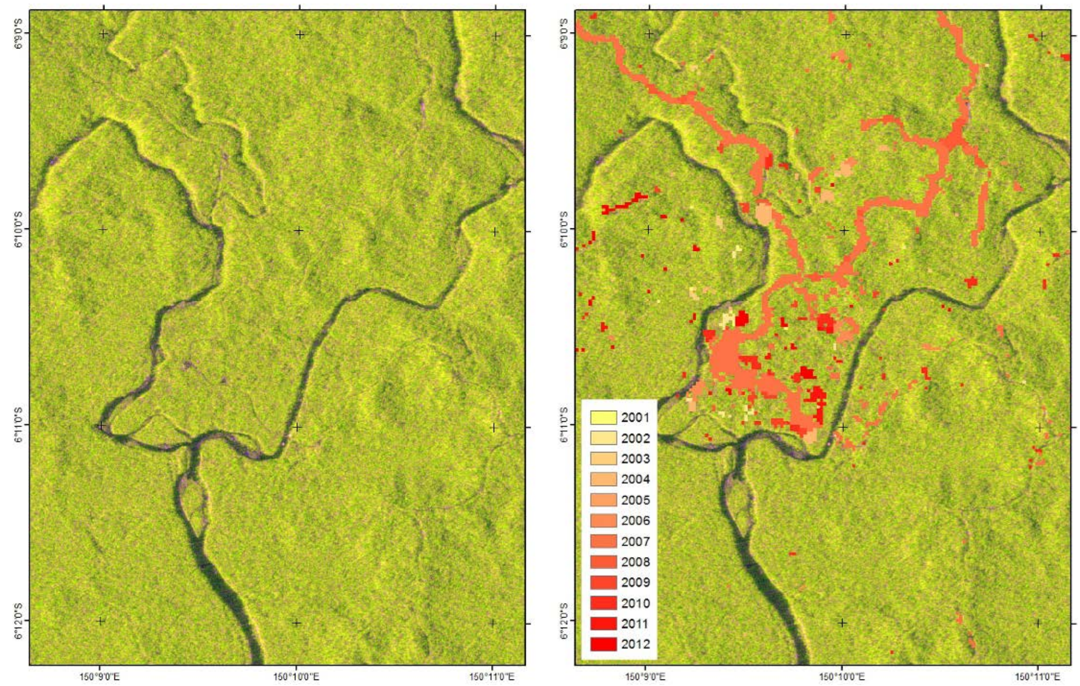


Figure 2.1-27 Satellite Views of a Selective Logging Site in Asengseng FMA 2

(Left) PALSAR-2 (10 m-resolution), year 2015; (Right) PALSAR-2 imagery plus Hansen's dataset

Figure 2.1-28 compares PALSAR-2 imagery and PALSAR imagery and high resolution imagery (10 m) and low resolution imagery (25 m). Although PALSAR-2 imagery seems to be able to detect ground features more clearly than PALSAR imagery does, it is not able to identify the selective logging site. The higher resolution imagery can detect ground features more clearly than the lower resolution. Even the logging road is not easy to identify from the lower resolution imagery.

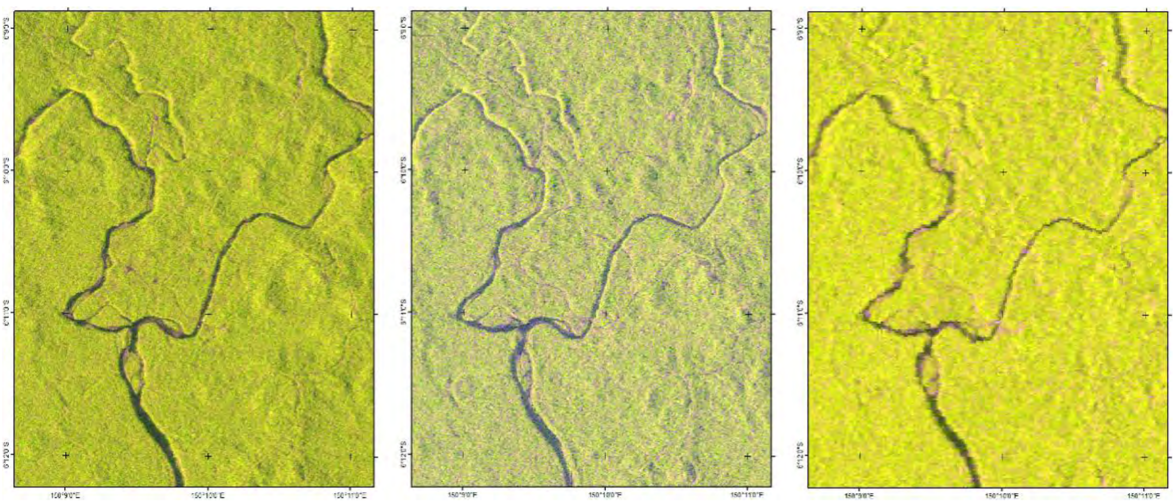


Figure 2.1-28 Satellite Views of a Selective Logging Site in Asengseng FMA 3

(Left) PALSAR-2 (10 m-resolution), year 2015; (Center) PALSAR (10 m-resolution), year 2010; (Right) PALSAR (25 m-resolution), year 2010

Forest degradation / deforestation caused by other drivers can be detected by Hansen's data in most cases (Figure 2.1-29 – Figure 2.1-32).

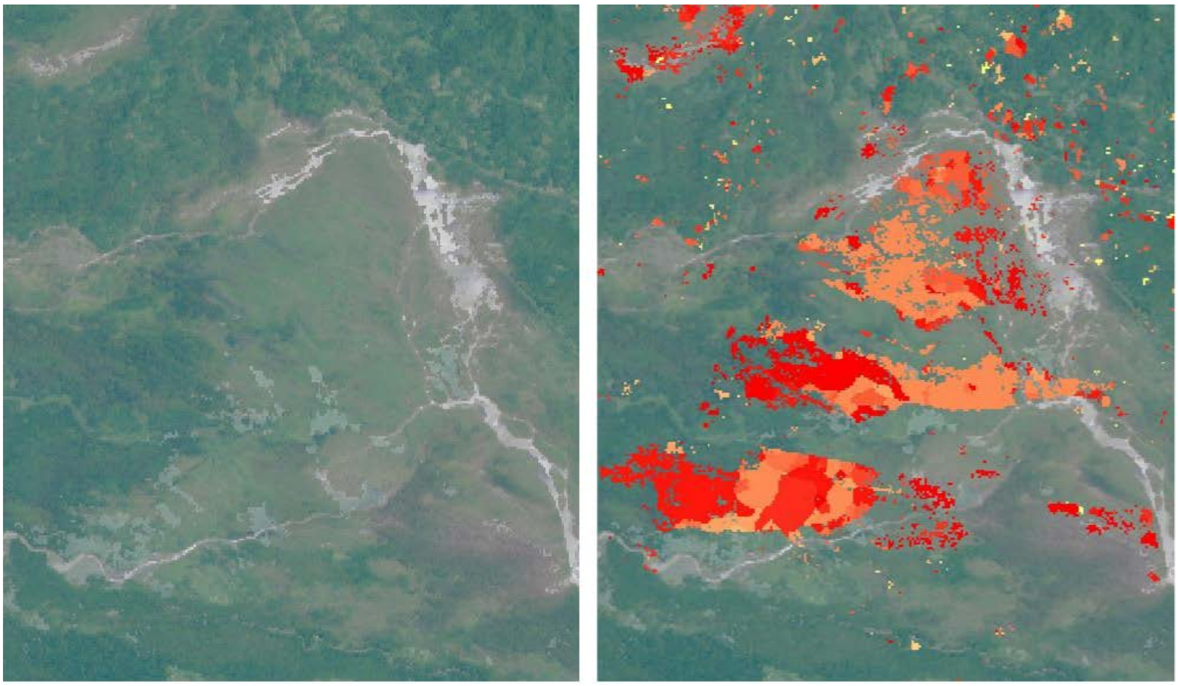


Figure 2.1-29 Detection of Vegetation Loss by Flooding

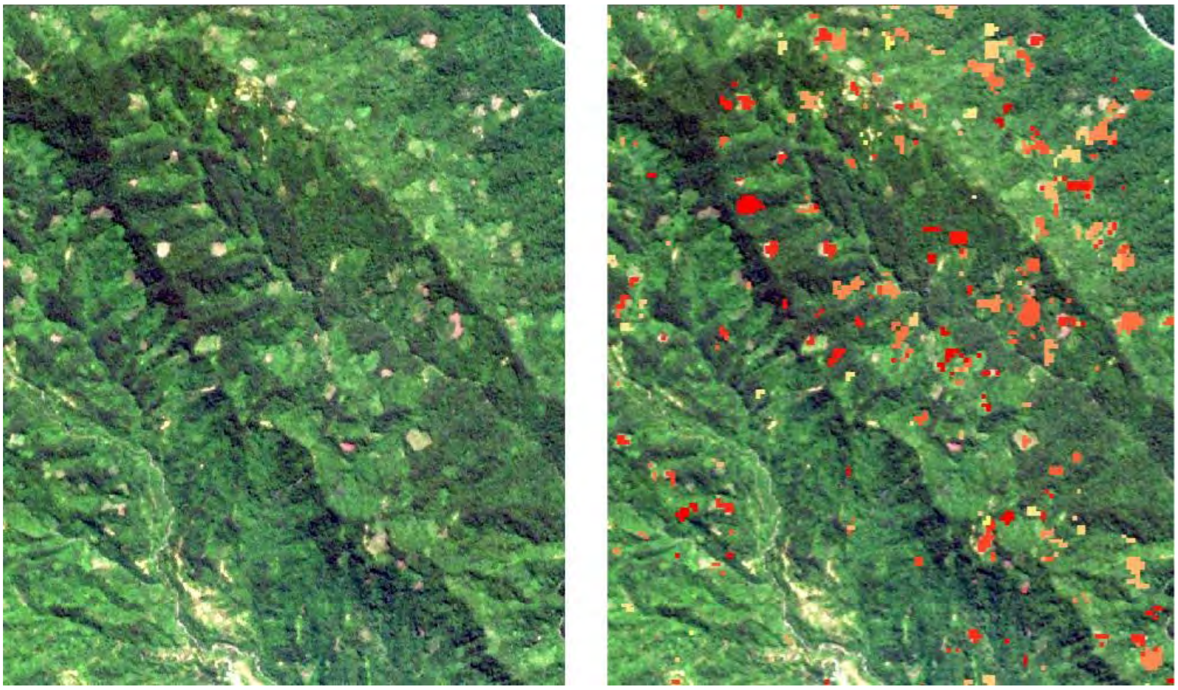


Figure 2.1-30 Detection of Vegetation Loss by Subsistence Agriculture

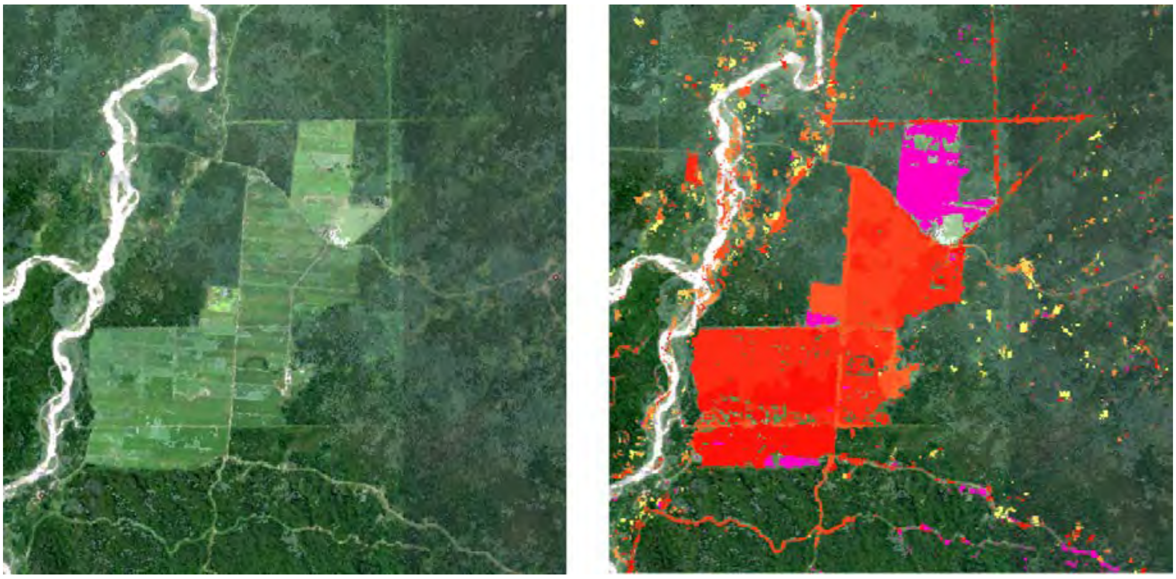


Figure 2.1-31 Detection of Vegetation Loss by Plantation Activity

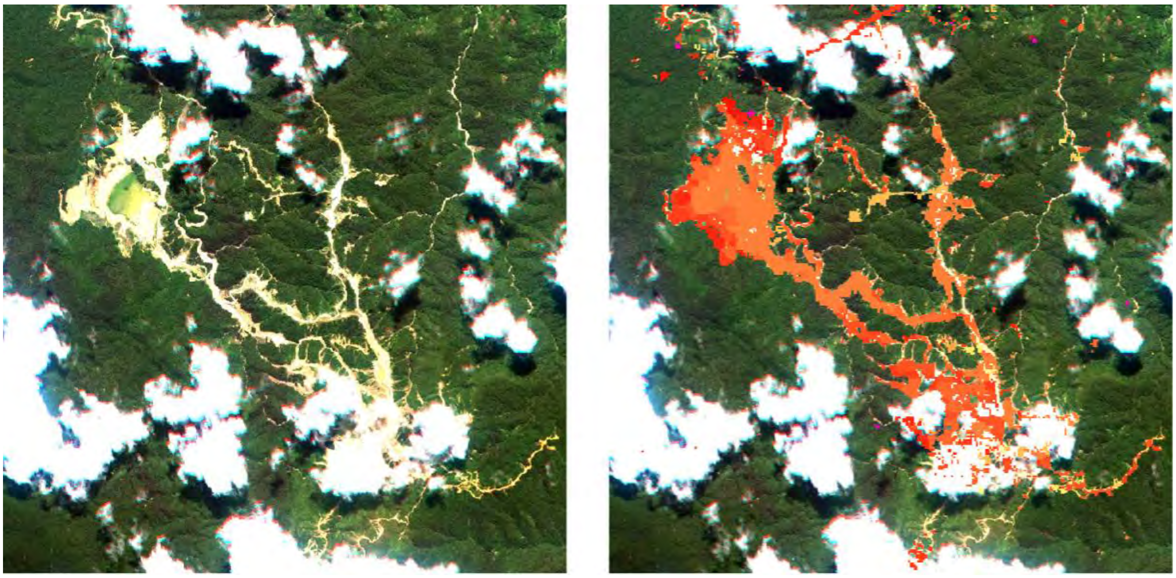


Figure 2.1-32 Detection of Vegetation Loss by Mining

3) Identification of Deforestation Drivers in an Area of 20 Hectares or More

There is a limit on the accurate identification of this information due to a limited budget and manpower. The key is how adequate monitoring can be performed while saving manpower. Therefore, this Project used as reference the Hansen data and interpreted the drivers at all the points where deforestation occurred in an area of 20 hectares or more using RapidEye satellite imagery (resolution of 5 m), LANDSAT Greenest Pixel (resolution of 30 m), imagery of Google Earth[15], etc., and checked what kind of drivers were observed and how frequently and how well they could be

[15] Mosaicked imagery utilizing the newest and finest available imagery among LANDSAT, Sentinel-2, imagery of DigitalGlobe, etc. It is said that the spatial resolution is between 15 m and 15 cm.

identified in the satellite imagery. After this process, the method for identifying deforestation and forest degradation drivers was proposed to the C/P.

Hansen Loss is a pixel-by-pixel representation of annual deforestation areas extracted from differences of annual series of LANDSAT imagery using a certain algorithm. However, this data must be used with attention paid to the point that any vegetation higher than 5 meters is identified as a forest in this data. As LANDSAT has a spatial resolution of 30 meters, Hansen Loss also has an equivalent spatial resolution, and the area per pixel is 900 m^2, equivalent to 0.09 hectares. To find the deforestation value of 20 hectares or more, it is necessary to use the Region Group function of ArcGIS to find an area in which 223 or more Hansen Loss pixels of the same year are concentrated in proximity to each other, or to convert Hansen Loss in raster format into polygons and calculate their area. However, although the use of the Region Group function allows you to determine that the same-year deforestation pixels in contact with each other at the corners belong to the same group, conversion into polygons allows you to determine that only the pixels sharing a side belong to the same group.

In this Project, the Region Group function was used to extract 1,231 deforestation areas of over 20 hectares throughout PNG for a period of 13 years from 2001 to 2013. The deforestation drivers for each of these deforestation areas were estimated by observing them in the LANDSAT Greenest Pixel (resolution of 30 m), RapidEye satellite images (resolution of 5 m) in 2011, and Google Earth. Also referenced were the mine and forest concession boundaries, plantation and farmland information in the Forest Base Map, boundaries of Special Agriculture and Business Leases (SABL)[16] and Forest Clearance Authority (FCA)[17], and FireWatch PNG (http://fire.pngsdf.com/ (accessed on 03 April 2017)), a fire detection system jointly developed by the University of Papua New Guinea (UPNG) and the European Union (EU). Volcanic eruption information and other information were also used in some cases.

[16] Permission of development for agricultural purpose leasing customarily-owned land. The permission fixes the boundaries.
[17] Authority of forest clearance by developers within SABL boundaries. The authority fixes the boundaries.

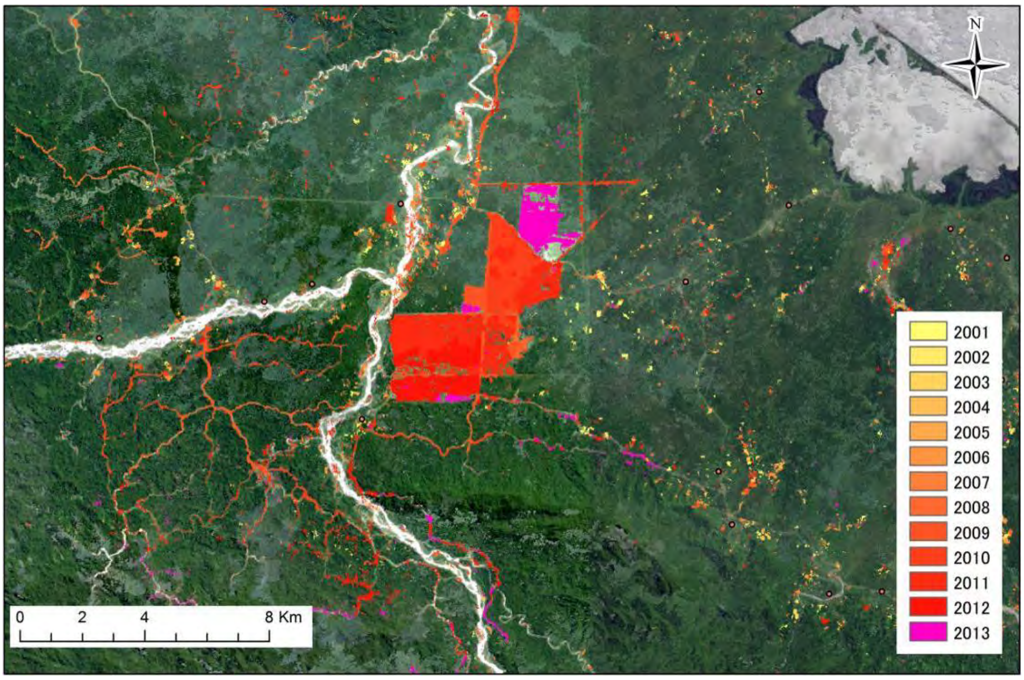


Figure 2.1-33 Conceptual Drawing of Extracted Deforestation Areas

Note: The areas shown in red, orange, and yellow in this figure are determined to be deforestation areas. These colors represent the years in which deforestation occurred.

The drivers were identified using the key-out method according to the rules shown in Figure 2.1-34. The drivers to be identified are thus exclusive to each other. Thus, any operator can identify the same driver for one deforestation area. As shown in the rules below, the identification operation started from drivers that were obvious and easily identifiable, such as mining activities and plantations, and then progressed to drivers that were difficult to interpret in satellite imagery such as fires. The drivers were indicated as "unknown" for the deforestation areas for which no driver could be identified until the end.

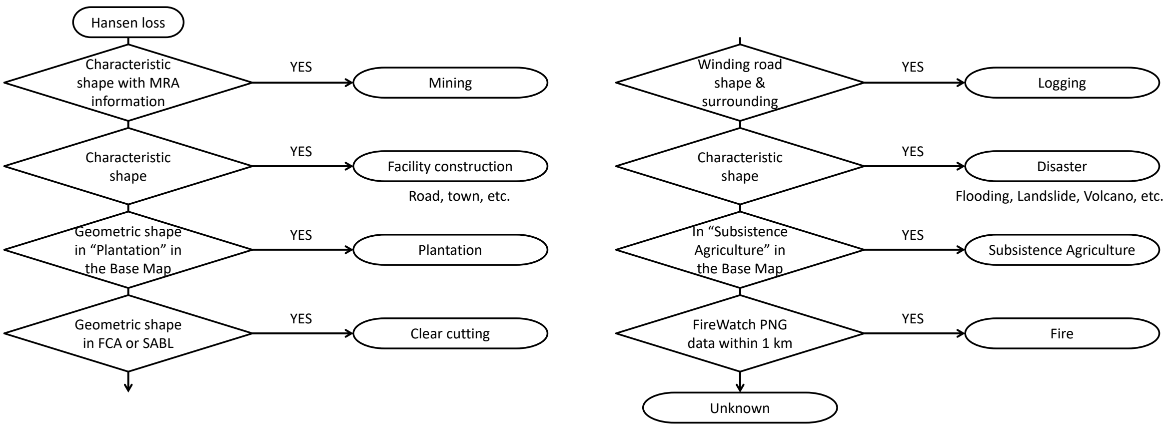


Figure 2.1-34 Rules Used to Identify Deforestation Drivers

The analysis discovered that, among 1,231 deforestation areas, over 20 hectares in total, 629 areas, which account for over 50% in number and over 70% in area, are either logging associated with plantation activities or replanting of cultivated crops themselves (Figure 2.1-35). Determining whether deforestation is due to logging or replanting of cultivated crops is equal to determining whether the land use in a certain area has changed from a forest to a plantation or has remained a plantation and therefore bears high importance in forest management. However, the current analysis operation could not go so far as to identify which.

Other identified deforestation drivers were forestry (opening of logging roads; 7.2% in area), logging for unknown land uses (many of which seem to be plantations; 7.1% in area), natural disasters (landslides, floods, and volcanic activities; 5.3% in area), unknown (2.8% in area), fires (2.2% in area), construction of buildings, etc. (2.1% in area), subsistence agriculture (1.8% in area), and mining (0.4% in area).

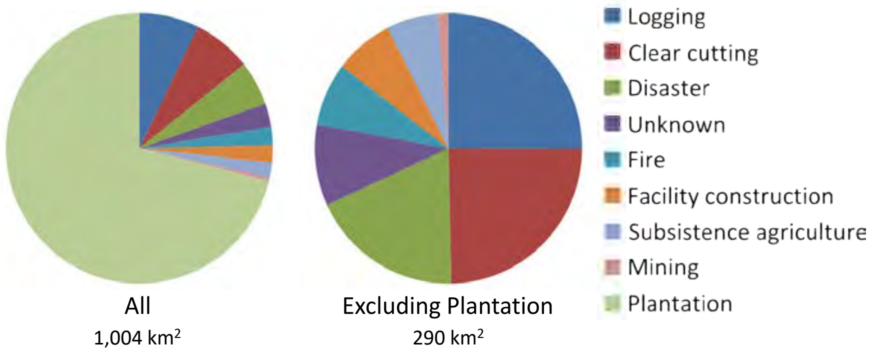


Figure 2.1-35 Driver-by-Driver Area Percentages of Deforestation in an Area of 20 Hectares or More

Note: The pie chart on the left shows the result of analysis of all 1,231 areas. The pie chart on the right shows the result of analysis of the areas excluding the 629 areas identified as plantations.

According to the detection using Hansen Loss, deforestation areas over 20 hectares reached a total of 1,004 km^2 in the 13 years from 2001 to 2013. If deforestation areas less than 20 hectares are added, the total deforestation area reaches 8,108 km^2. In other words, not all of the deforestation phenomena in PNG can be understood by identifying only drivers for deforestation areas over 20 hectares. However, a total of over 1.8 million deforestation areas with an area of one pixel (0.09 hectares) or more have been recorded over 13 years throughout PNG. It is practically impossible to identify all the drivers. Furthermore, the factors that are lowering the quality of forests in PNG not only consist of deforestation but also of forest degradation due to selective logging accompanying forestry activities. These factors can be detected neither in medium-resolution satellite images such as LANDSAT, which are freely available, nor in Hansen Loss. To identify the drivers of such minor deforestation and forest degradation, it may be better to classify them mechanically according to certain rules, instead of checking them one by one. For example, some possible rules are as follows:

- All Hansen Losses found in the places recorded as plantations in the Forest Base Map shall be regarded as due to deforestation resulting from plantations.
- All the Hansen Losses found within a certain distance (10 km) from villages shall be regarded as due

to deforestation resulting from subsistence agriculture. The other places not detected as Hansen Losses shall be regarded as due to forest degradation in progress, resulting from human activities such as collecting fuel wood and construction materials.

- The places recorded as logged over areas at PNGFA shall be regarded as due to forest degradation in progress resulting from selective logging.
- Other Hansen Losses that do not meet any of the above conditions shall be regarded as due to natural disasters.

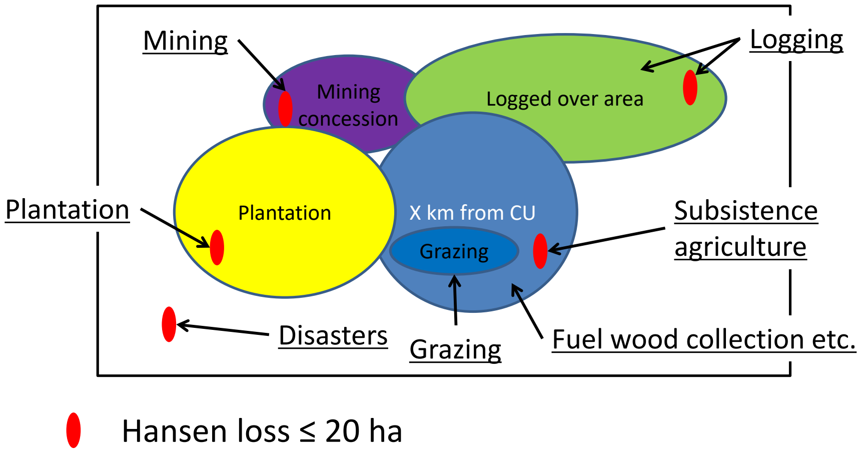


Figure 2.1-36 Automatic Detection of Deforestation and Forest Degradation (Schematic Image)

After automatically assigning deforestation and forest degradation drivers according to the above rules, check the Hansen Losses larger than a certain size (for example, 20 hectares) one by one and then identify their drivers using certain rules. For example, possible rules are as follows:

- The Hansen Losses inside the mining concessions shall be regarded as due to mining.
- The roads and buildings under construction shall be interpreted from their characteristic shapes.
- The winding roads under construction in forests shall be regarded as due to deforestation resulting from forestry activities.
- All the Hansen Losses found in the places recorded as farmland in the Forest Base Map shall be regarded as due to commercial agricultural activities.
- The Hansen Loss found near a recorded fire (within 1 km) in the same year, and not attributable to any other causes, shall be attributed to natural fires.

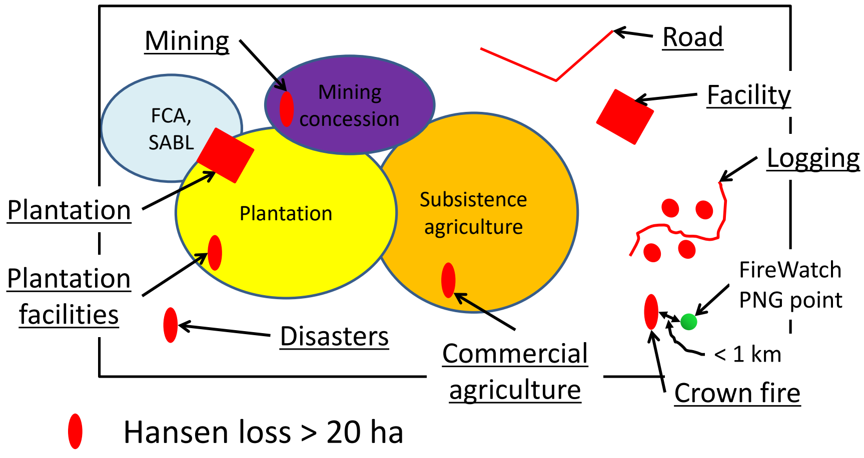


Figure 2.1-37 Detection of Deforestation over a Certain Size (Schematic Image)

Based on the above proposal, the long-term experts took the lead in PNGFA to discuss definitions and methods of deforestation and forest degradation (Annex 17), followed by examination on how to add information about deforestation, forest degradation and each driver into the Forest base Map and forest cover maps (Annex 18).

4）Examining to Detect Deforestation and Forest Degradation Using CLASlite

CLASlite (The Carnegie Landsat Analysis System Lite, Carnegie Institution for Science) is software that can analyze multiband optical satellite images such as LANDSAT and detect not only the disappearance of forests but also forest degradation that cannot be interpreted through visual checks. This Project estimated the points where deforestation and forest degradation occurred in the East Fergusson area in Milne Bay Province, an ex-pilot area. After that, the area was actually visited to compare the results of CLASlite and the actual conditions in the field.

CLASlite is software that can analyze multiband optical satellite imagery such as LANDSAT by removing areas covered by cloud and haze and combining the different bands to enable detection and display of forest cover, forest degradation areas, and exposed soil surfaces that cannot be intuitively interpreted with human eyes. This software is available free of charge to non-profit organizations such as PNGFA. This Project analyzed LANDSAT images from 2000, 2004, 2005, 2006, 2007, 2008, 2010, and 2014 in the East Fergusson TRP (Figure 2.1-38). The analysis results of 2010 and 2014 were then compared to extract the areas where deforestation and forest degradation occurred according to the changes in the forest cover status. When the results were compared with the LANDSAT imagery (Figure 2.1-39), it was found that the areas where logging roads were constructed roughly matched the extracted areas of deforestation. Some logging road areas that were not extracted had possibly been removed because the same points in both the 2010 and 2014 imagery were covered with cloud or haze, thus rendering the comparison between these years impossible.

The results of analysis by CLASlite were compared with the field status (Figure 2.1-40). Many of the areas identified as deforestation by CLASlite were areas with exposed soil such as logging roads. In the areas identified as forest degradation by CLASlite, the canopy was lost but understory plants flourished and no soil was exposed. From these observations, the analysis results by CLASlite seemed to reflect the field status to a certain degree. However, it took one month for this analysis in this area alone. Considering implementation of this analysis on a national level, a huge amount of time will be consumed. The introduction of CLASlite in PNGFA in not recommended because CLASlite will not compensate the dedicated efforts.

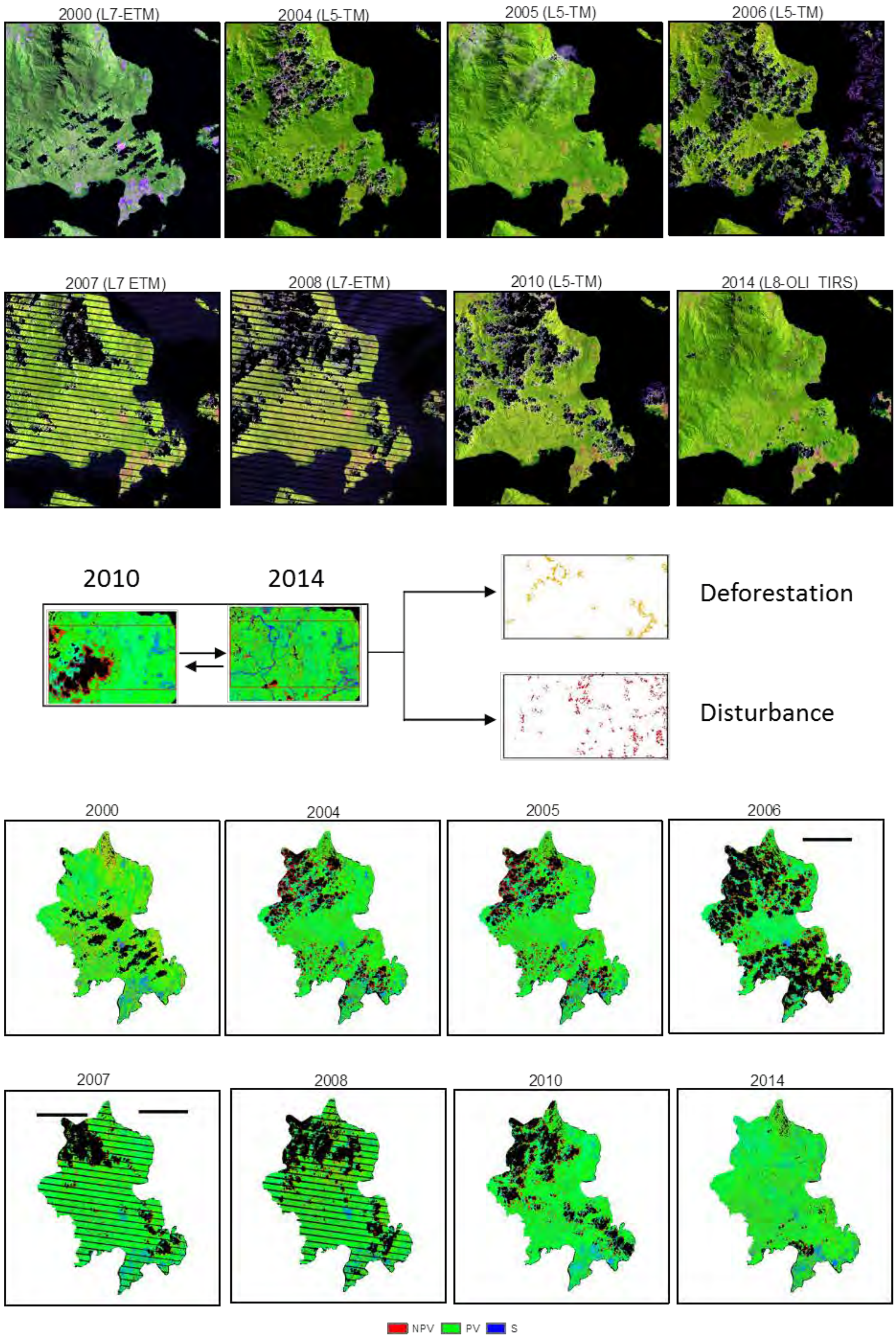


Figure 2.1-38 Conceptual Drawing of Analysis by CLASlite

Note: The top row shows how areas covered by cloud and haze are removed from the raw LANDSAT images. The middle row shows how the same points are compared in images of different years to detect deforestation and forest degradation. The bottom row illustrates areas with forest cover, forest degradation, and exposed soil, respectively.

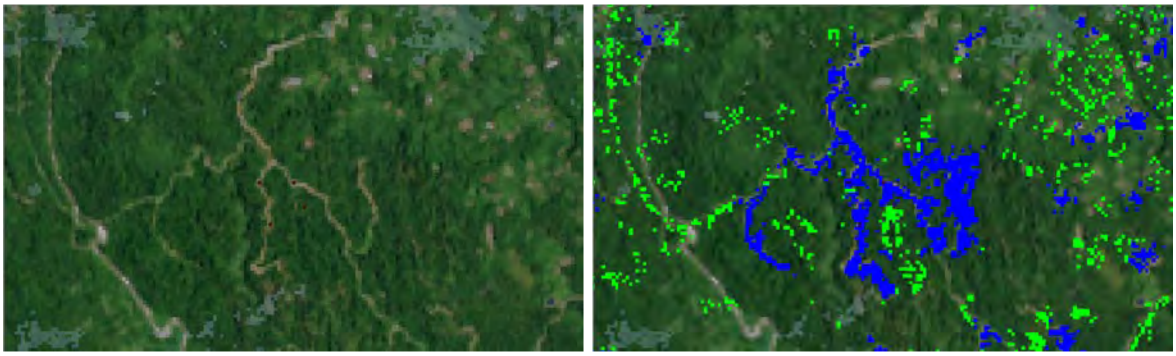


Figure 2.1-39 Comparison of LANDSAT Imagery with Deforestation and Forest Degradation Areas Extracted by CLASlite

Note: The left figure shows a LANDSAT image. The right figure shows a LANDSAT image on which analysis results by CLASlite are overlaid. The blue areas represent deforestation areas. The green areas represent forest degradation areas.

Figure 2.1-40 Comparison of CLASlite Analysis Results with the Field Status

Note: The upper left figure shows a forest in a healthy state. The upper right figure shows an area determined to have deforestation. Both of the lower figures show an area determined to have forest degradation.

(3) Identify Necessary Additional Information from Other Sources than Remote Sensing Data

Items examined in this section have already been described in the previous section (see 2.1.3（2）), so just summaries of each item are described here.

It was difficult to detect the marks of selective logging, which is a very important driver for forest degradation in PNG, utilizing available RS data directly. Estimating areas where selective logging is occurring indirectly is necessary, considering sustainable forest monitoring that uses RS data in PNGFA. As an alternative means for this, it is possible to extract logging roads utilizing free LANDSAT Greenest Pixel and assume that selective logging is occurring within a certain distance from the logging road. For this Project, road GIS data from 2000, 2005, 2011 and 2015 were developed on the national level (refer to 2.1.64）). Otherwise, it is also possible to consider that selective logging is occurring within logged over areas, which are digitized by PNGFA from maps of ALPs submitted by logging companies.

Although collecting fuel wood, cattle grazing and utilizing understory vegetation are also important drivers for forest degradation, it is very difficult to detect these activities utilizing RS data. It is possible to assume they are occurring within some distance from villages. The geospatial information of Census Unit[18] was used for specifying locations of villages.

It is sometimes difficult, with RS data, to identify if the driver of deforestation is caused by mining. The short-term expert team considered adding boundary data of mining activity obtained from the Mineral Resource Authority (MRA)[19] for identifying drivers.

Regarding fire, even if deforestation itself is caused by fire and can be detected by both optical and radar satellite imagery, it is very difficult to identify its driver. In this regard, only when the driver of some of Hansen's yearly vegetation loss cannot be clarified, FireWatch PNG — (http://fire.pngde.com (accessed on 03 April 2017)), a web site developed by UPNG with the support of the EU — was utilized to check for the presence of fire around the area in question in a particular year, helping to clarify whether the driver was fire or not.

(4) Develop the Manual on Updating the Forest Base Map

The Project team shared its understanding of data condition with the C/P, and discussions were held on policy and methods of updating forest cover maps through the activities described in 2.1.3（1）to 2.1.3（3）and 2.1.3（5）. At the same time, the technical transfer of data processing and management was implemented by preparing the procedure manuals, which were arranged with the C/P officers as one consolidated manual on updating the Forest Base Map (Annex 2).

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18 Point of national census operated every 5 years and location of villages

19 Government Agency established through the enactment of the Mineral Resources Authority Act 2005.

The consolidated manual is intended to be of assistance in understanding the forest cover maps, the data to be used to create a forest cover map, the method to update the Map, and the results of the examinations and discussions of the map. It is to be used by PNGFA officers, especially those of the I&M Branch, for their daily work in the future. The contents of the manual are shown in Table 2.1-25. Since the manual is expected to be used in routine activities, eight copies of it were made.

Table 2.1-25 Contents of the Manual on Updating Forest Base Map

1. Executive Summary
Introduction
Objectives
Structure of the manual
2. Workflows: Update of forest cover map (Forest Base Map)
Overarching structure
Workflows and timeline
Operating procedures
Essential specification / Structure of data and folder
3. Forest Base Map 2012
Process and methods of developing the Forest Base Map 2012
Accuracy assessment of the Forest Base Map 2012
Issues found in the Forest Base Map 2012 and a way to address them
Process and methods of developing forest degradation drivers of forest cover map
Discussion and lessons learned in developing forest degradation drivers
4. Forest Cover Map (Past)
Process and Methods of developing the Forest Cover Map 2000 / 2005
Forest cover change between 2000 - 2011
Issues found in the past Forest Cover Map and a way to address them
5. Forest Cover Map 2015
Process and Methods of developing the Forest Cover Map 2015
Forest biomass and carbon stock of Forest Cover Map 2015
Issues found in the Forest Cover Map 2015 and a way to address them
Annex
Forest Base Map 2012 (ver.1.1)
Forest Cover Map (Past)
Forest Cover Map 2015
Downloading and Processing LANDSAT Images
Downloading and Processing SAR
Manual to use Google Earth Engine (related to Greenest Pixel)
Arrangement of Global Forest Change data published by Hansen et al.
Digitizing road network utilizing LANDSAT imagery
Manual of topology check
Accuracy assessment of the Forest Base Map

Excel tips
Driver interpretation card
Procedure to create raster data (Geo﹣TIFF) with colormap file

（5）Update the Forest Base Map in the Pilot Area(s)

1）Revision of the Forest Base Map 2012

The Forest Base Map 2012 (ver. 1.0) was revised as the Forest Base Map 2012 (ver. 1.1) according to the basic design examined in2.1.3（1）. The Forest Base Map ver. 1.1 is shown in Figure 2.1-41. Vegetation area of the Map 1.1 in each province is shown in Figure 2.1-42.

Drivers of deforestation and forest degradation were developed in the Forest Base Map 2012 (ver. 1.1) by utilizing RS data and additional information examined in 2.1.3（2） and 2.1.3（3）. Distribution of drivers on the Map is shown in Figure 2.1-43, and the drivers area is shown in Figure 2.1-44.

A brief overview of the Forest Base Map 2012 was compiled in 'Fact Sheet No. 2 Papua New Guinea Forest Base Map 2012' (Annex 6), to disseminate the outputs

Designed layout maps (sizes A0, A1, A2, A3, and A4 for the entire country and each province) were created by a C/P officer for distribution of the maps developed in the Project. The map shown in Figure 2.1-41 Forest Base Map 2012 (ver. 1.1) is also this designed map.

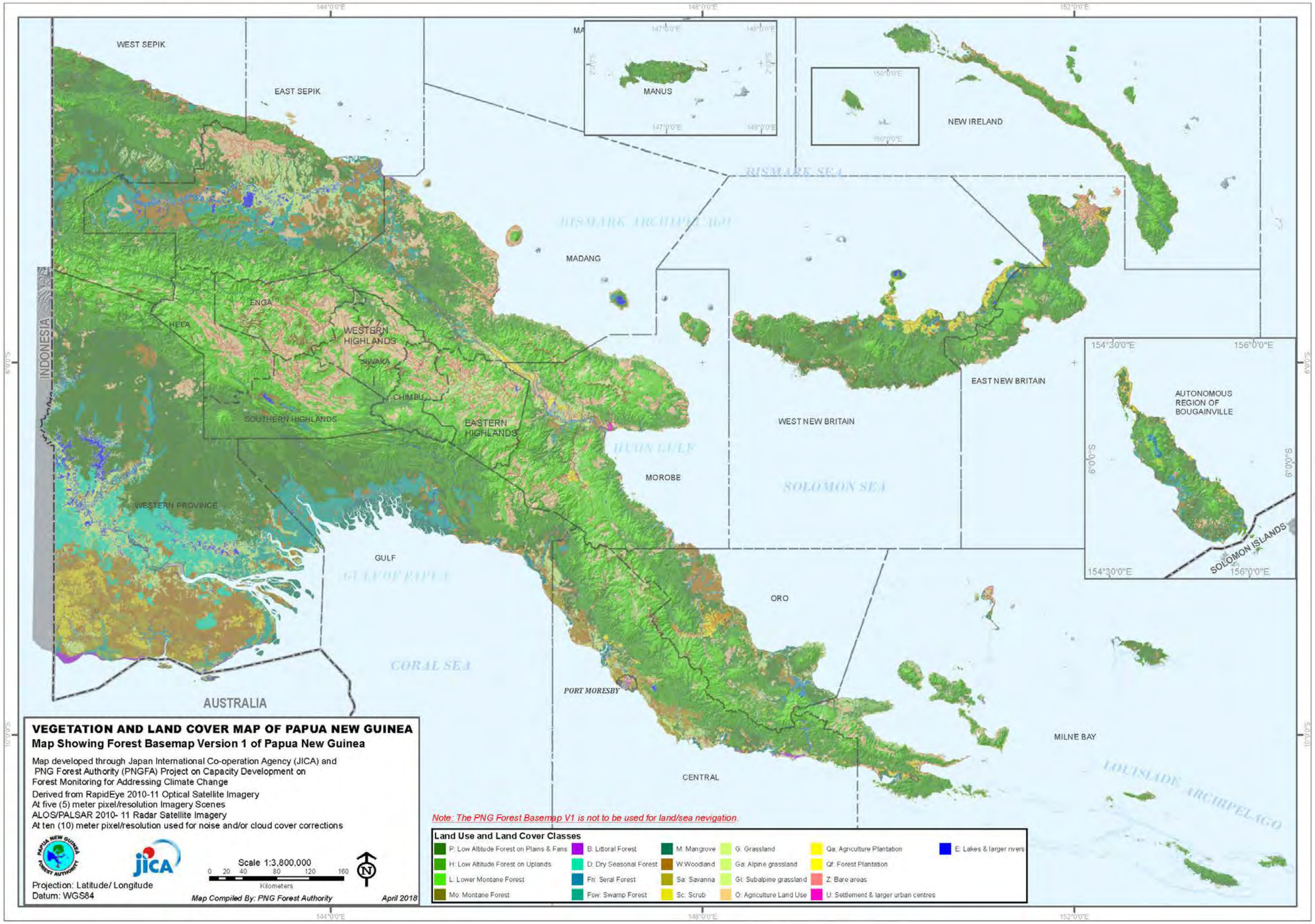


Figure 2.1-41 Forest Base Map 2012 (ver. 1.1)

	VEG	VEGNAME	SUM	CEN	NCD	ORO	MIL	GUL	WES	MOR	MAD	ESP
	P	Low Altitude Forest on Plains & Fans	8,707,393	292,663	86	365,484	209,994	1,037,694	3,219,756	92,047	487,379	678,469
	H	Low Altitude Forest on Uplands	12,264,035	1,101,655	32	728,478	616,187	1,200,039	629,928	845,576	921,766	1,011,379
	L	Lower Montane Forest	8,042,001	680,095		485,745	129,735	149,739	290,126	1,421,949	482,384	229,009
	Mo	Montane Forest	355,513	39,006		30,097	647		2,661	39,179	21,849	4,055
	D	Dry Seasonal Forest	935,368						935,368			
	B	Littoral Forest	70,358	12,076		894	4,379	1,023	37,194	1,103	1,059	2,077
	Fri	Seral Forest	158,719	6,762		26,476	1,166	356	9,833	3,705	5,801	24,439
	Fsw	Swamp Forest	2,035,431	9,065		18,202	1,118	465,646	684,614	20,519	95,286	508,138
	M	Mangrove Forest	521,933	52,658	305	15,267	46,700	241,240	111,843	3,150	277	17,783
	W	Woodland	3,062,749	172,725	1,071	177,622	12,001	136,701	1,574,990	52,079	98,179	680,002
	Sa	Savanna	639,969	113,592	9,970	23,732	35	14,486	478,122			
	Sc	Scrub	392,078	6,673	978	1,631	1,332		374,163	11		
	G	Grassland and Herbland	3,238,324	241,325	6,395	139,929	120,098	72,942	1,009,672	295,741	163,740	615,054
	Ga	Grassland (Alpine)	110,602	19,612		8,379	2,148		941	10,955	2,246	446
	Gi	Grassland (Subalpine)	86,979	11,580		6,562	426		344	18,207	6,827	183
	O	Cropland/Agriculture land	4,413,543	151,455	1,012	133,601	240,870	107,317	186,534	470,069	540,450	477,416
	Qa	Plantation other than Qf	411,614	6,440		78,527	22,874	1,069		35,048	23,639	1,338
	Qf	Forest Plantation	66,670	18,179			1,214			17,719	4,893	
	Z	Bare areas	23,880	152	6	412	50		27	9,001	2,890	
	U	Larger Urban Centres	23,896	692	6,095	1,025	772	202	727	7,361	1,497	752
	E	Lake & Larger Rivers	600,105	19,378	165	21,308	4,921	43,404	250,937	25,206	30,164	118,060
		SUM	46,161,159	2,955,783	26,114	2,263,371	1,416,666	3,471,860	9,797,778	3,368,621	2,890,325	4,368,599

	VEG	VEGNAME	WSP	SIM	ENG	EHP	SHP	HLA	WHP	JIW	WNB	ENB	MAN	NIL	ARB
	P	Low Altitude Forest on Plains & Fans	1,031,108	8,251	2,720	2,073	153,026	22,282	9,485	9,220	508,762	135,360	67,533	138,886	235,116
	H	Low Altitude Forest on Uplands	1,436,375	117,027	63,505	56,316	436,709	117,054	21,954	70,752	1,050,299	831,846	107,118	531,003	369,036
	L	Lower Montane Forest	611,335	283,511	606,659	597,381	565,842	657,590	132,980	201,434	66,313	269,688		103,008	77,478
	Mo	Montane Forest	18,002	15,852	108,371	13,368	9,163	19,510	15,086	18,668					
	D	Dry Seasonal Forest													
	B	Littoral Forest	2,265								1,111	2,458	20	1	4,700
	Fri	Seral Forest	2,976								20,373	18,427		6,910	31,493
	Fsw	Swamp Forest	137,879		377		15,516	244	80	46	24,365	58		644	53,636
	M	Mangrove Forest	669								8,299	2,636	3,755	14,622	2,730
	W	Woodland	66,858				14,375	380			33,882	2,311		20,193	19,382
	Sa	Savanna			32										
	Sc	Scrub	282					111			112	27			6,759
	G	Grassland and Herbland	106,321	30,188	21,432	193,577	49,985	28,771	12,784	8,748	32,069	17,537	5,790	24,994	41,230
	Ga	Grassland (Alpine)	1,802	752	40,796	763	2,265	17,778	1,601	100					16
	Gi	Grassland (Subalpine)	2,550	6,167	7,600	643	12,666	751	8,379	4,095					
	O	Cropland/Agriculture land	141,174	147,357	319,520	236,001	231,061	187,341	218,349	159,904	125,999	201,665	6,160	78,911	51,377
	Qa	Plantation other than Qf	1,479	169	126	4,592	23		9,639	5,978	146,980	21,552	750	16,412	34,981
	Qf	Forest Plantation			25	4,911	319		1,474			17,931			7
	Z	Bare areas	1,984		19	171	1,498	205	338	256	1,137	1,286	1,018	656	2,774
	U	Larger Urban Centres	318	600		837	182				185	619	514	359	1,158
	E	Lake & Larger Rivers	29,389	3,467	2,257	4,043	12,121	3,575	849	1,320	14,114	6,025	418	3,095	5,886
		SUM	3,592,766	613,341	1,173,438	1,114,676	1,504,751	1,055,593	432,998	480,522	2,034,000	1,529,425	193,077	939,696	937,760

		SUM	CEN	NCD	ORO	MIL	GUL	WES	MOR	MAD	ESP
	Forest Cover Area	(ha)									
	Forest	33,157,421	2,212,157	423	1,670,643	1,011,138	3,095,737	5,921,322	2,444,946	2,020,694	2,475,349
	Forest&Woodland	36,220,170	2,384,882	1,494	1,848,265	1,023,139	3,232,438	7,496,312	2,497,024	2,118,872	3,155,350
*	Forest&Woodland&Scrub&Savanna	37,252,217	2,505,147	12,442	1,873,627	1,024,507	3,246,924	8,348,597	2,497,035	2,118,872	3,155,350

		WSP	SIM	ENG	EHP	SHP	HLA	WHP	JIW	WNB	ENB	MAN	NIL	ARB
	Forest Cover Area													
	Forest	3,240,610	424,640	781,657	674,049	1,180,575	816,680	181,059	300,120	1,679,523	1,278,404	178,426	795,076	774,196
	Forest&Woodland	3,307,467	424,640	781,657	674,049	1,194,950	817,060	181,059	300,120	1,713,405	1,280,715	178,426	815,269	793,578
*	Forest&Woodland&Scrub&Savanna	3,307,749	424,640	781,688	674,049	1,194,950	817,171	181,059	300,120	1,713,517	1,280,741	178,426	815,269	800,337

		SUM	CEN	NCD	ORO	MIL	GUL	WES	MOR	MAD	ESP
	Forest Cover Rate	(%)									
	Forest	71.8%	74.8%	1.6%	73.8%	71.4%	89.2%	60.4%	72.6%	69.9%	56.7%
	Forest&Woodland	78.5%	80.7%	5.7%	81.7%	72.2%	93.1%	76.5%	74.1%	73.3%	72.2%
*	Forest&Woodland&Scrub&Savanna	80.7%	84.8%	47.6%	82.8%	72.3%	93.5%	85.2%	74.1%	73.3%	72.2%

		WSP	SIM	ENG	EHP	SHP	HLA	WHP	JIW	WNB	ENB	MAN	NIL	ARB
	Forest Cover Rate													
	Forest	90.2%	69.2%	66.6%	60.5%	78.5%	77.4%	41.8%	62.5%	82.6%	83.6%	92.4%	84.6%	82.6%
	Forest&Woodland	92.1%	69.2%	66.6%	60.5%	79.4%	77.4%	41.8%	62.5%	84.2%	83.7%	92.4%	86.8%	84.6%
*	Forest&Woodland&Scrub&Savanna	92.1%	69.2%	66.6%	60.5%	79.4%	77.4%	41.8%	62.5%	84.2%	83.7%	92.4%	86.8%	85.3%

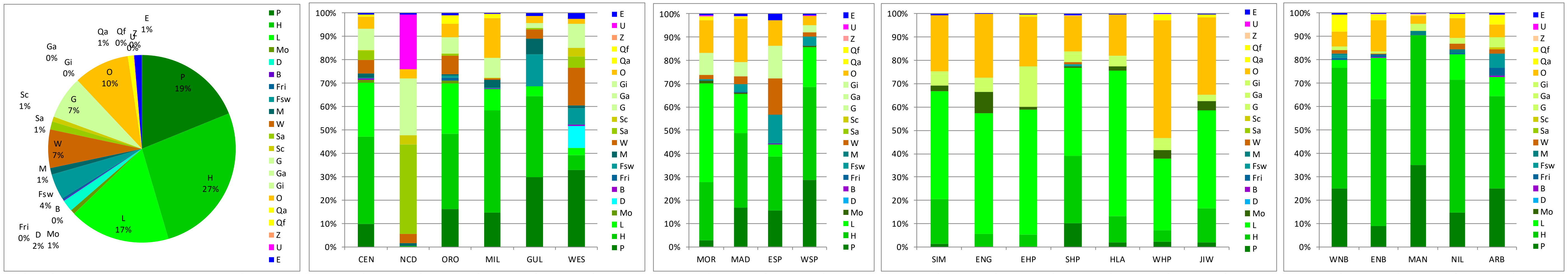


Figure 2.1-42 Vegetation Area (ha) of the Forest Base Map 2012 (ver. 1.1)

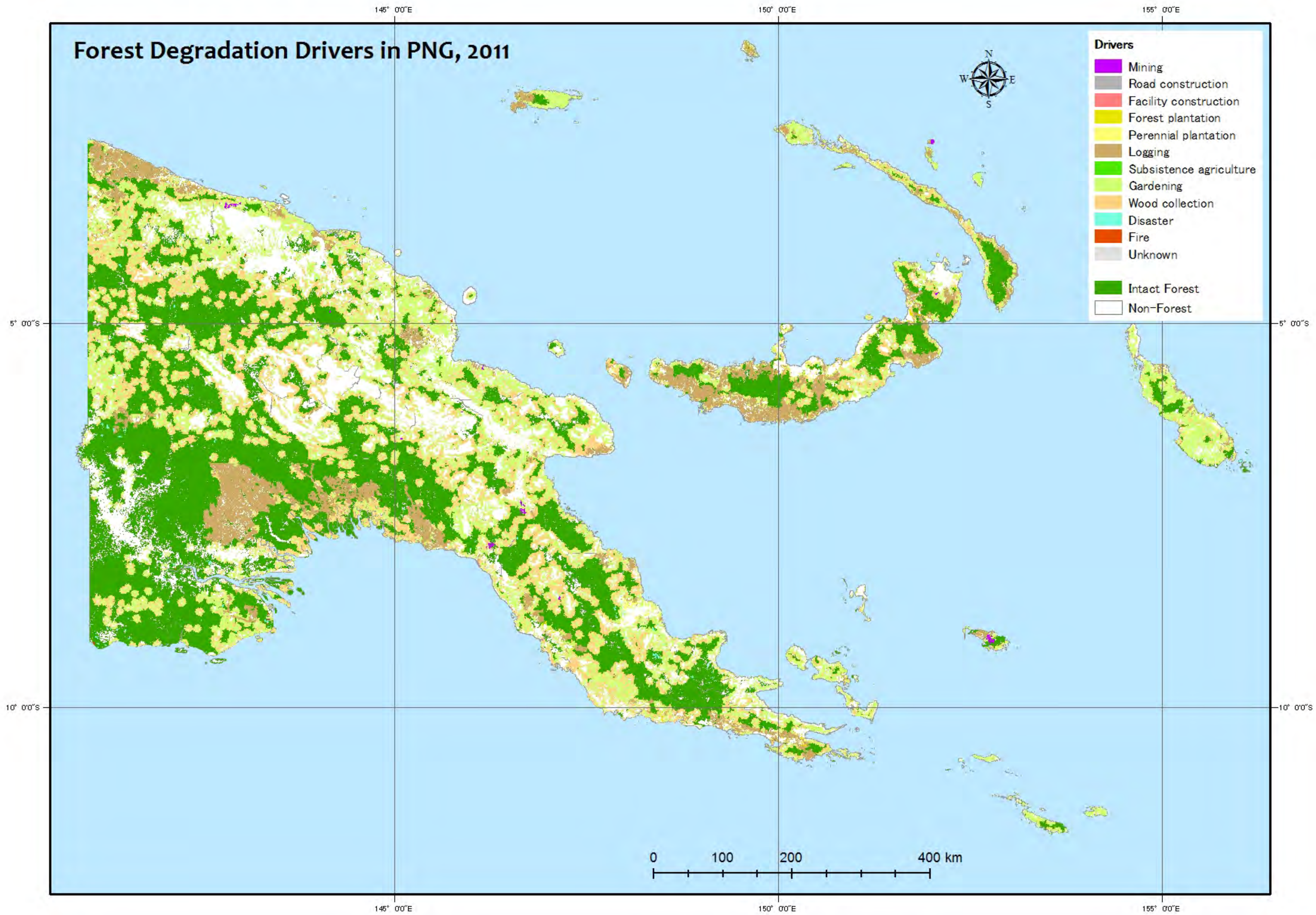
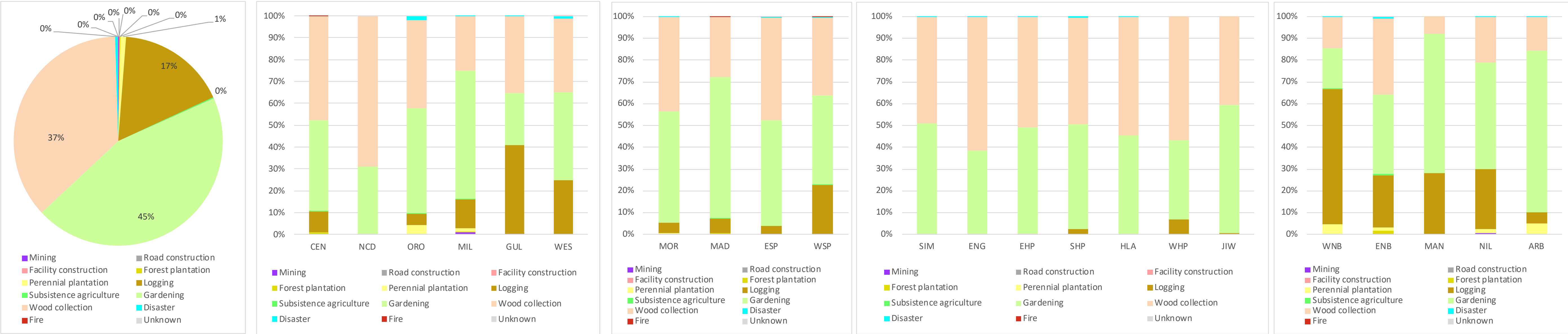


Figure 2.1-43 Distribution of Drivers of the Forest Base Map 2012 (ver. 1.1)

	Drivers	SUM	CEN	NCD	ORO	MIL	GUL	WES	MOR	MAD	ESP	WSP	SIM	ENG	EHP	SHP	HLA	WHP	JIW	WNB	ENB	MAN	NIL	ARB
	Mining	37,262	1,162	0	0	8,517	5,218	273	6,417	1,646	4,305	4,455	0	226	798	0	0	0	0	0	1,338	0	2,907	0
	Road construction	2,722	0	0	0	0	1,442	0	0	0	0	513	0	0	0	0	0	0	0	0	579	0	187	0
	Facility construction	1,630	0	0	0	0	581	589	0	145	0	135	0	0	0	0	0	0	0	180	0	0	0	0
	Forest plantation	34,225	12,658	0	0	2,687	0	0	1,266	5,836	0	0	0	0	576	0	0	41	0	137	11,024	0	0	0
	Perennial plantation	175,703	2,158	0	43,599	11,410	229	0	765	1,239	910	3,362	25	0	147	0	0	30	103	54,294	11,790	474	10,725	34,441
	Logging	3,512,466	148,504	0	47,753	106,917	626,746	720,713	85,983	115,480	63,834	432,329	0	0	0	12,621	0	8,047	1,231	724,572	182,551	42,279	159,544	33,361
	Subsistence agriculture	35,869	1,818	0	2,167	1,248	3,512	2,395	3,542	2,261	1,344	6,302	71	844	713	73	795	21	317	2,003	4,781	58	863	743
	Gardening	9,293,873	633,626	3,868	460,737	467,578	369,876	1,177,497	911,065	1,084,992	891,873	796,861	121,177	183,384	253,156	235,690	159,874	43,246	124,412	214,989	279,746	96,982	282,066	501,176
	Wood collection	7,578,478	732,405	8,573	388,916	199,108	544,289	977,640	775,314	463,411	860,090	695,540	117,326	295,095	262,168	237,441	191,132	67,796	86,050	169,140	268,620	12,251	122,555	103,614
	Disaster	90,487	783	0	18,178	394	3,018	36,535	1,906	2,188	4,868	7,920	25	324	670	3,571	981	0	0	1,306	6,940	0	358	523
	Fire	6,542	234	0	0	0	0	4,370	0	969	647	321	0	0	0	0	0	0	0	0	0	0	0	0
	Unknown	2,457	0	0	0	0	0	954	0	0	1,413	0	0	0	0	0	0	0	0	0	90	0	0	0
	(Intact Forest)	16,109,308	953,620	0	912,278	225,433	1,692,013	5,427,632	693,057	435,812	1,326,067	1,051,445	186,016	301,792	150,911	705,234	464,389	60,403	88,007	550,934	495,351	26,382	236,062	126,473
	SUM	36,881,022	2,486,968	12,442	1,873,627	1,023,293	3,246,924	8,348,598	2,479,316	2,113,980	3,155,350	2,999,183	424,640	781,664	669,138	1,194,631	817,171	179,585	300,120	1,717,558	1,262,811	178,426	815,269	800,330



* The Forest Base Maps are used. But, as for WNB and WSP, the revised Forest Cover Maps 2011 are used.

Figure 2.1-44 Area (ha) of Drivers of the Forest Base Map 2012 (ver. 1.1)

2) Creation of Past Forest Cover Maps

Past forest cover maps for 2000 and 2005 and the revised forest cover map for 2001 were created for the pilot provinces, West New Britain Province and West Sepik Province, as per the basic design examined in 2.1.3 (1). Drivers of deforestation and forest degradation examined in 2.1.3 (2) to 2.1.3 (3) were added to these forest cover maps. Past forest cover maps, vegetation changed area maps, vegetation areas of the maps, vegetation changed areas, distribution of drivers of the maps, and drivers areas of each province are shown in Annex 19.

3) Creation of Forest Cover Map in 2015

Forest Cover Map 2015, with drivers of deforestation and forest degradation, was created for the whole of PNG as per the basic design examined in and based on the knowledge clarified during the activities of developing past forest cover maps. The Forest Cover Map 2015, vegetation area of the Map 2015 in each province, distribution of drivers of the Map, and the area of drivers are shown in Annex 20.

A brief overview of the Forest Cover Map 2015 was compiled in 'Fact Sheet No. 9 Papua New Guinea Forest Cover Map 2015' (Annex 6), to disseminate the outputs

4) Assessment of the Drivers' Analysis by Comparing with Collect Earth Data

Information on deforestation and forest degradation drivers was added into the Forest Base Map 2012, the past forest cover maps, and the Forest Cover Map 2015. PNGFA has Collect Earth driver information (in Collect Earth this is called 'impact type'), which was prepared as sample plots in the NFI survey (Table 2.1-26). Though data development methods and the purposes of application of the Forest Base Map and Collect Earth data are different, it is important to clarify the features and differences of these data, so that PNGFA officers are able to understand the data content correctly for future use. Therefore, sample plots of Collect Earth data were overlaid on the Forest Base Map to compare these drivers' information. Each drivers composition is shown in Figure 2.1-45 and both drivers distributions are shown in Figure 2.1-46.

Table 2.1-26 Comparison of Driver Class between the Forest Base Map and Collect Earth

	Forest Base Map	Collect Earth
Driver (Impact type)	Mining	
	Road construction	
	Facility construction	
		Other human impact
	Forest plantation	
	Perennial plantation	
		Wokabout sawmill
	Logging	Logging

	Subsistence agriculture	
		Grazing
	Gardening[20]	Gardening
	Disaster	
	Fire	Fire
	Unknown	
	None (Intact Forest)	None (Intact Forest)

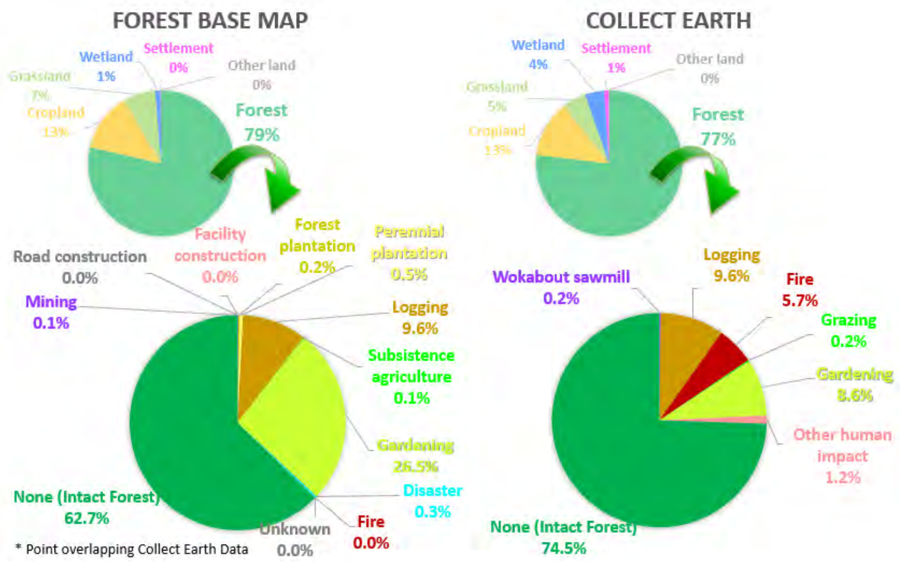


Figure 2.1-45 Drivers Compositions of the Forest Base Map and Collect Earth

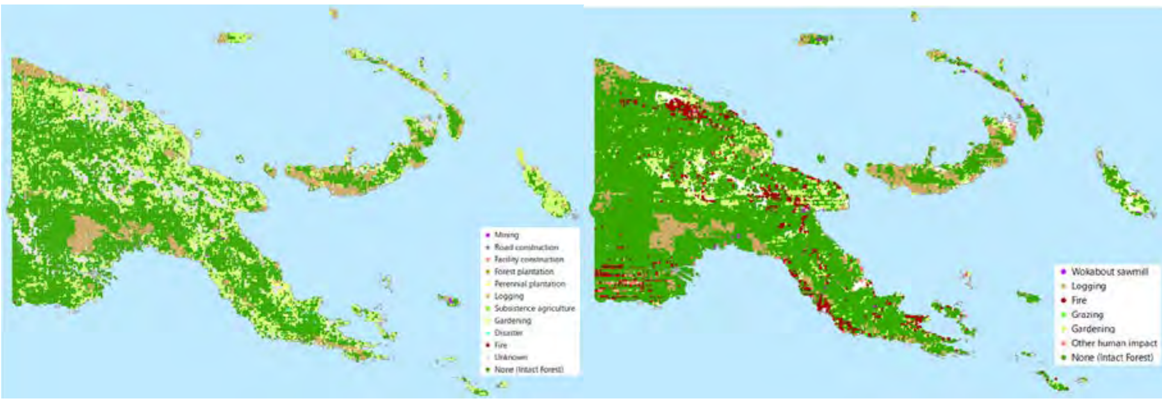


Figure 2.1-46 Drivers Distribution of the Forest Base Map and Collect Earth

The breakout of drivers in the Forest Base Map showed that the ratio of Intact Forest (Primary Forest) of the Forest Base Map was smaller than that of Collect Earth. The ratio of Logging was almost the same in both, the ratio of Gardening in the Forest Base Map was much larger and the ratio of Fire was smaller than that of Collect Earth. The reason for this is that even though the overlapping of the Loss area was small in

[20] The activity that is called Gardening in PNG refers to the home garden and the burning for it, usually performed around Settlement.

the analysis of the Forest Base Map, degraded forest was shown in all the areas of the Forest Monitoring Unit (FMU) [21] — due to the Forest Monitoring Unit (FMU), which overlays the Loss area, being treated as degraded forest. In addition, Fire could not be identified in the analysis of the Forest Base Map. The results of the assessment were shared and discussed with PNGFA officers and FAO staff who are implementing the NFI survey.

The method of developing drivers of deforestation and forest degradation, the analysis of the drivers and the issues and the lessons obtained from the discussions, were compiled as 'Analytical Report No. 1 Analysis of Drivers of Deforestation and Forest Degradation in Papua New Guinea' (Annex 6).

5) Trial of Forest Monitoring Using Google Earth Engine

Google Earth Engine is an efficient tool which provides free access to the standard processing and browsing of satellite images, such as LANDSAT and Sentinel-2, stored on Google's online server. It also provides advanced analysis with those images, without the need to download the images but rather through directly processing them via the Internet cloud system. Because it enables the ability to download only necessary data and analysis results, it is possible to utilize even in countries like PNG which do not have good quality Internet connectivity.

This Project developed a tool for monitoring deforestation (Annex 8), which uses Google Earth Engine to analyze chronological time series of satellite imagery. It was developed in the two logging concessions (Rottock Bay Consolidated Concession and Amanab Consolidated Concession) located in the pilot provinces of West New Britain and West Sepik. In addition, the Project created user's manuals for the tool (Annex 9). The tool is able to detect weekly and annual deforestation within the targeted concessions.

The developed tools can be used by PNGFA to monitor and prove the legality of forest operations. For example, a tool for detecting weekly deforestation can monitor whether the operations are performed according to a plan / application that has been submitted by comparing detection results with GIS information of the logging concession or in the ALP. Annual deforestation monitoring tools can also be used to report on national forest change dynamics. The services developed at the global level, such as GLAD (Global Land Analysis & Discovery) Alert, can also be used, but the tools developed in this Project can be adjusted and customized according to PNG's environment and purpose. Moreover, the code can be incorporated into existing tools (Collect Earth) supported by FAO, so further use is expected in the future.

[21] FMU (Forest Monitoring Unit) is a minimum polygon of forest cover map as a unit of data management in PNG-FRIMS, which is delineated based on Province boundaries, Forest Zone, Catchment area, LU class, forest type including crown. As for detail, refer to 2.1.4（1）.

6）Estimated Change of Forest Carbon Stocks

PNG's Forest Reference Level (FRL) was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in January 2017, with technical support from FAO. The FRL was reported in 'Papua New Guinea's National REDD+ Forest Reference Level – Submission for UNFCCC Technical Assessment in 2017'. In this report, point sampling that applies Collect Earth was assigned to areas of each forest type to calculate forest carbon stocks.

In the Project, forest cover maps in 2011 and 2015 were developed for the entirety of PNG, and forest cover maps in 2000 and 2005 were developed for West New Britain and West Sepik. Therefore, in the Project, forest carbon stocks for the whole of PNG were calculated on a trial basis using the Forest Cover Map 2015. Furthermore, the change of forest carbon stocks in West New Britain and West Sepik was calculated by using the Forest Cover Map 2000, 2005, 2011 (revised version) and 2015.

Forest living biomass was calculated assigning the Forest Cover Maps to areas, and values assigned in the 'PNG National REDD+ FRL 2017' were used for above-ground living biomass value and below-ground living biomass ratio, which was also the IPCC default value. Forest biomass carbon stocks were calculated by multiplying the forest living biomass by the default value in the IPCC guideline for carbon content, as shown in Figure 2.1-47.

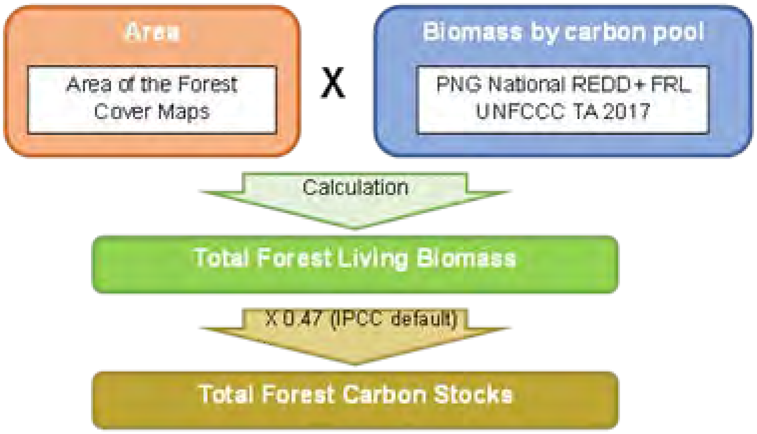


Figure 2.1-47 Basic Design of Forest Living Biomass / Forest Carbon Stocks Calculation Method

(i) Forest Carbon Stocks of PNG in 2015

For this calculation process, first, above-ground living biomass was calculated by multiplying the area for each land cover class (forest type) on the Forest Cover Map 2015 by the above-ground living biomass value assigned in the 'PNG National REDD+ FRL 2017'. Next, below-ground living biomass was calculated by multiplying the area for each land cover class on the Forest Cover Map 2015 by the below-ground biomass value. The below-ground biomass value was calculated by multiplying the above-ground biomass value by the below-ground biomass ratio. Total forest living biomass was calculated by adding the above-ground biomass and the below-ground biomass. Forest carbon stocks were calculated by multiplying the total forest living biomass by the default value in the IPCC guideline for carbon content.

Forest Cover Map 2015				AGLB value (t/ha)	AGLB of each forest type (Mt)	R	BGLB value (t/ha)	BGLB of each forest type (Mt)	Total Living Biomass (Mt)	GF	Total forest biomass carbon (Mt)
Forest type		Human impact	Area (ha)								
P	Low Altitude Forest on Plains & Fans	Primary	3,119,231	223	695.59	0.37	82.51	257.37	952.96		447.89
		Disturbance	5,014,087	146	732.06	0.37	54.02	270.86	1,002.92		471.37
H	Low Altitude Forest on Uplands	Primary	4,475,346	223	998.00	0.37	82.51	369.26	1,367.26		642.61
		Disturbance	7,128,517	146	1,040.76	0.37	54.02	385.08	1,425.85		670.15
L	Lower Montane Forest	Primary	3,345,477	140	468.37	0.27	37.8	126.46	594.83		279.57
		Disturbance	4,119,871	92	379.03	0.27	24.84	102.34	481.37		226.24
Mo	Montane Forest	Primary	257,917	140	36.11	0.27	37.8	9.75	45.86		21.55
		Disturbance	96,578	92	8.89	0.27	24.84	2.40	11.28		5.30
D	Dry Seasonal Forest	Primary	758,768	130	98.64	0.28	36.4	27.62	126.26		59.34
		Disturbance	176,439	85	15.00	0.28	23.8	4.20	19.20		9.02
B	Littoral Forest	Primary	22,518	223	5.02	0.37	82.51	1.86	6.88		3.23
		Disturbance	44,098	146	6.44	0.37	54.02	2.38	8.82		4.15
Fri	Seral Forest	Primary	67,900	223	15.14	0.37	82.51	5.60	20.74	0.47	9.75
		Disturbance	79,731	146	11.64	0.37	54.02	4.31	15.95		7.50
Fsw	Swamp Forest	Primary	945,622	223	210.87	0.37	82.51	78.02	288.90		135.78
		Disturbance	1,044,263	146	152.46	0.37	54.02	56.41	208.87		98.17
M	Mangrove Forest	Primary	163,685	192	31.43	0.49	94.08	15.40	46.83		22.01
		Disturbance	355,279	126	44.77	0.49	61.74	21.93	66.70		31.35
W	Woodland	Primary	1,493,062	130	194.10	0.28	36.4	54.35	248.45		116.77
		Disturbance	1,495,948	85	127.16	0.28	23.8	35.60	162.76		76.50
Sa	Savanna	Primary	348,076	130	45.25	0.28	36.4	12.67	57.92		27.22
		Disturbance	287,048	85	24.40	0.28	23.8	6.83	31.23		14.68
Sc	Scrub	Primary	298,100	70	20.87	0.4	28	8.35	29.21		13.73
		Disturbance	93,609	46	4.31	0.4	18.4	1.72	6.03		2.83
Qf	Forest Plantation	Primary	55	150	0.01	0.37	55.5	0.00	0.01		0.01
		Disturbance	67,896	98	6.65	0.37	36.26	2.46	13.31		6.25
Total									7,240.38		3,402.98

Figure 2.1-48 Calculation of Forest Carbon Stocks on Forest Cover Map 2015

In this calculation, the total forest carbon stocks of PNG in 2015 ware 3,402.98 Mt.

(ii) Change of Forest Carbon Stocks of West New Britain and West Sepik

Forest carbon stocks for 2000, 2005 and 2011 were also calculated for West New Britain and West Sepik using the Forest Cover Map 2000, 2005 and 2011 (revised version), following the same method.

Area of each land cover class (forest type), above-ground living biomass, below-ground living biomass, total living biomass and forest carbon stocks for 2000, 2005, 2011, 2015 in West New Britain and West Sepik were calculated as shown in Figure 2.1-49 and Figure 2.1-50.

	Forest type	Human impact	Area (ha)				AGLB (Mt)				BGLB (Mt)			
			2000	2005	2011	2015	2000	2005	2011	2015	2000	2005	2011	2015
P	Low Altitude Forest on Plains & Fans	Primary	108,313	98,428	82,930	74,590	24.15	21.95	18.49	16.63	8.94	8.12	6.84	6.15
		Disturbance	427,456	426,087	428,722	434,781	62.41	62.21	62.59	63.48	23.09	23.02	23.16	23.49
H	Low Altitude Forest on Uplands	Primary	455,523	436,064	379,438	356,424	101.58	97.24	84.61	79.48	37.59	35.98	31.31	29.41
		Disturbance	600,609	617,444	668,602	689,244	87.69	90.15	97.62	100.63	32.44	33.35	36.12	37.23
L	Lower Montane Forest	Primary	59,892	59,892	59,662	59,590	8.38	8.38	8.35	8.34	2.26	2.26	2.26	2.25
		Disturbance	6,491	6,491	6,650	6,723	0.60	0.60	0.61	0.62	0.16	0.16	0.17	0.17
Mo	Montane Forest	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	Dry Seasonal Forest	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	Littoral Forest	Primary	25	25	6	6	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	1,368	1,197	1,105	1,105	0.20	0.17	0.16	0.16	0.07	0.06	0.06	0.06
Fri	Seral Forest	Primary	11,679	7,682	6,271	6,206	2.60	1.71	1.40	1.38	0.96	0.63	0.52	0.51
		Disturbance	13,583	12,923	14,096	13,934	1.98	1.89	2.06	2.03	0.73	0.70	0.76	0.75
Fsw	Swamp Forest	Primary	13,305	8,877	6,320	6,024	2.97	1.98	1.41	1.34	1.10	0.73	0.52	0.50
		Disturbance	12,771	17,151	17,889	17,501	1.86	2.50	2.61	2.56	0.69	0.93	0.97	0.95
M	Mangrove Forest	Primary	1,184	1,162	1,162	1,162	0.23	0.22	0.22	0.22	0.11	0.11	0.11	0.11
		Disturbance	8,483	8,505	8,391	8,391	1.07	1.07	1.06	1.06	0.52	0.53	0.52	0.52
W	Woodland	Primary	19,493	17,569	15,034	13,399	2.53	2.28	1.95	1.74	0.71	0.64	0.55	0.49
		Disturbance	17,663	19,234	21,169	21,321	1.50	1.63	1.80	1.81	0.42	0.46	0.50	0.51
Sa	Savanna	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sc	Scrub	Primary	112	112	112	112	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qf	Forest Plantation	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total		1,757,949	1,738,842	1,717,558	1,710,512	299.78	294.01	284.96	281.51	109.81	107.69	104.36	103.10

	Forest type	Human impact	Total Living Biomass (Mt)				Total forest biomass carbon (Mt)			
			2000	2005	2011	2015	2000	2005	2011	2015
P	Low Altitude Forest on Plains & Fans	Primary	33.09	30.07	25.34	22.79	15.55	14.13	11.91	10.71
		Disturbance	85.50	85.23	85.75	86.96	40.18	40.06	40.30	40.87
H	Low Altitude Forest on Uplands	Primary	139.17	133.22	115.92	108.89	65.41	62.61	54.48	51.18
		Disturbance	120.13	123.50	133.73	137.86	56.46	58.05	62.85	64.80
L	Lower Montane Forest	Primary	10.65	10.65	10.61	10.60	5.00	5.00	4.99	4.98
		Disturbance	0.76	0.76	0.78	0.79	0.36	0.36	0.37	0.37
Mo	Montane Forest	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	Dry Seasonal Forest	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	Littoral Forest	Primary	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.27	0.24	0.22	0.22	0.13	0.11	0.10	0.10
Fri	Seral Forest	Primary	3.57	2.35	1.92	1.90	1.68	1.10	0.90	0.89
		Disturbance	2.72	2.58	2.82	2.79	1.28	1.21	1.33	1.31
Fsw	Swamp Forest	Primary	4.06	2.71	1.93	1.84	1.91	1.27	0.91	0.87
		Disturbance	2.55	3.43	3.58	3.50	1.20	1.61	1.68	1.65
M	Mangrove Forest	Primary	0.34	0.33	0.33	0.33	0.16	0.16	0.16	0.16
		Disturbance	1.59	1.60	1.58	1.58	0.75	0.75	0.74	0.74
W	Woodland	Primary	3.24	2.92	2.50	2.23	1.52	1.37	1.18	1.05
		Disturbance	1.92	2.09	2.30	2.32	0.90	0.98	1.08	1.09
Sa	Savanna	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sc	Scrub	Primary	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qf	Forest Plantation	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total		409.59	401.70	389.32	384.60	192.51	188.80	182.98	180.76

Figure 2.1-49 Calculation of Forest Carbon Stocks in West New Britain Province for 2000, 2005, 2011, 2015

In this calculation, the total forest carbon stocks of West New Britain was 192.51 Mt in 2000, which changed to 180.76 Mt in 2015.

Forest type		Human impact	Area (ha)				AGLB (Mt)				BGLB (Mt)			
			2000	2005	2011	2015	2000	2005	2011	2015	2000	2005	2011	2015
P	Low Altitude Forest on Plains & Fans	Primary	254,686	245,283	220,799	209,901	56.79	54.70	49.24	46.81	21.01	20.24	18.22	17.32
		Disturbance	711,439	714,476	721,632	719,326	103.87	104.31	105.36	105.02	38.43	38.60	38.98	38.86
H	Low Altitude Forest on Uplands	Primary	450,310	439,291	405,977	389,268	100.42	97.96	90.53	86.81	37.16	36.25	33.50	32.12
		Disturbance	863,080	863,543	876,877	892,882	126.01	126.08	128.02	130.36	46.62	46.65	47.37	48.23
L	Lower Montane Forest	Primary	359,010	358,648	356,552	355,356	50.26	50.21	49.92	49.75	13.57	13.56	13.48	13.43
		Disturbance	191,776	191,960	193,853	194,986	17.64	17.66	17.83	17.94	4.76	4.77	4.82	4.84
Mo	Montane Forest	Primary	17,960	17,960	17,960	17,960	2.51	2.51	2.51	2.51	0.68	0.68	0.68	0.68
		Disturbance	42	42	42	42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	Dry Seasonal Forest	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	Littoral Forest	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	1,972	1,799	1,611	1,611	0.29	0.26	0.24	0.24	0.11	0.10	0.09	0.09
Fri	Seral Forest	Primary	2,737	2,737	2,737	2,737	0.61	0.61	0.61	0.61	0.23	0.23	0.23	0.23
		Disturbance	239	239	239	239	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.01
Fsw	Swamp Forest	Primary	34,942	34,942	34,700	33,991	7.79	7.79	7.74	7.58	2.88	2.88	2.86	2.80
		Disturbance	101,333	101,111	101,297	101,895	14.79	14.76	14.79	14.88	5.47	5.46	5.47	5.50
M	Mangrove Forest	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	667	667	667	667	0.08	0.08	0.08	0.08	0.04	0.04	0.04	0.04
W	Woodland	Primary	12,568	12,568	12,440	12,314	1.63	1.63	1.62	1.60	0.46	0.46	0.45	0.45
		Disturbance	51,952	51,605	51,522	51,647	4.42	4.39	4.38	4.39	1.24	1.23	1.23	1.23
Sa	Savanna	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sc	Scrub	Primary	280	280	280	280	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qf	Forest Plantation	Primary	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total			3,054,993	3,037,150	2,999,183	2,985,102	487.19	483.03	472.93	468.64	172.68	171.15	167.43	165.85

Forest type		Human impact	Total Living Biomass (Mt)				Total forest biomass carbon (Mt)			
			2000	2005	2011	2015	2000	2005	2011	2015
P	Low Altitude Forest on Plains & Fans	Primary	77.81	74.94	67.46	64.13	36.57	35.22	31.70	30.14
		Disturbance	142.30	142.91	144.34	143.88	66.88	67.17	67.84	67.62
H	Low Altitude Forest on Uplands	Primary	137.57	134.21	124.03	118.93	64.66	63.08	58.29	55.89
		Disturbance	172.63	172.73	175.39	178.59	81.14	81.18	82.43	83.94
L	Lower Montane Forest	Primary	63.83	63.77	63.39	63.18	30.00	29.97	29.80	29.70
		Disturbance	22.41	22.43	22.65	22.78	10.53	10.54	10.65	10.71
Mo	Montane Forest	Primary	3.19	3.19	3.19	3.19	1.50	1.50	1.50	1.50
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D	Dry Seasonal Forest	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
B	Littoral Forest	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.39	0.36	0.32	0.32	0.19	0.17	0.15	0.15
Fri	Seral Forest	Primary	0.84	0.84	0.84	0.84	0.39	0.39	0.39	0.39
		Disturbance	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02
Fsw	Swamp Forest	Primary	10.68	10.68	10.60	10.38	5.02	5.02	4.98	4.88
		Disturbance	20.27	20.22	20.26	20.38	9.53	9.51	9.52	9.58
M	Mangrove Forest	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.13	0.13	0.13	0.13	0.06	0.06	0.06	0.06
W	Woodland	Primary	2.09	2.09	2.07	2.05	0.98	0.98	0.97	0.96
		Disturbance	5.65	5.61	5.61	5.62	2.66	2.64	2.63	2.64
Sa	Savanna	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sc	Scrub	Primary	0.03	0.03	0.03	0.03	0.01	0.01	0.01	0.01
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qf	Forest Plantation	Primary	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Disturbance	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total			659.87	654.18	640.36	634.48	310.14	307.46	300.97	298.21

Figure 2.1-50 Calculation of Forest Carbon Stocks in West Sepik Province for 2000, 2005, 2011, 2015

In this calculation, the total forest carbon stocks of West Sepik was 310.14 Mt in 2000, which changed to 298.21 Mt in 2015.

The result of this estimated change in forest carbon stocks has been compiled in Annex 4 as well.

2.1.4 Developing and Updating Information on Growing Stock in Forest

(1) Examine the Method for Defining a New Set of the Forest Management Units

The method for defining a new set of Forest Management Units (FMU) in PNG-FRIMS was examined based on the historical record of logging operations and vegetation type.

Old FIMS vegetation is composed of minimum base units called FMU (Forest Mapping Unit), which not only have vegetation type information but also information about the extreme physical limitations of slopes, altitudes, karsts and inundations, timber volume, etc. The Forest Base Map 2012 ver. 1.0 is divided by boundaries created in the process of RS analysis, which is the reason why the map has vast amounts of polygons and there are some problems in its data performance. Minimum base units of the Forest Base Map should be meaningful, useful and manageable units. The team had discussions on suitable minimum base units of the Forest Base Map for monitoring of forest area changes, forest management, and information to be added regarding forest location environment and forest resources such as timber volume. As a result of the discussion, the Forest Base Map was divided and merged using the following information (shown in Figure 2.1-52): province, forest cover type, tree crown size, Forest Zone, and catchment (watershed), the last of which was created from Geo SAR-DEM in the preceding T/C.

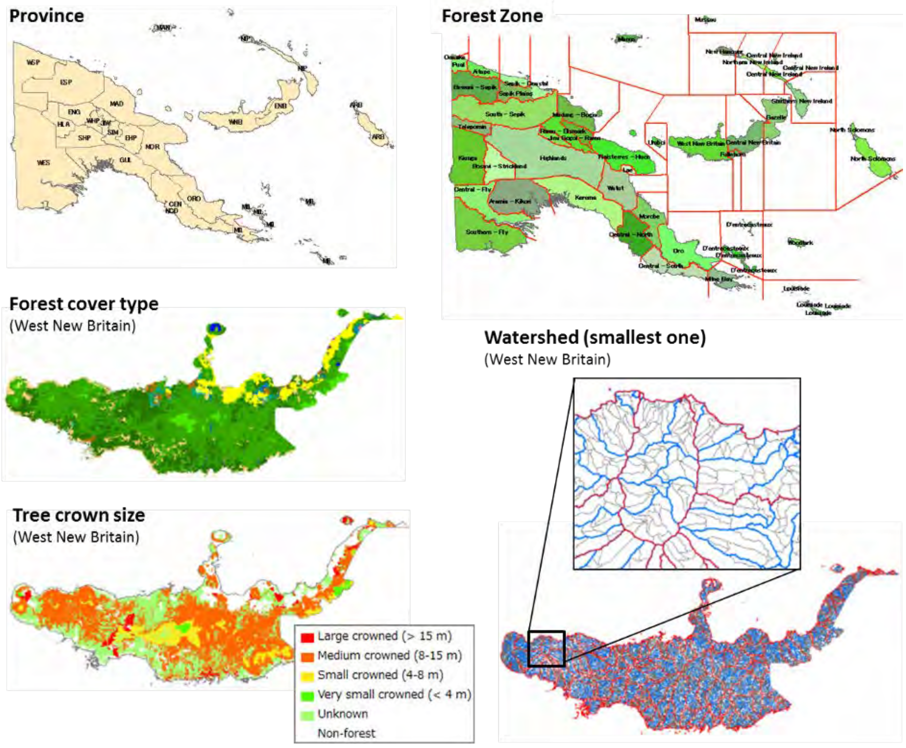


Figure 2.1-51 Information Used for Minimum Base Units of the Forest Base Map

The minimum base units of the Forest Base Map for the whole of PNG were updated with prepared data shown in Figure 2.1-51. The comparison of base units between the old FIMS vegetation and the Forest Base Map in West New Britain is shown in Figure 2.1-52. The size of the base units of the Forest Base Map is much smaller than the base units of the old FIMS vegetation.

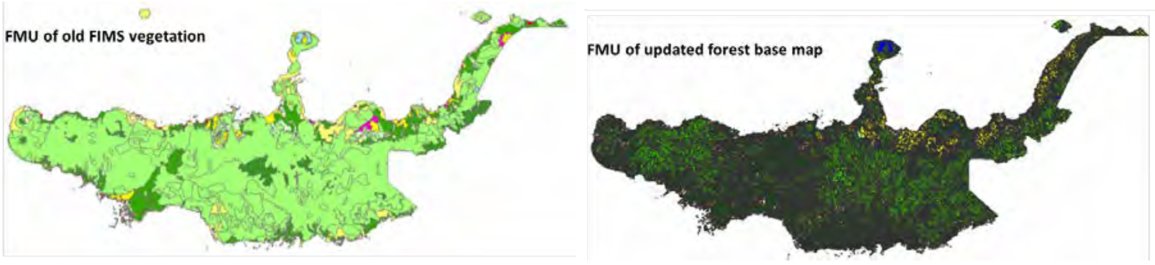


Figure 2.1-52 Comparison of Base Units between Old FIMS Vegetation and the Forest Base Map

The comparison of the size between concession area / logged over area and the updated forest base units (a part of West New Britain) is shown in Figure 2.1-53. The size of the forest base units is almost the same size of the logged over areas (maximum size 250 ha).

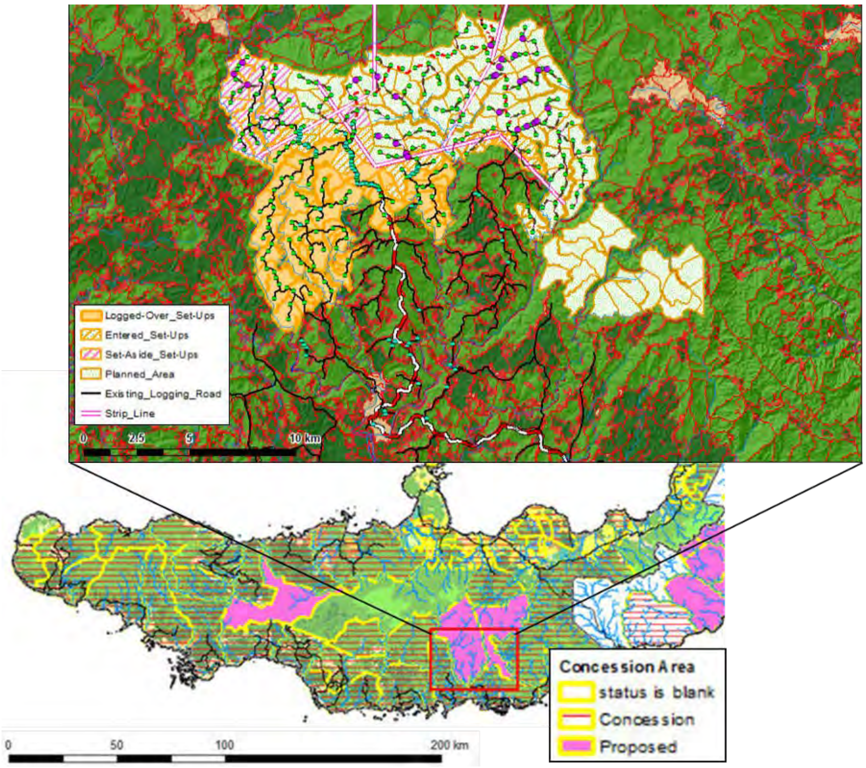


Figure 2.1-53 Comparison of the Size between Concession Area / Logged Over Area and the Updated Forest Basic Units

The team decided to refer to the updated minimum base units of the Forest Base Map as Forest Monitoring Unit (FMU), since that could be used as basic units for forest resource monitoring. A brief overview of FMU was compiled in 'Fact Sheet No.4 Forest Monitoring Unit (FMU) in Papua New Guinea Forest Cover Map' (Annex 6).

However, the FMU of the Forest Base Map could not be referred to as a 'Forest Management Unit' in this section, since it does not share boundaries with the set up area, which is the smallest polygon in the logging history record. On the other hand, the set up area (or logged over area) could not be used as a minimum unit for calculating the re-growth volume of forest stand because it is not composed of homogeneous forest stand — that is, it could not be used as a forest management unit by itself. For this reason, 'Forest Management Unit' was defined by multiplying the FMU of the Forest Base Map by the logged over area.

（2）Examine the Methods for Integrating a Forest Growth Model into PNG-FRIMS

1）Revision of PINFORM

The short-term expert team considered introducing a system which can simulate the re-growth process of a logged forest in PNG-FRIMS along with the future progress of the Project. It was needed to examine whether an existing model, PNG/ITTO Natural Forest Model (PINFORM), could be utilized. This model is a forest re-growth model based on Excel developed by the Forest Research Institute (FRI) and the International Tropical Timber Organization (ITTO) in their collaborative project. The model had a problem caused by its code — it was developed using an old code of Visual Basic (equal to or older than Visual Basic 6.0) on Excel 5, resulting in not being able to use it in the current version of Excel. Additionally, because the calculation part is a black-box due to there being a password, the whole picture of the model was not clear. Therefore, the short-term expert team first fixed the model so that it was compatible with the current version of Excel (Excel 2010) and then examined the functions. However, the contents of PINFORM are not completely clear yet because there is a part protected by an unknown password. Data must be processed as described in the manual for PINFORM.

The leader of the short-term expert team visited FRI, which is the administrator of the tool, reporting to and consulting with FRI regarding the revised PINFORM at the beginning of October 2015. From the FRI side, they would like to verify the validity of the model by using the survey data in FIPS and requested that the FIPS data be shared. Given their experience and performance, it was considered important for them to position utilization of GIS and tools in their work. Thus, in addition to data acquisition and training, it is also necessary to create and submit a research plan to PNGFA HQ for discussion. Subsequently, the Acting Director of FRI agreed to this.

2）Function of PINFORM

Operating PINFORM, inventory data recording tree species and Diameter at Breast Height (DBH) is transformed into a particular form which is required. PINFORM has a function for this transformation and it is possible to transform and analyze inventory data recorded in FIPS survey.

Several conditions can be set in PINFORM such as frequency of harvest, felling intensity, logging method, thinning frequency and intensity, method of thinning, growth index and fire regime. Time series of basal area dynamics, basal area by size classes, tree numbers by size classes, standing volumes and volume harvested can be selected as model outputs (Figure 2.1-54, Figure 2.1-55).

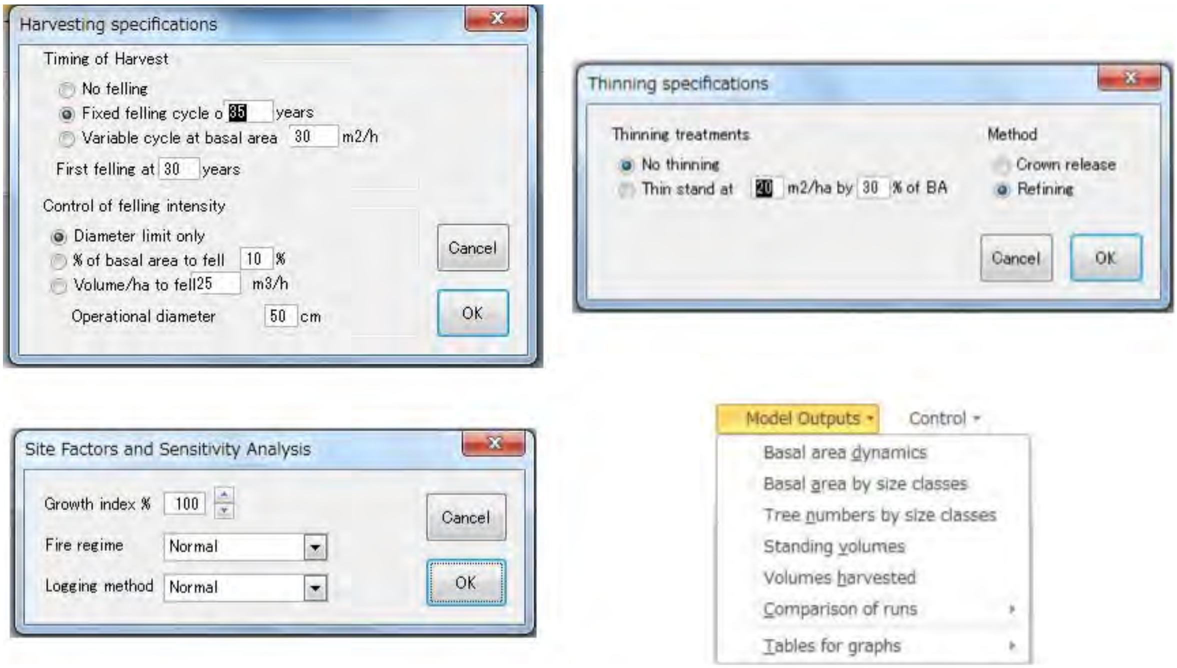


Figure 2.1-54 Condition Setting and Model Outputs of PINFORM

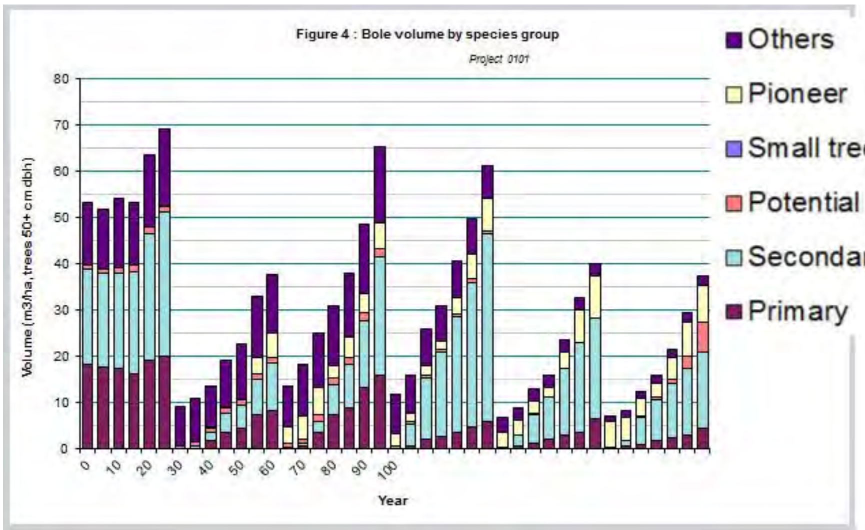


Figure 2.1-55 An Example of Model Output by PINFORM

3) Possibility of Introduction of PINFORM into PNG-FRIMS

The possibility of introducing PINFORM into PNG-FRIMS was discussed with the long-term expert team. The results of the study of PINFORM suggest that it can be utilized for certain purposes, as it can be used for the simulation of forest growth with FIPS data in areas for which FIPS data, including a complete set of the data of DBH, are available (some of which are in the concession areas). PINFORM is considered to have a high affinity, for example, with the Permanent Sample Plots (PSP) surveys and NFI, which are to be conducted continuously in fixed established plots. However, the result suggests that it is impossible to use PINFORM in the simulation in many other areas for which only the data of timber volume, but not of DBH are available.

In addition, as the accuracy of estimates simulated by PINFORM has not been evaluated, it has not been validated. PINFORM was created from the results of a total of more than 200 surveys conducted in PSP in the period between the early 1980's and late 1990's (although the details of the survey results are unknown as some of the data sheets cannot be studied because of password protection). It has been confirmed that at least 170 additional surveys had been conducted by the first half of 2009 (the surveys conducted since then have not been confirmed). It will be necessary to verify the accuracy of PINFORM with new data and improve models by giving appropriate tuning (calibration) to them before using them in simulations. Considerable labor (estimated at 1 to 2 man months) will be required for verification and improvement.

It is uncertain whether the accuracy of the projection with PINFORM at the regional level would improve, even when the reliability of the estimates has been improved to a satisfactory level with the verification of the accuracy and tuning of the models. This is because the nature of PINFORM only allows the simulation of forest growth at the plot level at an exact location where inventory data was obtained and it is difficult to simulate forest growth at other plots in the same region with different conditions including topography because of this nature. Therefore, it is not possible to choose one over the other between the simulation with PINFORM and that with a simple model such as linear prediction.

The conclusions mentioned below have been reached on the feasibility of integrating PINFORM into PNG-FRIMS.

(i) It is not possible to enter the timber volume data in FIMS directly into PINFORM because they do not contain the data on diameters and cross-sections at breast height.

(ii) It is theoretically possible to enter cross-sections at breast height per hectare by area and forest type in PINFORM by calculating timber volume by area and forest type. However, input of enormous resources (human resources, time and funds) in large-scale field surveys and data analysis for a long period of several decades will be required for selecting the appropriate parameter values for the simulation and verification of the accuracy of the results. The output of all these efforts will be a new computer program based on an algorithm that is different from that of the conventional PINFORM.

(iii) PNGFA (FRI of PNGFA in particular) has limited human resources. Considering that the NFI is conducted by PNGFA with assistance from the EU and FAO, it seems more practical and cost effective to discuss whether to utilize the results of the NFI or to conduct supplementary surveys after its completion, rather than to immediately begin discussions on the implementation of the aforementioned surveys and analysis.

Based on this, the short-term expert team and the long-term experts had discussions with the C/P and concluded that the Project does not intend to verify the accuracy of PINFORM but rather to use a simple forest growth model such as linear prediction (Annex 25). PNG-FRIMS shall be designed on a provisional assumption that forest growth will stop 35 years after logging, which is employed for the forest management system in PNG for convenience. This design will also make PNG-FRIMS easily re-designable in case this assumption changes in the future as a result of discussions or negotiations.

(3) Design and Develop the Database for Calculating and Recording Harvested Timber Volume and Timber Growth

Regarding forest stock, the short-term expert team tried to input existing PNGFA information into a database to integrate them. The following data were used as the target information: PNGRIS, which integrates timber volume information obtained between the 1950's and mid 1990's; FIPS, which is based on pre-surveys for setting new logging concessions by PNGFA implemented mostly between the 1980's and the present time; and PSP, which is the result of an inventory survey in PSP implemented by FRI between the 1990's and 2000's.

PNGRIS data is paper-based information integrating a variety of timber volume information obtained by PNGFA and the other organizations between the 1950's and mid 1990's. This data set is fundamental information for calculating timber volume in the current FIMS. In this dataset, the volumes of all trees which have DBH of > 50 cm are recorded, both merchantable and non-merchantable. Because there are various sources for the data, survey procedures are not unified (unknown in a lot of cases) and the detailed site locations are missing. How to calculate the timber volume is also unknown.

FIPS data is information from timber volume surveys, which PNGFA has been implementing mainly from the 1980's to the present to set new logging concessions by creating the Forest Management Agreement (FMA). Basically, in this survey only species which have high values as exporting timber on a particular list (the list of Species Groups and Species Codes for Log Exports in Procedures for Exporting Logs published by PNGFA; Annex 22) are measured (only DBH > 20 cm). Additionally, trees which are shaped poorly for timber are removed from the samples. To calculate the timber volume of each tree, the following common equations are used applying DBH and the merchantable height of each tree:

If there is no height data: $V = 0.00000515025*(3.14159*D)^{2.4762}$

DBH ≥ 50 cm: $V=0.189523+0.0000547982*(D-2.4)^2-0.0089213*H+0.0000528219*(D-2.4)^2*H$

DBH = 20 – 50 cm: $V=-0.001508+0.000044658*D^2+0.00005310227*D^2*H-0.00000061883*D^2*H^2$

Where V is timber volume (m^3), D is DBH (cm), and H is merchantable height (m).

The PSP data obtained by the FRI is mainly from the 1990's. In this survey, all trees (DBH ≥ 10 cm) including every species and every shape, were measured and recorded. To calculate timber volume of each tree, the following equations were used:

Merchantable height (m): $H_m = (D*a)/(b+D)$

Merchantable volume (m^3): $V_m = 0.5*(3.14159*(D/200)^2)*H_m$

Where D is DBH (cm) and a and b are species specific coefficients developed by Fox *et al.* (2010)[22].

The target of each survey is summarized in Figure 2.1-56. The PSP survey measures all trees with a DBH of 10 cm or more, PNGRIS focuses on all trees with a DBH of 50 cm or more and FIPS survey measures only merchantable trees with a DBH of 20 cm or more.

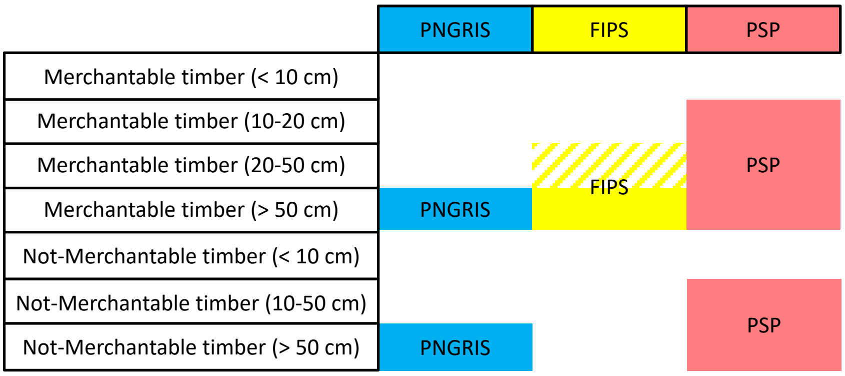


Figure 2.1-56 Targets of PNGRIS, FIPS, PSP Surveys

The short-term expert team first made a database of PNGRIS paper-based data. The data in each survey were then standardized and compared. The timber volume in FIPS was recalculated using the equation for PSP data. Figure 2.1-57 shows ratios of the merchantable timber volume to total volume (DBH ≥ 50 cm) of FIPS, PNGRIS and PSP, respectively. As merchantable timber volume, species in Group 1-3 in the list of Species Groups, which are regarded as valuable as exporting timber, were counted. The ratios in FIPS, PNGRIS and PSP (average ± s.e.) were 0.70± 0.02, 0.62 ± 0.01 and 0.56 ± 0.07, respectively. The difference in averages between FIPS and PNGRIS indicates a possibility that non-merchantable trees were not counted in the FIPS survey. Otherwise, there were some biases in methodologies when choosing sampling sites between the FIPS survey and PNGRIS survey series although it was not possible to verify this because of too many unclear points in the PNGRIS surveys. On the other hand, the averages in FIPS and PSP and those in PNGRIS and PSP were not significantly different. Although this might be due to the small numbers of the PSP sites (n =12), it can be said that the results in the FIPS survey and PINGRIS surveys were not completely different from the truth. Although there is a possibility that the PSP survey points themselves also had some bias, such as the accessibility of the sites, the short-term expert team assumed that the

[22] Fox et al. 2010. Assessment of Above Ground Carbon in Primary and Selectively Harvested Tropical Forest in Papua New Guinea. Biotropica 42: 410-419.

merchantable volumes of trees with a DBH of 50 cm or more in the FIPS survey and PNGRIS surveys were reliable.

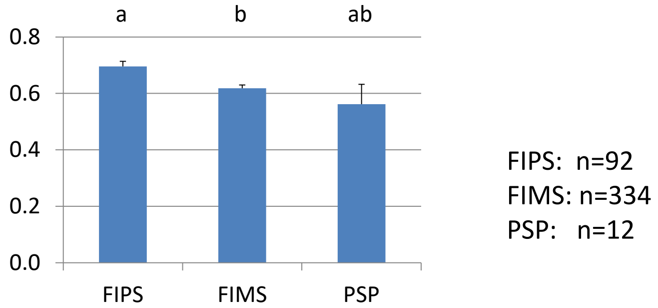


Figure 2.1-57 Ratios of the Merchantable Timber Volume (Group 1 - 3) to Total Volume (DBH ≥ 50 cm) of FIPS, PNGRIS and PSP

The error bars indicate the standard errors. The differences in the lowercase letters indicate the significance between the averages ($P < 0.05$, Tukey's Test)

Figure 2.1-58 shows the ratio of the timber volume of trees with DBH ≥ 50 cm to those with DBH 20 – 50 cm in FIPS data and PSP data. The ratios in FIPS and PSP (average ± s.e.) were 0.75± 0.01 and 0.52 ± 0.04, respectively, suggesting significant difference between the averages in FIPS and PSP. Considering this with the results that showed no significant difference in the averages in ratios of the merchantable timber volume to total volume (DBH ≥ 50 cm) of FIPS and PSP, it seemed that a large part of the trunks whose DBH were less than 50 cm were not counted in the FIPS survey. PNGFA targets only trees which have 50 cm or larger DBH for commercial logging, so the reason why trees with 20 – 50 cm DBH are also measured in FIPS is likely to be in order to obtain data for future logging — as it were, a kind of preliminary survey. Thus, the results in this range may be not so accurate; in some sites the results are completely missing. These results suggest that the data in FIPS are reliable when merchantable timber volume was estimated, though it is difficult to use that data to estimate the total forest carbon stock to contribute to REDD+ activities in the future.

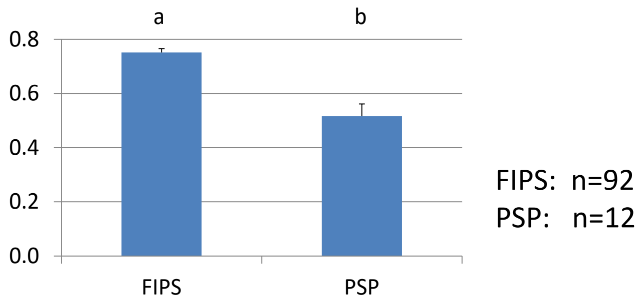


Figure 2.1-58 Ratio of the Timber Volume of Trees with DBH ≥ 50 cm to those with DBH 20 – 50 cm in FIPS and PSP

The error bars indicate the standard errors. The difference in the lowercase letters indicates the significance between the averages ($P < 0.05$, t- test).

The short-term expert team created a database of PNGRIS paper-based data. The data in the PNGRIS, FIPS and PSP surveys were then standardized extracting merchantable timber volume (DBH ≥ 50 cm). As merchantable timber volume, species in Group 1-3 in the list of Species Groups were counted.

As the forest zone and vegetation types of each site of the FIPS survey and the vegetation types of each site of the PSP survey were unknown, these were estimated from lists of existing tree species and those volume ratios of each site. It was not possible to specify small classifications of vegetation type; only large classifications such as “P” or “H” were applied for each site. At some sites, forest zones could not be estimated, so a list of possible forest zones was made. In this case, the figure of the site was weighted to calculate the average timber volumes of the forest zones.

The average timber volumes of each forest zone and each vegetation type were calculated from the extracted information from the PNGRIS, FIPS and PSP datasets and a timber volume list was prepared (refer to Annex 23). The average timber volume of each large classification of vegetation type were calculated, as well as those of each small classification, to fill the volume information into a classification of vegetation type which is not specified (for example, a location with a small vegetation classification subscripted with the letter “x”, indicating that the large classification is different between the Forest Base Map and PNGRIS). When timber volume at a certain point with some vegetation type was not shown on the list, the average timber volume of all forest zones and all vegetation types was assigned.

The estimated timber volumes were reviewed and approved by the officers of PNGFA after modification of an extremely large number in one forest zone utilizing the average values of data in other nearby forest zones. The approved timber volumes are attached to the Forest Base Map. Because the Forest Base Map contains timber volume information originated by FIMS as well, it currently has two kinds of timber volume information (that which originated from FIMS and that which was approved at this time). As the newly approved information refers to more data than the FIMS information, the accuracy of the new information is probably better.

The estimated figures obtained here are only tentative because data collection was not implemented in a consistent way. These values are prepared for replacement by results from the NFI survey operated by the FAO project in the future.

2.1.5 Examine the Method of Reflecting the Ground Sample Plot Information

In this section, the accuracy of driver estimation based on the examination in section 2.1.3 (2) was verified. The NFI preliminary survey, conducted by PNGFA with support from FAO using Collect Earth covered as many as 25,209 points throughout PNG. Of these, 235 survey points were selected that overlap with Hansen Losses of one hectare or larger and a comparison was made of the ground status as interpreted by the Collect Earth survey and by this survey (Figure 2.1-59, Figure 2.1-60). Although the drivers for the Hansen Losses of a size of 20 hectares or larger were already interpreted, an attempt was made to interpret Hansen Losses of different sizes in a similar way. Before comparing the two results, the deforestation drivers interpreted in each of them were compared (Table 2.1-27). Note that the results of the survey using Collect Earth were purposefully used as sample data to learn the approximate accuracy of the deforestation drivers interpreted in this Project. However, they do not necessarily accurately represent the current status and should be confirmed in the field surveys.

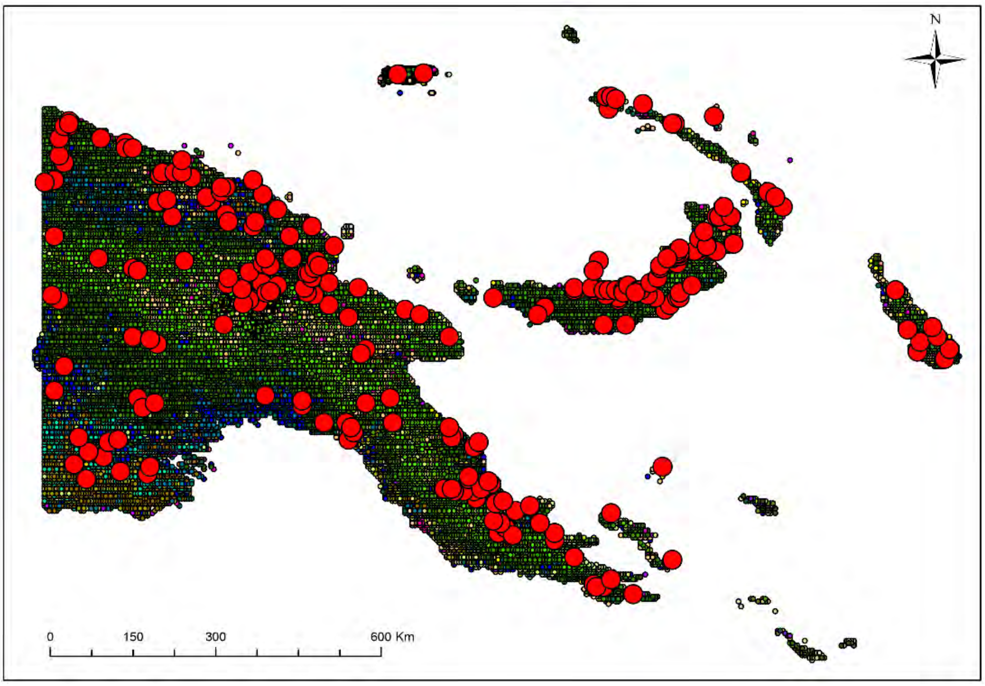


Figure 2.1-59 Ground Cover Analysis Results by FAO using Collect Earth and Survey Points used in This Analysis

Note: Large red dots represent survey points used in this analysis. Small dots in different colors represent different ground cover types.

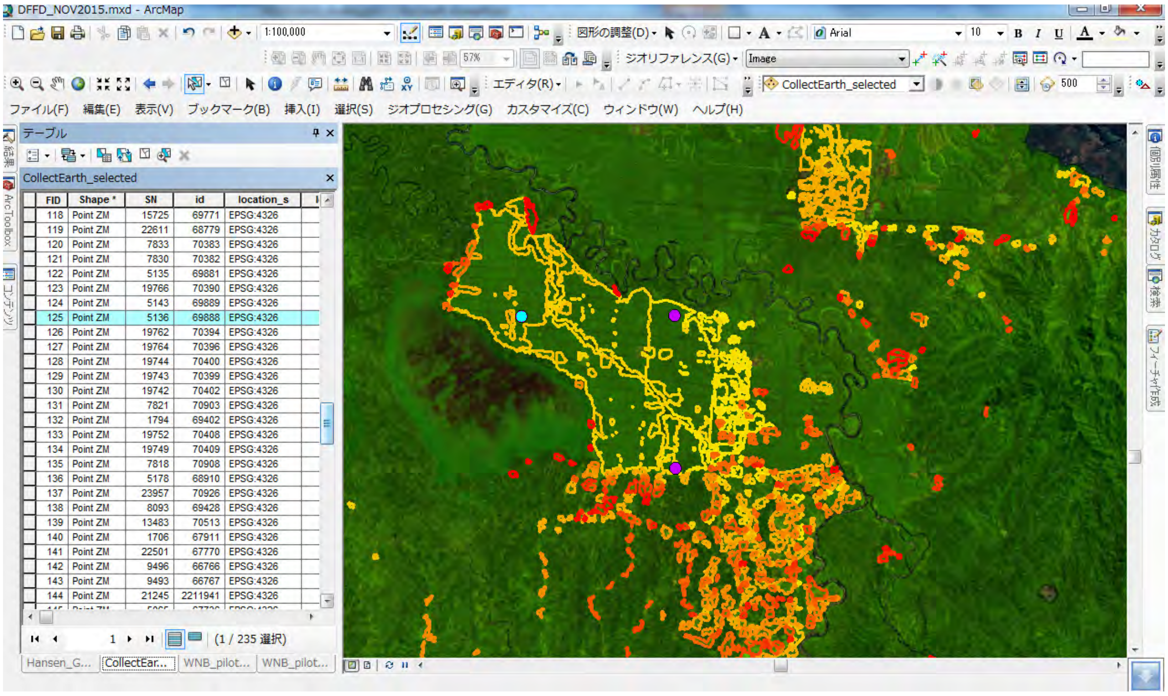


Figure 2.1-60 Conceptual Drawing Comparing Two Interpretation Results Using Hansen Losses and Collect Earth, Respectively

Table 2.1-27 Correspondence of Deforestation Drivers

JICA	FAO
Subsistence Agriculture	subsistence_agriculture subsistence_agriculture_shifting subsistence_agriculture_not_sure subsistence_agriculture_permanent
Commercial Agriculture	gardening
Plantation	other_crop, palm_oil, coffee, tea, coconut
Logging	logging
Flooding	(none)
Landslide	land_slides
Facility Construction	village, infrastructure, large_settlement
Fire	fire
Unknown	other_human_impact
(Others)	low_altitude_forest_on_plainsand low_altitude_forest_on_upland lower_montane_forest etc.

The results of accuracy verification through the comparison of the forest degradation drivers interpreted in this Project and the survey results using Collect Earth are shown in the error matrix (Table 2.1-28). The Overall Accuracy is 51%, showing a relatively low result. In particular, this table shows that logging-origin drivers have a low Producer's

Accuracy of 40% and suggests that, in many cases, they cannot be accurately detected using medium-resolution satellite images such as LANDSAT, used in this Project. On the other hand, plantation-origin drivers have a high Producer's Accuracy of 91%. Most of the areas detected as plantation-origin drivers in this Project are considered to be interpreted also as plantation-origin in the analysis using Collect Earth. However, the User's Accuracy was as low as 59%. This means that in this Project, though some deforestation areas were due to other drivers, they were interpreted as plantation-origin.

Table 2.1-28 Deforestation Driver Discrimination Efficiency

		Collect Earth analysis by FAO											
		Subsis. Agr.	Comm. Agr.	Plantat.	Logging	Flood.	Land-slide	Facility Const.	Fire	Un-known	Others	Total	User's Accur.
Our study	Subsistence Agriculture	50	3	2	7			8	1	8	13	92	54%
	Commercial Agriculture	1		1	1						1	4	0%
	Plantation	5	1	42	12			1		6	4	71	59%
	Logging	1			16					2	2	21	76%
	Flooding	2								1	6	9	0%
	Landslide						1			1	2	4	25%
	Facility Construction				1			1		1		3	33%
	Fire										1	1	0%
	Unknown	6		1	3				2	10	8	30	33%
	Total	65	4	46	40	0	1	10	3	29	37	235	
	Producer's Accuracy	77%	0%	91%	40%	−	100%	10%	67%	34%	−		

Overall Accuracy	51%

2.1.6 Examine the Method of Preparing Information Other than the Methods Above

1) Update of Constraints Data

There were constraints data in the previous FIMS, but they were old and there were issues of data completeness and positional accuracy. Because of this, the C/P suggested that there was a need to update the constraints data. Therefore, the constraints data that form the PNG-FRIMS database were updated by processing the latest accessible data. The short-term expert team examined accessible data and methods for processing the data with the C/P officers, and then decided which methods and data would be used. A description of the constraints data and the processed data are shown in Table 2.1-29. Details about the methods of data processing and the updated constraints data were compiled in 'Fact Sheet No.5 Constraints Data – Natural Condition Layers in the PNG-FRIMS' (Annex 6)

Table 2.1-29 Constraints Data

Constraints Data	Data Description	Processed Data
Altitude	Altitude land over 2400m altitude.	Shuttle Radar Topography Mission (SRTM) 30[23]

[23] Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global, https://lta.cr.usgs.gov/SRTM1Arc (accessed on 03 April 2017)

Constraints Data	Data Description	Processed Data
Slope (Extreme)	Slope (Extreme) land with over 30-degree dominant slope.	SRTM 30
Slope / Relief	Slope / Relief	SRTM 30
Mangroves	Land with dominant slope of 20-30 degrees and sub-dominant	Forest Base Map 2012
Inundation (Extreme)	Slope over 30 degrees and with high to very high relief.	PNGRIS 2008[24]
Inundation (Serious)	Mangroves land covered by mangroves.	PNGRIS 2008
Karst	Inundation (Extreme)	PNGRIS 2008

2）Addition of FCA Boundary Data

Logging with FCA under SABL has a large influence on the surrounding area, because it is conducted to convert a large forest area into farmland. Therefore, it is necessary to monitor this logging for forest management and the discussion of forest carbon stocks. As for the case of logging concessions, land developers are to apply for FCA for land development through PNGFA with the submission of a five-year plan and an annual plan, as well as a map of the FCA area. However, unlike the cases of logging concession areas and logged over areas, a system to convert the boundaries of applied FCA areas to GIS data at the I&M Branch does not exist for land development by developers. Although so-called FCA boundary data are available on the PNGFA GIS server, they are digitized data of the FCA boundaries on the maps provided by developers that only show the areas where they have actually logged. Therefore, these data are significantly different from the boundaries all of the project areas under FCA (Figure 2.1-61). The FCA boundary data on the GIS server has not been updated since they were created. There is no concrete plan to do so either. There are cases where, while a developer is actually operating within an approved FCA area, the developer seems to be developing land outside the FCA boundary, according to data on the JICA server.

[24] University of Papua New Guinea, 2008. Papua New Guinea Resource Information System

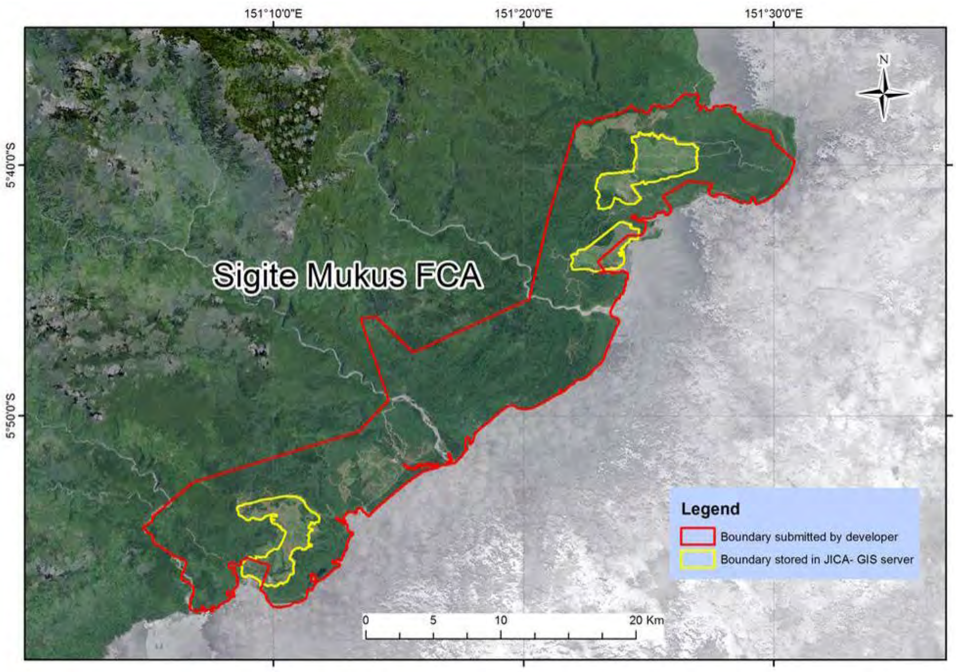


Figure 2.1-61 Comparison between the FCA Boundaries on the JICA Server at Present and the FCA Boundaries on the Map submitted by a Developer

The short-term expert team and the long-term experts have jointly recommended that PNGFA should develop a system to promptly generate GIS data for the boundaries of FCA project areas after applications for FCA have been made and for GIS data of logged over areas that are to be reported in annual plans after the plans have been submitted, in the same way as GIS data of the boundaries of logging concession areas are generated (Annex 24). Work to install the existing paper-based FCA information, which in the past involved large-scale FCA activities, were supported by local staff because of the huge amount of unprocessed information.

3) Addition of Logged Over Area Data

Logged over area information in ALPs submitted by logging companies is one of the best sources of information to accurately grasp deforestation and forest degradation caused by logging activities. Digitizing of logged over area information has commenced at the pilot sites. The targets of the digitizing include not only logged over area but also related facilities such as logging roads. Considering digitization of all logged over areas, more than 1,000 ALPs submitted after the 1990's must be processed; the workload is enormous. To examine how to utilize logged over area information in this Project, it was practical that historical logged over area only in limited areas (for example, pilot areas) should be digitized. The results of the examination in pilot areas were to be applied for logged over areas in the other areas to be digitized in the future.

Information about all logged over areas, which had not been included in the GIS data, was collected and made into a list. Scanning and digitizing of logged over area maps were implemented by sub-contracting during the period from July to December 2018 (Annex 25). The digitized data were double-checked by

PNGFA officers to control quality. However, the sub-contracted digitizing work was not completed because of the huge amount of information. Therefore, work digitizing the logged over area was also carried out by local staff together with FCA. There were 1,574 maps of FCA and the logged over area found. Forty-nine maps were lost in past PNGFA fires. As of 31st August 2019, 783 of the 1,574 maps were completely digitized. There were 724 maps that were only scanned and not digitized. There were 67 maps that were not scanned. After the Project terminates, the digitizing work should continue to be carried out at PNGFA. A list of the ALPs, Forest Working Plans (FWPs) and FCAs, and the progress of digitizing work, are shown in Annex 26.

A brief overview of logged over areas and concessions was compiled in 'Fact Sheet No.8 Forest Concession and Land Management Layers in PNG-FRIMS' (Annex 6).

4) Addition of Logging Road Data

Logging activity is one of the most important drivers of deforestation and forest degradation in PNG. However, in most cases it is difficult to monitor selective logging, which is frequently employed in logging activities by utilizing free satellite imagery, such as LANDSAT (spatial resolution of 30 m). On the other hand, understanding the distribution of logging roads, which can be observed even by mid-resolution satellite imagery, for estimating locations where logging activities have taken place, is one effective method for sustainably monitoring forest to specify places which have experienced selective logging and other forest management activities. Therefore, roads including the logging road network were digitized for the entire country of PNG for the years 2000, 2005, 2011 and 2015.

To develop historical road information, cloud-free mosaicked LANDSAT imagery from the years 2000, 2005, 2011 and 2015 was mainly used. Because roads located in non-forest areas such as grasslands and agricultural fields often could not be found by LANDSAT imagery due to the similar colors of the roads and the surrounding areas, GIS road information developed by UPNG, which consolidated available information as of around the year 2010, and RapidEye imagery (spatial resolution of 5 m) from 2011 procured in the Japanese Grant Aid Programme, were used. The completed road GIS information is shown in Figure 2.1-61. Logging road information was compiled in 'Fact Sheet No.7 Digitized Road Information' (Annex 6).

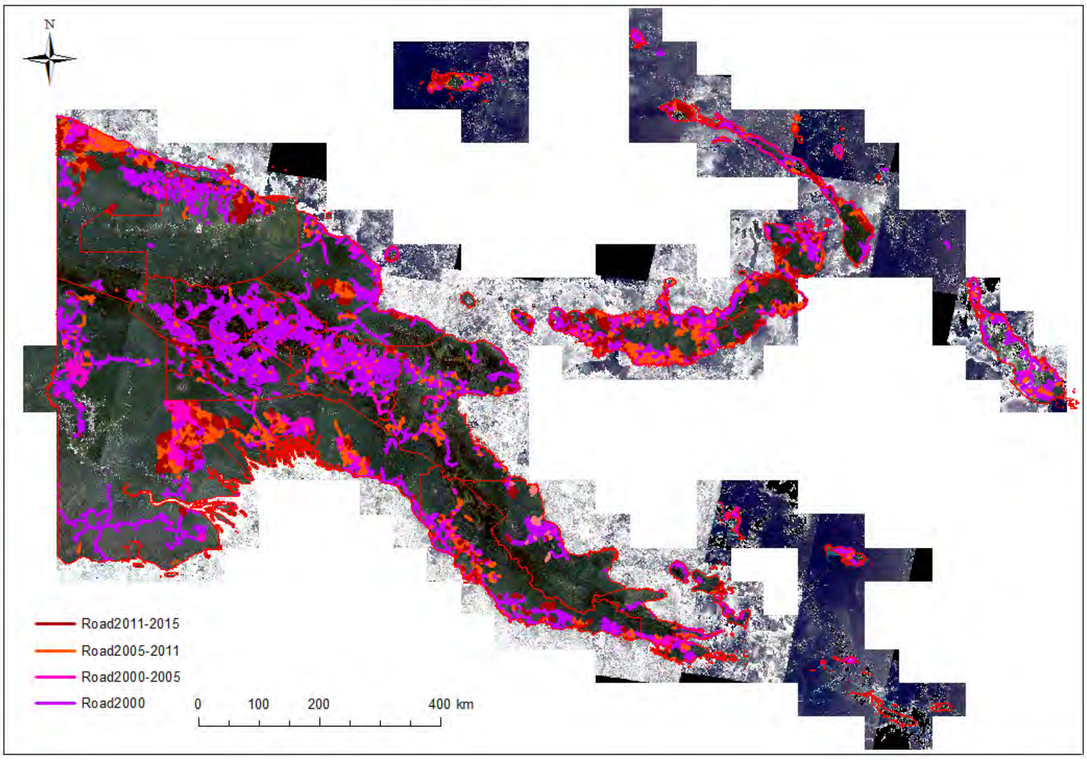


Figure 2.1-62 Map of Completed Road GIS Information

5）Arrangement of 10 m Interval Contour Data

The long-term expert and the C/P officers had a field visit in Aria Vanu Blk2 FMA from 30th April to 4th May 2017. In the report about the field visit, there was a lesson learned; contour line GIS data is too heavy for zooming in and out quickly on ArcGIS Explorer. Therefore, the available data set and method for arranging data were examined in consideration of the acceptable display processing speed and display clarity for field officers to review their field sites. As a result of the examination, contour lines were to be prepared in 3 m mesh raster data and colored by 10 m interval and 50 m interval. Labels of contour lines were to be prepared in annotation data in file geodatabase. Contour lines in raster data were prepared for the whole of PNG.

6）Addition of Hansen Data

Hansen data has several versions, which were published in 2013, 2014, 2015 (two times), and 2016. The “Loss Year” covered by each version is shown in Table 2.1-30. The short-term expert team checked the differences of spatial distribution (position) and area among these versions. If the 2016 version was selected to collect information, the 2013 version had position gaps of less than one pixel. There are also gaps of areas in 2014 Loss Year in 2015 version 1, 2012 and 2013 Loss Years in the 2014 version, and 2011 and 2012 Loss Years in the 2013 version. The reason for this was thought to be that LANDSAT 8 was included in the satellite image used for data analysis, analysis accuracy was improved, or the analysis method was adjusted.

In the Project, the Loss Year and Gain data from 2013 version, 2015 version 1, and 2016 version were developed as a relational database of FMU in the Forest Base Map. The differences in Hansen data versions are noted in the metadata file, as are the Hansen data versions used for data development.

Table 2.1-30 Comparison between Versions of Hansen Data

Version	2001	・・・	2008	2009	2010	2011	2012	2013	2014	2015	2016
2016 ver.	○	○	○	○	○	○	○	○	○	○	○
2015 ver.2	○	○	○	○	○	○	○	○	○	○	—
2015 ver.1	○	○	○	○	○	○	○	○	×	—	—
2014 ver.	○	○	○	○	○	○	×	×	—	—	—
2013 ver.	△	△	△	△	△	×	×	—	—	—	—

○: Presence of data. △: Presence of data, with position gap. ×: Presence of data, but with area gap. —: Absence of data.

7）Review of Forest Plantation Data

The I&M Branch, Forest Policy & Planning Directorate, started to create GIS data of forest plantations that were indicated on paper maps upon the request of the Plantations Branch, Forest Development Directorate. On the other hand, it became clear that there was a difference between the areas in the forest plantation data used in the Forest Base Map and statistical information on forest plantations at the Plantations Branch. This issue was discussed by the I&M Branch, Plantations Branch, and the long-term experts in order to identify the situation and consider countermeasures for the forest plantation data arrangement. The meeting minutes on 13th October, which includes details on this matter, are shown in Annex 27.

2.1.7 Develop a Prototype of Upgraded PNG-FRIMS

(1) Upgrading of FIMS to be Compatible with ArcGIS 10.2.2

The work to upgrade FIMS so that it is compatible with ArcGIS 10.2.2 was implemented in Japan. The new FIMS was installed in PNGFA at the same time as the work to update ArcGIS (ver. 10.0 -> ver. 10.2.2) in February 2015.

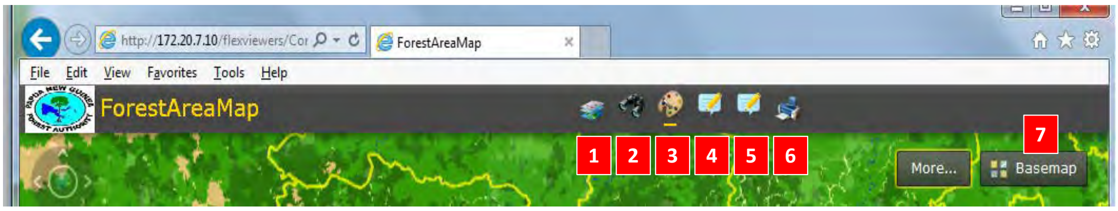
(2) Develop Functions to Support Assessment and Monitor Logging Operation Plans

The objective of the prototype is to have the C/P understand the forest information stored in PNG-FRIMS. Most of the officers, except from the I&M Branch, were not familiar with the forest map database. The LAN-Map makes it possible to allow every officer to access the forest map. It also makes it possible for them to get accustomed to using PNG-FRIMS in everyday work by sketching maps themselves.

Additionally, this opportunity is expected to lead to new requirements (functions) for PNG-FRIMS and the discovery of errors included in the current forest information. Therefore, a feedback function was added to the LAN-Map.

Table 2.1-31 Published Forest Information through LAN-Map

Category	Forest Information (Layer)	Attributes in Layer	Remarks
Logging	Concession Area	Name, Type (TRP, LFA or FMA), Status (Concession or Proposed), Purchase Date, Expiry Date, Remarks (Current or Expired), Remarks2 (Detailed memo)	Managed by FIMS
Vegetation	ForestBaseMap.v1.1		2012 based
	FMU	Vegetation Type	1972 based
Project Area	FCA	Name	Created by I&M Branch
	Forest Plantation	Name	
	Protected Area	Name	From Conservation and Environment Protection Authority (CEPA)
Topography	Satellite		Rapid Eye Image
	Topomap		1/100,000
	Hillshade		Based on SRTM



Functions		Remarks
1	Layer List	To turn layers on and off.
2	Search	To search for the attribute “Name” in the concession area layer.
3	Measure	To measure length and area for simple graphics (line or polygon) drawn by users.
4	Sketch	To create simple graphics (point, line and polygon) for planning or monitoring.
5	Feedback	To create feedbacks (e.g. the data error which user noticed, the request for adding information or adding new functions) as new point features on the map.
6	Print	To print all visible map displayed.
7	Switch Basemap	To choose background topography.

Figure 2.1-63 Overview of Functions

Figure 2.1-64 Sketch Function

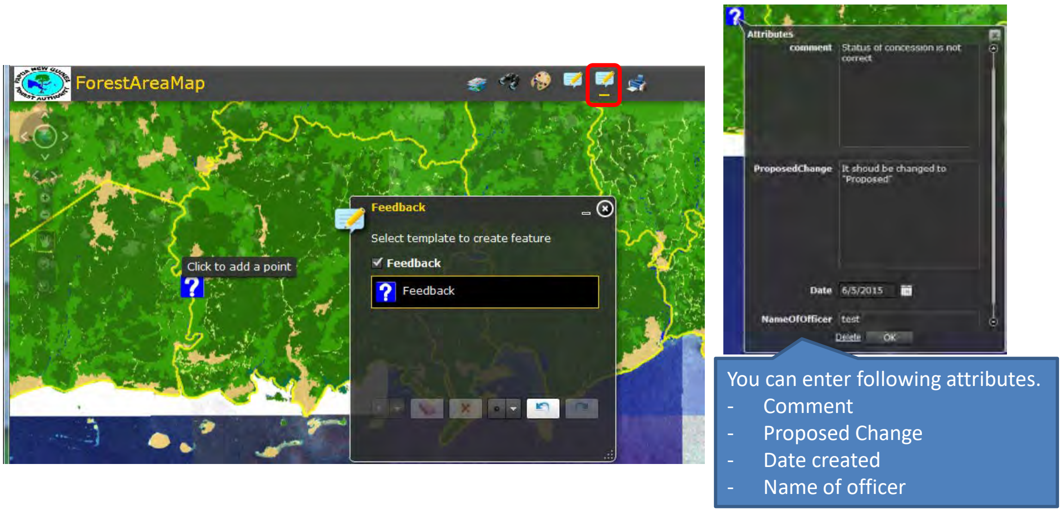


Figure 2.1-65 Feedback Function

（3）Extension Functions of LAN-Map

1）Job Request Function

There are three users of this function: clients, managers and cartographers. The application screens for each user are as follows.

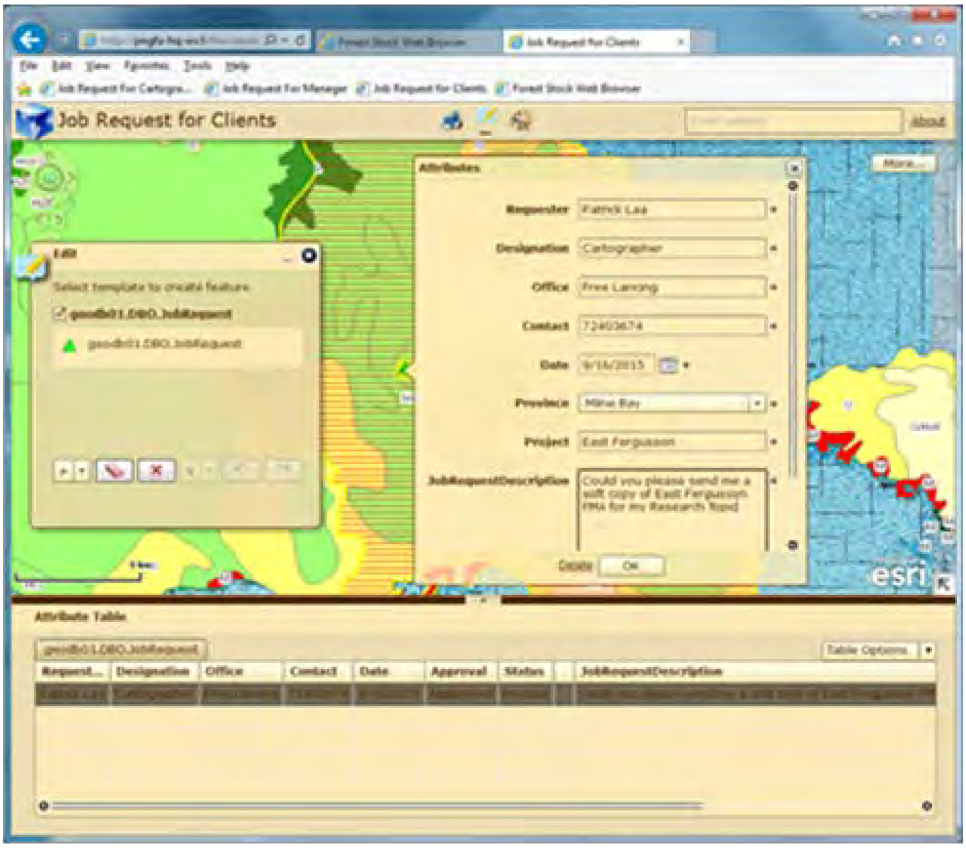


Figure 2.1-66 Job Request: Application Screen for Clients

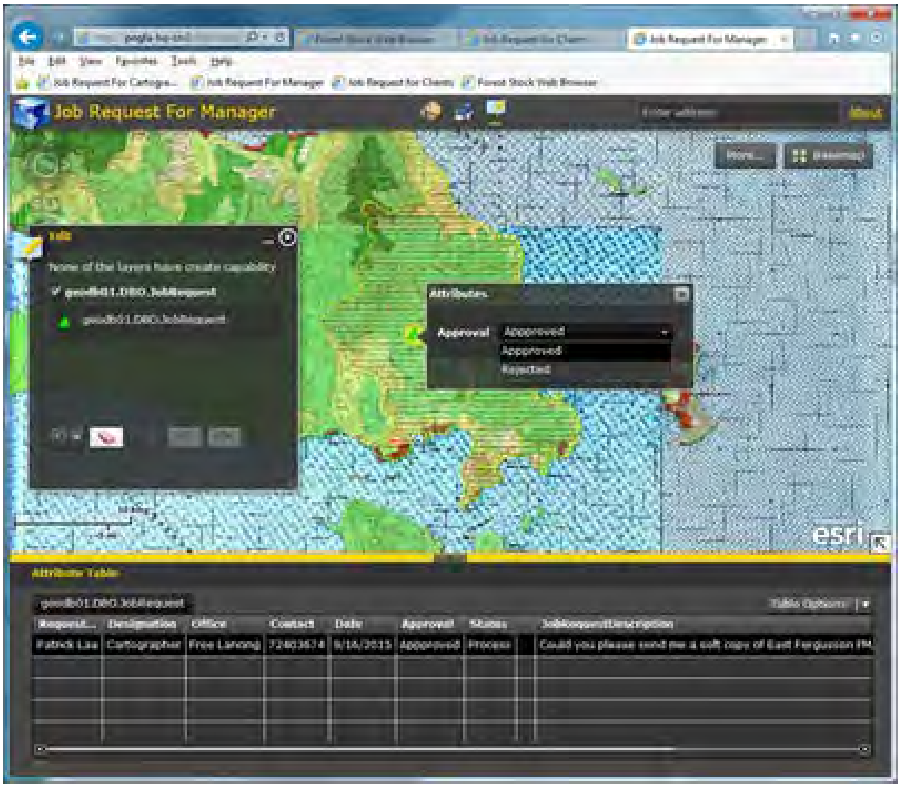


Figure 2.1-67 Job Request: Application Screen for Managers

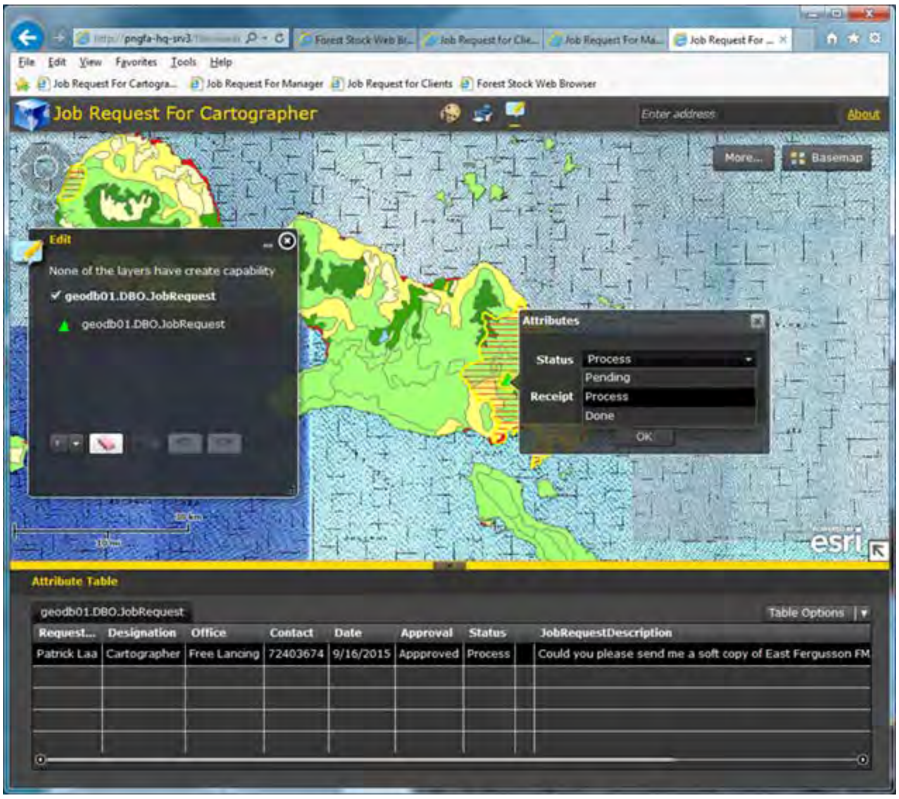


Figure 2.1-68 Job Request: Application Screen for Cartographers

2）Forest Volume Estimate Function

This function estimates forest volume at an area of interest digitized by the user. The application screen is as follows.

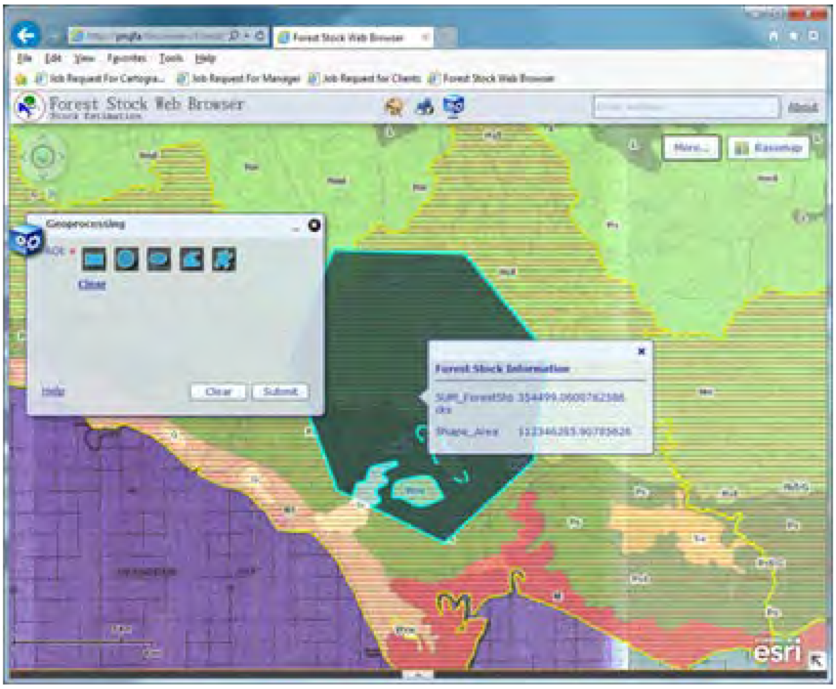


Figure 2.1-69 Forest Volume Estimate: Application Screen

(4) Portal Site for LAN-Map

Based on the basic design shown in 2.1.2, the short-term expert team developed a portal site that is a gateway to the LAN-Map.

1) Login Function

The access to the portal site needs a user name and password.

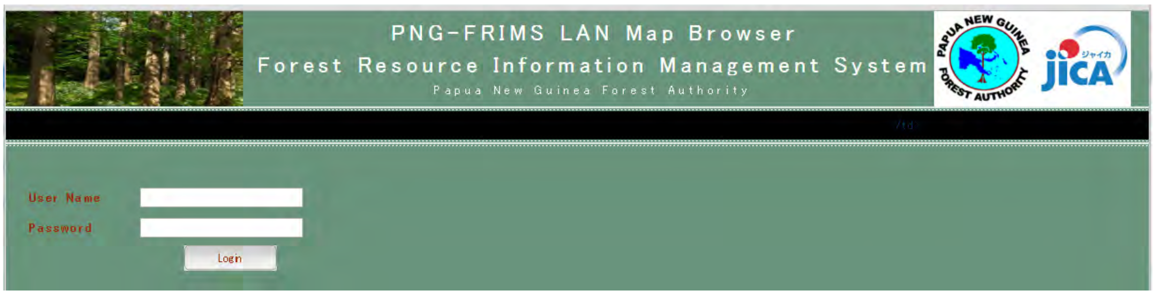


Figure 2.1-70 Portal Site: Login Screen

A user can belong to two or more groups and view maps in accordance with the privileges of each group. If the user belongs to two or more groups he/she can choose a group after login.

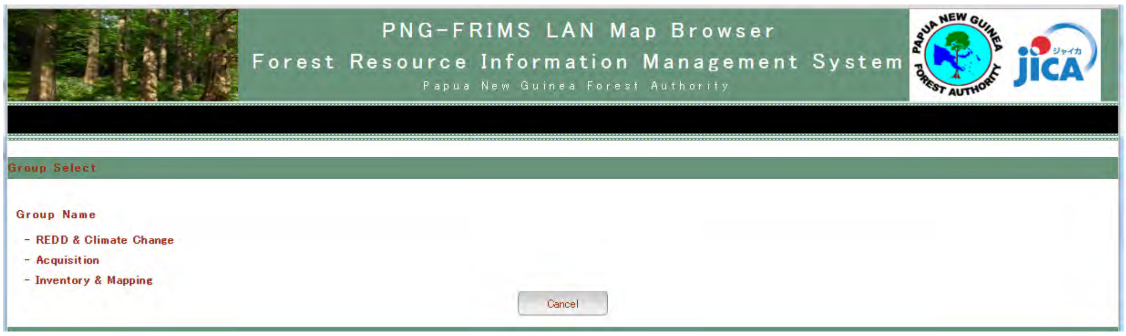


Figure 2.1-71 Portal Site: Group Select Screen

2) Menu Screen

The menu screen after login displays recent news and a list of maps that the user can see. In addition, a user who has administrator privilege can move to the system administration screen.

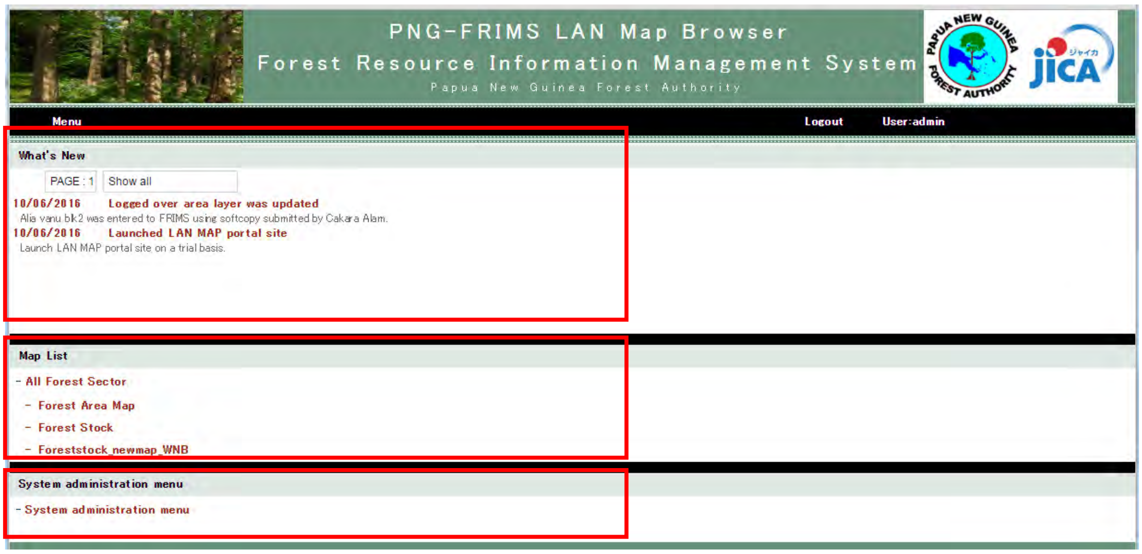


Figure 2.1-72 Portal Site: Menu Screen after Login (for Administrator)

3) Map Function

The user can move to the map screen after clicking on a map displayed on the menu screen. The news about the LAN-Map is displayed on the left side of the map screen. There is a 'Map URL Creation' button on the upper side of the screen which enables the creation of a permalink to the logging project map.

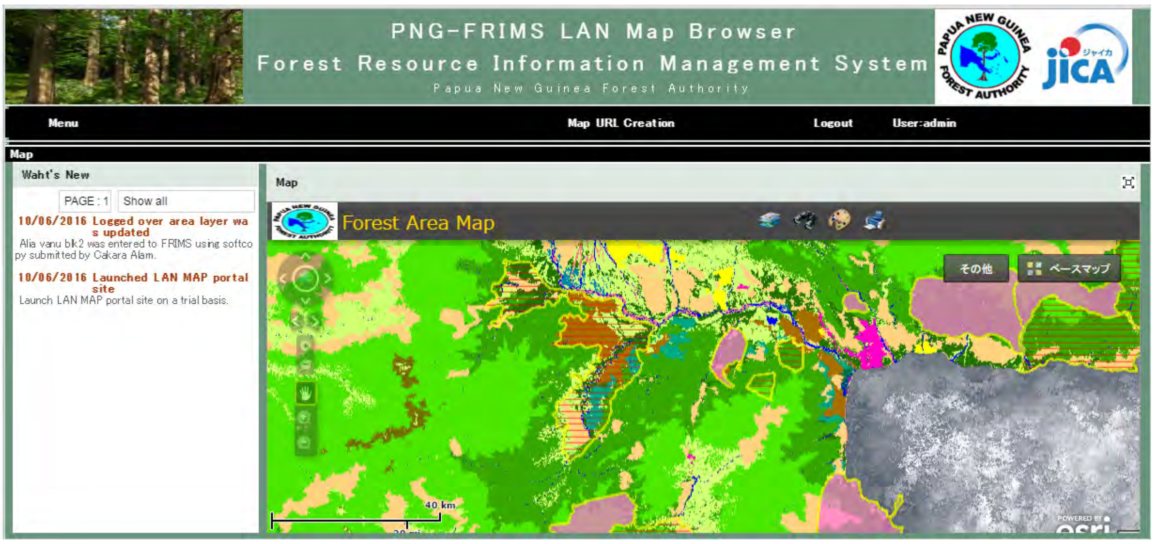


Figure 2.1-73 Portal Site: Map Screen

4) System Administrator Function

The system administration has four functions: 'User management', 'Group list', 'Map management' and 'Group management'.

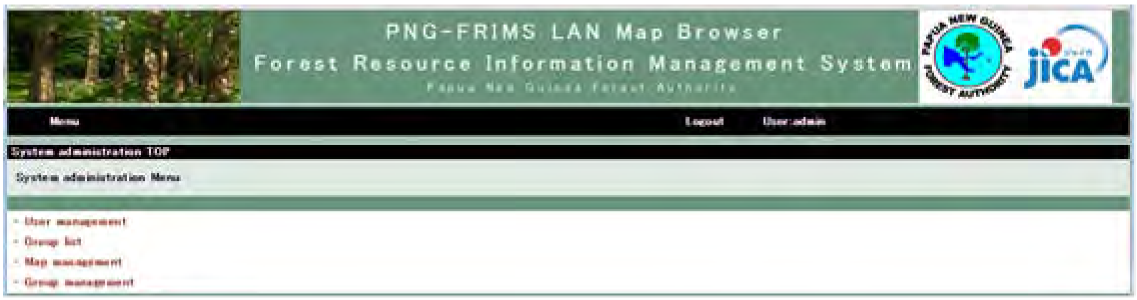


Figure 2.1-74 Portal Site: System Administration Screen

The user management function defines the user name and password, and sets the group of each user.

Figure 2.1-75 Portal Site: User Management Screen

The group list function defines the group. The rights of users to view maps will be assigned by the group to which they belong.

Figure 2.1-76 Portal Site: Group List Screen

The map management function controls the map name and its URL delivered on the LAN-Map.

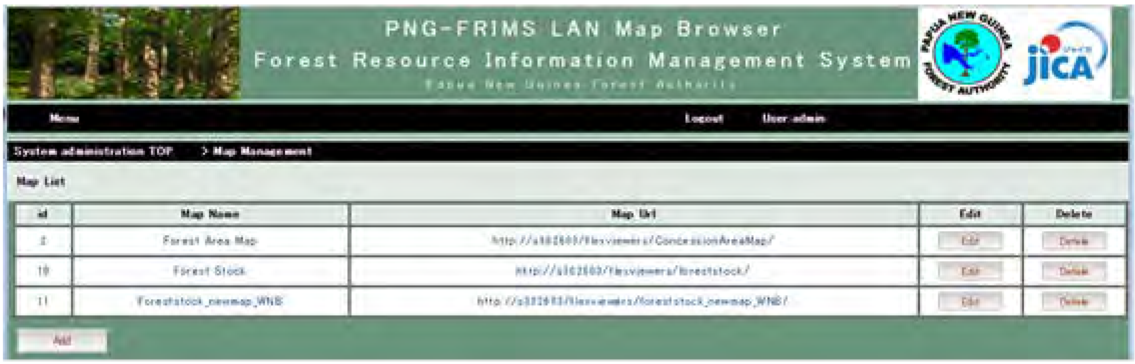


Figure 2.1-77 Portal Site: Map Management Screen

The group management function sets one or more maps that each group can see.

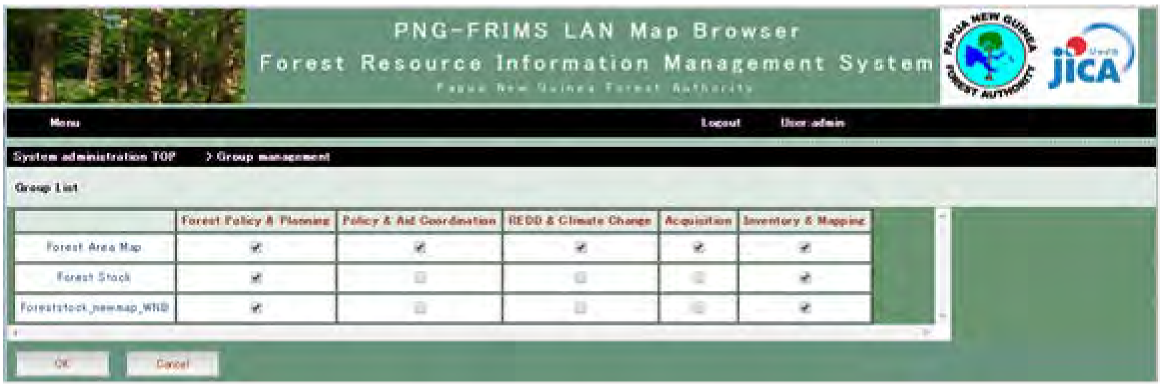


Figure 2.1-78 Portal Site: Group Management Screen

5）Map Sharing Function

In the URL creation screen, the user can focus on a point of interest by magnifying or scaling down the map, and issue a permalink for the map.

Figure 2.1-79 Portal Site: URL Creation Screen and Map Linked URL Created by this Function

(5) Adding Published Maps

Until now, PNG-FRIMS has been mainly providing maps for the monitoring of forest management plans. To examine the utilization of PNG-FRIMS for purposes besides the monitoring of forest management plans, PNG-FRIMS has started publishing maps for the Plantations Branch and Acquisition Branch.

1) Plantation Map for the Plantations Branch

The C/P and JICA expert team examined the expected work and its expected effect for the Plantations Branch as follows.

Table 2.1-32 Possible Utilization of LAN-Map for the Plantations Branch

Expected Work	Use of PNG-FRIMS	Expected Effect
To map boundaries of existing forest plantation projects	Boundary survey data by GPS	To promote proper forest manegement
Screening of grasslands for new plantation area	Grasslands of Forest Base Map Contour Satelite Imagery Constraints ILG boundary	To promote search for new plantation area
Sketch plotting of suitable land for tree planting	Glasslands of Forest Base Map Contour Satelite Imagery Constraints ILG boundary	To make the task easier

The map published on LAN-Map is as follows.

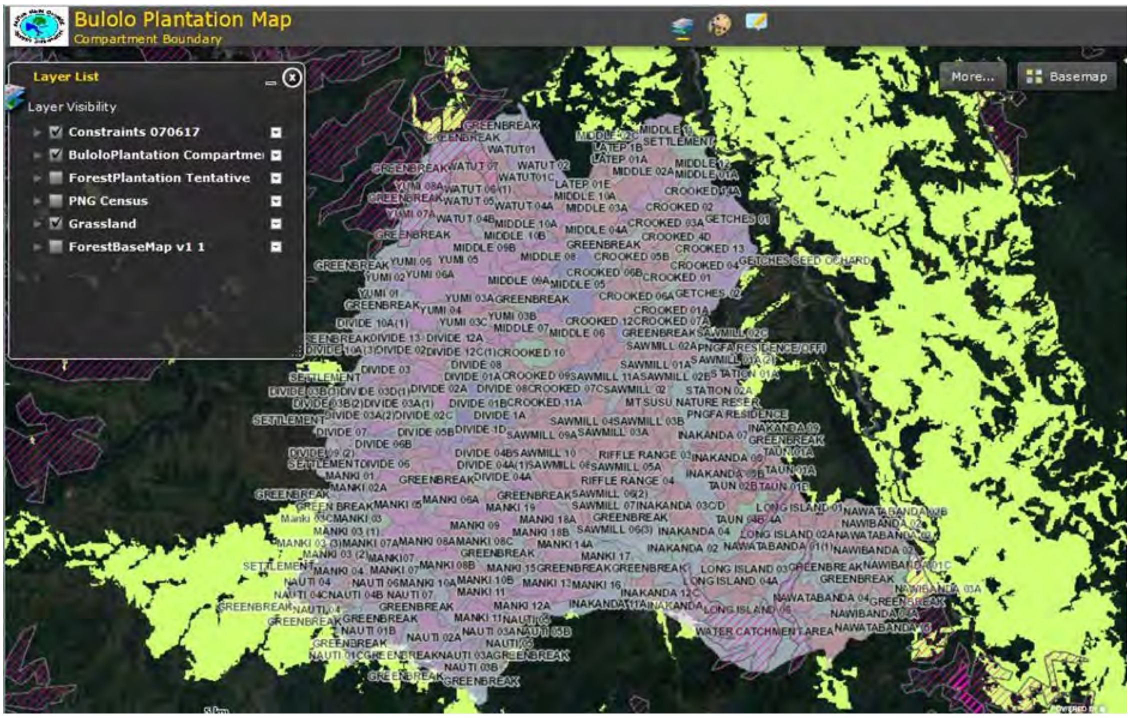


Figure 2.1-80 Map for the Plantations Branch

2）ILG Boundary Map for the Acquisition Branch

The C/P and JICA expert team examined the expected work and its expected effect for the Acquisition Branch as follows.

Table 2.1-33 Possible Utilization of LAN-Map for the Acquisition Branch

Expected Work	Use of PNG-FRIMS	Expected Effect
"Clan mapping", which is a system to map land according to customary land ownership by clans	Satellite Imageries Catchment Contour	To facilitate consultation with landowners

The map published on LAN-Map is as follows.

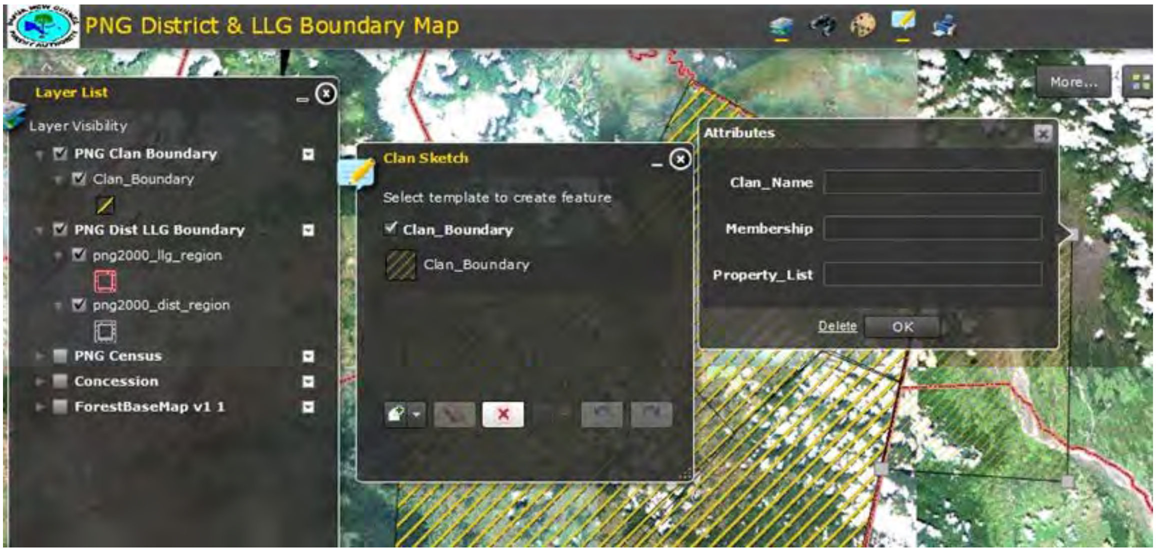


Figure 2.1-81 Map for the Acquisition Branch

(6) Calculation on Annual Allowable Cut Volume and Making Reports on It

The C/P and the JICA expert team examined the function of calculation and reporting on the Annual Allowable Cut (AAC) for the National Forest Plan. This function creates each result of calculation using both the Forest Base Map (new vegetation map) and FMU (old vegetation map). The target reports and the tool for reporting are as follows.

Table 2.1-34 Forest Classification of PNG

Appendix [illegible]: Forest Classification of PNG

[illegible]

Source: Original table and figures are prepared for NFB on 19th Nov. 2015 based on FIMS Database

*1: Area already acquired for FMA, TRP, LFA and TA

*2: Area under acquisition and allocation process for FMA or TRP

*3: Area not yet classified

*4: Area under WMA, extreme constraints and Mangrove

*5: Cause of calculation inconsistency to be found out

*6: Gross Forest Area in this table includes Woodland, Scrub and Savanna in ForestBaseMap 2012

Figures in italic indicates original values copied from the draft prepared for NFB on 19th Nov. 2015

Table 2.1-35 Annual Allowable Cut for PNG (Option1)

Calculation Example 1 **Net Production Area = Production Forest**

Appendix 5a_1: Annual Allowable Cut for PNG in NFP 2015 – 2020

Province	Net Production Area (ha) (c)	Logged Over Area in Net Production Area (ha) (k)	Un-logged Area in Net Production Area (ha) (l) ((c)-(k))	Regrowth Volume in Logged Over Area (m^3) (m)	Volume in Un-logged Area (m^3) (n)*1	Gross Merchantable Volume (m^3) (o) ((m)+(n))	AAC (m^3) (p) ((o) / 35)	Permitted Cut Under Projects (2013) (q)	Balance AAC(2013) (r) ((p)-(q))	Projected AAC 2015-2019 (000 m^3)				
										2015	2016	2017	2018	2019
Western	1,221,000					0		*826,000*	*817,793*	*736*	*736*	*736*	*736*	*736*
Gulf	2,238,137					0		*1,186,000*	*-368,997*	*1,066*	*1,066*	*1,066*	*1,066*	*1,066*
Central	360,432					0		*270,000*	*583,194*	*343*	*343*	*343*	*343*	*331*
Milne Bay	113,720					0		*58,000*	*228,773*	*109*	*109*	*109*	*109*	*109*
Oro	221,000					0		*288,000*	*622,728*	*153*	*153*	*153*	*153*	*153*
Morobe	195,941					0		*185,000*	*925,885*	*261*	*261*	*261*	*261*	*161*
Madang	384,980					0		*568,000*	*178,338*	*418*	*288*	*288*	*138*	*138*
East Sepik	521,500					0		*397,000*	*628,252*	*150*	*150*	*150*	*150*	*150*
Sandaun	1,085,627					0		*907,200*	*226,154*	*554*	*554*	*554*	*554*	*554*
Manus	33,667					0		*212,000*	*-177,880*	*166*	*166*	*132*	*132*	*132*
New Ireland	209,115					0		*180,000*	*-46,985*	*180*	*180*	*180*	*60*	*60*
ENB	215,687					0		*562,500*	*-243,788*	*380*	*380*	*380*	*380*	*380*
WNB	657,799					0		*2,538,700*	*-2,307,765*	*2,434*	*1,704*	*1,569*	*1,569*	*1,569*
AGB	46,720					0		0	*256,716*	*0*	*0*	*0*	*0*	*0*
SHP	98,750					0		*80,000*	*926,392*	*80*	*80*	*80*	*80*	*80*
EHP	0					0		0	*385,002*	*0*	*0*	*0*	*0*	*0*
Simbu	0					0		0	*213,179*	*0*	*0*	*0*	*0*	*0*
WHP	0					0		0	*266,584*	*0*	*0*	*0*	*0*	*0*
Enga	0					0		0	*508,097*	*0*	*0*	*0*	*0*	*0*
Total	7,573,077	0	0	0	0	0		8,258,400		*6,970*	*6,110*	*5,941*	*5,671*	*5,557*

Source: Original table and figures are prepared for NFB on 19th Nov. 2015 based on FIMS Database

*1: Volume is calculated by Forest Monitoring Unit of Forest Basemap 1.2 and its tentative volume

Figures in italic indicates original values copied from the draft prepared for NFB on 19th Nov. 2015

Table 2.1-36 Annual Allowable Cut for PNG (Option2)

Calculation Example 2 | Net Production Area = Production Forest + Potential Production Forest + Reserve Forest

Appendix 5a_2: Annual Allowable Cut for PNG in NFP 2015 – 2020

Province	Net Production Area (ha) (j)	Logged Over Area in Net Production Area (ha) (k)	Un-logged Area in Net Production Area (ha) (l) ((j)-(k))	Regrowth Volume in Logged Over Area (m³) (m)	Volume in Un-logged Area (m³) (n)*1	Gross Merchantable Volume (m³) (o) ((m)+(n))	AAC (m³) (p) ((o)/ 35)	Permitted Cut Under Projects (2013) (q)	Balance AAC (2013) (r) ((p)-(q))	Projected AAC 2015-2019 (000 m³) 2015	2016	2017	2018	2019
Western	3,221,592					0		836,000	817,792	736	736	736	736	736
Gulf	3,466,523					0		1,186,000	-365,997	1,066	1,066	1,066	1,066	1,066
Central	1,553,683					0		370,000	583,194	363	363	363	363	331
Milne Bay	796,330					0		38,000	338,772	109	109	109	109	109
Oro	933,328					0		388,000	433,738	153	153	153	153	153
Morobe	1,315,017					0		185,000	935,885	361	361	361	361	161
Madang	993,516					0		568,000	178,338	418	388	388	138	138
East Sepik	636,039					0		397,000	458,553	150	150	150	150	150
Sandaun	3,487,347					0		907,300	556,154	554	554	554	554	554
Manus	156,833					0		313,000	-177,880	166	166	133	133	133
New Ireland	611,473					0		180,000	-46,985	180	180	180	60	60
ENB	787,467					0		563,500	-363,798	380	380	380	380	380
WNB	1,096,367					0		3,538,700	-2,307,763	3,636	1,706	1,569	1,569	1,569
ARB	881,663					0		0	336,716	0	0	0	0	0
SHP	303,939					0		80,000	936,393	80	80	80	80	80
EHP	59,356					0		0	365,003	0	0	0	0	0
Simbu	167,073					0		0	313,179	0	0	0	0	0
WHP	174,310					0		0	366,384	0	0	0	0	0
Enga	63,666					0		0	306,097	0	0	0	0	0
Total	18,634,621	0	0	0	0	0	0	8,338,400		6,970	6,110	5,961	5,671	5,559

Source: Original table and figures are prepared for NFB on 19th Nov. 2015 based on FIMS Database

*1: Volume is calculated by Forest Monitoring Unit of Forest Basemap 1.2 and its tentative volume

Figures in italic indicates original values copied from the draft prepared for NFB on 19th Nov. 2015

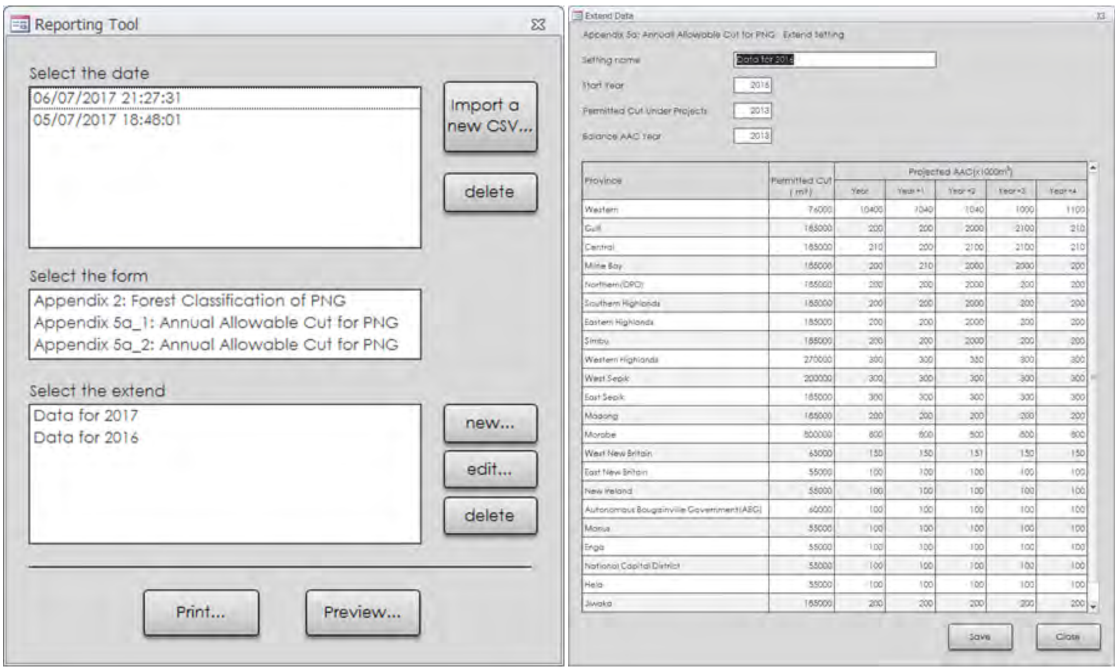


Figure 2.1-82 Reporting Tool Developed on a Trial Basis

(7) Enhancement of FIMS

The JICA short-term expert team developed an additional FIMS function in order to estimate potential timber volumes according to the Forest Base Map 2012. In addition, the system framework of FIMS was verified and improved to process the Forest Base Map 2012, which has a large amount of spatial data.

The total number of polygons in the previous forest vegetation map was about 13 thousand, which was being used to estimate potential timber volumes on FIMS. On the other hand, the total number of polygons in the Forest Base Map 2012 was greatly increased to around 1.1 million. For that reason, it was not practical for FIMS to adopt the same way of spatial processing as with the previous forest vegetation map, which executes spatial operations on the SQL server in PNG-FRIMS. Therefore, in order to improve processing efficiency, a replica of some forest information stored in the PNG-FRIMS server was placed in the client workstation. As a result of adopting this way, a practical estimate function was realized. It was also possible that placing the replica would complicate forest information management. Accordingly, a decision was made to adopt a separate operation, which divides the administrative client from other clients for general users. The system configuration diagram of PNG-FRIMS including FIMS is shown as below.

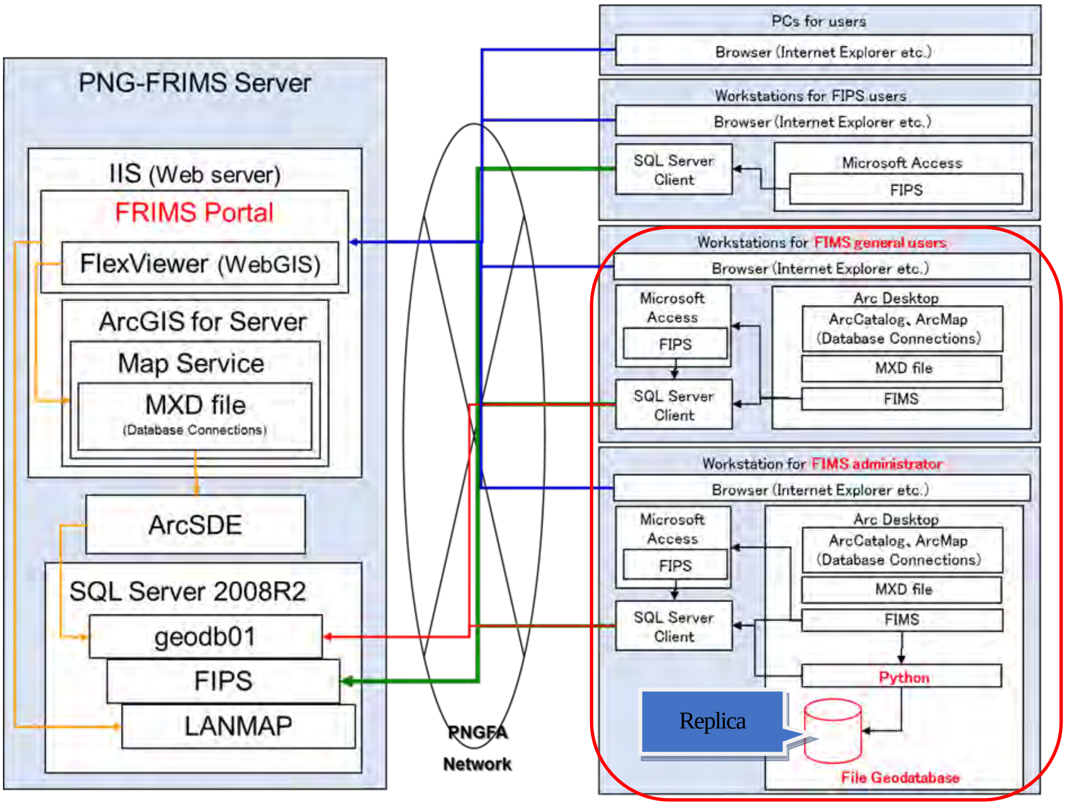


Figure 2.1-83 System Configuration Figure of PNG-FRIMS after Enhancement

The following table shows the difference in FIMS functions between the Administrator and a general user.

Table 2.1-37 FIMS Functions to be Used According to User Privileges

FIMS Function			User Privilege	
NO	Large Category	Small Category	Administrator	General User
1	Login		○	○
2	Main Screen（Province）	List of Provinces and Printing	○	○

		reports		
3	Updating Timber Volumes	for Zone	○	×
4		for FMU	○	×
5	Reports	Print	○	○
6		Preview	○	○
7		Export	○	○
8	Main Screen (Concession data)	List of concession areas by province and printing reports	○	○
9		File UP & Download	○	×
10	Large Map	Viewer	○	○
11		Editor	○	×
12		FMU Calculation	○	×
13		Import	○	×
14		Copy	○	○
15		Preview	○	○
16	Assessment by FIPS	List of concession areas by province	○	○
17	Administrator	Layer Management	○	×
18		User Management	○	×
19		FIPS Data Import	○	×
20		Appendix2 and 5 Calculation	○	×

FIMS integrated the AAC calculation module and also adopted the new system of 22 provinces in late March 2018.

The FIMS screens after the enhancement are shown in the following figures. Two kinds of forest vegetation maps became selectable in the login window.

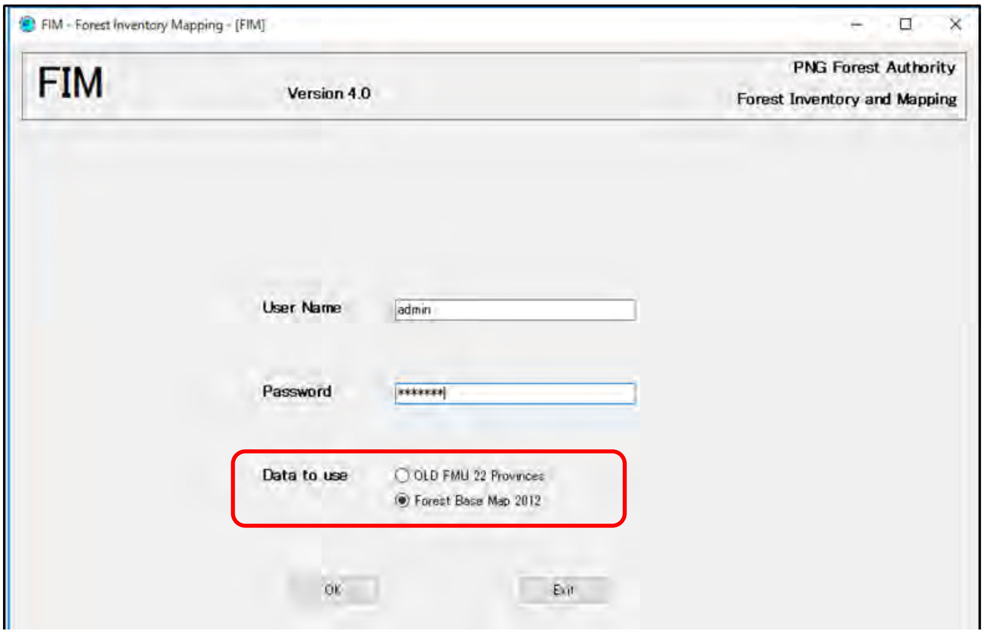


Figure 2.1-84 FIMS Login Screen after Enhancement

The list of provinces on the main screen was updated to show 22 provinces in line with the current situation in PNG. The related spatial operations and printing report functions were also improved based on the new PNG province system. The relevant forest information was also updated according to the boundaries of new provinces.

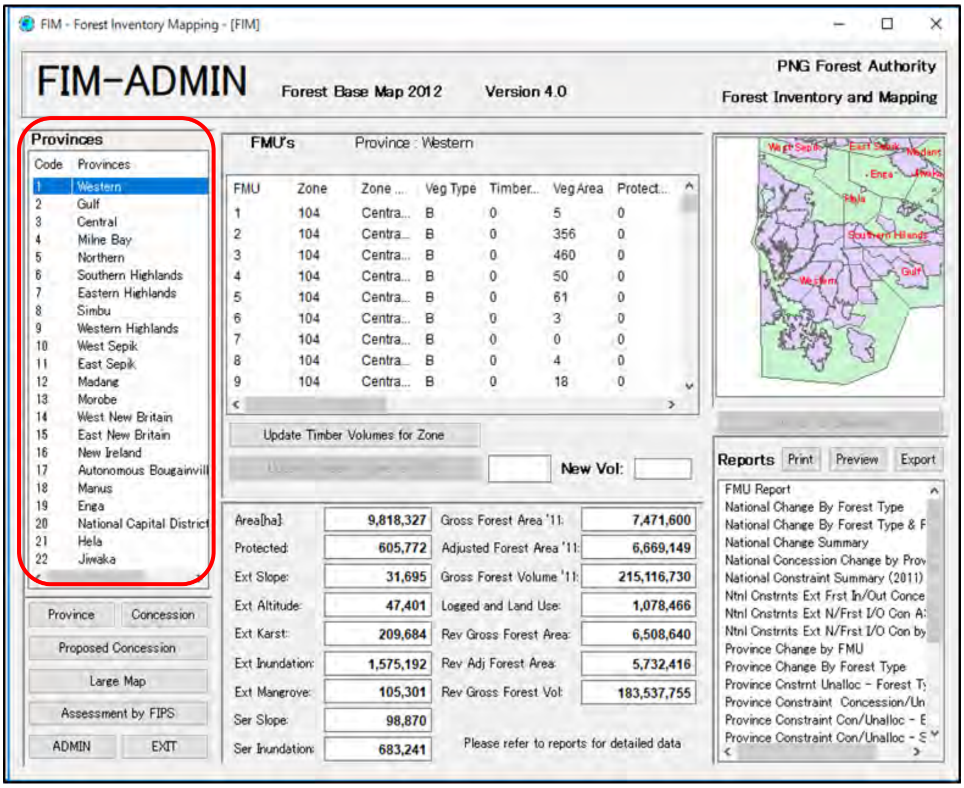


Figure 2.1-85 FIMS Main Screen after Enhancement

The AAC calculation module was integrated with FIMS as one of the functions for the Administrator.

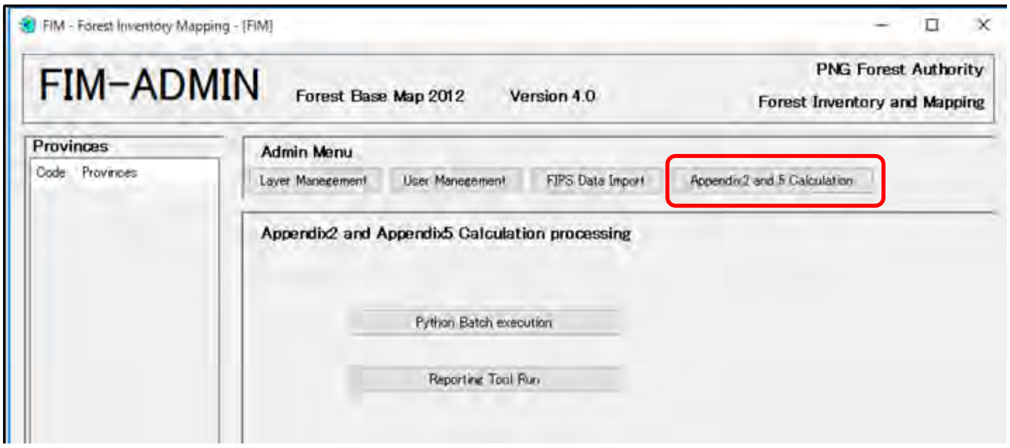


Figure 2.1-86 Administrative Screen after Adding AAC Calculation Module

The following requirements became clear through the trial of the improved FIMS with the AAC calculation function.

(i) Create an AAC record for each concession area

The AAC calculation function as of April 2018 only has a function to create an AAC record for each province. Therefore, through this function it was difficult to compare and verify the Permitted Cut, which the Project branch allocates to each operational logging project. For this reason, the JICA expert team decided to develop a function to create an AAC record of each concession area and to show a breakdown of the AAC of each province.

(ii) Change parameters to estimate regrowth volume of AAC

The AAC calculation as of April 2018 cannot change the parameters for the timing of the start of forest regrowth and the period required to recover — the start of regrowth is the next year after the logging year and 35 years are required to recover at 100 %. JICA expert team decided to develop a function to change the parameters to make a scenario of forest regrowth for each province in the future.

(iii) Estimate forest regrowth volume using the harvested year of each logged over area

The work of digitizing the ALPs is ongoing. The input of data of the harvested year for each logged over area is also being carried out through this work. The AAC calculation function as of April 2018 calculated the regrowth volume based on the purchased year of concession areas. Therefore, it will be possible to calculate more accurate forest regrowth volume using the harvested year for each logged over area and the purchased year of concession areas recorded in forest logging history data. For this reason, the JICA expert team decided to develop another new option to estimate the forest regrowth volume based on the harvested year of logged over areas.

Based on the aforementioned requirements for the improvement of the AAC calculation function, the JICA short-term expert team implemented the basic and detailed design for FIMS.

2.1.8 Operate the Prototype of PNG-FRIMS on a Trial Basis

Use of the prototype of PNG-FRIMS developed in 2.1.7 was started on a trial basis from April 2014 sequentially.

(1) Printing Function of LAN-Map

An issue about the printing function on LAN-Map was raised by the C/P in the process of the operation of the prototype. The C/P and the JICA expert team considered three options regarding user access to the LAN-Map printing function.

Table 2.1-38 Options of the Operation on Printing Function of LAN-Map

Option		Possible Advantage	Possible Disadvantage
1	All users can use the printing function on LAN-Map	- Helps the cartographer team reduce time spent on job requests for printing maps. - Officers other than the cartographer team can reduce time on requests to print maps as well. - Simplify user access control to LAN-Map.	- Increase the risk of forest information leak.
2	Managers and Directors can use the printing function on LAN-Map	- Reduce the risk of forest information leak.	- Too messy and complicated to control user access to LAN-Map. (Need to prepare lots of user groups and to duplicate the same kind of map — one with and the other without a printing function) - A user can take a screenshot of maps on LAN-Map.
3	Access to LAN-Map printing function is restricted	- Reduces the risk of forest information leaks. - Simplifies user access control of LAN-Map.	- Work requests remain a burden for cartographer team. - A user can take a screenshot of maps on LAN-Map.

According to the discussion with the C/P, LAN-Map has decided to adopt option 1 for the time being. To identify the user printing maps on LAN-Map, a footnote will be displayed on the map that shows the date and time when the printing function is executed as a countermeasure against the risk of forest information leaks. It will be possible for the administrator of LAN-Map to identify the user of the printing function by comparing the footnote with the user access logs stored in the server.

(2) AAC Calculation Function

PNG-FRIMS started to offer the first version of an AAC calculation function in November 2017. The C/P officers verified the reports provided by this function. After that, a difference of approximately 20,000 sq km in forest area was found between the results of the AAC calculation and the report in the Forest Base Map 2012. The difference was that the AAC calculation overestimated the forest area and underestimated the area of grassland. The result of the AAC calculation was affected by net production area of forest where logging activities are carried out.

The reason for the difference was that all of the areas in the constraint layers, which are areas such as wild management areas or areas of high altitude, were classified as forest areas in the first version of the AAC calculation. However, in the Forest Base Map 2012, the constraint layers include not only forest but also grassland. Because of this situation, the forest area was overestimated by the AAC calculation function.

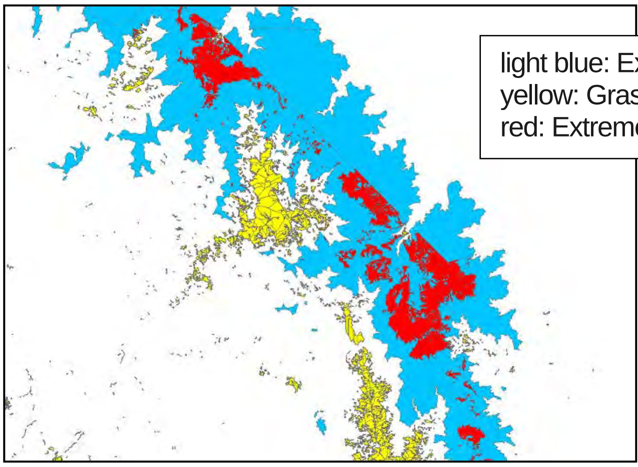


Figure 2.1-87 Example of Overlapping among Forest Information Affecting an Estimate of Forest Area

The JICA expert team modified the spatial operation calculation procedure and solved the issue of forest area overestimation (Annex 28).

- Calculation order on the first version of AAC estimate

  Protection Forest > Forest Plantation > Grassland > Other Areas > Production Forest > Potential Forest > Reserve Forest

- Calculation order on the second version of AAC estimate

  Grassland > Other Areas > Protection Forest > Forest Plantation > Production Forest > Potential Forest > Reserve Forest

The C/P officers began the trial operation of the improved FIMS, in which the AAC calculation function was added in April 2018. The operation verification of the improved FIMS was carried out by the processing AAC calculation function using results of digitizing the ALPs, which are also in progress.

2.1.9 Develop a Work Manual of the PNG-FRIMS Operation

The JICA short-term expert team developed the manuals on the PNG-FRIMS operation based on discussions with the C/P (Annex 3). The objectives of the manual were to accomplish the following three points.

- To explain all functions of each tool (FIMS, FIPS, LAN-Map and Portal Site) composing PNG-FRIMS
- To indicate how to install and maintain PNG-FRIMS for the system administrator
- To realize stable and sustainable operation of PNG-FRIMS

The contents of the manual are shown in Table 2.1-39.

Table 2.1-39 Contents of the Manual on the PNG-FRIMS Operation

Chapter	Remarks
1. Introduction	Outline of PNG-FRIMS
General information	Introduce JICA Project
Background and summary	Background of development of each tool
System configuration	Illustrate system framework and role of each tool
Aim of this manual	Describe assumed use case and assumed user
2. Overview of each application	Introduce basic role and functions of each tool
FIMS	Illustrate basic role and functions on FIMS
FIPS	Illustrate basic role and functions on FIPS
LAN-Map	Illustrate basic role and functions on FIMS LAN-Map
3. For Administrator	Illustrate installation and operation of PNG-FRIMS
FIMS	Illustrate the role and regular tasks of administrator, system operating environment, procedure of installation, Q&A, points of maintenance
FIPS	
LAN-Map	
Attachment	Detailed manuals / specifications for a specific user
PNG-FRIMS Installation Manual	
FIMS User Guide	
FIPS User Guide	
Simple manual on LAN-Map on PNGFA's Intranet	

2.1.10 Conduct Trainings Which are Necessary for PNG-FRIMS Operation

While discussions on PNG-FRIMS operation were taking place with the C/P officers, the trainings related to PNG-FRIMS operation technology used in the examinations were conducted for PNGFA HQ officers. These involved lectures, exercises and OJT. The technological fields in the training were (1) operation techniques for the PNG-FRIMS database; (2) RS / GIS and forest monitoring; and (3) biomass and carbon estimation. In addition, as described in 1.4.2, database training and RS / GIS training were held in Japan twice, in 2015 and 2017, with each training for four trainees over two weeks, for the purpose of learning database system construction technology and advanced RS imagery analysis technology.

Details on the content and achievements of the training sessions are shown in 'Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)'.

(1) Training on Operation Techniques for PNG-FRIMS Database

The main topics of the training regarding operation techniques for the PNG-FRIMS database field are as follow:

- Forest database quality evaluation
- Updating forest information
- PNG-FRIMS installation
- Sharing forest information on the Web using ArcGIS Server
- Design and develop new web application for contributing to the efficiencies and advances of forest management
- Maintenance of the data server
- Maintenance of PNG-FRIMS
- Delivery of map via LAN-Map
- Maintenance of the ArcGIS Desktop license
- AAC calculation
- Installation and Operation verification of the updated FIMS

Related to these topics, the Project discussed PNG-FRIMS data server maintenance. It was noted that one of the workstations hosting the ArcGIS license server was out of order in 2016. This problem seemed to come from deterioration in performance because it had been more than 5 years since the workstation had been introduced. The C/P and the short-term expert team restored the workstation. In addition, the short-term expert team explained the basic operations of the portal site installed on a trial basis to the C/P. On the other hand, the long-term expert had a meeting with the C/P to discuss arrangements for PNG-FRIMS data server maintenance. As a result, the arrangements for PNG-FRIMS data server maintenance shown in Table 2.1-40 were approved.

Table 2.1-40 Arrangement for PNG-FRIMS Data Server Maintenance

	Branch	Task	Frequency	Officer in charge
Overall (server and WS)	ICT I&M	Check the work done. Push trouble shooting.	Every month	Manager ICT Manager I&M
FRIMS Data Server	ICT	Windows Update	Every month	(Main) Thomas (Sub) Jason
	ICT	Kaspersky Update	Every two weeks	
	(update server maintained by Graham)			
	ICT	NAS Backup Check and Re-trigger	Every week	
	Relocation of NAS sever agreed (I&M → ICT server space)			
Japan-Grant Workstations	ICT	Give and cut-off internet connection to WSs	Every two weeks	
	I&M	Windows Update	Every month	(Main) Patrick (Sub) Jehu
	I&M	Kaspersky Update	Every two weeks	

（2）Training on Remote Sensing / GIS and Forest Monitoring

The main topics of the training regarding RS / GIS and forest monitoring field are as follow:

- Forest Base Map modification
- GIS Analysis for data management
- Accuracy assessment of the Forest Base Map
- GIS concept and introduction to ArcGIS
- Basic of RS imagery
- Introduction of SAR
- Acquisition and processing of RS data
- Development of forest cover map for the previous year
- Development of data for PNG-FRIMS
- Development of forest cover map in 2015
- Development of deforestation and forest degradation and their drivers into forest cover maps
- Forest monitoring
- Three -dimensional mapping with the GIS technology
- Land change modeling analysis
- Drone operation and analysis

（3）Training on Biomass and Carbon Estimation

The main topics of the training regarding biomass and carbon estimation field are as follow:

- Forest resource information analysis
- Application of additional information into PNG-FRIMS
- Calculation of forest biomass and carbon stocks
- Land change modeling analysis
- AAC calculation

2.2 Activities for Output 2

2.2.1 Review the Current Status of the Forest Planning System

（1）Examine the Current Forest Planning System and Document Issues

The long-term experts and C/P officers (the forest planning officer and the manager of I&M Branch) interviewed and had meetings with concerned PNGFA personnel to gain a grasp of the overall issues and problems in implementing the current forest planning system of PNGFA and to find countermeasures for addressing them (Table 2.2-1 and Table 2.2-2) (Activity 2.1.1 in the PDM).

Table 2.2-1 Issues / Problems in Planning and Implementing the Forest Plans and Methods / Solutions for Addressing Them

As of 24/Nov/2014, updated on 07/Jul/2019

<table>
<tr><th rowspan="2"></th><th rowspan="2">Contents</th><th rowspan="2">Current status</th><th rowspan="2">Issues/Problems</th><th colspan="4">Methods/Solutions for addressing the issues with spatial information</th></tr>
<tr><th>Training (e.g. GIS,GPS)</th><th>Review of working-flow</th><th>Preparation of data</th><th>Review of definition</th></tr>
<tr><td>National Forest Plan</td><td>・National Forest Developmant Guidelines
・National Forest Development Programme
・Provincial Forest Plans
・Statement of annual cut volumes</td><td>・Draft NFP will be submitted to the national forest board in Nov. 2014, but not endorsed yet.
・Revised draft is being prepared.</td><td>・The lack of valid provincial forest plans.
・Deficient annual allowable cut volume contradinting the picture.
・The absence of the practical national forest inventory.</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">Provincial Forest Plans</td><td rowspan="3">・Provincial Forest Development Guideline

・5 year rolling provincial forest development program</td><td rowspan="3">・Guidelines for provincial forest plans is being revised.
・WNB, ENB, and Madang province start reviewing their next provincial forest plans.</td><td colspan="5">Forest Plans Officer</td></tr>
<tr><td>・The lack of updated area information(e.g. logged over area)</td><td></td><td>I & M, PAD</td><td></td><td></td></tr>
<tr><td>・The lack of proper definition, identification and demarcation of forest areas</td><td></td><td>I & M, PAD</td><td></td><td>I & M, FSD</td></tr>
<tr><td rowspan="2">Forest Management Agreement</td><td rowspan="2">・35 year plan for logging</td><td rowspan="2"></td><td colspan="5">Acquisition Branch</td></tr>
<tr><td>・Gap between 1. Possible missions and 2. Available resources.
1. (1) Required re-registration of all ILG boundaries for all existing FMAs.
(2) Required registration of individual ILG boundary for proposed FMAs.
2. Available resources (finance, manpower and equipment) and skill (GPS, GIS and Map use).</td><td>I & M, ACQ</td><td></td><td></td><td></td></tr>
<tr><td rowspan="10">Forest Management Operation Plans</td><td rowspan="10">・5 year forest working plan

・Annual Logging plan

・Set-up plan</td><td rowspan="10">・The lack of logistics and human resouces to adequately inspect/monitor the forest resources and logging operations</td><td colspan="5">Project Allocation Directorate</td></tr>
<tr><td>・Lack of means to detect encroachment on Reserve Forest, Cultural Site and buffer zone (ex. village, river).</td><td>I & M, PAD</td><td></td><td>I & M, KKC</td><td></td></tr>
<tr><td>・Lack of means to prevent overlapping of FMA (TRP, LFA) and FCA (WMA, etc.).</td><td></td><td>I & M, PAD</td><td></td><td></td></tr>
<tr><td>・Lack of means to verify logging application for alleged Re-entry into logged over area in TRP and LFA.</td><td></td><td>I & M, PAD</td><td></td><td></td></tr>
<tr><td colspan="5">Field Services Directorate</td></tr>
<tr><td>・A map on a scale of 1:100,000 with 40m contour interval is too coarse for assessing road system for Annual Logging Plan and Set-Up Plan.</td><td></td><td></td><td>I & M, KKC</td><td></td></tr>
<tr><td>・Lack of means to detect the discrepancy between the submitted plan and actual operations in the field (e.g. felling and skidding track).</td><td>I & M, FSD</td><td></td><td>I & M, KKC</td><td></td></tr>
<tr><td>・Lack of resource (finance, manpower and vehicles) and skill (use of maps, GPS and GIS).</td><td>I & M, FSD</td><td></td><td></td><td></td></tr>
<tr><td>・Lack of means to mediate disputes when landowners bring up boundary and ownership issue again.</td><td>I & M, FSD</td><td></td><td>I & M, KKC</td><td></td></tr>
<tr><td>・Boundary of land ownership is not readily available when boundary of Set-Up Plans are determined in Annual Logging Plan.</td><td>I & M, FSD</td><td></td><td>I & M, KKC</td><td></td></tr>
</table>

I & M: Inventory and Mapping Branch
ACQ: Acquisition Branch
PAD: Project Allocation Directorate
FSD: Field Services Directorate

Table 2.2-2 Issues / Problems and Methods / Solutions for Addressing Them at Area / Provincial Office

As of 22/Aug/2016

Type of Plan	Contents	Means or methods of assessment	Issues/Problems encountered by Area Office, Provincial Office and Project Officer	Methods/Solutions for addressing the issues with spatial information
Provincial Forest Plan	・Consultation for revision with PFMC ・Provision of FIMS data		WNB ・Less interests among stakeholders ・Low level of ownership of Provincial Government on PFP ・Infrequent updating of geographical and resource information	WNB ・New spatial information and satellite imagery may enhance interests of stakeholders ・More frequent update of spatial information (e.g. logged-over area) may help raise interest of stakeholders for revising PFP
Five Year Plan	・Field Inspection	MLB ・Checking the License、Timber Permit、Minimum and Maximum Annual Allowable Cut（AAC）, facility construction WNB ・Checking the location of strip inventory line on site	WNB ・Lack of resources to detect the location of strip line ・Gap between actually harvested log volume and estimation from strip line survey ・No means to verify the reliability of strip line survey ・Re-opening of project boundary issues by landowners	WNB ・Submission of field book data and latitude-longitude coordinates of inventory strip may help identify and verify the location of strip line inventory survey and its estimation ・New spatial information and satellite imagery with precise boundary may remind and convince landowners on exact authentic boundaries
Annual Logging Plan (ALP)	・Endorsment ・Pre-approval	MLB ・Comparing ALP with 5 year plan and Timber Permit WNB ・Checking the consistency between ALP and 5 Year Plan ・Verifying the positional relationship between maps and actual sites	WNB ・Current contour map (40m pitch) is too coarse ・Current map scale (1/100,000) is too small ・Lack of resources (especially GPS) ・Insufficient skill (GPS and map reading)	WNB ・Providing large scale (for example 1/10,000) and fine contour line (10 m pitch) map in digital format ・Procurement of hand-held GPS with digital camera ・Training for GPS and map reading
Set-up Plan	・Approval ・Monitoring	MLB ・Checking the marked trees and set-up boundaries in the field (selection of tree and felling direction) ・Checking the skidding track location	MLB ・Insufficiency of information sharing (Logged-over area (ALP)) ・Lack of resource (finance, manpower, internet communication and spatial information) and skill (GPS and GIS) ・inconvenience to supervise the project (because of remote location and access) WNB ・Mismatching between map and actual site due to map obsoleteness ・Gap between field survey and actual DBH and volume size caused by un-skilled surveyors ・Finding unexpected gardening after ALP was established ・Awareness of landowners/chainsaw operators on forest conservation (value of lowering logging impact) is not high WSP ・Lack of resources (finance (vehicle, laptops and GPS) and manpower) and skill (GIS)	WNB ・Providing updated map to developer for establishing more accurately practicable plan ・Awareness raising by providing satellite imageries which enables LLGs/ landowners/ operators/ surveyors/ camp managers visually grasp the acutual site situation and the impacts of their practices (logging and gardening)

(2) Develop Appropriate Methods / Procedures Where Necessary for Solving the Issues

The long-term experts and the C/P identified which issues shown above should be addressed in the Project. Furthermore, the short-term expert team gave technical support so that the Outputs of Activity 1 would be reflected appropriately in the methods and procedures. In addition, target issues and procedures to be addressed were identified as shown in Table 2.2-3. Moreover, the issues listed below, which were additionally encountered by the C/P during the practical phase, were addressed in a timely manner, in coordination with the long-term experts (Activity 2.1.2 in the PDM).

- Development of additional functions in the AAC calculation function
- Technical support and cooperation in human resources to accumulate PNGFA administrative information in PNG-FRIMS Database
- Training and support for the C/P regarding the usage of drones to fill the gap between GPS and GIS in forest monitoring in the field

Table 2.2-3 Target Issues and Procedures

Approach	Target Issues	Procedures
Enhance AAC calculation in PNG-FRIMS	・Deficient annual allowable cut volume contradicting the picture.	・Design the new AAC calculation methodology and its manner of utilization in forest planning
		・Redefine the calculation method using updated PNG-FRIMS and Add in new functions suchas regrowth volume
		・Gather and update administrative information stored in PNG-FRIMS where necessary
		・Apply the concrete role of updated AAC in forest planning using updated figures
		・Develop guidelines how to utilize updated AAC calculation function in PNG-FRIMS for forest monitoring
Promote PFP formulation	・The lack of valid provincial forest plans	・Clarify the scope and directionality of PFP formulation in PNGFA and its supportive role of the Project
		・Explore the capability and input the importance of revising PFP guidelines, and participate the process of guidelines revision where necessary
		・Explore the capability of developimg PFPs in some provinces and participate the process of PFP formulation where necessary
		・Apply the concrete role of PNG-FRIMS in PFP formulation and orientation in PFP guidelines
		・Develop guidelines how to utilize PNG-FRIMS for PFP formulation and update the data/information supposed to be stored in PNG-FRIMS
Develop the capacity to monitor the forest recources in ground level	・The lack of logistics and human resouces to adequately inspect/monitor the forest resources and logging operations	・Select the items for improving forest inspection/monitoring in field and procure it to enforce the field activity in mainly pilot sites
		・Consolidate/develop the training materials and methodology through pilot sites' trial
		・Develop the capacity to monitor the forest resouces using above items to pilot sites' offices and other PNGFA officers where necessary
		・Consider the practical utilization of above items to implement PNGFA's regulations such as LCoP and PMCP through trainings and workshops
		・Develop manuals/guidelines to fully operate above items to improve forest inspection/monitoring

2.2.2 Experiment on a Series of the Operations of Forest Management Plans; Evaluation, Advice, Approval and Monitoring by Utilizing PNG-FRIMS

(1) Examine the Usage of PNG-FRIMS in the Evaluation, Advice, Approval and Monitoring of Forest Management Plans

The long-term experts and the C/P mainly discussed how to use PNG-FRIMS in evaluation, guidance, inspection (or creation) of a forest operation plan, and monitoring. The short-term experts provided technical support, technical review, consultation and training support for the C/P.

1) Examination of the Usage of GIS / GPS in Area / Provincial Offices

To examine the usage and dissemination of PNG-FRIMS in Area / Provincial offices, the JICA expert team and C/P officers selected data in PNG-FRIMS to share with those offices, and prepared a set of data and maps to be shared. The Project team explained the data and implemented GIS / GPS training for Area / Provincial officers, and then discussed the possibility of data usage.

As noted, data was shared with Area / Provincial offices. The maps prepared for the review are shown in Table 2.2-4.

Table 2.2-4 List of the Maps Shared

Region map
Magnified map
Topo Map
Forest Base Map
100m interval contour
50m interval contour
RapidEye (2010)
LANDSAT 4 (1990)
LANDSAT 7 (2000)
LANDSAT 7 (2005)
PALSAR 10m resolution (2010)
PALSAR 25m resolution (2007)
PALSAR 25m resolution (2008)
PALSAR 25m resolution (2009)
PALSAR 25m resolution (2010)
Digital Elevation Map created by SRTM
Hillshage (created by GeoSAR)
10m interval contour (created by GeoSAR)
Slope (created by GeoSAR)
Watershed (created by GeoSAR)
Normalized Difference Vegetation Index (NDVI)
Normalized Difference Water Index (NDWI)
Forest loss areas from 2001 to 2014, which was analyzed by Hansen et al. at the University of Maryland (shown in red)
Forest gain areas from 2001 to 2014, which was analyzed by Hansen et al. in at the University of Maryland (shown in blue)
Imagery accumulated highest value pixels of LANDSAT 7 in 2000 (less cloud)
Imagery accumulated highest value pixels of LANDSAT 7 in 2005 (less cloud)
Imagery accumulated highest value pixels of LANDSAT 7 in 2010 (less cloud)
Imagery accumulated highest value pixels of LANDSAT 7 in 2014 (less cloud)

Since only one or two ArcGIS Desktops are set up in each Area / Provincial offices — done so with procurement of Japan Grand Aid — ArcGIS Explorer, which is a free viewer, was installed and utilized. For GPS, the funds allocated as overseas activities cost in the Project was utilized.

Moreover, GIS / GPS were not being utilized at all at the beginning of the Project because the Area / Provincial officers with almost no GIS / GPS skills needed to improve their capacities. Therefore, a lot of time was spent during the Project implementing GIS / GPS training sessions for these officers. Details of the contents and achievements of the training sessions are shown in 'Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)'.

The capacities of PNGFA HQ officers engaged in this series of operations to train PNGFA field officers were also enhanced, as a result of the intensive support and successive field trainings in the initial stage. Officers at PNGFA HQ and the long-term experts compiled training materials, prepared with the support of the short-term experts, so that PNGFA can utilize GIS/GPS sustainably at their own initiative after the Project.

2）Examination of the Usage of Drones as a Forest Monitoring Tool

At PNGFA, drones were increasingly expected to be used in forest management planning and monitoring at the sites in response to the report on the results of the second training in Japan. Moreover, the long-term experts were leading studies of forest resource monitoring training using drones on site. In response to this, training on drone operation and the analysis of data acquired from it was conducted, and the application methods of drones in the forest management plans were examined (Table 2.2-5). The contents and achievements of this training are also shown in 'Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)'. One of the short-term experts played a leading role from a technical standpoint. Training materials created by the short-term experts were also compiled into procedure manuals by the officers at PNGFA HQ and the long-term experts. These have been continuously utilized at PNGFA. Moreover, a safety management manual for using drones at PNGFA was created by PNGFA HQ officers, with the support of the Project team.

Table 2.2-5 Training of Forest Monitoring Using Drones

Title	Participants	Contents	Duration	Achievement
Acquisition of data by automatic-flying-drone	Elizabeth Kaidong, Everlyn Paul, Patrick Laa, Jehu Antiko, Perry Malan, Rabbie Lalo	Setting of automatic flight using GSpro and its notes	14 -15 June 2018	Participants understood the automatic flight setting and points to note and data acquisition using Pix4D for analysis and surveys.

Analysis of data acquired with drones	Elizabeth Kaidong, Everlyn Paul, Patrick Laa, Jehu Antiko, Perry Malan, Rabbie Lalo	Analysis of data using Pix4D	14-15 June 2018	Participants understood the data processing of photographs acquired for surveys, and creation of ortho images and terrain data.
Discussion of the application of drones in forest monitoring	Everlyn Paul, Elizabeth Kaidong, Charles Pakure, Constin Bigol, Gewa Gamoga, Patrick Laa, Jehu Antiko, Beno Ningisere, John Orabi, Francis Vilamur, Perry Malan	Group work on how to use a drone understanding its function	19 June 2018	Participants compiled concrete items to verify the use of drones.

In the discussion of drone application in forest monitoring work, the following priority items at PNGFA were listed.

- Natural Forest Monitoring
- Plantations
- Forest Research (NFI)

Participants were divided into three groups for each theme, and they discussed which item could be realized with the application of drones. In the discussion, they also considered the classification of the existing monitoring methods and the utilization of GPS. At the end of the discussion, the representatives of the three groups presented their ideas and all participants exchanged views (Figure 2.2-1 - Figure 2.2-3).

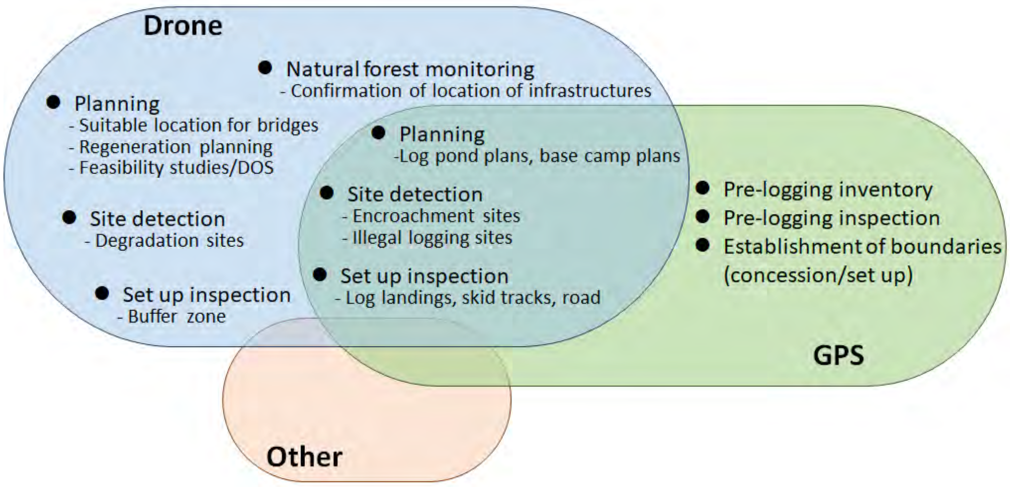


Figure 2.2-1 Future Direction of Forest Monitoring Using Drones (1) Natural Forest Monitoring

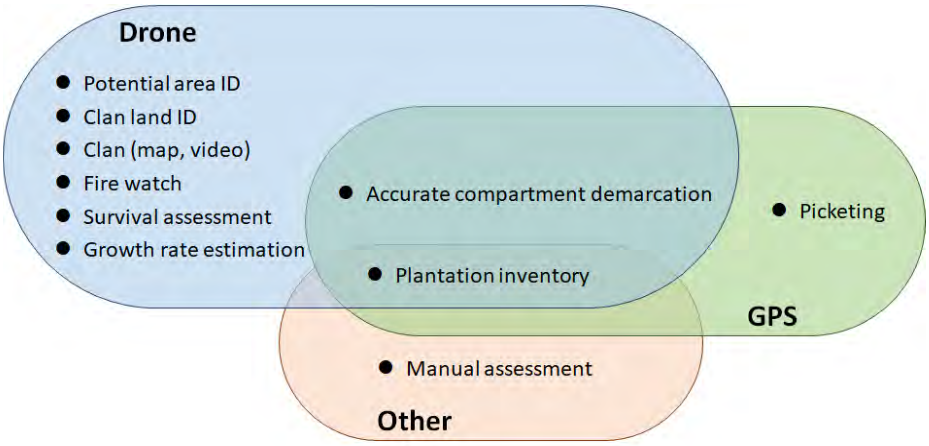


Figure 2.2-2 Future Direction of Forest Monitoring Using Drones (2) Plantations

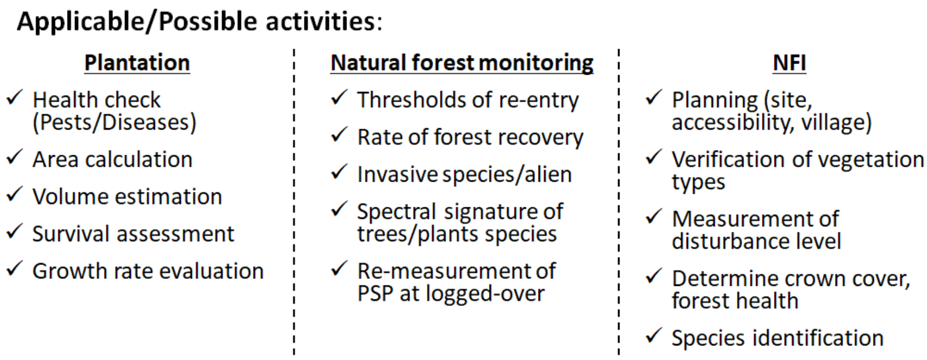


Figure 2.2-3 Future Direction of Forest Monitoring Using Drones (3) Forest Research (NFI)

In addition, a debriefing session on the future direction of drone application and issues of concern at PNGFA was held, and a proposal was created (Annex 29).

Based on this discussion, a practical training was held, through which a pilot trial of the forest management operations plans was conducted. Details are given in 2.2.2 (2) 2) .

(2) Conduct a Series of Operations of Forest Management Plans through Hands-On Training

1) Verification of the Possibility of Utilization of PNG-FRIMS

The long-term experts planned studies at the pilot sites to verify the feasibility of utilizing PNG-FRIMS in the forest management plans. Before starting the verification studies, the short-term and long-term experts prepared a hypothesis on the anticipated use of PNG-FRIMS and the effects expected. After that, the studies were organized by the long-term experts through discussions with the C/P, the training workshops described in 2.2.3, and the Project workshop held on 1st August 2017 (Activity 2.6 in the PDM). The compiled results are shown in 2.2.2 (3) .

The Project workshop held on 1st August 2017 aimed to improve the monitoring system of the forest management plans through steady operation of PNG-FRIMS based on several training sessions on GPS, GIS and LAN-MAP conducted at PNGFA HQ, Area / Provincial Offices and in pilot provinces. The summary of the workshop is shown in Annex 50.

2）Practical Training for Forest Monitoring Utilizing Drones

After considering the use of drones as a forest monitoring tool, described in 2.2.2（1）2）, a training was conducted to verify the possibility of practical application.

In the scenario of plantation management at the Kuriva Plantation Site (Table 2.2-6), photographing, overlap photographing and video shooting with drones were carried out with the aim of applying these data to the map management tasks such as area measurement and area classification on the GIS. The overlapped images were then analyzed with a dedicated software to create 3D point clouds, ortho images, Digital Surface Model (DSM) and contour maps (Figure 2.2-4).

Table 2.2-6 Content of Practical Training on Forest Monitoring Using Drones (1)

Title	Participants	Contents	Duration	Achievement
Data acquisition by drones and data analysis	Everlyn Paul, Elizabeth Kaidong, Patrick Laa, Jehu Antiko	- Data acquisition on actual site. - Analyze actual data.	20–22 June 2018	Participants understood the points to note at the time of acquiring the survey data at the plantation site aiming for its use in GIS.

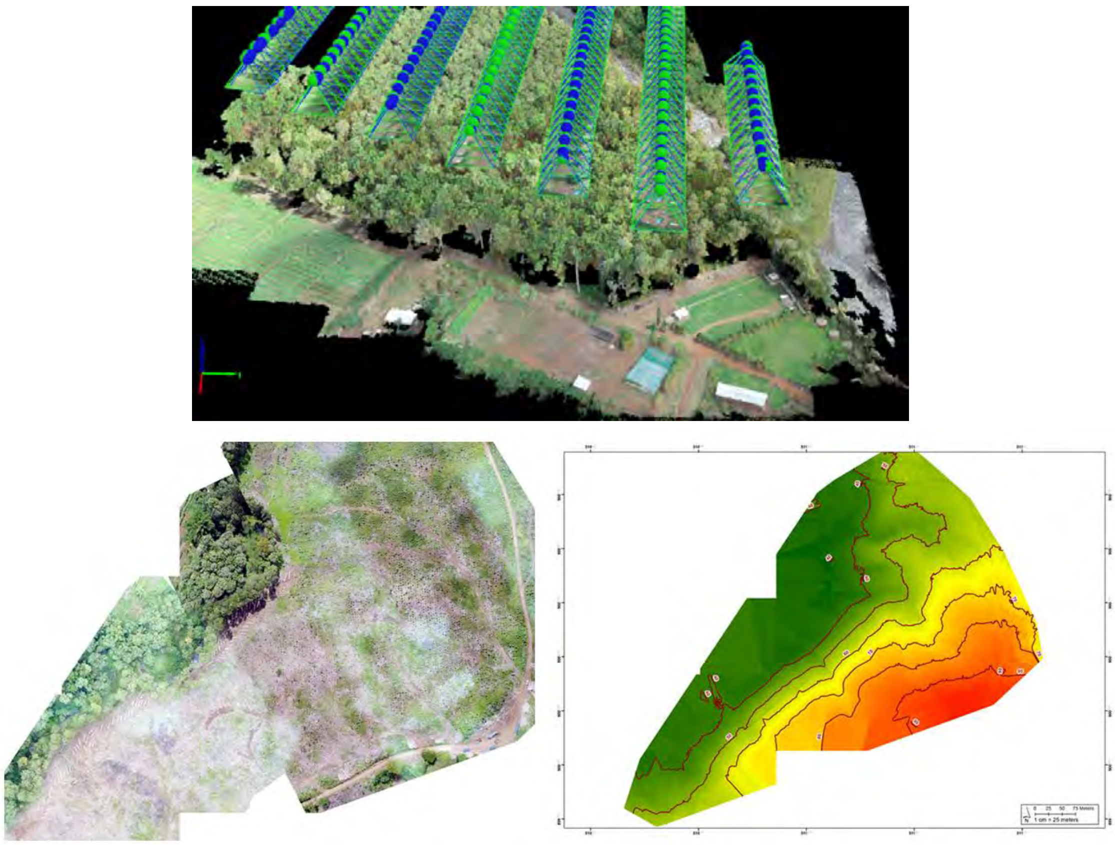


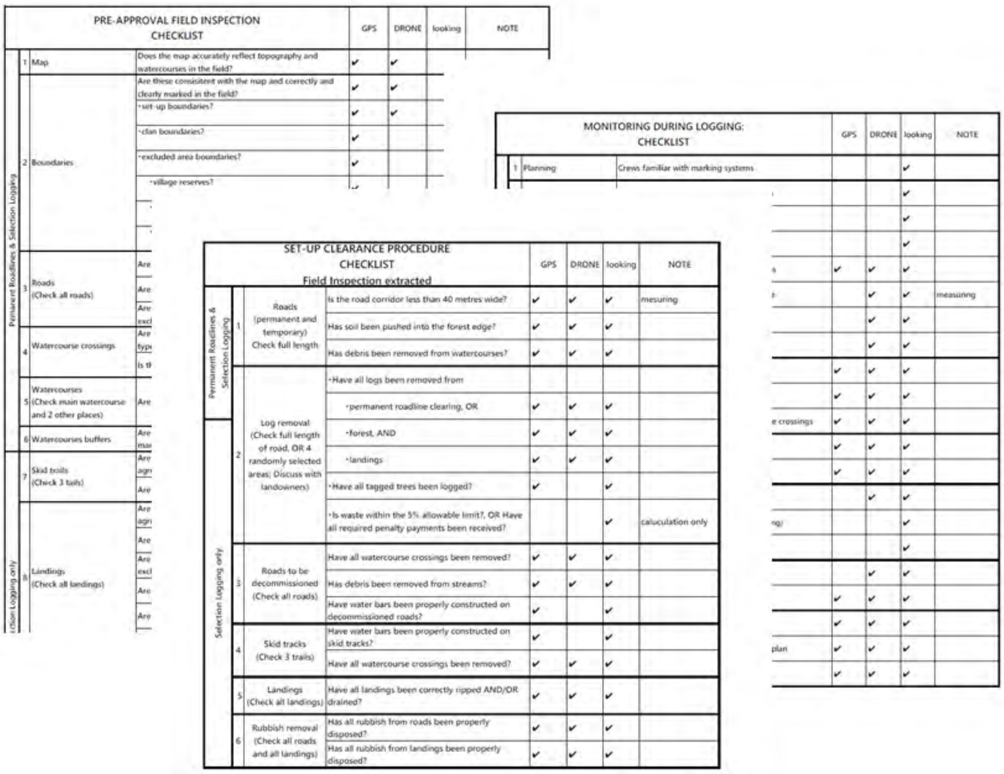
Figure 2.2-4 Achievement of Data Analysis

In response to the aforementioned training, PNGFA aims to utilize drones for forest monitoring (at logging sites) in natural forests. This is regarded as particularly important. Therefore, the Project team carried out drone training for staff of the Sandoaun Forest Office in West Sepik Province, in order to verify that employees can actually utilize drones at the logging site. In the training, the Project team used a drone to collect data at the logging site, and then analyzed this data and gained a grasp of the forest situation. Further, based on this data, the Project team examined the application of Key Standards (which are inspection items described in the Logging Code of Practice (LCoP)'s practical manual, Planning Monitoring and Control Procedures (PMCP)), which is the ordinary work of the forest office staff (see Table 2.2-6).

Table 2.2-7 Content of Practical Training on Forest Monitoring Using Drones (2)

Title	Participants	Contents	Duration	Achievements
Learning basic drone flying control	Jimu Silu (PFO Sandaun), Kalan (Supervisor/ Amanab 1-4 FMA), Jackelyn (Acting Supervisor/ Amanab 5&6), Brenda (Monitoring Officer/ Amanab 5&6), Steven Saki (Supervisor/ Bewani FCA), Conrad (Monitoring Officer/ Bewani FCA), Erick tin won (Supervisor/ Vanimo TRP), Paul (Silviculture Officer) HQ: Patrick La'a, Jehu Antiko	- Basic manual handling	23-24, 27 October 2018	Participants understood the basic operation of a drone.
Capturing aerial photo using drone in order to make up one whole set-up		- Acquire photographs etc. by automatic flight using manual and GSpro - Analysis of drone data using Pix4D	24-25, October, 2018	Participants understood that creation of images and terrain data from drone data is possible.
Discussing drone use for field monitoring		- Understand the functions of drones and discuss how to use on a daily basis	26, October, 2018	Participants compiled concrete checklist items to verify the use of drones.

The discussion on the practical use of drones for forest monitoring work was carried out based on the Key Standards using the data acquired from on-site monitoring and an ortho image created from the acquired data. PNGFA confirmed the effectiveness of using drones to monitor the forest and the effectiveness of using other methods by checking each Key Standards checklist item. By checking these, PNGFA identified the appropriate methods for forest monitoring in PNG (Figure 2.2-5). Through the on-site logging inspections, it was confirmed that GPS and drones can be used for tasks related to the logging of natural forests and for pre-approval, monitoring during logging, and set-up clearance related to the implementation of Key Standards. In particular, using drones to take photographs of the set-up becomes an effective monitoring tool; it is also presumed that drones have a deterrent effect on logging companies. On the other hand, the manual operation of drones in forest areas requires specialized skills; therefore, automatic flight operations were requested as the solution for the dissemination of drone use in PNG (see Annex 51). Checklist items for confirming the effectiveness of GPS and drone use are shown in Figure 2.2-5; they were to be compiled afterwards by the long-term experts in the guideline for LCoP.



PRE-APPROVAL FIELD INSPECTION CHECKLIST

			GPS	DRONE	looking	NOTE
1	Map	Does the map accurately reflect topography and watercourses in the field?	✔	✔		
2	Boundaries	Are these consistent with the map and correctly and clearly marked in the field?	✔	✔		
		•set-up boundaries?	✔	✔		
		•clan boundaries?	✔			
		•excluded area boundaries?	✔			
		•village reserves?				

MONITORING DURING LOGGING: CHECKLIST

			GPS	DRONE	looking	NOTE
1	Planning	Crews familiar with marking systems			✔	

SET-UP CLEARANCE PROCEDURE CHECKLIST
Field Inspection extracted

				GPS	DRONE	looking	NOTE
Permanent Roadlines & Selection Logging	1	Roads (permanent and temporary) Check full length	Is the road corridor less than 40 metres wide?	✔	✔	✔	mesuring
			Has soil been pushed into the forest edge?	✔	✔	✔	
			Has debris been removed from watercourses?	✔	✔	✔	
	2	Log removal (Check full length of road, OR 4 randomly selected areas; Discuss with landowners)	•Have all logs been removed from				
			•permanent roadline clearing, OR	✔	✔	✔	
Selection Logging only			•forest, AND	✔	✔	✔	
			•landings	✔	✔	✔	
			•Have all tagged trees been logged?	✔		✔	
			•Is waste within the 5% allowable limit?, OR Have all required penalty payments been received?			✔	caluculation only
	3	Roads to be decommissioned (Check all roads)	Have all watercourse crossings been removed?	✔	✔	✔	
			Has debris been removed from streams?	✔	✔	✔	
			Have water bars been properly constructed on decommissioned roads?	✔		✔	
	4	Skid tracks (Check 3 trails)	Have water bars been properly constructed on skid tracks?	✔		✔	
			Have all watercourse crossings been removed?	✔	✔	✔	
	5	Landings (Check all landings)	Have all landings been correctly ripped AND/OR drained?	✔	✔	✔	
	6	Rubbish removal (Check all roads and all landings)	Has all rubbish from roads been properly disposed?	✔	✔	✔	
			Has all rubbish from landings been properly disposed?	✔	✔	✔	

Figure 2.2-5 Use Checklist Items to Confirm the Effectiveness of GPS and Drone Use for Implementation of Key Standards

In response to previous study and workshops on the drone use, PNGFA aims to expand the use of drones at the sites. Therefore, PNGA procured additional drones in the Project having as pilot-sites West Sepik Province and West New Britain Province. The practical training detailed in Table 2.2-8 was held for staff in the target area. After this training, a final workshop was held and the drones were transferred to PNGFA so they can start using them on the logging sites.

Table 2.2-8 Content of Practical Training for Forest Monitoring Using Drones (3)

Title	Participants	Contents	Duration	Achievements
Overview and drone safety management	FPPD: Samuel Gibson, Rabbie Lalo, Elizabeth Kaidong FSD: John Orabi FSD WSP: Jim Silu, Steven Saki, Jackeline Paul FSD WMB: Jerry Kowin, Peter Lat, Clive Sewelu FSD Southern: Mark Betuel, Ori Renagi FSD Goroka: Florence	- Understanding features of drones and learning how to operate one safely	18 to 20 February 2019	Participants understood the overview of drones and points to be considered for safe operation.
Basic manipulation of drones		- Basic operation practice	18 to 21 February 2019	Participants understood the basic operation of drones.
Automatic flight and processing ortho images		- Acquisition of photograph data by automatic flight using GSpro - Analysis of drone	20 to 22 Februar, 2019	Participants understood automatic flight for the purpose of creating ortho images and actually create an ortho image.

	Plinduo FDD Bulolo: Ismael Miti FDD Kuriva: Aino Manidu PAD: Leslie Vaira	data using Pix4D		
Practical use of drones		Experience in using at actual logging sites in Kupiano	24 to 27, Febrary, 2019	Participants understood the preparation and points to keep in mind when using a drone in the field.

However, at an actual logging site, it is necessary to work in an environment different from that of the training, and technical difficulties are to be expected. Thus, a follow-up training was held in West New Britain, with case studies being summarized at the same time (Annex 30).

Table 2.2-9 Follow-up on Forest Monitoring Using Drone

Title	Participants	Contents	Duration	Achievements
Practical use of drone	FSD WSP: Kallan Ramute, Steven Saki HQ: Margaret Tong, Jehu Antiko	Automatic flight data acquisition and orthographic image creation in the Amanab area of West Sepik Province	20 to 24 May 2019	Participants understood how to use equipment in bad conditions like those at a logging campsite different from the training environment.

Figure 2.2-6 Pre-Logging Image (Amanab MU83) for Understanding Conditions

Figure 2.2-7 Active-Logging Image (Amanab UT110) for Understanding Conditions

Figure 2.2-8 Post-Logging Image (7 months after logging, Amanab UT98) for Understanding Vegetation Restoration

Figure 2.2-9 Post-Logging Image (5 years after logging, Amanab WA54) for Understanding Vegetation Restoration

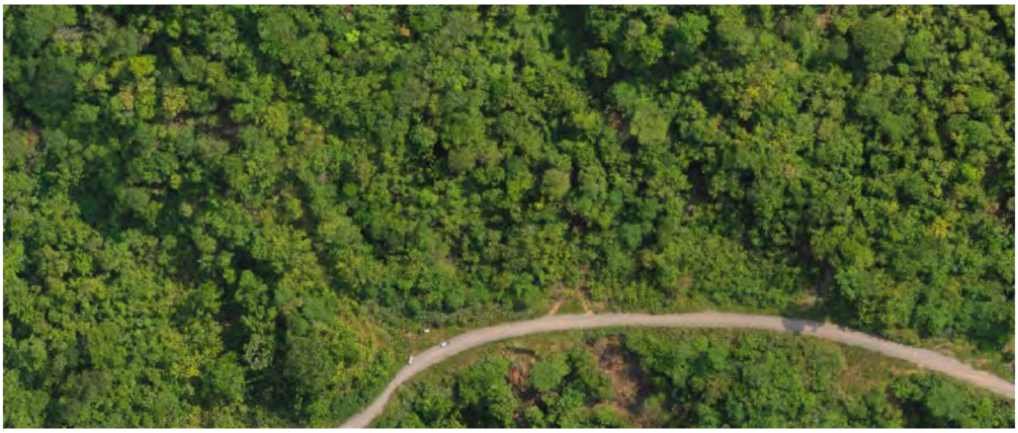


Figure 2.2-10 Post-Logging Image (10 years after logging, Amanab FF03) for Understanding Vegetation Restoration

PNGFA drone applications were compiled as 'Fact Sheet No. 10 Drone Applications in Sustainable Forestry Management and Monitoring in PNGFA' (Annex 6).

(3) Determine How to Utilize PNG-FRIMS in a Series of Operations Related to Forest Management Plans

Based on the results of the discussions and the trials detailed in 2.2.2（2）, the method for utilizing PNG-FRIMS in a series of operations related to the forest management plans was arranged. Details are shown in Table 2.2-10 ~ Table 2.2-13.

Table 2.2-10 Possible Contributions to Forest Planning Utilizing PNG-FRIMS

No	Section in charge	Target		Use of PNG-FRIMS		Points of JICA project activities			Way of verification	
		Purpose	Relevant regulation (Type of Plan)	Data (attribution)	Tool (Function)	Study points	Expected effect	Outcome	Feasibility study at pilot site	desk study/ simulation
1	PAD	To evaluate a proposed five year plan	PMCP Attachment 3-check item 2, 4, 5, 6	Set-up (Logged and Planned), Coup Permanent road Log Pond Base Camp Satellite Imagery Logging Plan Map Census (Roads and Rivers)	LAN Map (Area Calculation, Distance Measure) GIS/Free GIS	a) To check applicability of each spatial information to the check items b) To clarify necessary map scale of each purpose and position accuracy of each spatial information. c) To develop new reporting procedures based on PNG-FRIMS	a) To promote accurate evaluation b) To reduce the time and costs for evaluation	GPS/UAV/GIS manuals Guidelines for forest planning	✔	✔
2	PAD, Prov./Project Office, Area Office	To evaluate an annual logging plan	PMCP Attachment 8-check item 1, 2, 5	Set-up (Logged and Planned), Coup Infrastructure obligation(Constraints) Permanent road Satellite Imagery Contour Project Area Logging Plan Map	LAN Map (Area Calculation) GIS/Free GIS GPS UAV Picture	a) To check applicability of each spatial information to the check items b) To clarify necessary map scale of each purpose and position accuracy of each spatial information. c) To develop new reporting procedures based on PNG-FRIMS	a) To promote accurate evaluation b) To reduce the time and costs for evaluation	GPS/UAV/GIS manuals Guidelines for forest planning	✔	✔
3	PAD, Prov./Project Office, Area Office	To approve construction of a new log pond	PMCP Attachment 18-check item 2 Key standard 2	Log Pond Buffer zone Logging Plan Map	Lan Map GPS (Position Acquiring, Distance Measure, Area Calculation) GIS/Free GIS UAV	a) To check applicability of each spatial information to the check items b) To clarify necessary map scale of each purpose and position accuracy of each spatial information. c) To develop new reporting procedures based on PNG-FRIMS	a) To promote accurate evaluation b) To reduce the time and costs for evaluation	GPS/UAV/GIS manuals Guidelines for forest planning	✔	✔
4	Prov./Project Office	To evaluate a set-up plan (monitoring during logging)	PMCP Attachment 12 Part A (Permanent Roadlines & Selection Logging)	Road Excluded area (village, cultural, garden) Stream, Watercourse Bridge, Culvert Landing Topography Satellite Imagery Contour	GPS (Distance measure) Tape Picture GIS/Free GIS (Area calculation) UAV	a) To check applicability of each spatial information to the check items b) To clarify necessary map scale of each purpose and position accuracy of each spatial information. c) To develop new reporting procedures based on PNG-FRIMS	a) To promote accurate evaluation b) To reduce the time and costs for evaluation and monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
5	Prov./Project Office	To check the area of skid tracks (monitoring during logging)	LCOP Page 40 E Felling and skidding E.5 Skid Tracks (i)	Set-up (Planned), Satellite Imagery	GPS GIS/Free GIS UAV	To check the usefulness of tools	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
6	Prov./Project Office	To check the consideration of protected areas such as "Buffer zones" in set-up plans	LCOP Page 8 A Planning A2 Set-up plans (ⅳ)	Set-up (Planned), Satellite Imagery	GPS GIS/Free GIS UAV (Distance Measure)	To check the usefulness of tools	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
7	Prov./Project Office	To check roads with protected areas such as "Buffer zones"	LCOP Page 21 C Road Construction and Maintenace C2 Road Corridor (Major Logging Road) (ⅵ)	Set-up (Planned), Satellite Imagery	GPS GIS/Free GIS UAV (Distance Measure)	To check the usefulness of tools	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
8	PAD	To verify location and a certain area size	PMCP Section ** (Log Pond)	Log Pond Contour Satellite Image Topo map	LAN Map (Area Calculation) GIS/Free GIS UAV	To check applicability of each spatial information to the check items	To promote proper evaluation	GPS/UAV/GIS manuals Guidelines for forest planning		✔

9	Prov./Project Office	To verify water crossing location in the field	PMCP Section * (Set-up)	Set-up (Planned), Satellite Imagery	GPS (Position Acquiring) UAV	To check the usefulness of tools	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
10	Prov./Project Office	To verify area of 'Buffer Zones' or 'Special Management Buffer Zones'	LCOP	Set-up (Planned), Satellite Imagery	GPS (Area Calculation) UAV	To check the usefulness of tools	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
11	Prov./Project Office	Reforestation requirement	TP (Project Agreement)	Set-up (Planned), Satellite Imagery	GPS (Area Calculation, Position Acquiring), GIS/Free GIS (Area Calculation) UAV	To check applicability of each spatial information to the check items	To promote proper monitoring	GPS/UAV/GIS manuals	✔	
12	FDD/FSD	Reforestation (Painim Graun)	800,000ha Plantation	Set-up (Planned), Satellite Imagery	GPS (Taking Picture), GIS/Free GIS (Area Calculation) UAV	To check applicability of each spatial information to the check items	To promote a task in charge and a national policy	GPS/UAV/GIS manuals	✔	
13	Prov./Project Office	Waste Management/Disposal Plan/Damage Assessment	Set-up/LCOP	Set-up (Planned), Satellite Imagery	GPS (Taking Picture) UAV	To check applicability of each spatial information to the check items	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
14	Prov./Project Office	To support reporting for PDB (Project Development Benefit) and infrastructure obligations	TP	5YP, Satellite Imagery	GPS (Taking Picture) UAV	To check the usefulness of tools	To promote proper evaluation and monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
15	Prov./Project Office	To check scaling	(Set-up)	Set-up (Planned), Satellite Imagery	GPS (Taking Picture) GIS/Free GIS UAV	To check the usefulness of tools	To promote proper monitoring	GPS/UAV/GIS manuals Guidelines for forest planning	✔	
16	Forest Plans Officer	Planning for National/Provincial Forest Plan		Forest base map Concession area Logged Over Area Constraints		To verify the forest re-growth model function of FRIMS	To promote proper planning	GPS/UAV/GIS manuals Guidelines for forest planning		✔
17	Acquisition Branch	Clan Mapping to map land according to customary land ownership by clans	THE 34 - STEPS IN THE FOREST RESOURCE ALLOCATION PROCESS Section *	Satellite Imageries Catchment Contour	LAN Map, GIS/Free GIS UAV	To check the usefulness of tools	To facilitate consultation with landowners	GPS/UAV/GIS manuals	✔	✔
18	Plantation Branch	To map boundaries of existing forest plantation projects		Boundary survey data by GPS	LAN Map, GIS/Free GIS, GPS (Position Acquiring) UAV	To check the usefulness of tools	To promote proper forest management	GPS/UAV/GIS manuals	✔	✔
19	Plantation Branch	Screening of grasslands for new plantation area		Forest base map Contour Satelite imagery Constraints ILG Information	LAN Map, GIS	To check the usefulness of tools	To promote searching for new plantation area	GPS/UAV/GIS manuals		✔
20	Plantation Branch	ID (identification) boundary survey on State-land forest plantation (e.g. Kuriva 8,500ha)		Forest base map Contour Satelite imagery Constraints	GIS/Free GIS GPS UAV	To check the usefulness of tools	To make the task easier	GPS/UAV/GIS manuals	✔	
21	Plantation Branch	Sketch plotting of suitable land for tree planting		Forest base map Contour Satelite imagery Constraints ILG Information	LAN Map (Sketch) GIS/Free GIS	To check applicability of each spatial information to the check items	To make the task easier	GPS/UAV/GIS manuals		✔

22	Natural Forest Management Branch	To get an indication for necessity of rehabilitation from harvested volume per hectare by set-ups		Logged over area (Harvested volume)	LAN Map	To check the usefulness of tools	To make the task easier	GPS/UAV/GIS manuals		✔
23	Natural Forest Management Branch	Planning and implementing forest rehabilitation		Set-ups	LAN Map (Sketch)	To check applicability of each spatial information to the check items	To make the task easier	GPS/UAV/GIS manuals		✔
24	Project Branch	To assess and approve 5-year and annual loggign plans submitted by logging companies	PMCP section *	Forest base map Concession area Constraints layer Contour Satelite image etc.	LAN Map	Compare the current method with the proposed method using LAN Map	1. Avoid an encroachment logging and overlapping of project boundaries. 2. Promote accuracy and reduce time for assessment including field inspection	GPS/UAV/GIS manuals Guidelines for forest planning	✔	✔
25	I&M	-	-	Forest base map Concession area Constraints layer Contour Satelite image etc.	(Potential) LAN Map	Create a logging map with electric data on behalf of developers who do not have GIS skills. Design a logging plan together with developers (Help developers design an appropriate logging plan)	PNGFA find a new income source. PNGFA find a new income source and promote the reduced impact logging.	New business model (data entry service).		
26	Forest Plans Officer Acquisition Branch	To estimate forest volume		Forest base map Concession area Logged Over Area Constraints	FIMS	Compare an actual harvest volume with estimated volume of FRIMS	Improved the attribution of forest base map	Forest base map ver.2	✔	✔
27	Forest Plans Officer Acquisition Branch	To estimate the stock of regenerating forest. To report estimated forest volume to PFMC.		Forest base map Concession area Logged Over Area Constraints	FIMS	Verify the forest re-growth model function of FRIMS	Adjusted FRIMS function	FIMS function improved	✔	✔
28		To find illegal loggings		Satelite Imageries(ALOS etc.) Logged over area etc.	LAN Map		Find an illegal logging and provide direction to logging company timely.	Create continuous forest monitoring method	✔	✔
29	I&M	To sell forest maps		All forest information	Arc Map	Thematic forest information map based on FRIMS	New business model (map distribution service).	PNGFA find a new income source.	✔	✔

Table 2.2-11 Possibilities for Utilizing PNG-FRIMS for Logging Operation Monitoring System According to PMCP (1995) and LCoP (2015)

No.	Regulation			Rate of effectiveness					Check Item	Tool / System	Data / Function	Section in charge
	Type	Type of Plan	Reference Source	Gr 1	Gr 2	Gr 3	Gr 4	Avg.				
1	PMCP	5YP	Attachement 3 Tick sheet for Five Year Plan Evaluation - 2	A	A	A	A	A	Area to be logged is limited to five thirty-fifth (5/35) of the total loggable area	LAN Map LAN Map	Logging Plan Map Area Calculation	PAD PAD
2	PMCP	5YP	Attachement 3 Tick sheet for Five Year Plan Evaluation - 4	A	A	A	A	A	The permanent roads to be constructed are in a logical and practical location	LAN Map	Logging Plan Map	PAD
3										LAN Map	Distance Measure	PAD
4	PMCP	5YP	Attachement 3 Tick sheet for Five Year Plan Evaluation - 5	A	A	A	A	A	Check that new log ponds to be constructed are in a logical and practical location	LAN Map	Satellite Imagery	PAD
5										LAN Map	Logging Plan Map	PAD
6										LAN Map	Census (Roads and Rivers)	PAD
7	PMCP	5YP	Attachement 3 Tick sheet for Five Year Plan Evaluation - 6	A	A	A	A	A	Check that new logging base camps to be constructed are in a logical and practical location	LAN Map	Satellite Imagery	PAD
8										LAN Map	Logging Plan Map	PAD
9										LAN Map	Census (Roads and Rivers)	PAD
10	PMCP	ALP	Attachement 8 Tick sheet for Annual Logging Plan Evaluation - 1	A	A	A	A	A	Check consistency of the ALP with the approved Five Year Plan on Area to be logged	LAN Map	Logging Plan Map	PAD
11	PMCP	ALP	Attachement 8 Tick sheet for Annual Logging Plan Evaluation - 1	A	A	A	A	A	Check consistency of the ALP with the approved Five Year Plan on infrastructure obligations	LAN Map	Logging Plan Map	PAD
12										GPS	Taking Picture	Prov./Project Office
13	PMCP	ALP	Attachement 8 Tick sheet for Annual Logging Plan Evaluation - 2	A	A	A	A	A	The maximum area of 150 hectares per set-up has not been exceeded	LAN Map	Area Calculation	PAD

14	PMCP	ALP	Attachement 8 Tick sheet for Annual Logging Plan Evaluation - 5	B	A	A	A	A	The permanent roads to be constructed are in a logical and practical location	GPS	Position Acquiring	Prov./Project Office
15				A						GIS/Free GIS	Contour	Prov./Project Office
16				A						GIS	Contour	Area Office
17				A						GIS	Constraints	Area Office
18				A						GIS	Project Area	Area Office
19										LAN Map	Logging Plan Map	PAD
20	PMCP	Log Pond	Attachement 18 Tick sheet for Log Pond Proposal Evaluation - 2	A	A	A	A	A	Check that the site of plan is in accordance with buffer zone requirements (Key standard No.2)	LAN Map	Logging Plan Map	PAD
21										GPS	Position Acquiring	Prov./Project Office/PAD
22										GPS	Distance Measure	Prov./Project Office/PAD
23	PMCP	Set-up	Attachment 12 Part A Mnitoring During Logging: Checklist & Master Summary 2. Road Constrution	A	A	A	A	A	Roads constructed to approved standards	GPS	Position Acquiring	Prov./Project Office
24										GPS	Distance Measure	Prov./Project Office
25										GPS	Taking Picture	Prov./Project Office
26										GIS/Free GIS	Contour	Prov./Project Office
27										GIS/Free GIS	Constraints	Prov./Project Office
28	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary	A	A	A	B	A	Roads properly compacted (classification of roads should be also reported)	GPS	Distance Measure	Prov./Project Office
29										GPS	Taking Picture	Prov./Project Office
30	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 2. Road Constrution	A	A	A	A	A	Roads follow approved surveyed roadlines	GPS	Position Acquiring	Prov./Project Office
31	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 2. Road Constrution	A	A	A	A	A	Road corridor is less than 40 meters wide	GPS	Distance Measure	Prov./Project Office
32	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 2. Road Constrution	A	A	A	B	A	Streams are free of soil	GPS	Taking Picture	Prov./Project Office
33	PMCP	Set-up	Attachment 12 Part A Mnitoring During Logging: Checklist & Master Summary 2. Road Constrution	A	A	A	B	A	Roads are properly drained	GPS	Taking Picture	Prov./Project Office
34	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 3. Bridges and Culverts on Roads	A	A	A	A	A	Bridges are properly constructed	GPS	Taking Picture	Prov./Project Office
35	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 3. Bridges and Culverts on Roads	A	A	A	A	A	Culverts are properly constructed	GPS	Taking Picture	Prov./Project Office
36	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 3. Bridges and Culverts on Roads	A	A	A	A	A	Roads are properly drained at watercourse crossings	GPS	Taking Picture	Prov./Project Office
37	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 5. Felling	A	A	A	A	A	Stumps height less than 30cm (above fluting)	GPS	Taking Picture	Prov./Project Office
38										GPS	Position Acquiring	Prov./Project Office
39										Tape		Prov./Project Office
40	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary	A	A	A	A	A	Watercourse crossings located as per plan	GPS	Taking Picture	Prov./Project Office
41										GPS	Position Acquiring	Prov./Project Office
42	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 7. Temporary Watercourse Crossings on Skid Trails	A	A	A	A	A	Watercourse crossings constructed as per plan	GPS	Taking Picture	Prov./Project Office
43	PMCP	Set-up	Attachment 12 Part A Monitoring During Logging: Checklist & Master Summary 8. Landings	A	A	A	A	A	Landings located as marked out in the field	GPS	Taking Picture	Prov./Project Office
44										GPS	Position Acquiring	Prov./Project Office
45										GPS	Area Calculation	Prov./Project Office
46	LCOP	LCOP	Page 40 E. Felling and Skidding E.5 Skid Tracks (i)	A	A	A	A	A	The area of skid tracks should not exceed 10% of the area of the Set-up.	GPS	Distance Measure	Prov./Project Office
47	LCOP	LCOP	Page 8 A. Planning A.2 Set-up plans (iv)	A	A	A	A	A	Set-up Plans will take account of the areas designated as 'Buffer Zones' or 'Special Management Buffer Zones' and any other special management actions agreed for natural and cultural values. Trees retained for biodiversity reasons should be kept in patches rather than as individual trees.	GPS	Position Acquiring	Prov./Project Office
48										GPS	Distance Measure	Prov./Project Office
49										GPS	Area Calculation	Prov./Project Office
50										GIS/Free GIS	Distance Measure	Prov./Project Office
51	LCOP	LCOP	Page 21 C. Road Construction and Maintenance C.2 Road Corridor (Major Logging Road) (vi)	A	A	A	A	A	Roads should avoid Buffer Zones and Special Management Buffer Zones designated for biodiversity and other natural and cultural reasons. The width of roads will be minimised where these buffer zones cannot be avoided.	GPS	Position Acquiring	Prov./Project Office
52										GPS	Distance Measure	Prov./Project Office
53										GIS/Free GIS	Distance Measure	Prov./Project Office

The rate (A, B or C) is filled in according to the following standard.
A: Very useful, B: Probably useful, C: Irrelevant

Table 2.2-12 Further Possible Effective Utilization of PNG-FRIMS for Logging Operation Monitoring System

No.	Type of Plan / Regulation	Purpose	Tool / System	Data / Function	Section in charge
1	Log Pond	To verify location and a certain area size	LAN Map	Area Calculation	PAD
2			GPS	Area Calculation	PAD
3	Set-up	To verify water crossing location in the field	GPS	Position Acquiring	Prov./Project Office
4	LCOP	To verify area of 'Buffer Zones' or 'Special Management Buffer Zones'	GPS	Area Calculation	Prov./Project Office
5	TP / Project Agreement	Reforestation requirement	GPS	Area Calculation	Prov./Project Office
6			GPS	Position Acquiring	Prov./Project Office
7			GIS/Free GIS	Area Calculation	Prov./Project Office
8	800,000 Plantation	Reforestation (Painim Graun)	GPS	Taking Picture	FDD/FSD
9			GIS/Free GIS	Area Calculation	FDD/FSD
10	Set-up/LCOP	Waste Management/Disposal Plan/Damage Assessment	GPS	Taking Picture	Prov./Project Office
11	TP	To support reporting for PDB (Project Development Benefit) and infrastructure obligations	GPS	Taking Picture	Prov./Project Office
12	Set-up	To check scaling	GPS	Taking Picture	Prov./Project Office

Table 2.2-13 Possible Utilizations of PNG-FRIMS for Tasks at PNGFA other than Logging Operation Monitoring System

No.	Points/Purposes	Tool / System	Data / Function	Section in charge
1	Planning for National/Provincial Forest Plan			Forest Plans Officer
2	To map clan Mapping of land according to customary land ownership by clans	GIS/Free GIS	Satellite Imageries Catchment Contour	Acquisition Branch
3	To map boundaries of existing forest plantation projects	LAN Map GIS/Free GIS GPS	Digitization Boundary survey by GPS	Plantation Branch
4	Screening of grasslands for new plantation area	LAN Map, GIS	Extraction Contour Satellite Imagery Constraints ILG Information	Plantation Branch
5	ID (identification) boundary survey on State-land forest plantation (e.g. Kuriva 8,500ha)	GIS/Free GIS GPS	Boundary survey by GPS Forest base map Contour Satellite Imagery Constraints	Plantation Branch
6	Sketch plotting of suitable land for tree planting	LAN Map GIS/Free GIS	Forest base map Contour Satellite Imagery Constraints ILG Information Area calculation	Plantation Branch
7	To get an indication for necessity of rehabilitation from harvested volume per hectare by set-ups	LAN Map	Harvested volume	Natural Forest Management Branch
8	Planning and implementing forest rehabilitation by utilization set-ups information on current LAN Map	LAN Map	Set-up information	Natural Forest Management Branch

2.2.3 Hold Training Workshops to Disseminate the Project Outputs in Pilot Areas

Training workshops were held in July 2018 and February 2019 to disseminate Project outputs in the pilot areas. Details about the contents of these workshops, as well as about the training sessions on forest monitoring using drones, are presented in 2.2.2（1）2） and 2.2.2（2）2）.

2.2.4 Examine the Content of Inputs to the Process of Developing the Next Forest Plans

The NFP sets forth a policy of sustainable forest management in PNG. However, it has not officially been renewed since the first NFP was laid down in 1995. Using PNG-FRIMS to support the development of the next NFP was defined as a Project activity. As a result of the review of the current status of the forest planning system, described in 2.2.1 (Activity 2.1 in the PDM), the Project decided to address the PFP and the AAC — main contributing factors that hinder the renewal of the NFP. Specifically, the following was to be implemented.

(i) The development of AAC calculation functions in PNG-FRIMS based on the current status of PNGFA forest resource management, and consideration of utilization methods in the forest planning system, including NFP

(ii) A review of PNG-FRIMS utilization methods in the PFP guideline, which sets forth a specific policy for developing PFP, and in each PFP; support, where necessary, in the implementation stage

The short-term expert team gave comprehensive technical support to the long-term experts and the C/P regarding the utilization of PNG-FRIMS (Activity 2.4 in the PDM).

(1) Upgrading and Expanding ACC Calculation Function Based on Current Forest Resource Management in PNG

To upgrade and expand the AAC calculation functions based on the current status of forest resource management, the Project team identified the forest resource management cycle in PNG. In the existing AAC calculation, when a logged over area is created by a logging operation, it takes away from the 'net production area' in a single, uniform way. Based on this, the AAC will decrease as the logging operation progresses. However, apart from administrative issues, 'growing stock (regrowth volume)' accumulates with age in such logged over areas; this stock contains what will become fellable timber in the future. Moreover, a 'potential production area' — where an operation is planned, but has not yet started — and 'expired forest' — where an operation was implemented, but the next utilization policy has not yet been defined, or an operation has never been implemented and utilization policy has not been defined — also can contain fellable timber in the future. The development of forest plans that check the dynamic state of AAC, including forest resources, contributes both sustainable economic growth and forest management.

Using this design concept, the short-term expert team, utilizing the Forest Base Map, redefined the calculation method, and developed the functions listed below to contribute to an AAC calculation based on the current forest plan.

- A function for calculating regrowth volume which is dependent on the incidence status of logged over area
- A function for calculating the timber volume of potential production forest and expired forest

The following two conditions of the current regrowth volume calculation function conform to PNGFA policy: (i) commercial timber of harvested forests recovers in 35 years, and (ii) regrowth volume is introduced into the AAC beginning with the year following logging. However, these conditions can be changed in accordance with new findings from future research and administrative decisions. Based on requests made by the long-term experts and the C/P, condition (ii) was enhanced so that the number of years used to calculate regrowth volume can be changed freely.

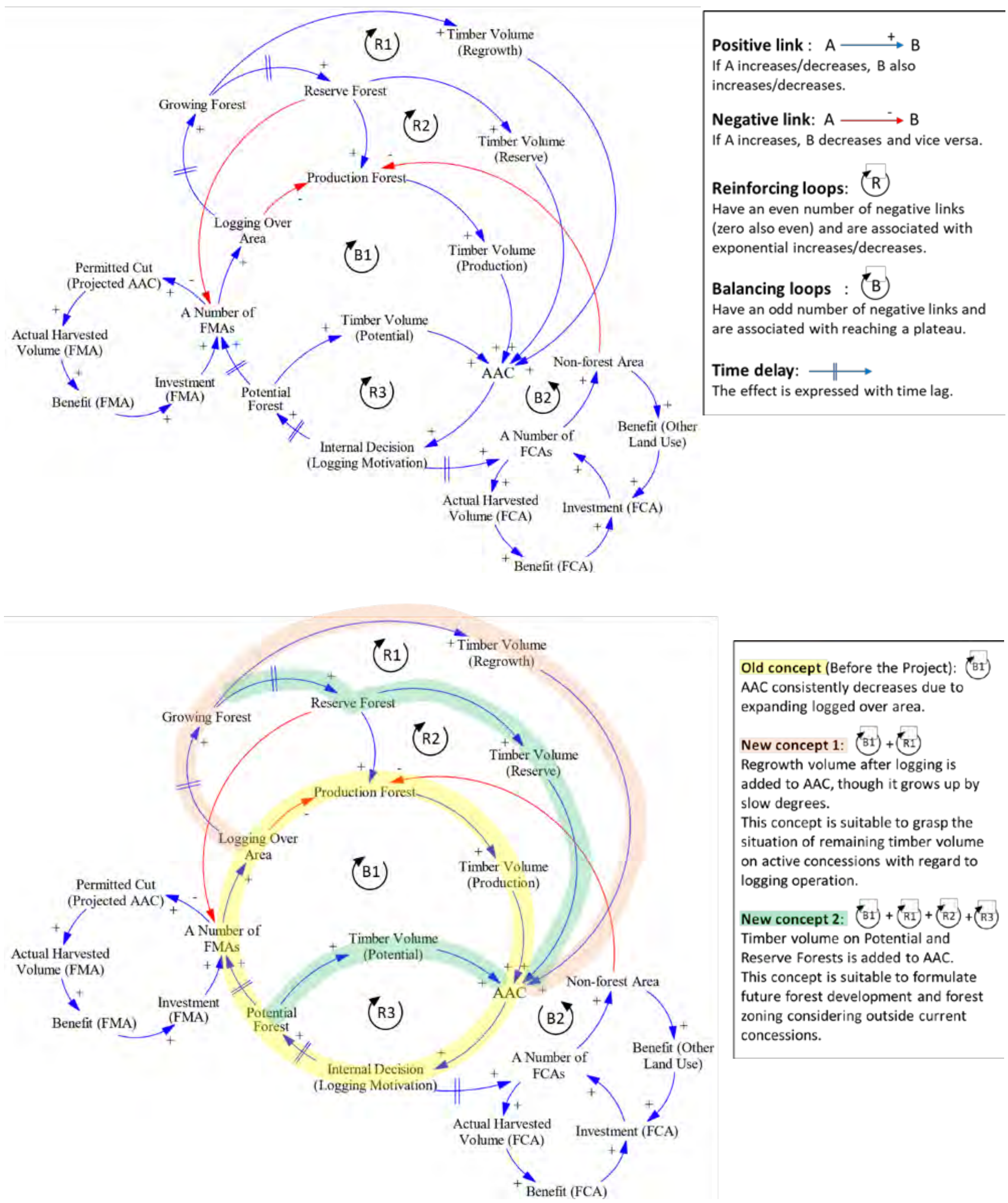


Figure 2.2-11 Causal Loop Diagram of the Forest Management Cycle in PNG

Moreover, in calculating regrowth volume, the method on how to input the information on logged over area that reflects reality into PNG-FRIMS is extremely important. In PNGFA, there was a mechanism for the I&M Branch to input information on forest plans held by the Project Branch into FIMS; however, information on logged over area was not input (Figure 2.1-12). Therefore, the Project formulated a protocol for inputting information on logged over area described in the ALPs, one of the forest plans, and hired local staff to supplement the lack of human resources in PNGFA and to have them engage in the work. In order to improve the accuracy of the AAC, continuously inputting information on logged over area after the Project is extremely important. Thus, the long-term experts proposed a more efficient way of sharing forest planning information inside PNGFA, as shown in Figure 2.1-13 and Figure 2.2-14.

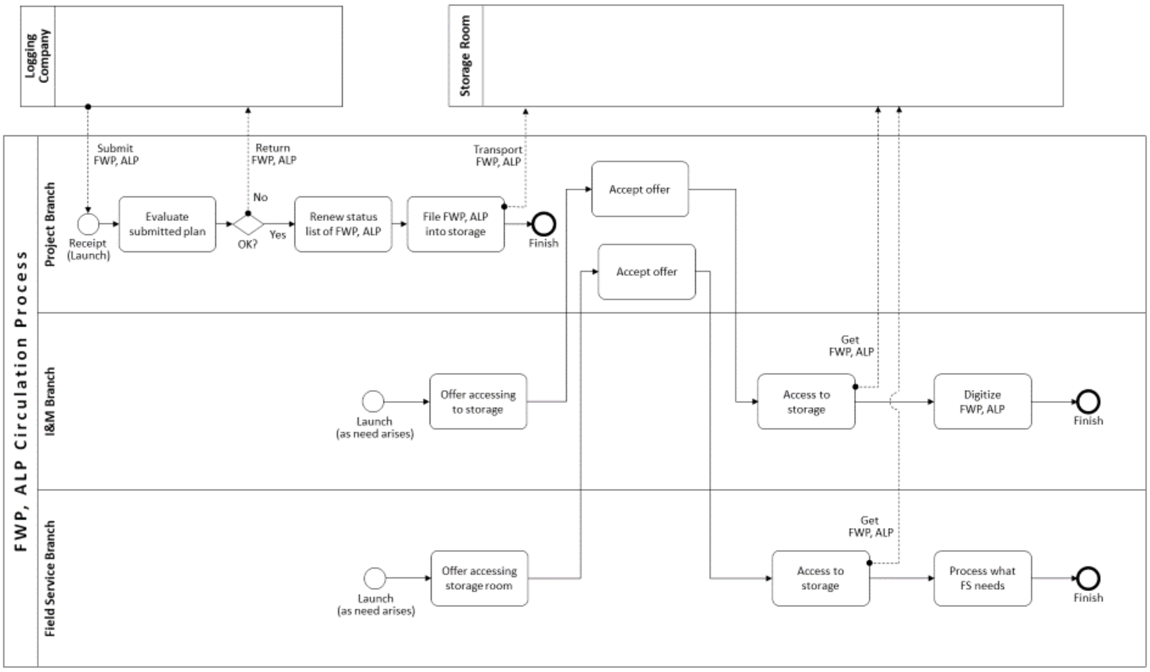


Figure 2.2-12 Work Flow Diagram of FWP, ALP Circulation (Present Situation: As-Is Process)

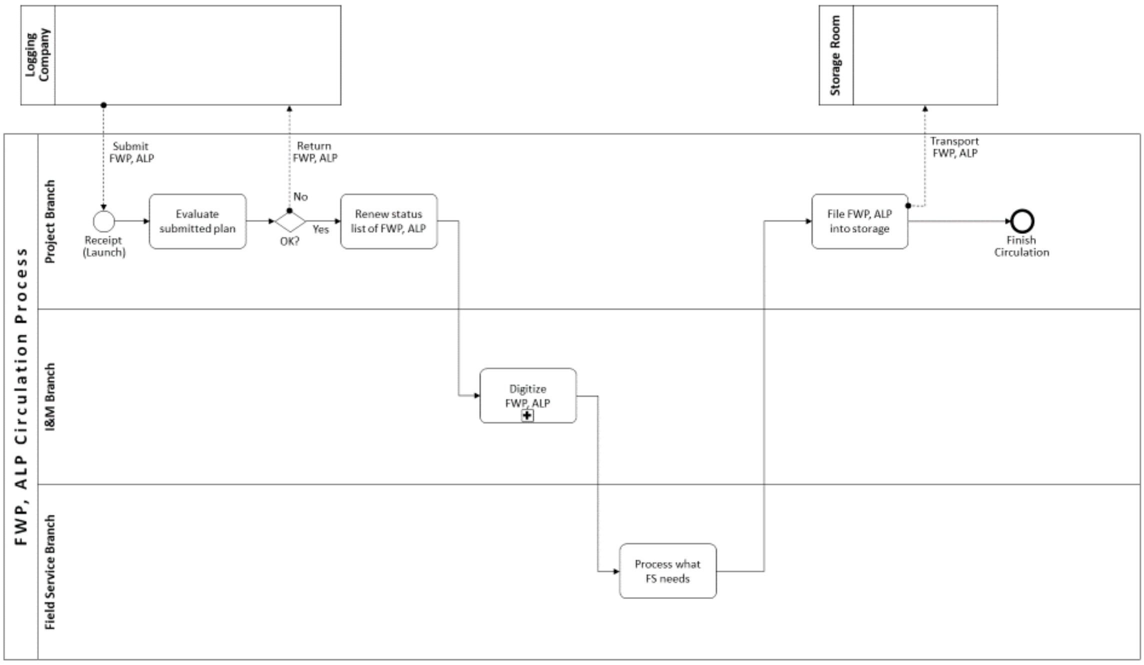


Figure 2.2-13 Work Flow Diagram of FWP, ALP Circulation (Preferable Situation: To-Be Process)

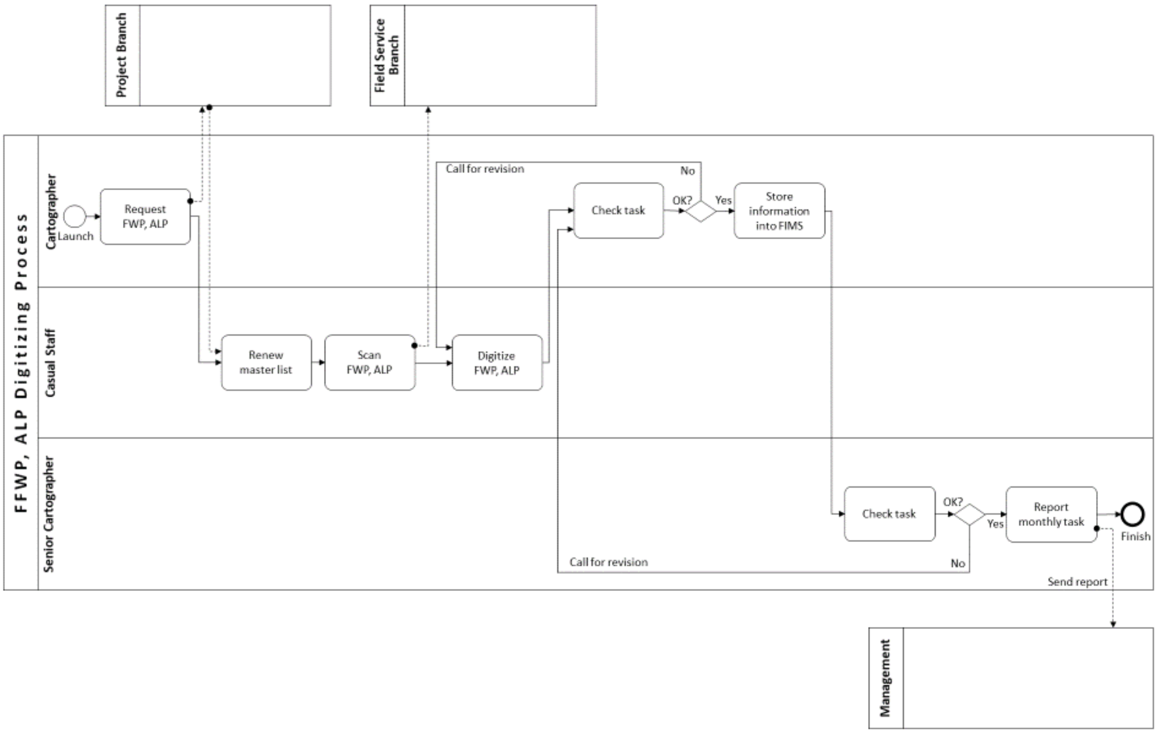


Figure 2.2-14 Work Flow Diagram of Digitizing FWP, ALP Circulation

(Preferable Situation: To-Be Process)

（2）Examine the Utilization of PNG-FRIMS for PFP

1）Simulation on Deforestation and Forest Degradation Using Land Change Modeler

To examine the possibility of using Land Change Modeler (Clark Labs, Clark University) as a forest management and planning tool, the short-term expert team studied the following land use change simulation using it.

(i) Simulation on Deforestation and Forest Degradation– Simulation on Effects of Enlargement of Plantation and Agricultural Field

(ii) Simulation on Deforestation and Forest Degradation – Simulation on Distribution of Deforestation and Forest Degradation

(iii) Possible Location of Future Deforestation Simulated by Land Change Modeler

Details of simulation of land use change utilizing Land Change Modeler are shown in Annex 31. In addition, it was compiled as ‘Analytical Report No. 2 Analysis of Future Forest Change Modeling in Papua New Guinea’ (Annex 6).

(i) Simulation on Deforestation and Forest Degradation – Simulation on Effects of Enlargement of Plantation and Agricultural Field

Land Change Modeler enables the estimation of the drivers of deforestation through the comparison of land use at two points in time and enables the simulation of a case in which deforestation continues at the current pace (a 'business-as-usual' (BAU) case). The simulation on the effects of the enlargement of plantations and agricultural fields around Kimbe, West New Britain Province, is described.

An area (of approximately 4,870 km^2) in the pilot province of West New Britain, where the developments of plantations along with population growth have been causing rapid deforestation, was used in the simulation. A 2011 Forest Base Map and a 2014 Forest Cover Map, which were created by comparing the forest base map with a LANDSAT Greenest Pixel and a corrected base map of the changes detected in the comparison, were used as the land use maps of two points in time.

In the beginning, the 2011 and 2014 maps were compared to elucidate what types of land use increased and what types of land use decreased between 2011 and 2014. The comparison revealed that the areas of agricultural plantations (Qa) and subsistence farmland (O) had increased between 2011 and 2014. Therefore, the development of agricultural plantations and subsistence farmland was selected as the driver of deforestation and their distribution in the future (in the year 2030) was estimated. The elevation (SRTM, resolution of 30 m), slope, distance from the sea, population density (kernel analysis), the boundaries of reserves, wetland and active concession areas, and the 2011 land use boundaries, were used as the model parameters.

The accuracy of the models of agricultural plantations and subsistence farmland was estimated at 80.83% and 81.73%, respectively. Because this figure is larger than the threshold of 80% for sufficient accuracy, this model is considered a valid model. The boundaries of the inundation area are the parameters that have the largest influence on the accuracy of the model.

A forest cover map for 2030 was created in the simulation using these models. The map predicts increases in the areas of agricultural plantations and subsistence farmland by 17.7% and 124.9%, respectively, and decreases in the areas of lowland forest, hill forest, wetland forest, open woodland and grassland by 16.7%, 2.8%, 31.8%, 64.6% and 26.6%, respectively (Figure 2.1-14). This map is considered representative of the land use pattern in 2030 if the current trend in deforestation and forest degradation (BAU) continues until 2030.

Table 2.2-14 Influence that Each Parameter Has on the Accuracy of the Model of Subsistence Farmland

Land use	Area 2011 (ha)	Area 2014 (ha)	Area 2030 (ha)	Change in Area Comparing 2014 and 2030 (%)
P	39,564	38,232	31,848	-16.7
H	271,024	269,568	261,913	-2.8
Fri	4,131	4,070	4,070	0
Fsw	8,373	7,791	5,314	-31.8
W	6,010	4,942	1,749	-64.6
L	32,018	32,018	32,018	0
M	108	108	108	0
G	5,879	5,503	4,039	-26.6
Z	51	51	51	0
E	1,505	1,497	1,497	0
Es	60,864	60,864	60,864	0
Qa	51,572	54,054	63,606	17.7
O	6,907	9,307	20,930	124.9

The biomass of the vegetation in the area concerned was estimated by multiplying the area of each land cover type on the map by IPCC default factors. All the agricultural plantations in this area were assumed to be oil palm plantations. The biomass of the vegetation in this area was estimated to decrease by 4.1 Mt in the period between 2014 and 2030. This figure corresponds to 7.5 Mt CO_2-eq and, thus, a loss of approximately US$ 37 million, on the assumption that 1t CO_2-eq is worth US$ 5.

The area of agricultural plantations is expected to increase by 9,552 ha between 2014 and 2030. If this area is assumed to increase at a constant rate in this period, the cumulative area increase will be 81,192 ha × year. If the yield of palm oil per unit area is assumed at 3.74 t ha^{-1} $year^{-1}$ [25] and its price is assumed at US$ 562 t^{-1} [26], the revenue from the sales of palm oil is expected to increase by US$ 170 million in this period. The total area of lowland and hill forests is expected to decrease by 14,040 ha in the same period. If this area is assumed to decrease at a constant rate, the cumulative area loss will be 119,348 ha × year. If the harvesting period and price per unit volume of timber are assumed for 35 years at US$ 142m^{-3} [27], respectively, a loss of approximately US$ 17 million is expected from the area loss. In conclusion, an increase in revenue of US$ 116 million is expected from the deforestation and forest degradation on the BAU basis in the period between 2014 and 2030 (Table 2.2-15).

25 http://www.soyatech.com/Palm_Oil_Facts.htm (accessed on 03 April 2017)
26 http://www.indexmundi.com/commodities/?commodity=palm-oil&months =300 (accessed on 09 June 2016)
27 https://www.wageningenur.nl/upload_mm/5/c/1/b0b121e8-469b-4e65-9689-c4e6fd7c8d1e_WOt-technical%20report%2010%20web versie.pdf (accessed on 03 April 2017)

An estimation similar to the one mentioned in the preceding paragraph was conducted in cases in which 1) only open woodland and grassland could be converted to agricultural plantations and 2) only grassland could be converted to agricultural plantations. Increases in revenue of US$ 85.2 million and US$ 28 million in the period between 2014 and 2030 were expected in cases 1) and 2), respectively. As restrictions on the changes in land use increase, the extent to which revenue increases from such changes is reduced. The policy of the government on forest management will depend on whether it can find value in conserving the forests themselves without deforestation and forest degradation.

Table 2.2-15 Comparison of Revenue Increases between 2014 and 2030 with Different Scenarios

	Scenario 1	Scenario 2	Scenario 3
Net forest loss	19,711 ha	14,816 ha	11,623 ha
Net P&H loss	14,040 ha	11,623 ha	11,623 ha
Net plantation gain	9,552 ha	4,657 ha	1,464 ha
Price of increased carbon due to plantation development	-37.3 mil USD	2.00 mil USD	1.82 mil USD
Price of palm oil from newly developed plantation	171 mil USD	83.2 mil USD	26.2 mil USD
Price of increased timber due to developing oil palm plantations	-16.9 mil USD	0 mil USD	0 mil USD
Net increase in profit	116 mil USD	85.2 mil USD	28.0 mil USD

Note) Scenario 1: BAU; Scenario 2: Newly developing plantations are only allowed in W and G after 2014, increase in subsistence agriculture is BAU; Scenario 3: Newly developing plantations are only allowed in G after 2014, increase in subsistence agriculture is BAU

(ii) Simulation on deforestation and forest degradation – Simulation on distribution of deforestation and forest degradation

The simulation of the distribution of deforestation and forest degradation in the whole area of the pilot province of West New Britain Province (approximately 20,340 km^2) is described in this section.

A 2011 Forest Base Map and a 2005 Forest Cover Map were used as the land use maps of two points in time. Information on drivers of forest degradation and deforestation were attached to each polygon in each map in advance. In this analysis, (a) forest land cover with drivers such as facility construction, road construction, forest plantation, perennial plantation, subsistence agriculture, “gardening” and selective logging was assumed as “degraded forest” and (b) forest land cover with drivers such as disasters and wood collection, or without any drivers, was assumed as “non-degraded forest”.

In the beginning, the maps for 2005 and 2011 were compared to elucidate what types of land cover increased and what types of land cover decreased between 2005 and 2011. The comparison revealed that the main changes in land cover were the degradation of hill forest (H), plain forest (P) and woodland (W) and the conversion of P into perennial plantation (Qa) and subsistence agriculture fields (O). These land cover changes were put in a model to estimate land cover in 2026. The following were used as the model parameters: elevation (SRTM, resolution of 30 m), slope, distance from the sea, distance from rivers, distance from forest edge, distance from forest / perennial plantation, distance from subsistence agriculture field, distance from degraded forest (as of 2005), population density (kernel analysis), boundaries of reserves, wetland, active concession areas (as of 2005) and forest types.

The accuracy of the model was estimated at 82.31%. Because this figure is larger than the threshold of 80% for sufficient accuracy, this model is considered a valid model. The forest types are the parameters that have the largest influence on the accuracy of the model, followed by, in descending order, the following: distance from forest / perennial plantation, distance from subsistence agriculture field.

A forest cover map for 2026 was created in the simulation using this model. The map predicts increases in the areas of degraded H, degraded P and degraded W by 33.8%, 7.3% and 47.7%, respectively, and decreases in the areas of non-degraded H, non-degraded P and non-degraded W by 51.7%, 54.0% and 55.4%, respectively. This map is considered representative of the land use pattern in 2026 if the current trend in deforestation and forest degradation (BAU) continues until 2026.

This indicates that areas of non-degraded forest would decrease from about 612,000 ha in 2011 to 333,000 ha in 2026 and areas of degraded forest would increase from about 1,105,000 ha in 2011 to 1,358,000 ha in 2026. Pearson *et al.* (2014) suggests that carbon emissions from a unit area caused by forest degradation reaches 12% of that of deforestation. About 165,000 ha of area is simulated as experiencing forest degradation by logging between 2011 and 2026. Assuming average forest carbon stocks of 200 Mg C ha^{-1}, carbon emissions from forest degradation by logging during this period is estimated as the following:

$$165{,}000 \times 200 \times 0.12 = 396{,}000 \text{ (Mg C)}$$

Further, assuming 1 t CO_2-eq = 5 USD, the estimated value of carbon emitted due to forest degradation by logging activity between 2011 and 2026 in West New Britain Province is estimated as the following:

$$396{,}000 \times (44/12) \times 5 = 7{,}260{,}000 \text{ (USD)}$$

(iii) Possible Location of Future Deforestation Simulated by Land Change Modeler

Estimates of possible locations that would experience deforestation in the future, and the drivers of this estimated deforestation, helps identify areas where forest conservation is a high priority and areas to be monitored intensely. It is very difficult to predict the exact location of deforestation in the future because it is dependent not only on geospatial conditions but also on social circumstances, such as traditional practices in the various habitats, changes in policy, and the activities of private companies. However, it is possible to predict locations with a high probability of deforestation because lands suitable for human activities tend to be distributed in areas with certain conditions, such as areas that are flat, warm, close to roads, and close to villages. This kind of information can be used to choose areas for protection, for example. In this section, conditions that affect deforestation are estimated and the probability of deforestation in each location is predicted in West New Britain Province.

Forest Cover Maps for the years 2005, 2011 and 2015 were used for the analysis. Firstly, deforested areas were identified with each driver of deforestation by comparing maps from two time points, namely 2005 and 2011, and 2005 and 2015. Then, two maps were obtained, one containing forest cover information for 2011 with deforestation information from 2005 to 2011, and another containing forest cover information for 2015 with deforestation information from 2005 to 2015. These two maps were utilized for the analysis

The deforestation rates between 2005 and 2011 and 2005 and 2015 were 1.08% and 1.42%, respectively. Deforestation was caused by various drivers, such as agriculture, logging, wood collection, plantation, road construction and disasters. Among the drivers, plantation, agriculture and logging were the major drivers of deforestation. Deforestation occurred mainly in four types of forest, namely, hill forest, plain forest, woodland and swamp forest. In this analysis, simulations were performed for each type of land transition with an accumulated size between 2011 and 2015 that was larger than 200 ha in the whole of West New Britain Province. The simulated transitions are listed in Table 2.2-16.

Table 2.2-16 Seven Types of Land Transitions Simulated in this Analysis

Rank	Land Cover in Year 2011	Land Cover in Year 2015	Area (ha)
1	Plain forest	Deforested (Plantation)	1,813
2	Hill forest	Deforested (Plantation)	1,800
3	Woodland	Deforested (Plantation)	1,331
4	Swamp forest	Deforested (Logging)	435
5	Plain forest	Deforested (Logging)	310
6	Hill forest	Deforested (Agriculture)	294
7	Hill forest	Deforested (Logging)	255

There were 17 kinds of geospatial data stored in the PNG-FRIMS that were employed as the independent variables for establishing a model to predict land cover change potential. The variables are listed by order of influence on the model in Table 2.2-17. The total accuracy of the model was 76.04%. The most influential variable on the model was distance to plantation, followed by land cover for 2011, then timber volume, and the rest as shown in the table below.

Table 2.2-17 Variables Employed for the Analysis and Sensitivity of the Model to Forcing a Single Independent Variable to be Constant

Model	Accuracy (%)	Skill Measure	Influence Order
(With all variables)	76.04	0.7365	N/A
Distance to Plantation	51.41	0.4655	1 (most influential)
Land Cover for 2011	56.34	0.5197	2
Timber Volume	64.85	0.6133	3
Active Concession	68.03	0.6484	4
Distance to Village Point	69.89	0.6688	5
Distance to Sea	73.71	0.7108	6
Driver of Deforestation	74.69	0.7216	7
Slope	75.54	0.731	8
Distance to Road	75.81	0.7339	9
Year of Disturbance	76.02	0.7362	10
Distance to Forest Edge	76.02	0.7363	11
Elevation	76.04	0.7365	12
Forest Density	76.04	0.7365	13
Deforestation Density	76.04	0.7365	14
Standard Deviation of Elevation	76.04	0.7365	15
Population Density	76.04	0.7365	16
Distance to Agriculture	76.14	0.7375	17 (least influential)

Figure 2.2-15 shows the relationships between land change and the most influential independent variables. Most of the deforested areas were distributed within 5 km of the boundaries of plantations (Figure 2.2-15-a). Land cover change between 2011 and 2015 occurred intensely in woodland (4.1%) and swamp forest (2.4%) (Figure 2.2-15-b). Areas with high timber volume tended to experience major land cover change (Figure 2.2-15-c). The simulated model seemed to reflect the effects of these physiographic features.

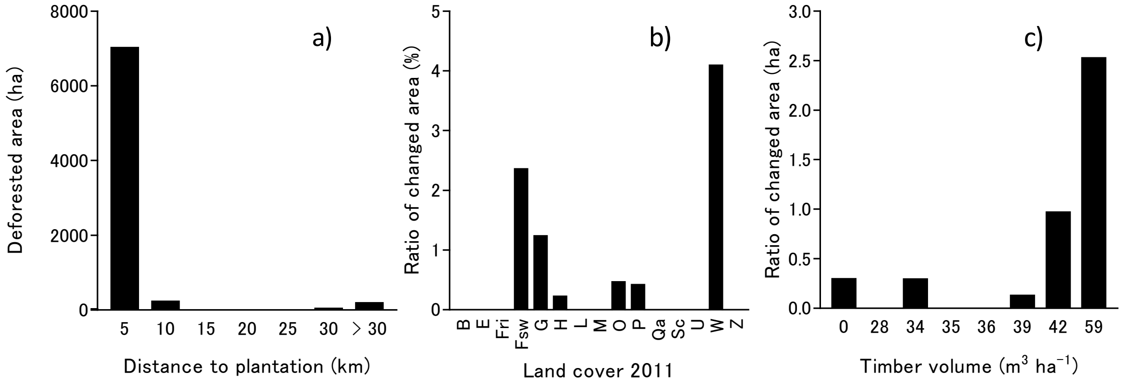


Figure 2.2-15 Relationships between Deforested Areas and Distance to Plantation (a), Land Cover in 2011 (b) and Timber Volume (c)

An estimate of the probability of land cover change in each location in the whole of West New Britain Province was performed using the simulated model. Figure 2.2-16 shows the result of the estimation in part of the western part of West New Britain Province. Lands with a high probability of land cover change are unevenly distributed. In comparison with Figure 2.2-17-a, it was found that areas with a high probability are located along the boundaries of plantations and roads. High probability areas are also related to the distribution of areas with high timber volume (Figure 2.2-17-b). In addition, the distribution of active concessions and village points, etc., may affect the result of the estimation. Meanwhile, along the boundaries of plantations, for example, there was difference in the possibility among the locations. This indicates that there are both highly and poorly susceptible areas to the effect of the operation of plantations. This sort of analysis to identify areas highly susceptible to deforestation would be useful for helping make decisions in forest management, such as setting protected areas. However, it is important to note that events not observed in the past cannot be simulated in this kind of future analysis.

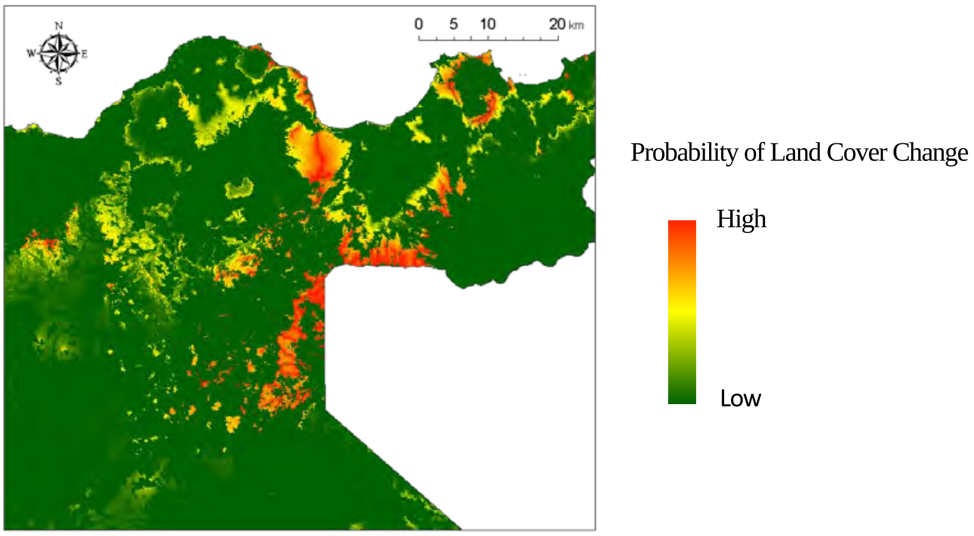


Figure 2.2-16 Probability of Land Cover Change in the Western Part of West New Britain Province

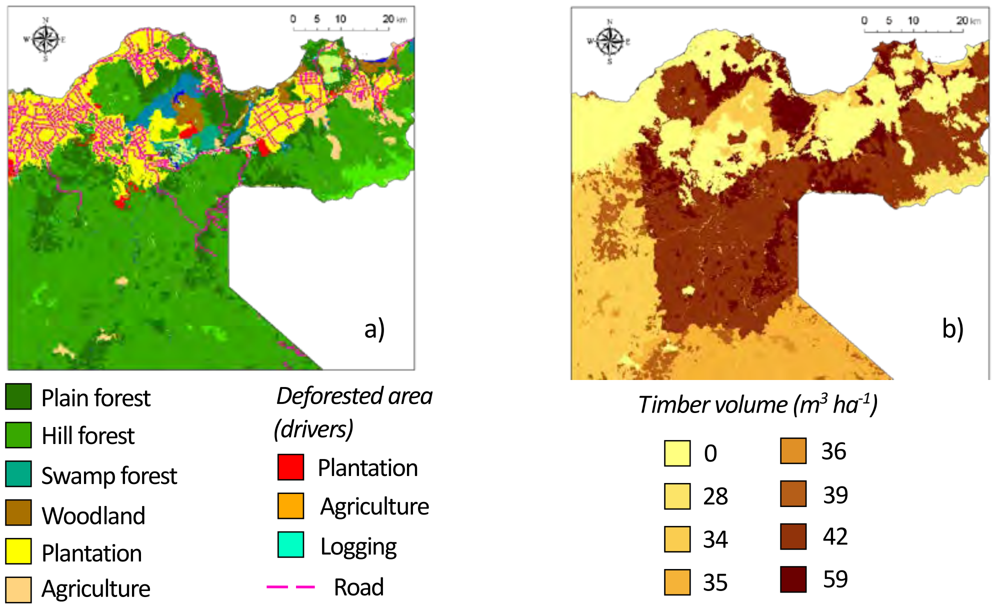


Figure 2.2-17 Land Cover and Road (a) and Timber Volume Distribution (b) in the Western Part of West New Britain Province

(iv) Capacity Building Related to Simulation of Land Use Change Utilizing Land Change Modeler

A manual for simulation of land use change utilizing Land Change Modeler was created based on trial simulations implemented before (Annex 10). Capacity building of the C/P was held following this manual. The details of the contents and achievements of training are shown in 'Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)'.

2) Review the Possibility of Utilizing PNG-FRIMS for PFP

The possibility of utilizing PNG-FRIMS for PFP was discussed by the long-term expert team, the C/P, and concerned authorities such as FCPF (Forest Carbon Partnership Facility). As a result of these discussions, the usefulness of PNG-FRIMS for PFP was recognized, especially in regards to the following points.

- Use of the Forest Base Map
- AAC calculation
- Tailor-made mapping using the Forest Base Map and other layers in PNG-FRIMS
- Possible utilization of Land Change Modeler

2.2.5 Prepare Guidelines of the Overall Forest Planning Using PNG-FRIMS

As a result of activities shown in 2.2.2 ~ 2.2.4, it was recognized that support for the enforcement of LCoP was important; a guideline for LCoP was created by the long-term expert. In addition, information of the usage of PNG-FRIMS was compiled as 'Training Manual for GPS_GIS_LAN-MAP for Efficient Forest Monitoring' and 'Utilization of UAV in the Forest Area' by the Project team (Annex 11) (Activity 2.5 in PDM).

2.3 Activities for Output 3

2.3.1 Utilization of PNG-FRIMS in the Calculation of the Forest Reference Emission Level and Forest Reference Level

PNG-FRIMS is a 'spatial information' database that has been developed for the purpose of utilizing data that has 'location information' owned and managed by PNGFA for forest management and planning. However, the JICA expert team exchanged opinions on the utilization and contribution of PNG-FRIMS in calculating the REDD+ Forest Reference Emission Level and Forest Reference Level (FREL / FRL).

（1）Examination of the Content of FREL / FRL Submitted to the UNFCCC

1）Review of the Methodology of FREL / FRL Submitted to the UNFCCC

PNG (in this case PNGFA) has been analyzing land use and annual land use change for the whole country, utilizing the point sampling-based analysis tool called "Open Foris / Collect Earth" developed by FAO. This tool was adopted for the submission of FREL / FRL to the UNFCCC. PNG was the first country to utilize the results of annual land use analysis by point sampling-based methodology for FREL / FRL (the calculations of other countries are based on wall-to-wall mapping every 5 or 10 years). This is a very interesting example and method.

Collect Earth is a tool for operators to efficiently interpret, input, and analyze data on land use and land use change for each set plot (a Systematic Sampling Grid point at 4 km interval in PNG) by utilizing the high-resolution satellite imagery of Google Earth and Bing Maps, annual LANDSAT cloud-free mosaic images on Google Earth Engine, and the logged over area information provided by PNG-FRIMS images. Although it is sampling based, it is possible to analyze the annual land use change based on the detailed current land state with consistent time series change detection, even by non-GIS users with a user-friendly interface.

In the current methodology, annual deforestation and degradation (disturbance) are recorded as CO_2 emissions. Although it is not mentioned in the PNG report, the long-term experts pointed out that this methodology did not take into consideration the regrowth of forest (removal by forest). Since forest regrowth (removal of CO_2) takes over 30-40 years after logging (unless the land is made into cropland and grassland), it is necessary to go back to the period before the years 1975 to 1985 if the forest removal amount is considered. However, it has been pointed out that for a country like PNG, where deforestation is relatively small and many of the emissions are thought to originate from forest degradation, it is a matter to be addressed over time.

2）Result of Technical Assessment of the REL / FRL Submitted to the UNFCCC

A Technical Assessment (TA) by UNFCCC's reviewers was held in mid-March 2017 in regards to the FREL / FRL submitted by PNG in January 2017. The FRL and evaluation reports, finalized through comments made during Skype meetings and in questionnaires, and draft reports were posted on the UNFCCC website in January 2018. According to the report of PNGFA and the FAO consultants, the items pointed out in the final report were as follows.

(i) Improvement of explanation on the method of maintenance of activity data and calculation of emissions

PNG compiled a report containing the method and results of the development of Activity Data once in 2013, and scheduled a revised / expanded version (including the emission calculation) in 2017, but PNG could not submit it during the TA period. As a result, it was not possible to obtain a complete evaluation of FRL and reproduction and transparency from the TA. (A revised report will be compiled in 2019)

(ii) Relevance of the emission factor of the forest degradation layer (regeneration after harvesting and repeated logging)

Although it was reported that most forest degradation in PNG is selective cutting derived from logging, by using the current method (judging the presence or absence of disturbance with reference to the change history of data using Collect Earth to grasp the current situation by high resolution satellite images and time series satellite data), it was pointed out that the uncertainty of the emission factors seems to be high because a considerably wide degradation level is classified as one class (until the completion of the NFI survey and resetting of the emission factors, it is most practical to use existing PSP and the average value of the emission factors of a wide range of degradation level).

(iii) Distinction of proxy use of managed land (Managed / Unmanaged Classification)

Although the current Collect Earth method is focused on the analysis of human impact, such as from logging, it was pointed out that there are insufficient classifications of disturbances of a natural origin. Although it was not possible to make a revision within the TA period, in the Land Use Land Change and Forestry (LULUCF) part of the Green House Gases (GHG) inventory, which PNG is currently putting together, the exclusion of non-access areas using accessibility investigated in the NFI pre-inventory is being considered.

According to the report, the most challenging issue among these three items was (ii) Absorption and repeated disturbance after deforestation / degradation. Since the solution to this problem was not easy, as an improvement in the TA period, it was assumed that there is a certain absorption after deforestation, taking into consideration the amount of absorption based on the statistics. However, monitoring repeated disturbance was considered as a future item for improvement.

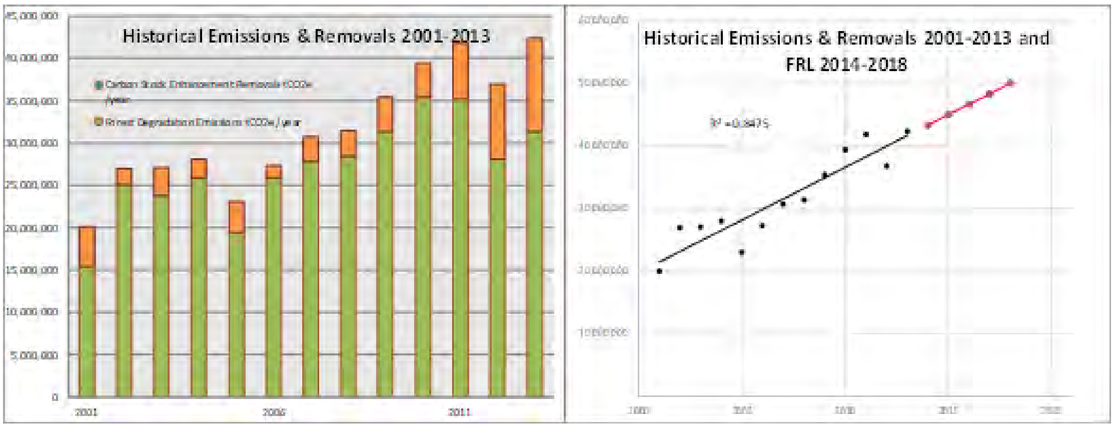


Figure 2.3-1 Chart / Graph of the Modified FREL / FRL Submitted to UNFCCC by PNG in May 2017

(2) Examination of Calculation Method of Forest Carbon Emission / Removal Using PNG-FRIMS

1) Consideration of Direction Based on Problem Analysis of the FREL / FRL

PNG-FRIMS, which manages the legal and administrative forest resources and logging information of PNG (namely PNGFA), is the system that utilizes the area and attribute information recorded from the forest management concessions of the 1950's. PNG-FRIMS may be able to contribute to solving the issue with the current FAO-supported methodology — which is that CO_2 removal through regrowth after deforestation cannot be taken into consideration.

Activity 1.3.4 of Output 1 examined a model to be used for Output 3, taking into consideration the amount of CO_2 by forest regrowth. However, it is difficult for PNG to set the parameters at each place in a short period, and it is not realistic to introduce sophisticated models in a span of several years. Therefore, the Project considered a simple model as a practical tool. As a method of utilizing PNG-FRIMS, providing a highly independent dataset was considered. This dataset would verify historical data used as a basis for the formulation of FREL / FRL, as verification within PNG using another database, a simple regrowth / removal model — namely, providing useful data for domestic verification in the calculation process. In this case, it is also important not only to simply compare the estimated values of emissions and removals, but also to make them effective for promoting domestic verification systems and capacity development.

In addition, even if a report on future FRELs / FRLs and emissions and removals resulting from REDD+ activities were dealt with by Collect Earth or a newly-developed version of it, in order to reflect the removal amount, it is said that more than 2 NFI cycles would be required. Therefore, during or by that time, the usefulness of using concession records derived from PNG-FRIMS remains unchanged, including records of logged over area already used by Collect Earth.

Among the issues pointed out by the UNFCCC TA, the most challenging issue is absorption and repeated disturbance after deforestation / degradation. Because it is difficult to evaluate the continuous re-growth stage of trees with only the current RS method / data, the use of forest management records or information was considered as a future improvement / solution method, specifically the digitized boundaries of the timber logged over area on maps (or a soft copy) submitted by logging companies.

However, as the total amount and status of related data existing at PNGFA could not be grasped, the Project supported the organization and preparation of data for its implementation. First, the total amount was grasped and then organized through the work of local sub-contractors; this was followed by hiring local staff for data entry. As the target of digitizing in the Project was data on the concessions / provinces where pilot activities were being conducted, in order to carry out development at the national level, a new system for the continuous input of data and the confirmation of data integrity should be considered. In the Project, the effects and issues for implementation were confirmed through activities in the pilot provinces and areas (details are reported in 2.2.4 （1）).

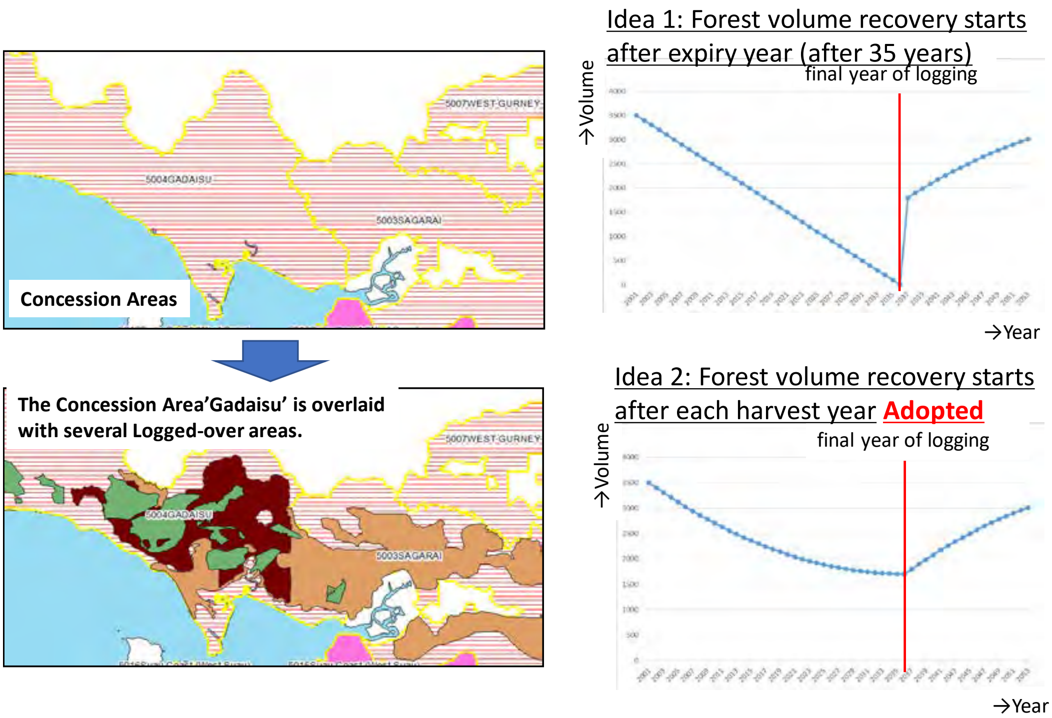


Figure 2.3-2 Utilization of Management Information on Forest Regrowth in Logged Over Areas

2）Examination of Estimation of Carbon Emissions from Forest Degradation Using PNGFA Logging Data

The estimation of forest carbon emissions / removals, made using logging data owned by PNGFA and in reference to the directionality detailed in 2.3.1 （2）1）, was examined (see Annex 5 for details). It was also compiled as 'Analytical Report No. 3 Potential in Papua New Guinea to Estimate Emissions from Forest Degradation Caused by Logging Based on Field Methods (using FRIMS)' (Annex 6).

(i) Background concerning the examination of the situation regarding wood production in PNG and estimation of carbon emissions from logging

Timber production in PNG is a key sector of the national economy, but also one of the main sources of forest degradation. As PNG is actively involved in sustaining its forest resources, it is important to estimate the impact of activities that take place within PNG forests. Carbon stocks are a good indicator of these impacts, and past emissions were estimated to make projections in the PNG FRL submitted in 2017. To calculate FRL, degraded areas were assessed by RS analysis. These emissions may also include those from post-logging (from fire, gardening, etc.) and removals from regrowth. Whereas estimates of forest degradation in the FRL of other countries are done by measuring direct impacts and those solely linked to harvesting practices which are observable at sites right after operations, in PNG such information is included in routine monitoring conducted by PNGFA. One question is how to utilize this potential for carbon monitoring. The main objective of this report is to evaluate the potential in PNG for estimating logging emissions based on field and proxy methods and by using data in PNG-FRIMS. As such, consideration was given to international methodologies recommended by IPCC and adopted in FRL, relevant data available at PNGFA, and the future improvement of PNG FRL and forest management.

(ii) Methodology adopted by FRL in IPCC Standard: Volume Method

There are two main methodologies for estimating logging impact on forest carbon (GOFC-GOLD, 2016):

Method 1: The RS method, using medium-resolution imagery for determining Activity Data (AD) and the Stock-Change method for calculating Emission Factor (EF)

Method 2: A combination of timber extraction rates, management plans and/or high-resolution imagery (for AD), and the Gain-Loss method (for EF).

Many countries that have submitted FRL have opted for Method 1. This choice was facilitated by open sourced 30 m resolution images. In PNG, land use transitions (deforestation, forest degradation and carbon stock enhancement) were determined by RS. The EF of forest degradation was calculated as the difference in carbon stocks before and after logging. Four countries (the Republic of Congo, Ghana, Guyana and

Suriname) chose the Volume Method (VM), elaborated in Pearson et al. (2014), for their FRL to count logging emissions as direct loss associated with extracted timber volumes.

Net emissions	=	Activity Data	x	Emission Factor
Emissions from industrial timber production tCO2e		Extracted volumes m3		Biomass loss associated to timber extraction activities tCO2e/m3

Figure 2.3-3: Overview of Volume Method Methodology (Pearson et al. (2014))

In the VM, it is recommended that AD be determined by using actual harvested volume data that is complete and consistent over more than 10 years and has originated from reliable sources. To account for all emissions sources associated with harvesting, Total EF is calculated by calculating the total Extracted Log Emissions (ELE), Logging Damage Factor (LDF) and Logging Infrastructure Factor (LIF). To calculate each EF, there is no need for historical data, but it is necessary to sample parameters that can be directly assessed in the field, such as extracted logs, wasted log pieces, deadwood from trees surrounding felled trees, and forest removal for the construction of skid trails, log decks, roads, ponds and camps. The field inventory method is now well documented, for example in the Standard Operating Procedures (SOP) from Winrock International (2018).

(iii) Estimation of logging emissions in PNG and possibility of use in FRL and MRV

Timber extracted volumes are recorded in the Field Services Directorate database for all provinces and projects; this information is for the year 2000 and after (and is digitized from 2010). Information on collateral damage is recorded in setup logbooks (but not in a database), with the exception of skid track areas and felled deadwood.

Table 2.3-1 Organization of the Possibility of Using Volume Method in PNG

Sources of degradation		Data (unit)	Documents
Logging infrastructure Factor	Forest clearance for roads	- L, W, Area (ha) - Merchantable volume (m3)	- Setup logbook - Setup scaling sheet
	Forest clearance for log decks	- L, W, Area (ha) - Merchantable volume (m3)	- Setup logbook - Setup scaling sheet
	Forest clearance for skid trails	- L, W, Area (ha) - Merchantable volume (m3)	- NO RECORD - Setup scaling sheet
Logging Damage Factor	Felling	Felling deadwood	NO RECORD
	Wasted log pieces	Stump, top, buttress (m3)	Post harvest assessment
Extracted Log Emission	Log extraction	Merchantable log volume (m3)	Setup scaling sheet and DB

In the future, complementary support for monitoring is expected from improved spatial information in PNG-FRIMS and drone utilization (to capture skidding and felling gap areas in particular). It is also expected from the Decision Support System (DSS) for volume data management and NFI for updates on the carbon content of different forest strata and to provide information on deadwood.

PNGFA's volume data can be used to determine PNG's logging AD because they fulfill most requirements regarding consistency, completeness, accuracy and reliability. A country-specific logging EF can be developed based on PNGFA information available from routine forest monitoring (see Table 2.3-1) and a full sampling plan. It is recommended that the sampling plan be designed for several concessions (representing as much as possible the range of extraction rates) and that it cover all indicators of impact that can be directly assessed in the field. In four relevant FRL countries, the FRL was based on two methods: the VM to assess emissions from forest degradation and the RS method to estimate emissions from deforestation. Total logging emissions in PNG were simulated based on volume data from the Field Services Directorate (excluding volumes generated in Forest Clearance Authority concessions) and the value of EF as calculated in the Republic of Congo.

Table 2.3-2 Simulation Results of Total Logging Volume of PNG by Volume Method

Year	AD (Mm3)	Total EF (tC/m3)	Total logging carbon loss (MtC)	Total logging emissions (MtCO2e)
2010	3.1	1	3.1	11.2
2011	2.7	1	2.7	9.5
2012	2.6	1	2.6	9.4
2013	2.8	1	2.8	10.0
2014	3.3	1	3.3	11.8
2015	3.6	1	3.6	13.1
2016	2.3	1	2.3	8.2
2017	3.5	1	3.5	12.4

Based on that, the consideration of specific methods of carbon monitoring and routine assessment conducted by project supervisors for setup clearance (method of log measurement, waste assessment, etc.) is beneficial as input into the development of the national carbon MRV system.

(iv) Future direction for the practical use of Volume Method in PNG

When it is developed, the VM produces outcomes that can be useful for forest management: (a) historical and projected emissions from logging, (b) historical volume datasets, and (c) a specific EF for logging in PNG. First, the potential for estimating logging emissions can be a critical element for Emission Reduction programmes (in the context of REDD+), carbon projects (in the context of voluntary carbon offset) and in a relative measure for Sustainable Forest Management standards (climate components). Second, trends in timber production can be used for the general purpose of forest management, including the adjustment of AAC and the comparison of province extraction rates. Third, logging EF (tons of carbon loss per m^3 extracted) is a good indicator of the environmental / carbon efficiency of harvesting practices. Thus, it can enable the comparison of practices between or within concessions. Moreover, the development of EF provides methodological experience to PNGFA and can facilitate the calculation of two EFs, which is critical for differentiating conventional and improved practices.

The key finding is that the VM is specific to logging; used as an in-house method, most of the required data is available at PNGFA. The development of AD requires a historical dataset, while EF needs a sampling approach; guidance for conducting the VM and field inventory is well developed. The remaining needs are limited to the need for experts and scientific publications on the methodology of Pearson et al., and for financial options to support or reward the development of logging EF. The next steps would be to compare benefits from both RS and RS+VM approaches, develop research to produce EF, promote carbon initiatives focused on sustainable practices, develop the DSS system and new monitoring methods such as using drones, and design a Roadmap for developing a logging EF (including by identifying relevant fund options).

(3) Map-Based Calculation of Forest Carbon Emissions and Removals Using the Forest Cover Map

At the country level, although point sampling (Collect Earth) was adopted as the only practical and realistic method for PNG, in two provinces where forest monitoring pilot projects have been conducted, the development of wall-to-wall mapping at intervals of every five years was assisted by this Project. The training that contributes to the FREL / FRL calculation process using this data is meaningful as a means to compare and verify the forest emission and removal amount submitted to the UNFCCC, as well as for the FREL / FRL calculation process; moreover, it is useful in the consideration of Policies and Measures (PaMs) in REDD+ supported by the FCPF. Therefore, the trial calculation was carried out using PNG-FRIMS.

The forest cover maps of the pilot provinces, West New Britain Province and West Sepik Province, were created for 2000, 2005, 2011, and 2015 in the Project activities. Therefore, these forest cover maps were used by the Project team in conducting calculations of emissions and removals on a trial basis.

1) Basic Design of Calculation Method on Emissions and Removals

The forest cover maps for 2000, 2005, 2011 (revised version), and 2015 were used to calculate the change in areas that occurred between each year. Areas that had changed from forest to non-forest were designated as ‘Deforestation’, and areas that had changed from non-forest to forest were designated as ‘Afforestation / Reforestation’. Furthermore, the forest class areas that overlap with Hansen Loss areas were designated as ‘Forest Degradation’, overlaying each forest cover map on Hansen Loss data. The forest cover map for 2005 was overlaid on Hansen Loss data from 2000-2004; the forest cover map for 2011 was overlaid on Hansen Loss data from 2000-2010; and the forest cover map for 2015 was overlaid on Hansen Loss data from 2000-2014 (Figure 2.3-4).

The values for above-ground living biomass (AGLB) and below-ground living biomass (BGLB), etc., that were used to calculate the forest carbon stocks were applied in reference to the values calculated in ‘Papua New Guinea’s National REDD+ Forest Reference Level – Submission for UNFCCC Technical Assessment in 2017’.

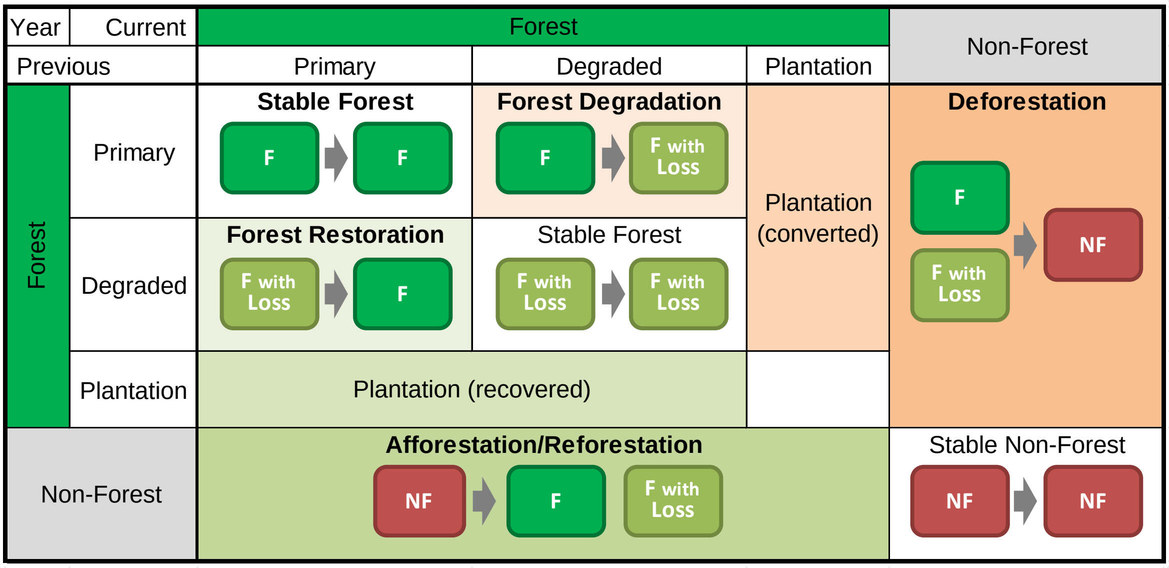


Figure 2.3-4 General Picture of Changing Type of Forest Cover Classes

2）Results of Trial Calculation of Forest Carbon Emissions and Removals of Pilot Provinces

The average annual carbon emissions and removals from 2000 to 2005, from 2005 to 2011, and from 2011 to 2015 were calculated for West New Britain Province and West Sepik Province. The results are shown in Figure 2.3-5 and Table 2.3-3 for Wes New Britain, and Figure 2.3-6 and Table 2.3-4 for West Sepik.

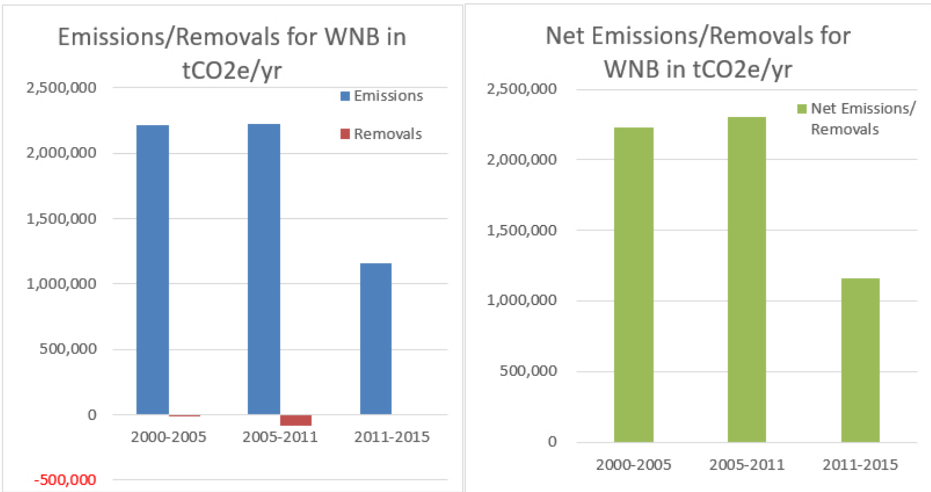


Figure 2.3-5 Annual Average of Carbon Emissions and Removals in West New Britain Province

Table 2.3-3 Annual Average of Carbon Emissions / Removals from 2000 to 2015 in West New Britain Province

	Amount of tCO2/yr			
Terms	Deforestation	Forest Degradation	Afforestation	Net Emissions/ Removals
	Emissions	*Emissions*	*Removals*	*Emissions/ Removals*
2000-2005	2,001,781	217,194	-6,808	2,225,784
2005-2011	1,865,404	356,847	-82,862	2,305,114
2011-2015	746,030	410,369	0	1,156,399
2000-2015	1,612,363	324,569	-35,414	1,901,517

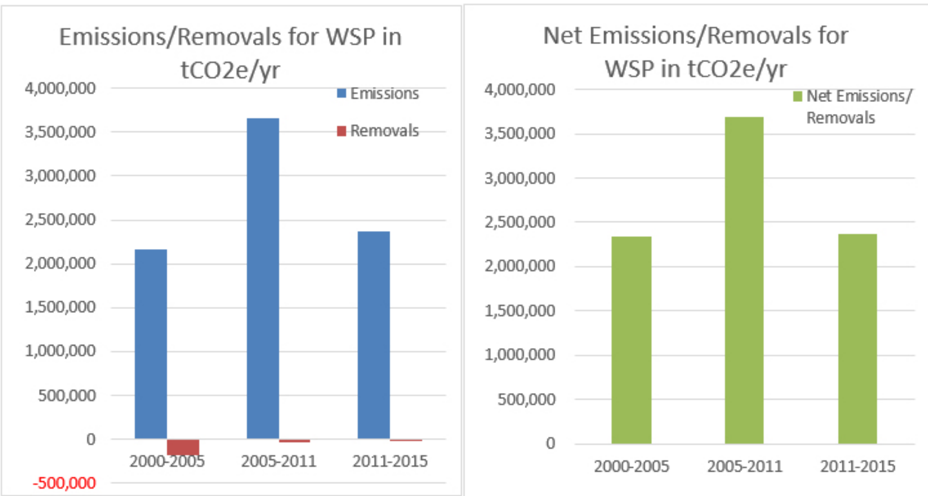


Figure 2.3-6 Annual Average of Carbon Emissions and Removals in West Sepik Province

Table 2.3-4 Annual Average of Carbon Emissions / Removals from 2000 to 2015 in West Sepik Province

	Amount of tCO2/yr			
Terms	Deforestation	Forest Degradation	Afforestation	Net Emissions/ Removals
	Emissions	*Emissions*	*Removals*	*Emissions/ Removals*
2000-2005	2,031,767	127,653	-177,738	2,337,158
2005-2011	3,339,459	323,270	-33,124	3,695,853
2011-2015	1,796,391	574,165	-2,514	2,373,070
2000-2015	2,492,077	324,970	-73,166	2,743,881

In this analysis, the net emissions and removals of West New Britain Province showed a slight increase from 2000 to 2011, and drastic decrease from 2011 to 2015. According to the Tree-Cover Loss trend (Figure 2.3-7) of Global Forest Watch, there was no obvious change in tree cover loss from 2001 to 2011. There was also no obvious decrease after 2011. However, the tree cover loss recorded in the Global Forest Watch Tree-Cover Loss trend is not the same as ‘deforestation’ — it includes changes in both natural and planted forest. That is to say, it includes changes in plantations. In the current analysis, new plantations are classified as forest change, but tree cover loss in existing plantation areas has been excluded from this classification.

This analysis shows a large amount of net emissions and removals between 2005 and 2011 in West Sepik Province. According to the Global Forest Watch Tree-Cover Loss trend, tree cover loss generally increased from year to year. A detailed review of the forest cover maps indicated that change from forest to Agriculture land use (O) increased from 2005 to 2011, which seemed to affect the results of large emissions during those years. Looking only at plantations, there tended to be an annual increase, but the amount of change to O was larger than change to Forest plantation (Qf) / Plantation other than forest plantation (Qa) in the maps. Therefore, change caused by plantations was hardly visible in the results.

Since changes to O and Qf / Qa classes in PNG have a large effect on the results of this type of analysis, it is important to improve the accuracy of these classes to get better output.

Figure 2.3-7 Tree-Cover Loss Trend in West New Britain (left) and West Sepik (right)

https://www.globalforestwatch.org/dashboards/country/PNG (accessed on 25 April 2019)

2.3.2 Identification of Forest Resource Information that Can Be Provided from PNG-FRIMS for REDD+ Activities

To identify information that can be provided by PNG-FRIMS for Project-based REDD+ activities, the following three activities were implemented.

(i) Identification of data required for the implementation of REDD+ projects in PNG

(ii) Identification of data that can be provided by PNG-FRIMS

(iii) Identification of information that is lacking in PNG-FRIMS by comparing information required for developing a Forestry Climate Change project and information currently available in PNG-FRIMS

Regarding the activities in this section (1) to (3) above, PNGFA and the PNG government clarified that the implementation of these activities should not be limited to the project level because PNG now aims to implement REDD+ at national level. Therefore, at the third JCC meeting in August 2016, it was decided to delete "project level" from the PDM. Thus, subsequent activities related to “project level” needed to be considered based on this change.

In the background of the above , at the beginning of the Project, there was a movement to acquire Verified Carbon Standard (VCS) certification through REDD+ pilot activities, while the PNG government had been considering implementing REDD+ projects at the province level along with establishing FREL / FRL. Therefore, the Project decided to provide forest resource information through the use of PNG-FRIMS without regard to project-based REDD+ activities.

At the beginning of the Project, there were some project-based REDD+ activities / frameworks which the Project could work with; for example, the project framework in Central Suau, Milne Bay Province supported by GIZ, the Lowering Emissions in Asia's Forests (LEAF) project for land use plan-making in Madang Province supported by United States Agency for International Development (USAID), etc. Information that could be provided for the provincial and national level, targeting the PNG Climate Change and Development Authority (CCDA) and each provincial government, could be from RS imagery in appropriate scale, the Forest Base Map (for the entire country), forest cover maps (two pilot provinces), land use change prediction maps and the results of change factor analysis, etc. Information regarding suitable land for new afforestation has been considered as well.

In addition, the direction to implement the REDD+ activities at the provincial and national levels is becoming clearer in PNG. In the National REDD+ strategy, which was formulated by the CCDA with the support of FCPF / United Nations Development Programme (UNDP), it is mentioned that the “PNG approach to REDD+ will, not directly support the establishment of REDD+ Projects targeting the voluntary carbon market….” It has become apparent in recent years that PNG is not planning to limit the activities of REDD+ at Project level but instead to expand them at the national level, as is seen in the National Consultation formulated in ‘Policy Issues and Options Studies Towards Developing PNG's National REDD+ Strategy’.

(1) Organizing the Methodology and Data Needed to Implement the REDD+ Project Development

This activity contributed to providing a clear and practical understanding of the main frameworks of performance-based payments and methodologies associated with project-based activities in PNG in the sector of LULUCF. Furthermore, it was divided into the following two activities.

1) Identification of Data Required for the Implementation of REDD+ Projects in PNG

- Review (exhaustively) on-going and planned REDD+ projects in PNG: frameworks in which Emission Reduction (ER) performance is enhanced; or, on the other hand, investigate the most appropriate type of methodology, and data requirements to apply to the selected methodologies
- Develop network of PNGFA with REDD+ project implementing organizations where PNGFA receives methodological support from experienced implementing organizations,

2) Review of International Methodologies regarding the Carbon Offset Frameworks

- Review main carbon offset frameworks (Clean Development Mechanism (CDM), REDD+, Voluntary, bilateral like JCM, etc.), follow developing trends internationally and in PNG
- Continue networking with organizations involved in standards (OCCD, VCS, DOE, etc.) and invite methodology experts to REDD+ pilot project sites for broad evaluation and advice

The details of on-going and planned REDD+ projects in PNG, such as type of methodology, parameters used in monitoring, and relationship to PNGFA, were reviewed. The results are shown below (refer to Annex 32 for details).

A summary of project methodologies used in PNG is shown in Table 2.3-5.

Table 2.3-5 Summary of Project Methodologies Used in PNG

Project	Manus	Central Suau	April Salumei
Fund	Non-Governmental Organizations (NGO)	Private	Donor
Carbon Methodology	Own	VCS 0010	VCS 0010, VCS 0007
Community/Biodiversity	No	Not yet (Climate, Community & Biodiversity Standard (CCBS))	CCBS (Bd gold)

So far, two methodologies have been employed in PNG REDD+ projects VM0007 (REDD) and VM 0010 (logged to protected forests). Each one has a long list of data and parameters used in monitoring. An exhaustive list is given in Table 2.3-6.

Table 2.3-6 Data and Parameters Used in Monitoring

Data and Parameters Used in Monitoring	Details / Conditions	Source
VM OOO7 REDD Methodology framework		
Forest cover map	- Forest / Non-forest classification accuracy 90% at least - Monitoring every 5 years at least - Map must be stratified (module X-STR for details)	RS + GPS (B)
Degradation	Forest degradation phenomenon and causes	PRA

		(Participatory Rural Appraisal)
Result of limited degradation survey	Is the degree of degradation is enough to implement REDD+?	PRA
$A_{def, PA, int}$	Area recorded as deforestation in project area in stratum (i) per converted land use (u) at time (t)	RS (C) Every 5 years
Carbon stocks in above and below ground biomass		
A_{sp}	Area of sample plots	Field survey
N	Number of plots	Field survey
DBH	Diameter at breast height	Field survey
A_{sf}	Area of sampling frame	Field survey
GHG from biomass burning		
$A_{bum,i,t}$	Area burnt in stratum (i) at time (t)	RS (E)
$C_{AB, tree, i}$	Carbon stock in above ground biomass in tree t in stratum (i)	RS (F)
Carbon stocks in the long term wood products pool		
A_i	Total area of the stratum (i)	GPS, RS (A), parcel records
$V_{ex,i}$	Volume extracted in stratum (i), if possible by wood product and species Gross volumes, not net volumes used commercially	RS (F), satellite, aerial, ground or harvest records
Estimation of market effects		
PML_{FT}	Mean merchantable biomass = AGB (DBH>50cm) / total AGB	Calculation
VM OO10 IFM LtPF (other than the methodology VM 0007)		
Illegal logging (PRA)	Whether illegal logging is occurring; how far from roads	PRA
Result of limited illegal logging survey	If enough logging for REDD+	Field survey
$A_{dist, i,t}$	Area disturbed in stratum (i) at time (t)	GPS, RS (D, G)
$A_{DIST\_IL, i}$	Area potentially impacted by illegal logging in stratum (i)	Identify using PRA potential logging areas; field survey using GPS to delineate details
$C_{DIST\_IL, i,t,PRJ}$	Biomass carbon of trees cut and removed through illegal logging in stratum (i) at time (t)	Field survey in sample plots
$A_{P,i}$	Total area of illegal logging sample plots in stratum (i)	Field survey
PMP_i	Merchantable biomass = gross BM DBH>15cm / total ABG BM N.B: PMPi -> forest planning -> legal limit -> extractable volume	Forest inventory

Data types needed are shown below.

- Forest condition: Forest cover map, area burnt, carbon stock in trees, total area of stratum
- Forestry / biomass data: Volume extracted if possible by wood product and species (gross volumes, not net volumes used commercially), merchantable biomass (% BM in tree > 15cm), merchantable biomass (% BM in tree > 50cm)

- Deforestation / carbon data: Carbon stocks in above- and below-ground biomass, result of limited illegal logging survey, biomass carbon volume of trees cut and removed through illegal logging, total area of illegal logging sample plots, degradation, result of limited degradation survey, illegal logging (PRA), area potentially impacted by illegal logging, area of recorded deforestation in project area, area disturbed.

Further, the items listed below were studied and organized. The short-term expert team summarized questions for assessing PNG-FRIMS suitability in Project support as well as the stakes of considering carbon methodologies in PNG-FRIMS enhancement.

- Existing carbon project methodologies in the forestry sector: main methodologies and methodologies specifically useful in PNG
- Data / parameters and methods used to assess forest degradation in projects
- The procedure to estimate forest carbon stock changes in large scale projects

The five methodologies most representative of REDD+ addressed drivers and proposed activities are VM0010, 11, 04, 06 and 15. Other VCS methodologies are more general tools.

Table 2.3-7 Type of Baseline and Project Activities

Methodologies	Baseline Activities	Project Activities
VM0010/11 Logged to Protected Forests	Selective logging Planned degradation Unplanned deforestation	Protection
VM0004 Avoid peat conversion for agriculture plantations	Agro-plantation activities Planned deforestation Unplanned degradation	Conservation
VM0006/15 Landscape approach	Slash-and-burn and wood collection Unplanned deforestation Unplanned degradation	Mixed activities
VM0003/05 Reduced impact logging (RIL)	Selective logging Planned degradation Unplanned deforestation	Low impact logging

Methods for the determination of deforestation and degradation are summarized in Table 2.3-8.

Table 2.3-8 Summary of the Determination Methods for Main DD (Forest Degradation and Deforestation) Drivers

DD Drivers	Methods of Determination	
	Ex-ante Estimation (calculation, modeling)	Ex-post Monitoring
Forest degradation		
Illegal logging	Landscape approach (VM0006/15)	All methodologies consider land use change in project period
Legal selective logging	Logged to Protected Forests (VM0010/11)	Reduced Impact Logging methodologies (VM0003/05)
Deforestation		
Slash-and-burn for subsistence agriculture	Landscape approach (VM0006/15)	All methodologies consider land use change in project period
Clear cutting for commercial plantations	VM0004	Not considered as project emissions (otherwise the methodology is not suitable)
Fire	As yet no specific methodology dealing with avoiding forest fires	All methodologies consider land use change in project period

Items on the list of questions regarding the availability of data required for methodologies in PNG-FRIMS are shown in Table 2.3-9.

Table 2.3-9 Items on List of Questions about Access Availability of Data Required for Methodologies in PNG-FRIMS

Global Object	Specific Object
Boundary	Current situation
Stratification	Historical trends
	Consistency
	Remote sensing data pre-processing
	Attribute
	Model
	Land transition
Carbon stock changes	Analysis of drivers
	Carbon density (EF)
	Activity data (AD)
	AD calibrate a deforestation model
Degradation	Estimation of past trends
	Current situation
DD	Monitoring of future events

In addition, with regard to activities in this section, PNGFA and the PNG government clarified that the implementation of these activities should not be limited to the Project level because PNG now aims to implement REDD+ at the national level. Therefore, at the third JCC meeting in August 2016, it was decided to delete "Project level" from the PDM. However, this is an effective arrangement of information for the implementation of multi-scale REDD + projects in the future.

(2) Examination of Possible Contribution of PNG-FRIMS to Activities Other than FRL Calculation

PNG-FRIMS is a ‘spatial information’ database that has been developed for the purpose of utilizing data that has ‘location information’ owned and managed by PNGFA for forest management and planning. Since it is effective for the Sustainable Management of Forest (or Sustainable Forest Management; SFM), which can be positioned as a part of in REDD + in a broad sense, the Project examined the information and contributions that PNG-FRIMS can provide to activities other than FREL / FRL calculation. However, these are not activities which are implemented in the Project, but rather are considerations / proposals of possibilities by the Project member in charge. Moreover, they were discussed with PNGFA and utilized to consider the direction and activities of future projects (refer to Annex 12 and 33).

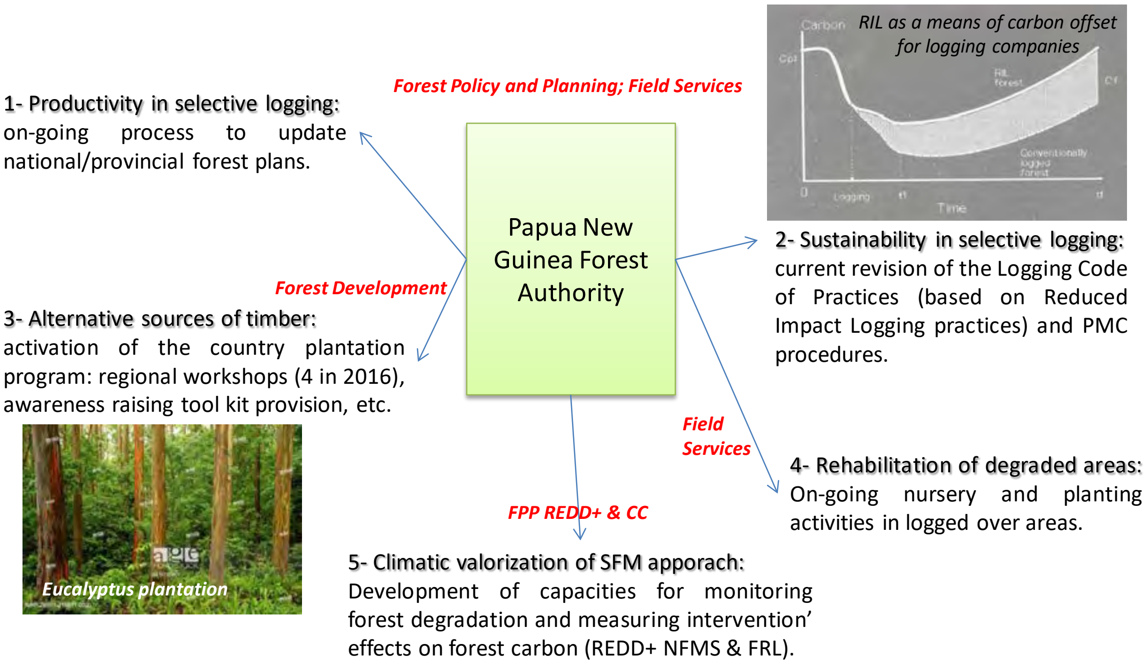
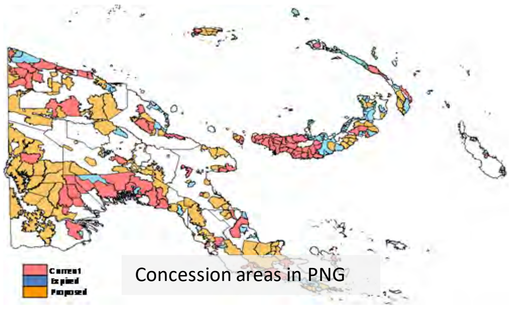


Figure 2.3-8 Contribution Activities for Sustainable Forest Management Using PNG-FRIMS (draft)

1) Support in Land Use Planning and Land Suitability Analysis (Draft)

Planning of forest utilization concerning land potential and risk by PNGFA can be considered as an activity for this kind of support. A breakdown of the activities and content of the possible support given by PNG-FRIMS are summarized in the table in the figure below.

Activity: PNGFA planning of forestland uses regarding land potentialities and risk



Development activities	*Zones sought*	*Consideration*
Selective logging	Lowland forest	Forest Management Agreements
Forest timber plantation	- Grasslands - Strongly degraded areas	Plantation zones
Forest regeneration	- Logged Over Areas - Other Degraded forestland	Priority areas for planting
Conservation	High value (Biodiversity, etc.)	Buffer/CA (with CEPA)

Possible support from PNG-FRIMS

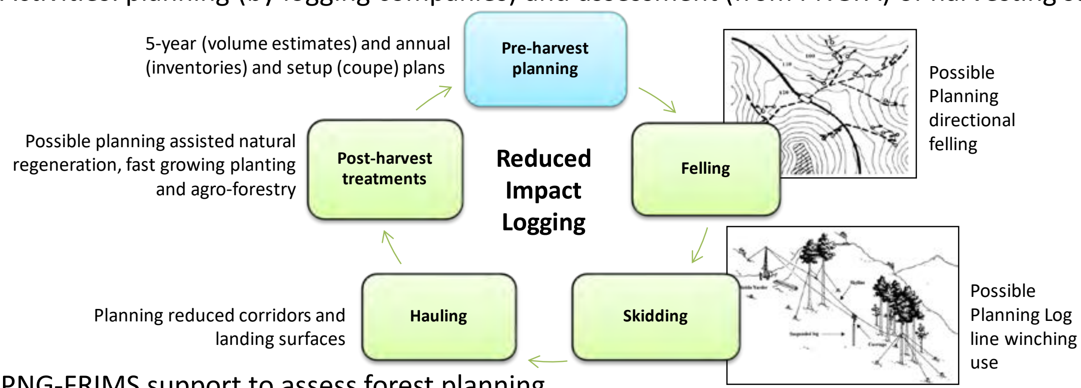
Info sought	Evaluation/monitoring methods	PNG-FRIMS functions used
Land potential (timber volumes per area)	Position and numerical info acquiring	**Forest Base Map, FIMS**
Environmental constraints (grassland, degraded)	Position acquiring and attributes	**LAN Map, GIS**
Maps of clan	Boundary position and area calculation	**LAN Map, GIS**
Deforestation and Degradation spots and drivers	Position acquiring and area calculation	**RS imagery**

Figure 2.3-9 Support in Land Use Planning and Land Suitability Analysis

2）Support in the Planning of Harvest Operations (using Reduced Impact Logging) (Draft)

Planning of logging activities by timber logging companies and timber logging assessments by PNGFA can be considered as an activity for this kind of support. The content of the possible support from PNG-FRIMS by assessing the forest plans are summarized in the table in the figure below.

Activities: planning (by logging companies) and assessment (from PNGFA) of harvesting steps



PNG-FRIMS support to assess forest planning

Info sought	Evaluation/monitoring methods	PNG-FRIMS functions used
Whether setup area < 150ha	Area calculation	**LAN Map**
Logged area < 1/7 of total log-able area	Area calculation	**LAN Map**
Conservation area > 10% concession area (excluding buffer zones)	Area calculation	**LAN Map**
Position of trees of interest	Position acquiring; picture	**LAN Map, GPS**
Remaining stump height < 30cm	Position acquiring; picture	**GPS**
Skid tracks area < 10% of setups area	Area calculation	**GPS, GIS**
Road corridor width < 40m	Distance measurement	**GPS**
Log landings < 3 and < 0.25 ha/setup	Position acquiring; Area calculation	**LAN Map, GPS**
Buffer zones not overlapped	Buffer position and distance to harvest	**GPS, GIS**
Post-harvest treatment provided (replanting)	Area calculation; Position acquiring	**GPS, GIS**

Figure 2.3-10 Support in the Planning of Harvest Operations (using RIL)

3）Support in the Development of Forest Plantation Programs (Draft)

Development and management of afforestation plantations by PNGFA or timber logging companies can be considered as activities for this kind of support. The priority areas and content of the possible support by PNG-FRIMS are summarized in the table in the figure below.

Activity: development (PNGFA) and management (PNGFA or timber companies) of forest plantations.

Priority areas:

Largest State-owned plantation

Largest plantation in pilot provinces

Province	Plantation	Start	Area (ha)	Species	Ownership
Central	Brown River	1955	1266	Tectona grandis	State
	Kuriva	1985	1440	T. grandis	State
Milne Bay	Ulabo	1985	1500	E.deglupta	State
Morobe	Bulolo/Wau	1985	12,000	Araucaria, Pinus	State
	Umi	1990	764	Pinus/Eucalytus	State
Madang	Gogol	1975	12,375	A.Mangium	(JANT)
	North Coast	1985	1,748	E.deglupta	State
New Irel.	Kaut	1986	570	E.deglupta	Community
WNB	SBLC	1972	12,000	E.Deglupta	(SBLC)
East New Britain	- Kerevat	1950	2,385	T. grandis	State
	- Open Bay	1972	14,000	E.Deglupta	(OBT)
West High.	Waghi	1962	2100	E.grandis, robusta	State
South High.	Lalibu	1972	440	Pinus patula	State

PNG-FRIMS support:

Info sought	Evaluation/monitoring methods	PNG-FRIMS functions used
Mapping and survey of plantation boundaries	Acquiring position of existing plantations; area calculation	LAN Map, GIS, GPS
Mapping of land suitable for new plantations (grasslands, degraded areas)	Acquiring position of grasslands and degraded areas; area calculation	LAN Map, GIS
Sketch plotting of possible project areas	Designing position; area calculation	LAN Map

Figure 2.3-11 Support in the Planning of Harvest Operations (using RIL)

4）Support in the Regeneration of Degraded Zones (Draft)

Nursery beds and afforestation in areas where forests have been degraded, which can be done by PNGFA or a logging company, can be considered as activities for this kind of support. The priority areas are: areas where logging has finished, called in this Project 'Logged Over Area (LOA)', and areas where mangrove forests are degrading. The content of the possible support by PNG-FRIMS are summarized in the table in the figure below.

Activities: Interventions (nursery, planting etc) in degraded areas from PNGFA (or logging companies)

Priority areas:

PNG-FRIMS support:

Info sought	Evaluation/monitoring methods	PNG-FRIMS functions used
Zones for planting native species	Acquiring position of young LOA (< 5 years)	RS analysis of logging road network => Delimitate LOA boundaries and Logging closure time
Zones for fast growing species.	Position of Heavily degraded LOA (any age)	
Zones where assistance is not necessary	Position of LOA > 5 year without heavy disturbance	

Info sought	Evaluation/monitoring methods	PNG-FRIMS functions used
Zones for interventions (Assisted Natural Regeneration) involving local communities	Acquiring positions of Mangrove boundary and degradation spots	- Forest Base - Outsourced data (Google Earth engine, Maryland University website, etc.)

Figure 2.3-12 Support in the Regeneration of Degraded Zones (Draft)

5）Support in the Estimation of Carbon Benefits

This support is fundamental; there are two activities to be considered: 1) monitoring of forest cover change; and 2) measurement of the effect of intervention activity. A breakdown of the activities and case examples were organized into tables and pictures in the figure below.

Activities. 1: monitoring forest cover changes (assessment of historic emissions and removals)

Info sought	Evaluation/monitoring methods	PNG-FRIMS functions used
Land classification and Forest stratification	Boundaries and attributes	**Forest Base map**
Deforestation and forest degradation in roads, skid trails, log landings	Position acquiring, area calculation	**Remote sensing tools**
Reforestation in plantations and regeneration	Position acquiring, area calculation	**RS, LAN Map, GIS**

PNG-FRIMS support:

Activiies. 2: measuring effects from interventions

	CONVENTIONAL LOGGING	*REDUCED IMPACT LOGGING*
Roads [m/ha]	24	20
Skid trails [m/ha]	205	71
Log landings [m2/ha]	103	57
Trees damaged [%]	56	29

Intervention example:
PaMs fostering application of RIL within (country' or province') operators. Ex.: material support, incentives for good practices, etc.

LAN Map, GIS, GPS

Only possible through Field inventory

EF natural forest → EF Logged forest → EF RIL forest

Figure 2.3-13 Support in the Estimation of Carbon Benefit

The content detailed above in 1) to 5) are also summarized as the PaMs proposal for SFM as a logical framework (Table 2.3-10; see Annex 34 for the content supplement). In addition, for each sub-approach, the purpose and PaMs have been organized. The PaMs show particular awareness of the contribution of PNG-FRIMS, but it would be useful if it were possible to clarify what can be applied immediately and what can be recommended for the future.

The major goal of SFM is to limit the impact of forestry activities on forest carbon. The approaches for achieving this goal are: 1) Reduce the impact of logging in natural forests; 2) Switch logging out from natural forests; and 3) Valorise forest products. The sub-components for these are: regarding approach 1), improve planning of operations (zoning and regulation), improve monitoring of forest cover and carbon stock change, and improve control of compliance of operations; regarding approach 2), support was given for the development of a forest plantation program; regarding approach 3), a forest product value chain approach was organized.

Table 2.3-10 Logical Framework of PaMs Actions for SFM

SFM Goal	Approaches	Sub-approaches	Objectives	PaMs
Limit impact of Forestry activities on forest carbon	**[1] Reduce the impact of logging in natural forests**	**Improve Planning of operations (zoning)**	*Maximize repartition of production activities*	*Land use planning*
Holistic approach for paradigm shift	*(2.1: strengthen capacities for SFM)*	**Improve Planning of operations (regulations)**	Limit wood extraction through legal levers	Amendment of harvest quota (ex.: AAC, MMD)
(this corresponds to the GCF concept note [draft Jan 2018]: component 2. improved management of production forests)			Incentivize good practices through fiscal levers	Experimentation of measures influencing practices (tax, fines, etc.)
			Incentivize good practices through commercial levers	Increase engagement of wood standard organizations
			Support operators practices	Knowledge and know-how development of Reduced Impact Logging
				PNGFA provision of data and planning tools
		Improve Monitoring of forest cover and carbon stock changes	Facilitate monitoring using RS	Continue development of FRIMS and DSS database and management capacities

				Development of internet connection in provinces for monitoring purposes
				Acquisition of high resolution images
			Facilitate monitoring from data analysis	Facilitation of data sharing from operators (Actual harvested volumes)
			Facilitate field monitoring through integrating carbon parameters to routine assessment of logging projects	Provision of FRIMS info and GPS to field assessors
				Promotion of operators and communities' involvement in monitoring
				Development of enabling conditions: funds, staffs, training and review of 'field assessment sheet' document
		Improve Control of compliance of operations	Improve logistic aspects of control	Facilitation of the independence of supervisors (house, cars)
				Build operators capacities to respond to supervisors' advices (one focal point, trainings)
			Improve technical aspect of control	Engagement of operators in post-harvest treatment
			Activate legal levers for improving control	Hardening of procedures to increase operators consideration of supervisors recommendations
			Activate fiscal levers for improving control	Study of systems to compensate income loss due to operations suspension
	[2] Switch logging out from natural forests	**Support development of forest plantation programmes**	Develop smallholder plantations	Access to demand in material, forest data and training for managing plantations

	(2.3: increase sustainable production through plantations)			extension services (awareness raising, training on nursery or plantation management)
				Propose incentives, for example: half of seedlings provided
			Develop industrial plantations	Increase state owned plantations to reassure investors fearing land tenure issues
				Promote awareness raising campaigns with landowners on plantations
				Propose double royalties for landowners accepting plantation projects
				State the intention of selling abandoned plantations
	[3] Valorize forest products *(2.2: promote alternative production and processing)*	**Wood value chain approach**	Improve the Wood value chain	Analysis of the components of PNG wood Value Chain
				Favor multiplication of wood processing plants
				Valorization of wood plant' by-products (biomass-to-chips or biomass-to-power)
		Livelihood	Develop livelihood options based on forest products	Valorization of NTFPs though sensitization sessions
				Development of small-scale wood production (and PNGFA record system)

PNG's REDD + activities are implemented based on the National REDD + Strategy (NRS) ; however, in the preparation for the Concept Note of the Green Climate Fund (GCF) project, the Inputs of the Project were fully utilized, having in reference the contents of PaMs, which were organized this time. It is also expected that PNGFA will continue to utilize the Inputs and refer to the organized PaMs, during the study of countermeasure activities and their implementation for the formulation of the REDD+ Finance Investment Plan (RFIP).

（3）Consideration of Information Provided from PNG-FRIMS for PFP

PNG established its NRS in 2017 with the support from the FCPF readiness project. However, because FCPF suggested to PNGFA the implementation of the PFP as a REDD+ finance investment plan, as part of the preparation of NRS, the contribution made to the PFP in the JICA Project was organized. JICA has been giving support to improving the issues about the data in PFP; however, in order to formulate PFP, (i) a preparatory review of PFP guidelines, and (ii) a review of data required in PFP documents were conducted (see Annex 35 for details).

1）Review of the Contents and Process of Guideline for PFP

FPF guidelines 1995 was composed of the following sections: ‘Introduction’, ‘Potential uses of the existing forest’, ‘Current forest uses’, ‘Forest development goals and GL’, ‘Future development of forests’, ‘Social forestry’, ‘Provincial action program’, and ‘Validity’. The summary of each section is organized in Table 2.3-17.

Table 2.3-11 Content of PFP Guidelines 1995

Sections	Summary
1- Introduction	Gen obj, forest policy principles, persons producing and consulted
2- Potential uses of the existing forest	Definition services/products, service uses, product uses, land uses
3- Current forest uses	Protected Areas: status, activities; Production Areas: status, activities
4- Forest development goals and GL	Province goals using forests, priorities, safeguards
5- Future development of forests	Forest resources map, proposition of new PA: potential, priority. Proposition of new production areas: potential, priority
6- Social forestry	Current and expected extension activities : location, activities, actors
7- Provincial action program	Program, projects, activities, timeline
8- Validity	5 years

In addition, additional contents found in PFPs designed in 2008 were organized in Figure 2.3-14 (the red colour represents the data related to spatial information, the blue colour represents other added data). Potential uses of existing forests were combined into the Introduction’, and forest resource map, suitable area for logging and suitable area were added as ‘Analysis of the situation’. In addition, forest plantations, SFM and REDD+ were mentioned in the section on ‘Future development of forests’. Lastly, monitoring and evaluation were added to the section on ‘Validity’.

Introduction + Potential uses of the existing forest

1. **Province profile + Stakeholders feedback; SWOT analysis**
2. **Current forest uses**
3. **Forest development goals and safeguard**
4. **Analysis of the situation** (suitability analysis)
   - Forest resources map
   - Not suited vs. suited areas for logging (environmental suitability/constraints)
   - Not suited vs. suited areas for logging (status)
5. **Future development of forests:**
   - Proposition of PA: potential areas, priority areas
   - Proposition of FMA: potential timber, priority areas
   - Proposition of Forest plantations: potential, priority
   - Proposition of further initiatives promoting SFM and REDD+ objectives
6. **Social forestry** (seminar, workshop, training)
   - Current extension activities (actors, locations)
   - Proposed extension activities
7. **Provincial action program**
   - Programme, projects, activities and timelines
   - Needs in budgets, and technical and administrative staff
8. **Validity, Monitoring & Evaluation**

Figure 2.3-14 Additional Content Found in PFPs Designed in 2008

Based on the above review results, the contents of the indicative PFP guidelines (2018) are summarized in Table 2.3-12. In Chapter 4 'Analysis of the situation', the current situation is assumed through land suitability analysis; in Chapter 8 'Validity', the budget and source of funding is summarized. In addition, monitoring and evaluation are assumed to be added (see Table 2.3-12 for a summary of the contents). Moreover, REDD + related efforts may be added to future forest development items. As for the Project, it is considering providing forest information from PNG-FRIMS.

Table 2.3-12 Indicative PFP GL 2018

Sections	Content
Introduction	Objectives, principles, stakeholders, Potential uses of the existing forest
1- Province profile	Location, Soil and Climate, Vegetation, Demography, Economy, Stakeholders feedback, SWOT analysis
2- Current forest uses	Protected Areas: status, activities; Production Areas: status, activities
3- Forest development goals and GL	Province goals using forests, priorities, safeguards
4- Analysis of the situation (land suitability analysis)	Forest resources map, areas not suited to logging, areas environmentally suited, status of areas
5- Future development of forests	Proposition of potential and priority areas for new Protected Areas, FMAs, plantations and other
6- Social forestry	Current and expected extension activities (location, activities, actors) including seminar, workshop, training
7- Provincial action program	Program, projects, activities, timeline; needs in human resources
8- Budget and source of funding	Cost estimation (act./budget), possible funds (province, PNGFA, external)
9- M & E	Validity of the plan, monitoring and evaluation act scheduled

2）Review of Data Required for PFP Document

The type of information required to design PFPs were reviewed by the Project team and C/P. As for the strategy of the provincial government, support from FCPF 2 project[28] is expected. As for forest data provided to the provincial government by PNGFA, support from the JICA project is expected (see Figure 2.3-15 for details).

[28] Project Title: Forest Carbon Partnership Facility II. Executing Agency: United Nations Development Programme. Implementing Partner: CCDA/PNGFA. Start Date: 1 January 2018. End Date: 31 December 2020

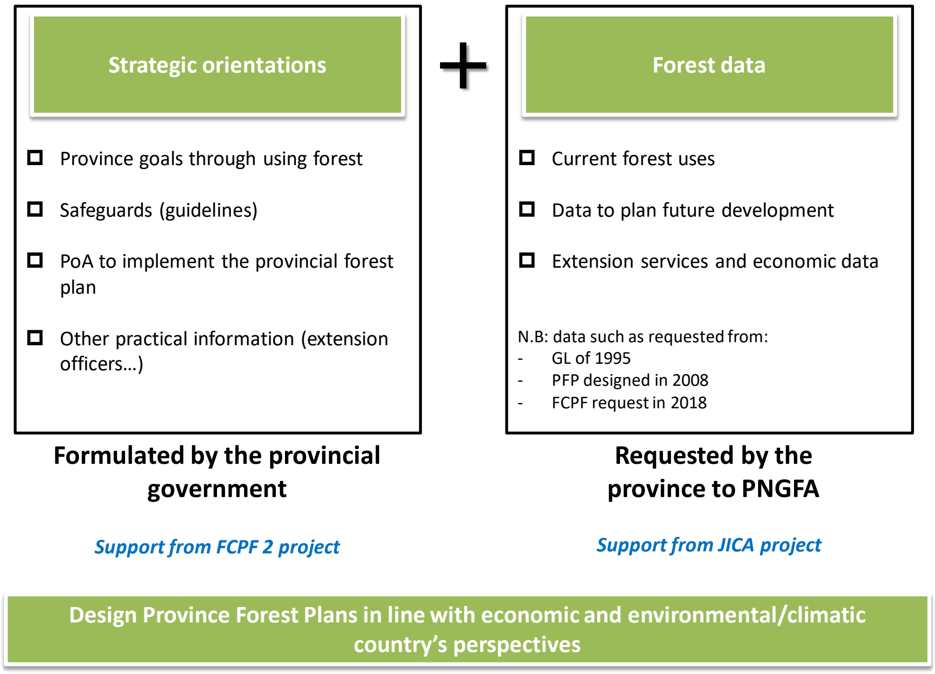


Figure 2.3-15 Types of Information Required to Design PFPs

In addition, the most up-to-date data among the data used in PFP were analyzed.

- To describe the current forest uses, information on existing protected areas (PAs) is updated by CEPA. Regarding existing production forest areas, information related divisions of PNGFA are used, but although not all information is completely stored in the database, PNG-FRIMS can support improvement on a lot of information. However, it should be noted that it is necessary to further verify technical and budgetary feasibility (see Table 2.3-13 for details).
- To plan future development of forest, the information on that is particularly revised by PNG-FRIMS includes forest resource maps, suitability / priority analysis of protected areas, suitability / priority analysis of forest management areas, suitability / priority analysis of plantation areas, etc. In addition to this information, information such as existing development and proposed development areas, value chains, timber production / export volume, royalties, revenues and taxes are also organized as databases, while it is thought necessary to examine information linked to spatial information (see Table 2.3-14 for details).

Table 2.3-13 Finding Most Updated Data (1)

Information Sought	Most Updated Sources	Possible Ways of Improving PNG-FRIMS
1) To describe current forest uses		NB: these options need examination of technical and budget feasibility
Existing Protected Areas (PAs)	CEPA, PNG-FRIMS	To update based on CEPA update Aug 2019
Existing production areas: Total	PNG-FRIMS (FIMS): - Adjusted Forest Area - Revised Gross Volume	Update constraints (Inundation and Karst) if there is possible method

FMA	FMA status: PAD, FSD Logged over areas: PNG-FRIMS	To integrate in PNG-FRIMS To update
AAC	PNG-FRIMS	To integrate in PNG-FRIMS
Processing activities	Province, PFO, DSS	To integrate in PNG-FRIMS
TA	Area / Provincial Offices	To integrate in PNG-FRIMS
FCA	PAD, PNG-FRIMS	To update
Community forestry	PFO	To integrate in PNG-FRIMS
Plantations	FDD, PNG-FRIMS	To update

PAD: Project Allocation Directorate; FSD: Field Services Directorate; PFO: Procince Forest Offices; FDD: Forest Development Directorate; DSS: Decision Support System; CEPA: Conservation and Environment Protection Autority

Table 2.3-14 Finding Most Updated Data (2)

Information Sought	Most Updated Sources	Possible Ways of Improving PNG-FRIMS
2) To plan future development of forest		NB: these options need examination of technical and budget feasibility
Forest resources map	Forest Cover Map 2015	On-going design of Forest Cover Map 2020
Suited and priority areas for PA (biodiversity and other values)	CEPA assessment, Province or LLG	To integrate in PNG-FRIMS
Suited and priority areas for FMA (constraint, timber density, etc.)	PNG-FRIMS (FIMS)	To update
Suited and priority areas for plantations (degraded forest and grasslands, soil)	Forest Base Map, forest degradation map PNGRIS and NFI for update	To update
3) Non forest data		
Existing and proposed extension activities	PFO	To integrate in PNG-FRIMS
Timber value chain: Annual harvest rates	FSD, dat in ALP: “Actual harvested volume”	Tp digitize in PNG-FRIMS
Timber production	DSS, Marketing branch, prov	To integrate in PNG-FRIMS
Log export	SGS, Export branch	No integration expected
Royalties	FSD royalty officers	No integration expected
Revenues, taxes, fees, infrastructures, jobs	Province, PFO, DSS	No integration expected

PAD: Project Allocation Directorate; FSD: Field Services Directorate; PFO: Procince Forest Offices; FDD: Forest Development Directorate; DSS: Decision Support System; CEPA: Conservation and Environment Protection Autority

3）Proposal of Directionality toward PFP Creation (FCPF Cooperation)

Regarding the PFPs, FCPF is requesting the revision of each PFP in Madang Province, West New Britain Province and East New Britain Province as an activity of the Project, PNGFA plans to approve FCPF request with the following conditions.

- Revision of the PFP guidelines, which are guidelines to be created by each province, based on recent changes in the situation related to forest and forestry

- In revising the PFP, PNGFA and consultants should work in support of the activities of provinces and governments, which are the guidelines creators
- For the revision activities of PFP guidelines, allow to include the activities of the Project, and reflect the findings and outcomes of the Project

Based on these results, the JICA Project decided to cooperate with the PFP guidelines and the revision work of PFP.

Needs:

- Active participation in teams centred on FCPF consultants and proactive incorporation of the results of JICA projects (e.g., describing PNF-FRIMS utilization in the PFP guidelines; in the PFP review work, PNG-FRIMS provided Forest Base Map, etc.)
- As for the review work of PFP, since only a few people are in charge of PNGFA, and because there is a limitation on input from this project, collaboration with FCPF consultants is planned for the preparation of PFP
- Concerning the data required for PFP, consider the method, the system, and the regulations for collecting data from the directorates / sections, with related data in PNGFA
- Consider and adjust the contents of data to be delivered by the GIS team of PNGFA, long-term experts and short-term experts so that the potential of PNG-FRIMS can be maximized
- Detect the causes that prevent PFP approval and performance in some provinces (of the 22 provinces, PFPs were formulated but are no longer valid in 19 provinces, were not implemented in Jiwaka Province and Hela Province, which were new provinces, and were not needed in the National Capital District)
- Evaluate reproducibility in other provinces with respect to trial results in pilot provinces (new guidelines, identification of reliable data sources, interagency cooperation, etc.)

Some preliminary suggestions for new guidelines:

- Make the content not too complicated (e.g. avoiding precise analysis of degraded drivers) and suitable for the capacity of PNGFA and provincial governments
- Reflect the importance of forest-based land use plan in PFP and present the possibility of contribution in PNG-FRIMS
- Present a standard format that reflects recent findings such as SFM and REDD +, and also provide a business workflow diagram for the provincial governments' work procedures and PNGFA's support system, etc., to encourage the provincial governments to formulate PFP voluntarily and continuously.

2.3.3 Provide Technical Input to Committees Related to Climate Change (Hosted by External Organizations)

(1) Technical Support of PNGFA at Climate Change Related Meetings and Events Sponsored by an External Organization

1) MRV-Technical Working Group (MRV-TWG)

Using the opportunity presented by the MRV Technical Working Group (MRV-TWG) organized by the CCDA (formerly the Office of Climate Change and Development, OCCD), the Project team gave technical input by reporting the results of the Project. In addition to that, long-term experts also participated and gave input as appropriate.

A presentation was given at MRV-TWG, held on17th March 2015, regarding the following content (see Annex 52).

- Time Frame of JICA Project (Former / Current)
- Review of Outcomes of Former JICA Project
- Review of Scope of New / Current JICA Project
- Introducing Outcomes of the Project by 2014
  - Basic Design of PNG-FRIMS
  - Accuracy Evaluation of Forest Base Map (ver.1.0)
  - Integration with Existing FIMS / PNGRIS Data / Info
  - Identifying the Requirement for REDD+ Support
  - Preparation for Data Sharing and Enhancement
  - Publicity (International / In-Country)
- Summary & Way-forward

Another presentation was given at MRV-TWG on 27th August 2015. The progress and outputs of the Project were shared with stakeholders, deepening technical understanding.

In the first half of 2016, the CCDA issued a series of studies for REDD+. These studies, commissioned by the FCPF REDD+ Readiness project and by EU-FAO, are listed here:

- National circumstances for REDD+, assessment of drivers and study of abatement levers
- National Forest Monitoring System (NFMS), Greenhouse Gas inventory (GHGi), FREL for REDD+
- Assessment of business cases for enacting a set of policies and measures to reduce the future impact of key agricultural commodities on forest cover in PNG
- The Forest Law Enforcement, Governance and Trade (FLEGT) programme action plan in PNG.

Input from PNGFA and the Project team for recent CCDA studies was summarized as follows:

- National circumstances / Drivers / Abatement levers: PNGFA, thanks to PNG-FRIMS, provided data and maps necessary to study National circumstances. The consultant in charge of the study worked closely with the JICA-PNGFA project.

- NFMS, GHGi, FREL: The roles of PNG-FRIMS and the Forest Base Map have been highlighted as essential components to determine Activity Data (land use changes).
- Impact of agricultural commodities on forest cover: The integration of PNGFA in the committee controlling future agriculture projects is important for avoiding competition / overlapping with logging projects. Also, the role of PNG-FRIMS and the Forest Base Map are important for supporting control of land use planning.
- Modeling future development of palm oil: This work can now be realized in and by PNGFA thanks to FRIMS, the Forest Base Map and the enhancement of analytical capacities brought by JICA.

In 2016, many consultations on FREL / FRL, which was the main subject of PNG, were held. As a result of this the committees related to climate change, including MRV-TWG, were not held; therefore, the opportunities to disseminate the progress related to the outcomes of the Project as well as to input these activities to the communities were limited.

In 2017, the Technical Working Group or Committee was not held; however, several unofficial meetings were held to prepare GCF proposals. Moreover, the Project team was invited to participate in these meetings, as the important stakeholder working inside of PNGFA. The long-term expert team took part in these meetings. Prior to these meetings, the JICA expert team held consultations in advance, and the input of technical aspects and information was provided during those consultations. At the meetings, the schedule for the preparation and submission of GCF proposals, the plan of activities for the forest sector examined by PNGFA and the Project, the schedule for submitting the request form for the next JICA project, and the timing of confirming detailed contents were shared.

2）TLVS Workshop

A workshop on the Timber Legality Verification System (TLVS) was held as part of the support of the Timber Legality Standard (TLS), organized by FAO and funded by the EU. There was a request for a report giving an overview of PNG-FRIMS, as a spatial information database and the basis of appropriate forest operation management and monitoring by PNGFA. PNGFA and JICA considered the preparation of the presentation materials to be a technical input opportunity for the concerned parties. The Chair's Summary stated expectations for TLVS to utilize PNG-FRIMS. An outline of the presentation given on 20th June 2018 is as follows.

Title: How Can PNG-FRIMS Contribute to TLVS?

- What is FRISM?
- What is FRIMS? (available GIS data / layers)

- What are the Functions of FRIMS?
- Contribution to monitoring / planning of LCoP
- Contribution to TLVS through the DSS

(2) Examination of Utilization Method of Information of PNG-FRIMS Corresponding to a Request from an External Organization

As PNG-FRIMS contains a greater variety of information, especially forest information, than any other database in PNG, other organizations sometimes request that PNGFA provide information to them. Although PNGFA is very cautious about providing data, from the viewpoint of data confidentiality, it is necessary to provide data strategically in order to actively participate in the formulation of the policies of other organizations that are expected to have an impact on forest management.

The Project has tried to identify, utilizing information stored in PNG-FRIMS, possible locations to be specified as High Conservation Value Forests (HCVF) and High Carbon Stock (HCS) — these locations are considered to be areas in which conversion to oil palm forest should be avoided according to the international palm oil certification system. Development of oil palm forest is one of the drivers of deforestation in PNG. Thus, PNG is planning to control the development of oil palm forest through the spread of the international certification system in the whole country.

HCVF is a kind of forest that has great biological, ecological, social, and cultural value; such forests are of outstanding significance and critical importance. HCS forests, such as secondary forests, are carbon rich ecosystems that cannot be distinguished using an HCVF approach. Identifying both kinds of ecosystems before developing agricultural fields has become a requirement, so different types of analyses are necessary. It is efficient to utilize certain kinds of information — such as forest cover, protected areas, village points, soil, climate, geology, and roads — in identifying HCVF and HCS. Therefore, PNGFA, which owns this information, is expected to play a certain role.

The Project analyzed the methodologies used to identify HCVF and HCS and examined how to utilize the information stored in the PNG-FRIMS (see Annex 36). Thereafter, the Project tried to specify and identify the possible locations of HCVF and HCS by utilizing information available in PNG-FRIMS, and share the result with the C/P for discussion about how to utilize the information stored in PNG-FRIMS.

Table 2.3-15 Possibilities of Obtaining and Utilizing Spatial Information for Identifying HCV Areas

	Global (examples)	National (in case of PNG)
Biodiversity priority area	Global IUCN Red List	Biodiversity priority area (CEPA)
Designation of authorities	World Heritage Sites	Protected area (CEPA)
Natural habitat	Ramsar sites	Biodiversity priority area (CEPA)
Low levels of disturbance	Hansen loss	Forest cover map (PNGFA)
High connectivity	Hansen tree-cover	Forest cover map (PNGFA)
Remaining natural ecosystems	Intact Forest Landscapes	Forest cover map (PNGFA)
Presence of RTE ecosystems	Global IUCN Red List	Biodiversity priority area (CEPA)
Remote and/or poor rural areas	Open Street Maps	Census unit (PNG statistical office)
Naturally low soil fertility	FAO/UNESCO Soil Map	PNGRIS (UPNG)
Important wetlands	CIFOR map	Forest cover map (PNGFA)
Municipal water sources	---	---
Steep areas, or areas of high rainfall	WorldClim	PNGRIS (UPNG)
Arid or dryland areas	WorldClim	PNGRIS (UPNG)
Access to health centres or hospitals	Open Street Maps	GeoBook (UPNG)
Water and electricity infrastructure	---	---
Low capacity to accumulate wealth	---	---
Living “day to day”	---	---
Small or subsistence scale farming	---	Forest cover map (PNGFA)
Indigenous hunter-gatherers	---	---

Table 2.3-16 Typical Data Needed for Integration of HCV-HCS-FPIC

ENVIRONMENTAL DATA	SOCIAL DATA	GEOSPATIAL DATA
• Topography and slopes	• Location of villages	• Digitised Elevation Model (DEM)
• Vegetation cover	• Stakeholder mapping, including local NGOs and development projects	• Company development plans
• Soil (especially peat)		• Satellite images (e.g. Landsat/ Sentinel)
• Hydrology	• Demographics	• LiDAR data (if available)
• Existing biological studies (recent)	• Ethnographic tenure data	• Initial land cover maps
• IUCN Red List and maps	• Land cadastre	• Administrative boundaries
• CITES list	• Existing socioeconomic studies (recent)	• Other concessions’ boundaries
• Key Biodiversity Area	• Language background	• Protected area boundaries
• National protected species list	• Cultural background	• Moratorium maps (if applicable)
• Protected areas	• Ethno-botany studies	• Forest and state area maps
• Analysis of relevant environmental plans, policies and regulations	• Socioeconomic status and development needs	• Land system maps
	• Relevant official social and development plans, policies and regulations	• Spatial planning maps
• History of forest disturbance		• Physiographic regions

2.3.4 Conduct Training on Measurement and Reporting of Carbon Emissions and Removals from Forests

The training on measurement and reporting of carbon emissions and removals from forests, which was part of a broader course on international carbon offset frameworks, contribution of the Project to REDD+ and possibility of REDD+, trials of forest carbon emission and removal calculation, and possibility of estimation of carbon emissions from forest degradation by logging at the field level using PNG-FRIMS were reviewed and discussed.

The contents of these training sessions regarding measurements and reporting of carbon emissions and removals from forests are shown in Table 2.3-17. A training document on ‘International Carbon Offset Frameworks’ can be found in Annex 37, and a training document on the ‘Possibility of REDD+ in PNGFA Activities’ is in Annex 38. The contents and achievements of this training are also shown in ‘Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)’.

Table 2.3-17 Contents of Training on Measurement and Reporting FREL / FRL and Achievements of the Training

Title	Participants	Contents	Duration	Achievement
International Carbon Offset Frameworks	Constin Otto Bigol, Margaret Tongo, Ledino Saega, Samuel Gibson, Perry Malan, Patrick La’a, Jehu Antiko, Gewa Gamoga, Karokaro Mau, George Gunga, Jason Sigamata, Elizabeth Kaidong	- Introduction of existing carbon project methodologies in the forestry sector: main methodologies and methodologies specifically useful in PNG - Introduction of data/parameters and methods used to assess forest degradation in projects - Introduction of the procedure to estimate forest carbon stock changes in large scale projects - Explanation of relevant matters required for REDD+ in PNG-FRIMS	Jun. 2015 (1day)	Interested PNGFA officers got a small overview of international carbon offset frameworks, but this was insufficient
REDD+ Concept & JICA-PNGFA Project	Constin Otto Bigol, Margaret Tongo, Gewa Gamoga, George Gunga, Perry Malan, Patrick La’a, Jehu Antiko	- Review and discussion of contribution of the JICA-PNGFA Project to REDD+ and possibility of REDD+ in PNGFA activities	Jun. 2016 (1day)	Though there are a few chances to discuss REDD+ at PNGFA, this was a chance to consider availability of PNG-FRIMS in REDD+ and possibility of REDD+ in PNGFA activities
Trial Forest Carbon Emissions and Removals Calculation	Perry Malan, Jehu Antiko	- Introduce a trial calculation of carbon emissions and removals using forest cover maps for 2000, 2005, 2011 and 2015 and Hansen Loss	11 Mar 2019	Database and RS/GIS officers confirmed one of the applications of forest cover maps; carbon emissions and removals.

		year data.		
Possibility of Estimating Carbon Emissions from Deforestation Due to Logging at the Field Level Using PNG-FRIMS	Ruth Turia (Dr), Dambis Kaip, Gewa Gamoga, Perry Malan, Rabie Lalo, Elizabeth Kaidong (Forest Planning & Policy Directorate) Andrew Aopo, Lyall Umbo, Kusip Ivo, John Orabi (Field Services Directorate) Magdalene Maihua, Guduru Romeo, Charles Pakure (Project Allocation directorate) Hitofumi Abe (Dr), Masamichi Haraguchi	-Introduction and review of main methodologies to estimate emissions from forest degradation due to logging - PNG potential to calculate emissions based on available information and practical case of use in the context of REDD+ (for the national FRL) - Additional activities to examine the possible utilization of outcomes from developing the Volume Method (volume data, Emission Values, Emission Factors) for general purpose of forest management	23 May 2019	General knowledge in carbon methodologies in the Forestry sector was acquired. Main potentialities from daily activities in each PNGFA Direction were identified. Gaps in estimation of emissions were analyzed. Capacities and resources to increase PNGFA operationality for future needs in estimating carbon emissions specific to the logging sector were developed. Outputs of this workshop were summed up as a report 'Potential in Papua New Guinea to Estimate Carbon Emissions from Forest Degradation Caused by Logging Based on Field Methods (by Using FRIMS)'.

Chapter 3. Lessons Learned and Recommendations

3.1 Lessons Learned in Project Management

3.1.1 Outputs Dissemination Activities: Publications (Fact Sheet Series, Big-Book)

Since the purpose of the JICA T/C is to improve the capacity of the C/P and to improve their organization system as well as NFRIMS, the reports compiled in the Project are also about capacity strengthening, and many of the deliverables defined in the PDM are mainly manuals aimed at improving the forest administration and management (policy, planning and monitoring) of PNGFA. There was no publication that defined the outcomes for external sharing.

In general, especially regarding REDD+, there has been an increase in requests from other government agencies and related projects for the sharing and utilization of forest resource information in PNG-FRIMS, such as the Forest Base Map. Despite this, PNGFA has been cautious in sharing results externally, because of a lack of materials explaining the information (e.g. methods and specifications for maintenance, restrictions, and precautions).

As for the Project, in order to improve matters on this issue, materials (such as about the background, purpose, development method and specifications, summary of results, limitations, and notes) were compiled into a Fact Sheet series to explain the products developed in PNG-FRIMS. In addition, themes which are useful organized as results of analysis and examination were compiled as Analytical Reports, although their external disclosure as 'Facts' should be done carefully.

Table 3.1-1 Fact Sheet and Analytical Report

Report No	Theme
Fact Sheet No. 1	JICA-PNGFA Project Outline
Fact Sheet No. 2	Papua New Guinea Forest Base Map 2012
Fact Sheet No. 3	PNG-FRIMS
Fact Sheet No. 4	Forest Monitoring Unit (FMU) in Papua New Guinea Forest Cover Map
Fact Sheet No. 5	Constraints Data – Natural Condition Layers in the PNG-FRIMS
Fact Sheet No. 6	Watershed and Catchment Data
Fact Sheet No. 7	Digitized Road Information
Fact Sheet No. 8	Forest Concession and Land Management Layers in PNG-FRIMS
Fact Sheet No. 9	Forest Cover Map 2015
Fact Sheet No. 10	Drone Applications in Sustainable Forestry Management and Monitoring in PNGFA
Analytical Report No. 1	Analysis of Drivers of Deforestation and Forest Degradation in Papua New Guinea

Analytical Report No. 2	Analysis of Future Forest Change Modeling in Papua New Guinea
Analytical Report No. 3	Potential in Papua New Guinea to Estimate Emissions from Forest Degradation Caused by Logging Based on Field Methods (using FRIMS)

In addition, with regard to the Forest Base Map, for which particularly large number of requests are received, it was proposed by the C/P that it should be compiled as an Atlas that included the organization of development methods in the preceding T/C, together with profiles such as characteristic tree species for each province, logging concessions, constraints, and protected areas. This was organized by the C/P as the 'Papua New Guinea Forest Base-Map and Atlas' and the 'Papua New Guinea Forest Resource Information Management System (PNG-FRIMS)' (commonly known as the 'Big-Book').

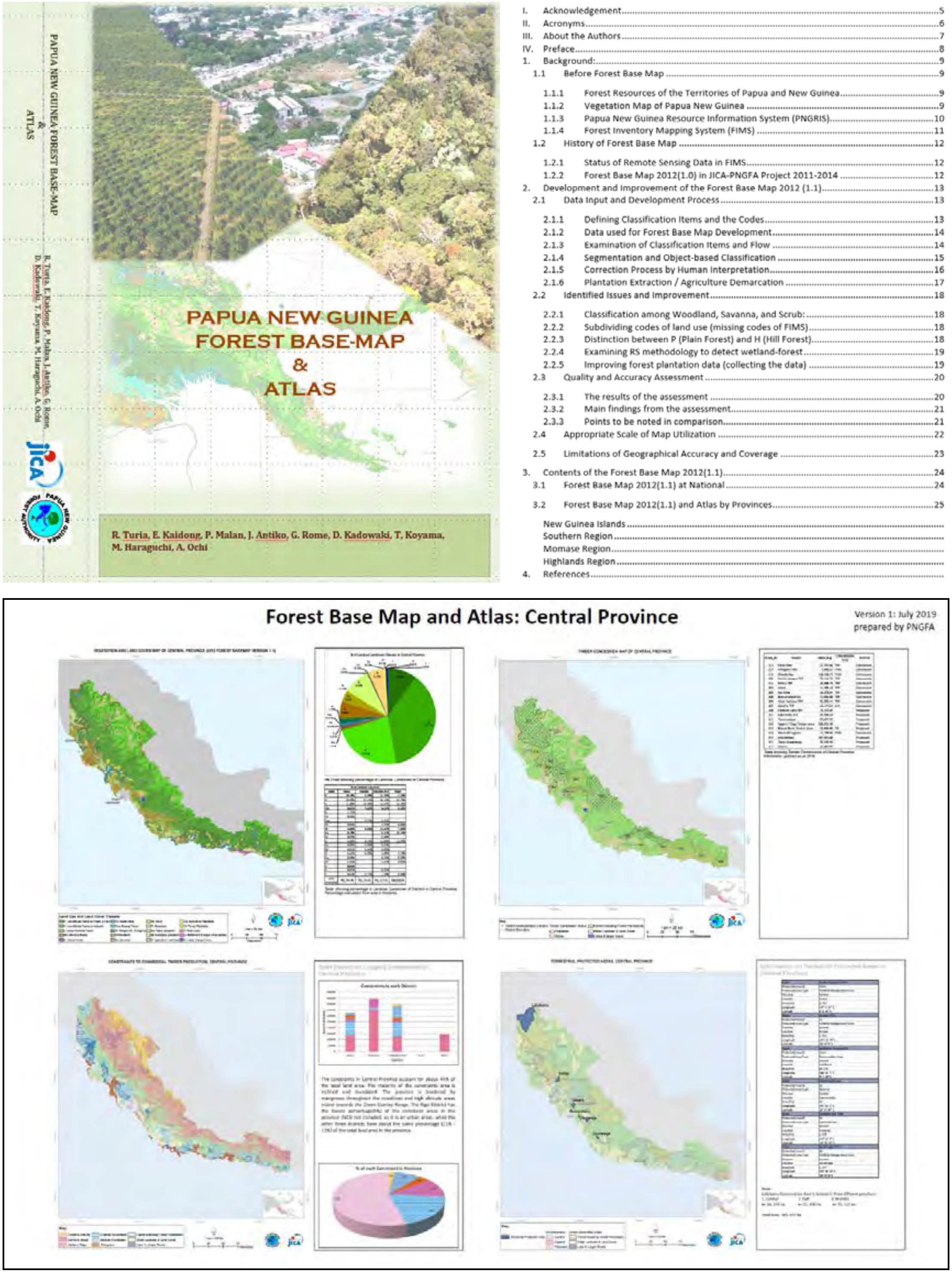


Figure 3.1-1 Publication of Forest Base Map (Papua New Guinea Forest Base-Map and Atlas)

3.1.2 Practice in Forest Planning and Monitoring of the Latest Technology (e.g. Drones)

This Project was designed in 2013 and started in 2014. Because the subsequent evolution and improvement of forest monitoring technology was remarkable, it became necessary to consider the application of the latest technology while considering the contents of the PDM. Therefore, various new technologies related to PNG-FRIMS (such as UAV / drone, Collect Earth, Google Earth Engine, GLAD Alert, and JJ-FAST) were introduced in the training in Japan held in September 2017 on 'Forest Resource Monitoring and Data Management'. Such technologies were also examined for their future utilization for the forest management plan and monitoring work in PNG.

In response to the results of and reports about the training in Japan, the C/P made a large request for the utilization of UAV / drones for improvement on problems in the forest operation planning and monitoring in the field. Therefore, field trials on forest operation planning and monitoring were conducted and, as a result, UAV / drone utilization manuals and guidelines have been developed. In addition, the C/P officers who participated in the training in Japan took the initiative in drone training for forest management, planning and monitoring in PNG, which included local staff. This local training was featured in the media (see Figure 3.1-2 and links immediately following (accessed on 4 March 2019)).

In addition, the activities and results were reported at the Pacific Islands Region UAV workshop held in Fiji in May 2019. It was highly appreciated by people in the region and neighboring countries, who were impressed because the practice had progressed not only in technical examination and research and development, but also in forest planning and monitoring work.

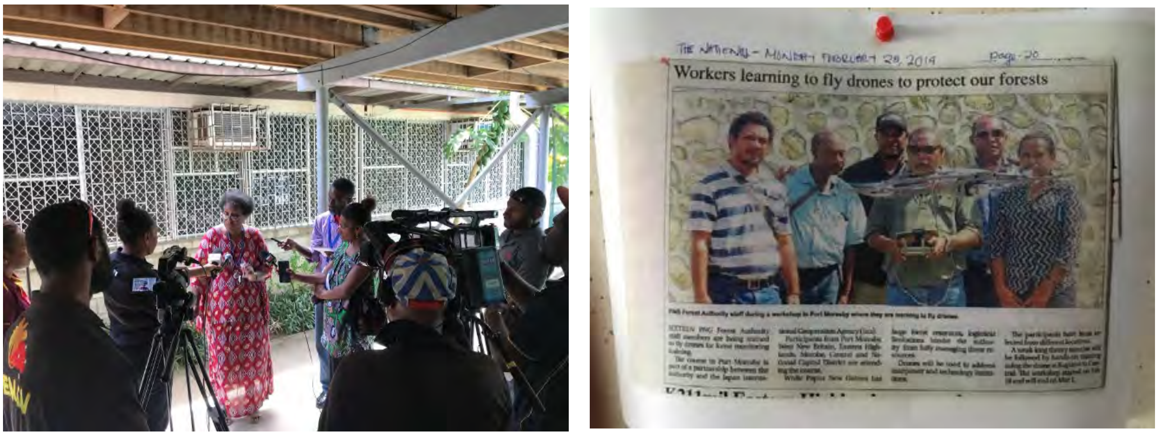


Figure 3.1-2 Drone Training and News Media in PNG

- Post-Courier, 21st February 2019, 'Forestry Hosts Drone Workshop':
  https://postcourier.com.pg/forestry-hosts-drone-workshop/
- Loop, 26th February 2019, 'Forestry staff trained on drone usage':
  http://www.looppng.com/tech/forestry-staff-trained-drone-usage-82785
- Loop, 2nd March 2019, 'Forestry officers upskilled on drone usage':
  http://www.looppng.com/tech/forestry-officers-upskilled-drone-usage-82886
- EMTV Online, 3rd March 2019, 'PNG Forest Authority Incorporating Drones for Forest Monitoring'
  https://youtu.be/Qdp8_7ktm9o

3.1.3 Setting up Implementation System with Local Sub-Contract and Local Staff / Experts

There are three members on the cartographer team in the I&M Branch, which is responsible for developing GIS data. At the beginning of the Project, technology transfer for all tasks was carried out for all members, but with the limited number of workers and their regular work duties, it became difficult for all members to participate in all of the technology transfers. Therefore, the system has shifted so that the technology can be learned and work promoted, with the roles of the three members being shared. One is responsible for overall management as the team leader, one is mainly responsible for PNG-FRIMS operation and management, and one is mainly responsible for creating data and maps.

The Project has been steadily expanding and strengthening PNG-FRIMS behind the lead of the C/P. However, at some point in the process, it became apparent that additional work was needed for the initial plan of the Project. Specifically, it became clear that it was desirable to develop logging history information (logged over area) for the logging concessions as data that can be used to accurately understand deforestation and degradation that accompanies forestry activities. It further became clear that the maintenance of boundary information about FCA areas was also desirable, in order to grasp FCA activities, which are a major deforestation factor.

All of this work is important for the expansion and reinforcement of PNG-FRIMS. However, it was concluded that it would be difficult for only the C/P and the assignment of Project members to implement the work. In addition, although the kinds of work are diverse, they are related to each other, and it is necessary to communicate closely with PNGFA officers to carry them out. In addition, it is desirable to be able to control access to information in order to deal with PNGFA's internal information when performing work operations. In order to meet these requirements, a proposal was made to the C/P and JICA by the Project team, to utilize local sub-contractors and local staff / experts, and to put an implementation system in place.

On-site sub-contracting work promoted stock checking and the listing of concession information managed by PNGFA, as well as logging plans and logging history submitted by logging companies. As a result of confirming with Directorates and Area / Provincial offices other than the I&M Branch, it was clear that not all information was collected at the I&M Branch and that there was a lack of data — as this data is for the logging concessions which were approved about 50 years ago. Therefore, although complete development is difficult, the investigation and scanning of paper maps stored at PNGFA and the conversion of GIS data were both promoted in order to make improvements on these issues.

Since PNG logging is basically selective logging, it is difficult to reliably detect logging locations with medium resolution satellite images such as LANDSAT. Therefore, a system — which combines buffer analysis from relatively easy-to-confirm logging roads and logging records submitted by the companies for monitoring — was developed by the Project with the use of local sub-contractors. At the same time, because the C/P had hoped to use satellite data to actively monitor logging activities, an early logging location detection system using Google Earth Engine was also examined and developed for pilot provinces.

As a follow-up on issues and needs that have become apparent through local sub-contracting work, several local staff / experts were employed to carry out listing and map scanning, and GIS data conversion (digitizing) of logging plans, logging records, and FCA areas under the control and management of the C/P. In addition, local staff / experts made a substantial contribution to preparation for the drone training and the final seminar. This system and the outputs were also recognized by PNGFA management; the Project Director, Managing Director and the new Minister of Forests stated that the continued employment of the local staff / experts will be considered after the Project.

3.1.4 Contribution to Climate Change Measures in Collaboration with Other Donors (FAO, UNDP / FCPF)

PNG submitted the FRL, which is one of the four elements of REDD+ readiness, to the UNFCCC in January 2017, with the support of the FAO. The revised version was completed after technical assessment and published in March 2018, as was the evaluation report. In addition, NRS was officially approved in May 2017, having been prepared by the CCDA with the support of the FCPF and the UNDP. PNG-FRIMS, which was supported by JICA, also contributed to the submission, being utilized in preparation of the FRL and NRS as a source of important forest resource information owned and managed by PNGFA.

PNG also created and submitted the proposal Concept Note to the GCF based on the contents of the FRL and NRS, with the coordination of the CCDA and FCPF / UNDP and cooperating with related organizations, including JICA. One of the activities in the Concept Note is ‘Enhancing monitoring and enforcement of PNG’s Timber Legality Standard’, which is related to the utilization of PNG-FRIMS and expansion of JICA Project Outputs. Adoption of the Concept Note has not been decided upon yet, but currently, the concerned parties are working together to prepare the RFIP. The JICA Project is also giving input.

Information and contributions can be provided by PNG-FRIMS to SFM, which is positioned as part of REDD+ in a broad sense. These were considered and proposed based on discussions with stakeholders, and were further used in considering the future direction of PNGFA. In addition, with regard to the PFP, about which PNGFA is supporting the provincial government with the assistance of the FCPF, there were reviews of 1) the preparation process of PFP guidelines and 2) the data required in PFP documents. These reviews were given as input to PNGFA and FCPF as possible uses of PNG-FRIMS. These inputs were expected to be utilized in the revised PFP guidelines, currently being finalized and in future implementation.

In addition, the development of the TLS in PNG has been promoted by the FAO with EU funds based on the support of ITTO. Study of the TLVS is underway, as a concrete implementation of TLS. As a result of a presentation about PNG-FRIMS at the TLVS workshop, PNG-FRIMS and the DSS have been positioned as important existing systems to be utilized under TLVS in a broad sense. In particular, expectations were raised about utilizing drones in the implementation of LCoP, which is supported by JICA, as a baseline and monitoring tool to promote and verify proper logging activities.

In addition, logging data collected and managed in a conventional manner by PNGFA, and used in estimates of carbon emissions from forest degradation, were investigated. Specifically, the potential for preparing and utilizing this information in PNG-FRIMS in the future was looked at, organized, and proposed. In the current PNG FRL, measurement of forest degradation is performed on a RS basis. However, in PNG — where timber production is important and is a driver of forest degradation — the Volume Method, based on IPCC guidelines and adopted in other countries, may have potential as a way of evaluating policies and measures on timber harvesting. The Volume Method might possibly improve the FRL in the future, and using it can be considered a future PNGFA activity.

3.2 Recommendations on Future Forest Monitoring

Forest monitoring in PNG has made great progress based on the support and contributions of the Japan's Grant Aid Programme and the JICA T/C, which began in 2010-2011. Moreover, in recent years the REDD+ readiness stage, implemented under the UNFCCC and in cooperation with the support of FAO and UNDP, has borne fruit in the National Forest Monitoring System (NFMS), one of the requirements of that stage. In the future, SFM and REDD + will shift from readiness to implementation and monitoring policies and measures. The following sections, in which recommendations for future forest monitoring have been organized, are based on the contents described earlier in this report.

3.2.1 Complete Implementation of the Logging Code of Practice (Support for Timber Legality Certification and Verification)

The LCoP was formulated in 1995 and was reviewed in 2014 (the revised version has not been approved as of August 2019). However, thus far it has been difficult to say that it has been sufficiently implemented and monitored, due to technical and financial challenges. Improvements in monitoring methods, such as forest resource information developed in PNG-FRIMS and the utilization of drones, will eventually establish the capacity and system for the full implementation of LCoP. In addition, since the reduction of CO_2 emissions by logging activities is anticipated with the full implementation and monitoring of LCoP, it is also expected to be a REDD+ activity. LCoP compliance is also expected as one of the implementations of the TLS, and PNG-FRIMS, which prove and verify the legality of the produced timber, is also expected as part of the broader TLVS. In addition, for REDD + activities and TLVS support, it is important to measure the impact of the full implementation of LCoP from the perspective of carbon emissions and legality, and ensure an implementation monitoring system based on these perspectives. Through this, more direct contributions are possible.

3.2.2 Local Deployment of PNG-FRIMS (Collaboration with Decision Support System)

PNG-FRIMS is a system established at the headquarters of PNGFA, and the C/P at HQ had acquired capacity related to maintenance and operation. In the pilot provinces and concessions, utilization of PNG-FRIMS has been considered and tried, but it is difficult to say that capacity strengthening and system maintenance are sufficient. In particular, the operation of the PNG-FRIMS LAN-Map was planned only on the PNGFA intranet in the initial plan, in consideration of information security. However, with regard to DSS, a plan to connect the headquarters and provincial offices with a dedicated line was overlooked. DSS is currently located in the externally accessible De-Militarized Zone and is controlled by users and passwords. Although the URL creation function of maps has already been realized as LAN-Map's DSS support function, PNG-FRIMS also needs to be installed in the same zone as DSS. Security measures are also necessary for the external publication of PNG-FRIMS.

3.2.3 Updating Volume Information of PNG-FRIMS / Forest Map Using NFI Data

The NFI project currently being implemented by PNGFA and FAO with EU funding has been conducting ground surveys on approximately 1000 selected sites from all over PNG. The NFI project is scheduled to end in September 2019; however, the activities are taking much longer time than planned, for example, accessing the survey locations, promoting the awareness of landowners for the survey and collecting biodiversity information. As a result, the survey could not be fully completed but it will be organized once only in some areas (the survey will continue with FCPF-II funds until the end of March 2020, after which the EU is considering continuing support). In addition to detailed forest carbon stocks per forest type based on PNGRIS, timber volumes can also be obtained once the NFI surveys and analysis are completed. Although consideration was given to revising the commercial timber volume set in the PNG-FRIMS Forest Base Map using NFI data, it could not be completed, so it is expected to be revised after the end of the surveys and analysis.

3.2.4 Quantitative Evaluation of Reduced Impact Logging and Examination and Construction of Regrowth Model of Secondary Forest

As mentioned in 3.2.1, the full implementation of the LCoP is also expected to be a REDD + activity, Reduced Impact Logging, but there are issues where definitions and data for impact assessment are not sufficiently organized and collected. First, it is necessary to analyze the relationship between existing PSP data and logging data, and establish a PSP monitoring system in the future. In addition, functions have been developed in PNG-FIRMS, one that simulates the process of restoring forest after felling and one that estimates AAC. At first, incorporating PINFORM was considered, but it was difficult to clarify the details of the model and the data was based on specific regions, so implementation was postponed and a simple linear regrowth model was used. However, an examination of scientific foundations and the construction of forest regrowth models of secondary forest based on field survey results are expected.

3.2.5 Improvement of Accuracy of Forest Plantation Information, Selection of Suitable Site and Implementation of Plantation

During the development of PNG-FRIMS, it became clear that there was a gap between the information about plantation area possessed by the Forest Development Directorate (including the Plantations Branch) and the information prepared in the form of PNG-FRIMS by the I&M Branch. The plantation forest information of PNG-FRIMS / the Forest Base Map was prepared based on GIS data possessed by the I&M Branch. On the other hand, the information of the Plantations Branch is based on information from the measurement and data of the plantation company and the afforestation staff in the field, but it is not necessarily GIS data. Moreover, a lot of information has not been updated for a long time. Nevertheless, PNG has set a planting target of 250,000 ha by 2025 and a target of 800,000 ha by 2050 in Vision 2050. However, it is challenging considering that the existing plantation area is 50,000 ha. In order to achieve these goals, it is necessary to improve the accuracy of the existing forest plantation information and select a suitable area for plantation to promote it. It is hoped that the capacity development of on-site afforestation staff for updating the plantation data that was announced by the C/P in the final JCC meeting, and information sharing between the Forest Development Directorate and the Forest Policy and Planning Directorate, will be implemented.

3.2.6 Practice of Accounting for Carbon Estimates from Forest Degradation Using Logging Data

Under the activities of Output 3 of this Project, estimates of forest carbon emissions, made using logging data collected and managed in a conventional manner by PNGFA, were investigated. In addition, issues related to their potential and implementation were organized. PNGFA is interested in how effective the implementation of the LCoP, which is a means for SFM, would be as a mitigation measure for climate change (and as a REDD+ activity) and interested in the practical application of this proposal. In order for it to be put into practice, it may be necessary to collect more data, as currently both the quality and quantity of data are not sufficient to implement estimates of forest carbon emissions. In addition, effort and cost will be required; the results of actual emissions calculation should be verified in the pilot area; and, based on the results, consideration should be given to revising the LCoP and PMCP.

The contents described above were included in the application for the next JICA Project, scheduled to be submitted by PNGFA. As for the Project, the preparation of the request for the next project is also considered to be significant as part of the capacity development of the C/P. The reference materials prepared during the request process are attached for reference (Annex 39 and 40).