

**Papua New Guinea
Forest Authority**

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

**FINAL REPORT
(Summary)**

September 2019

JAPAN INTERNATIONAL COOPERATION AGENCY

KOKUSAI KOGYO CO., LTD.

GE
JR
19-046

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)

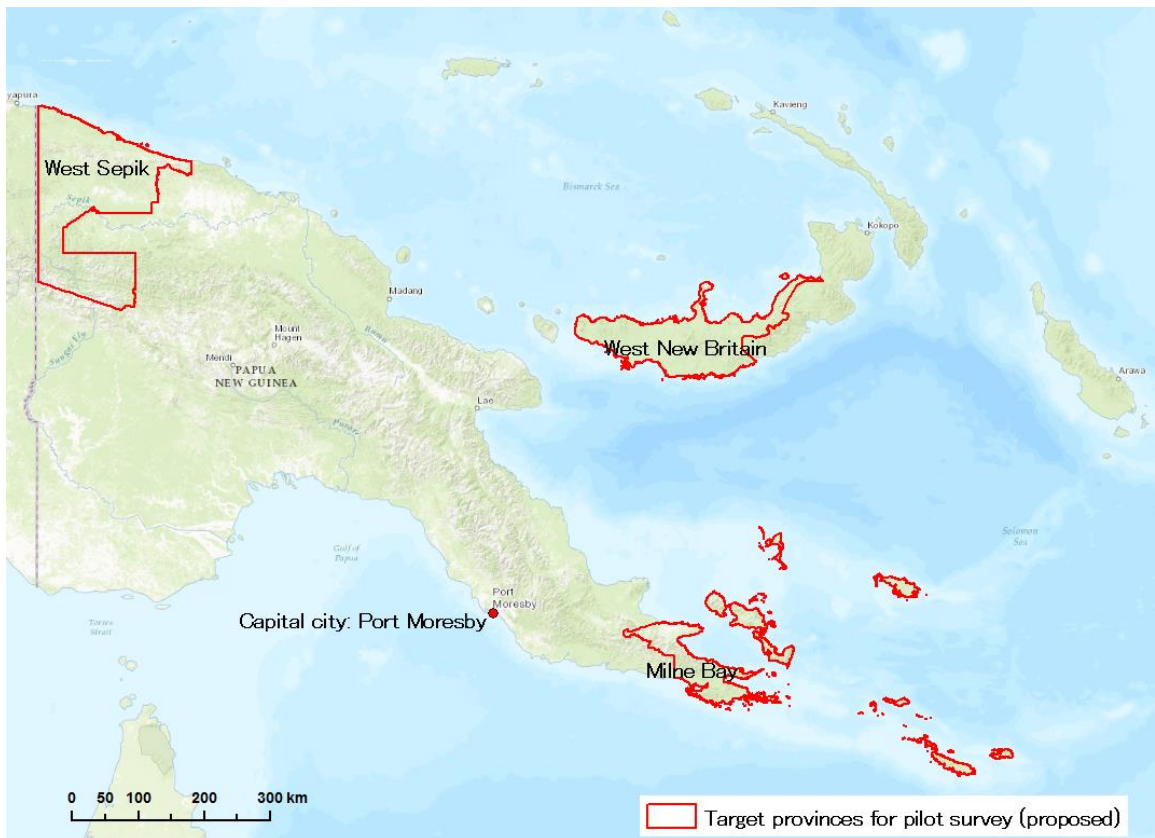


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Abbreviations

AAC	Annual Allowable Cut
AD	Activity Data
ALP	Annual Logging Plan
C/P	Counterpart
CCDA	PNG Climate Change and Development Authority
CfRN	Coalition for Rainforest Nations
CIFOR	The Center for International Forestry Research
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
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
FREL	Forest Reference Emission Level
FRI	Forest Research Institute
FRL	Forest Reference Level
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
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
JCC	Joint Coordinating Committee

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
LIF	Logging Infrastructure Factor
LULUCF	Land Use, Land Use Change and Forestry
MRA	Mineral Resource Authority
MRV	Measurement, Reporting and Verification
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
NRS	National REDD+ Strategy
NSO	National Statistical Office
OCCD	Office of Climate Change and Development
OJT	On-the-Job Training
PALSAR	Phased Array type L-band Synthetic Aperture Radar
PaMs	Policies and Measures
PDM	Project Design Matrix
PF	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
PSP	Permanent Sample Plots
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
REL	Reference Emission Level
RFIP	REDD+ Finance Investment Plan
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
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

Preface

Background of the Project

Papua New Guinea (hereinafter referred to as “PNG”) has one of the largest tropical rainforests in the world — playing an important role for PNG in many aspects and contributing to the national economy through timber exports and rich biodiversity. In recent years the tropical rainforest’s potential to contribute to the mitigation of climate change has been discussed. However, the areas of forests in PNG decreased from 82% to 71% between 1972 and 2002¹, 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 GIS system, and PNGFA also attained basic institutional capacity. However, 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.

Purpose and Goal of the Project

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.

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.

Outputs

- 1: PNG-FRIMS is expanded and enhanced.

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

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

- 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.

Project Target Group: Staff of PNG Forest Authority (PNGFA)

Project Target Areas: The whole of PNG and pilot areas of the Project, which are West New Britain Province, Milne Bay Province and West Sepik Province

Work Flow

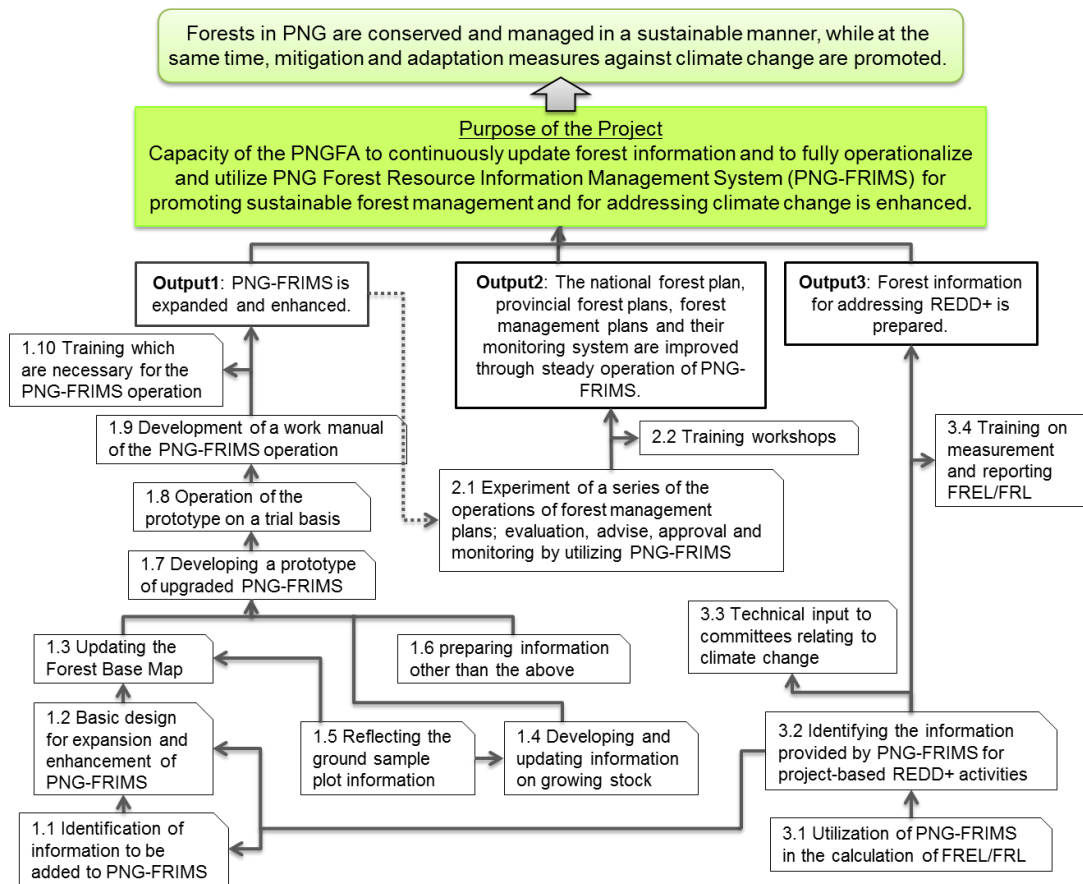


Figure 0-1 Implementation Flow of the Project

Project Operations

Technology Transfer

The plan of technology transfer and guidance for the counterpart (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. The technology transfer policy, training content and achievements were compiled in the final report of on the Technology Transfer Plan and Achievements (July 2019 version) (Annex 44).

Outputs of the Project

Technical cooperation outputs from the Project are shown in Table 0-1.

Table 0-1 Technical Cooperation Outputs

Outputs	Annex No.	Indicators in Project Design Matrix (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

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

<https://www.jica.go.jp/project/png/002/index.html> (Japanese)

<https://www.jica.go.jp/png/english/activities/activity12.html> (English)

2) Project Facebook Page

<https://www.facebook.com/jica.png.forest.monitoring/>

3) Project Fact Sheet & Analytical Report

Table 0-2 Project Fact Sheet Series (Annex 6)

No.	Title	Issued date	Number of copies
Fact Sheet No.1	JICA-PNGFA Project Outline	Nov. 2014 Feb. 2018	500 copies
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
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Table 0-3 Project Analytical Report Series (Annex 6)

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 (Annex 7)

Papua New Guinea Forest Base-Map and Atlas

Papua New Guinea Forest Resource Information Management System (PNG-FRIMS)

5) Attendance at COP20 and COP21 (Annex 46)

6) Project Debriefing Meeting (22 November 2017) (Annex 47)

7) Project Final Seminar (18 July 2019) (Annex 49)

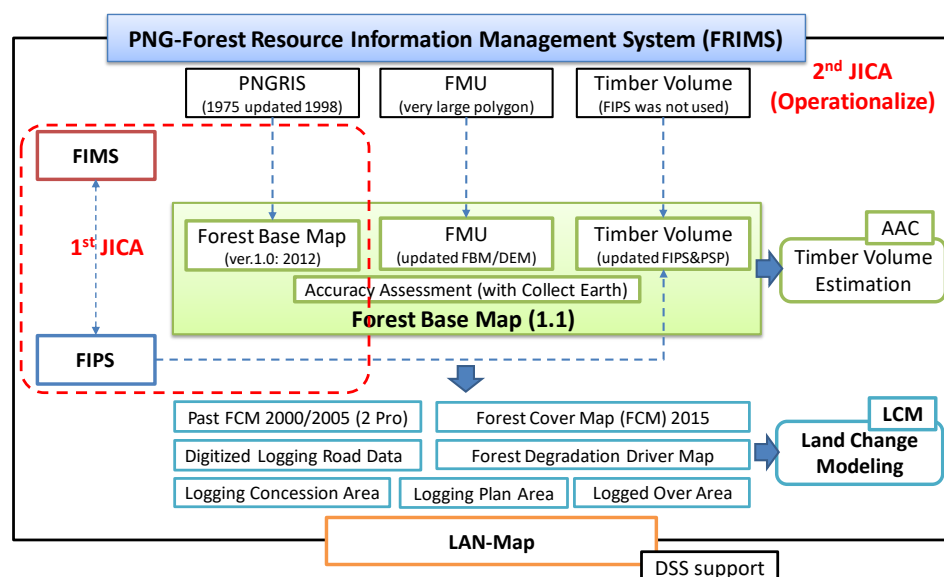
8) TLVS Workshop (Annex 48)

9) Coverage by CNN

Chapter 1. Output 1: Expansion and Enhancement of PNG-FRIMS

Summary of Output 1: Establishment of capacity and system for forest resource information to be used in forest planning and monitoring

- In the forest base map (ver. 1.0) prepared in the preceding Project, although revisions were made mainly to vegetation information, FMU (Forest Monitoring Unit) and (commercial) Timber Volume setting, revision and accuracy assessments were not implemented. Therefore, it was not possible to reach the stage of actual use. In this Project, FMU and Timber Volume setting, revision and accuracy assessments were implemented, after which the forest base map (ver. 1.1) was compiled.
- FIMS (Forest Inventory Mapping System: Estimating timber volume on a map basis during logging concession planning) and FIPS (Forest Inventory Processing System: Setting the timber volume of logging concession using inventory survey data) were updated in the preceding Project. In this Project, the system was revised to use the forest base map (ver. 1.1). This revision made preparation for estimates of timber volume and the AAC (Annual Allowable Cut).
- Based on the revised forest base map (ver. 1.1), a 2015 forest cover map (nationwide), past forest cover maps (2 pilot provinces), logging road information, deforestation / degradation driver information and more were prepared. In addition, logging concession areas, logging plan areas, and logged over areas were prepared. This information was used to develop a function to predict future land use changes and it was utilized as reference information for forest planning.
- The data and functions developed through this Project are defined as PNG-FRIMS, and a system (LAN Map) which distributes data on the PNGFA headquarters intranet was developed so that users without GIS skills can also access and utilize forest resource information. In addition, preparations have been made for cooperation with DSS (Decision Support System), which is a database of PNG logging related information (with no spatial information).



1.1 Identifying Information to Be Added into PNG-FRIMS

1.1.1 Study on Schema of Information to Be Added into PNG-FRIMS

The short-term expert team of Kokusai Kogyo Co., Ltd. has organized forest information to be added into PNG-FRIMS as shown in the following figure.

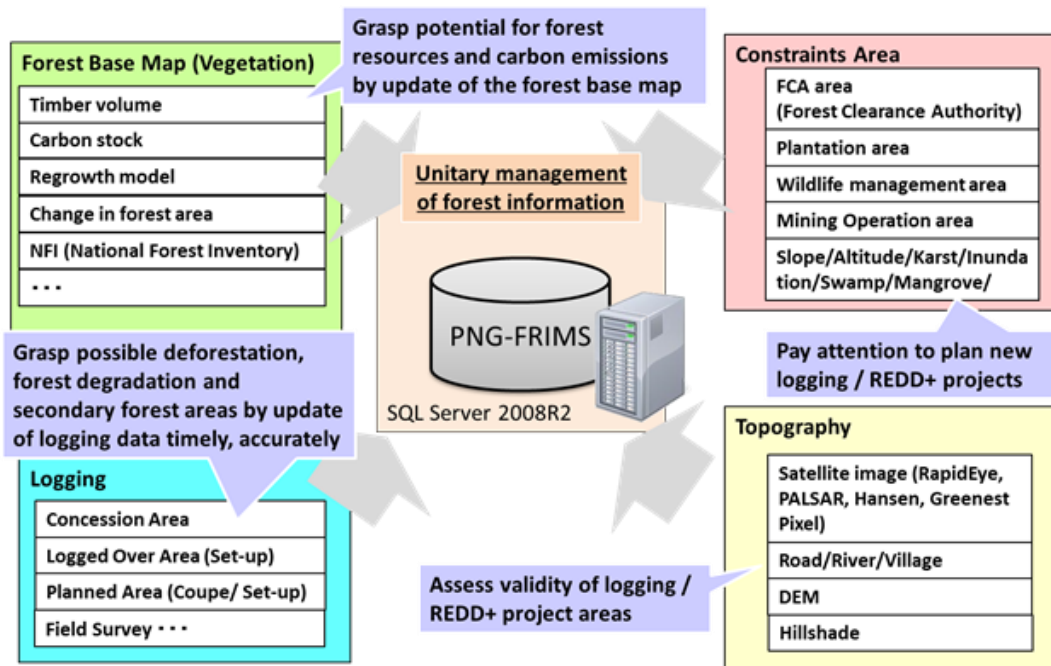


Figure 1-1 Schema of Information to Be Added into PNG-FRIMS

1.1.2 Logging Concession

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, considering how to address these issues, and then entering and revising the data, based on the policies for addressing the issues, together with the C/P. Information about the logging concessions is managed by Cartographer team and Forest Plans officer in Inventory and Mapping (I&M) Branch and Acquisition Branch. According to the C/P, the lists managed by Forest Plans officer in I&M Branch and in the Acquisition Branch 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 completeness, positional accuracy, temporal accuracy, and thematic accuracy.

1.1.3 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”. 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.

(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, and specified the requirements for harvesting history. The difference in harvesting histories between the current data specification and improved data specification is shown in the following figure.

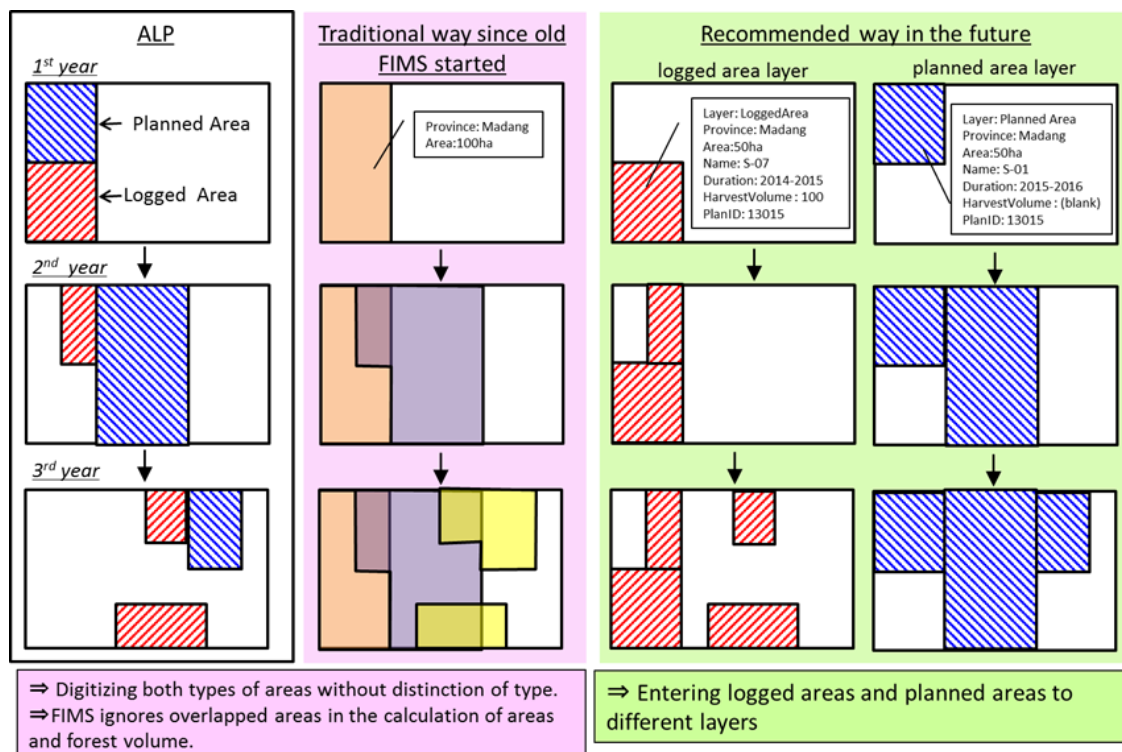


Figure 1-2 Storage of Harvesting History in PNG-FRIMS (Comparison of Old and New Ways)

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

The data specification of logging information has become detailed. Accordingly, the C/P and the long-term expert proposed using soft copies with annual logging plans 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. 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 to define the work procedure for data entry on harvesting history.

1.1.4 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 to identify possible forest information added into PNG-FRIMS.

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 (refer to 'Fact Sheet No. 3 PNG-FRIMS' (Annex 6)).

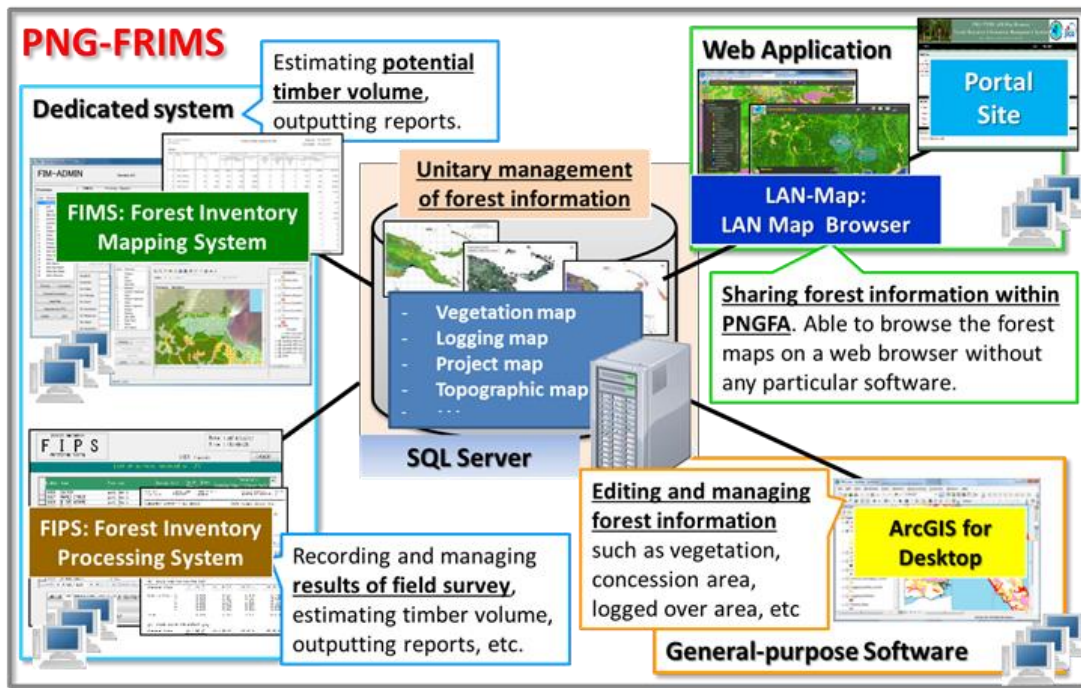


Figure 1-3 Structure of PNG-FRIMS

1.2.1 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) out of consideration for technical transfer efficiency. For the update, the JICA expert team carried out improvement design for the FIMS functions.

1.2.2 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 1-1 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	<ul style="list-style-type: none"> - 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.

1.2.3 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.

1) Job Request Function

The C/P and the short-term expert team started a job analysis about the current work flow for job requests. The C/P tried to improve the current processes through the unitary management of job request information on LAN-Map. The data specifications were defined taking into account the roles of each actor: the client, manager and cartographer.

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.

1.2.4 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. 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.

1.2.5 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 1-4 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 1-5 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 confirmed possible solutions.

1.3 Updating the Forest Base Map

1.3.1 Basic Design for Detecting Forest Area Changes with Remote Sensing Technology

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 team developed the basic design for detecting forest area changes, 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.

(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.

(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.

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.

(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 Remote Sensing (RS) imagery from multiple years. Arrange forest degradation information for the past forest cover maps according to the method used in stage (i).

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.

(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).

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.

(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.

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) Issues on the Forest Base Map (ver. 1.0) and Policies of Addressing Them

1) Classification among Woodland, Savanna and Scrub

In the preceding T/C, uncertainty of classification among Woodland, Savanna and Scrub remained an issue. In this Project, this matter was discussed with the C/P and it was decided to keep the classification based on the FIMS map and not to consolidate the classes even though uncertainties of the classification remain.

2) Examining Methodology to Detect Wetland-Forest

In the preceding T/C, examination of methodologies to detect distribution of wetland was desired. Therefore, the short-term expert team examined extraction methodologies to detect wetland-forest utilizing P-band microwave of Geosynchronous Synthetic Aperture Radar (GeoSAR), false color composite of LANDSAT-8, and analysis of Normalized Difference Water Index (NDWI).

The results of the examination suggested that digitizing work or object-based segmentation that refers to LANDSAT-8 imagery were two of the options to detect wetland forest using RS data. However, because a ground survey is necessary to ensure the accuracy of the information, it is difficult to investigate the distribution of wetland forest targeting all of PNG. Practically speaking, updating the Forest Base Map to integrate wetland information which refers to the information in FIMS should come first. Moreover, as

necessary, the accuracy of the information should be enhanced locally, digitizing or using object-based segmentation of RS data such as LANDSAT-8 imagery and ground survey.

3) 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 new Forest Base Map were totally different. In the Project, the causes of this discrepancy were examined, and it was revealed that the relationship between slopes of the forests and tree composition in this region was different from that in the other regions in PNG. Through discussions with C/P officers, the Project decided that the definition of P and H in the Forest Base Map would not be changed (6° as the threshold was used) by reason that slope information was more useful than tree composition information (refer to Annex 13).

4) 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. 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. The detailed rule applied for the subdivision is shown in Annex 15.

5) Addition of New Attributes

New information shown in Table 1-2, which was thought of as useful for developing information on growing stock in forest and deforestation and forest degradation in 1.3.2(1), and the examination of the method for defining a new set of the forest management units in 1.4.1, were arranged as attributes of the Forest Base Map.

Table 1-2 New Attributes Added to the Forest Base Map

Attribute	Data Description / Note
Sub-vegetation type	Sub-vegetation type / 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 ³
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

³ Accompany to E.T. Hammermaster and J.C. Saunders, Forest resources and vegetation mapping of Papua New Guinea, PNGRIS Publication No. 4 (1995)

Attribute	Data Description / Note
	database from Hansen data ⁴ / 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

6) Treatment of Small Studded Islands

Some issues 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 Geobook⁵, and then countermeasures against them were discussed with the C/P (refer to Annex 16).

(3) 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. The accuracy assessment was implemented by comparing the land use class in the Forest Base Map with the land classification used in the National Forest Inventory (NFI) Pre-Inventory, collected using Collect Earth⁶ with support from UN-REDD/ the Food and Agriculture Organization of the United Nations (FAO), as reference data.

Error matrices were shown using forest / non-forest categories, six land categories of the Intergovernmental Panel on Climate Change (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 14.

The accuracy of classification using forest / non-forest categories in PNG is shown in Table 1-3. 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. The O.A. of classification using all land use categories in PNG was 60% as shown in Table 1-4. Details of checking each class were included in Annex 2. Through the discussions with the C/P on the results 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.

⁴ Planetary-scale annual forest loss/gain area data delivered by University of Maryland in the United States. Hansen, Potapov, Moore, Hancher, et al., Global Forest Change 2000-2015, <https://earthenginepartners.appspot.com/science-2013-global-forest> (accessed on 03 April 2017)

⁵ University of Papua New Guinea Remote Sensing Centre, PNG Geobook

⁶ 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.

Table 1-3 Classification Accuracy Using Forest / Non-Forest Categories in PNG

		NFI			U.A.
		Forest	Non-forest	Total	
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

Table 1-4 Classification Accuracy Using All Land Use Categories in PNG

		NFI																				Total	U.A.				
		Forest										Wood Savanna/Scrub		Grassland		Cropland		Wetlands		Other				Settlements			
		P	H	L	Mo	D	E	Fri	Fsw	M	Qf	W	Se	Sc	G	Ga/G	Q	Qa	E	Z	U						
Map	Forest	P	2446	1138	4		40	21	70	308	31	16	65	9	18	41	184	26	90	31	4529	54%					
		H	1122	4920	109			9	47	18		4	17	6	17	41	225	21	23	4	22	6506	74%				
		L		58	4208	74						2				16	56	18	165	7	6	1	13	4624	91%		
		Mo			19	186										6	2	25						239	78%		
		D	121	8			207	1	5	47			65	3	3	13					7				480	43%	
		E	8					6			3	1	7							1					27	22%	
		Fri	17	18	11				4	11	1		5				3		2	3	6				82	5%	
		Fsw	297	38			48	6	22	314	11		90	15	11	33		13	1	116		6			1021	31%	
		M	17					2	11	2	34	104		5	2			3	2	62		2			247	42%	
		Qf	3	3	1					1			7	1		2	1	1	11	2					33	21%	
		W	267	33	1		326	5	16	247	7		307	115	40	51		36	5	104		2			1562	20%	
		Se	5	1	1		34			8	3		77	132	8	27		11		9	1	6			323	41%	
		Sc	2	1	1	1	33			3			58	85	11	8		1		2					206	5%	
		G	83	44	45		53	3	7	72	4	1	98	24	36	689	20	152	15	303	7	19			1685	41%	
		Ga/C				7	12									2	23	70	2						1	117	60%
		Q	225	299	363	4	7	12	16	46	6	7	21	9	24	233	30	1211	132	47	2	165				2858	42%
		Qa	13	6						1			2			2	10		66	132		9				242	55%
E	13	18	3		2		4	6	3		1	2	1	19	2			208		2				285	73%		
Z	2	1	1											1	4			3	2					15	13%		
U																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%					

1.3.2 Processing and Analysis of the Remote Sensing Data on a Trial Basis

(1) Examining Remote Sensing 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. 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 Phased Array type L-band Synthetic Aperture Radar (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 Engine⁷ (<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 1-6).

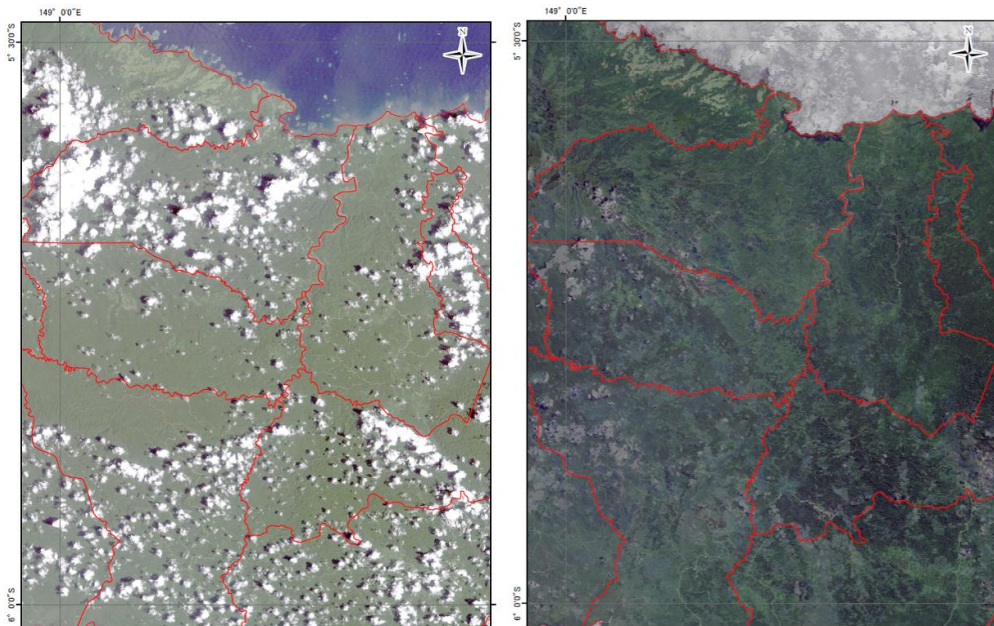


Figure 1-6 A Comparison of LANDSAT Imagery (Left) and LANDSAT Greenest Pixel (Right)

⁷ A cloud-based platform for browsing and analyzing a massive amount of satellite imagery information.

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. 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. 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.

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 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.

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 1-5) to examine how to detect forest degradation and deforestation caused by each driver (see to 1.3.2(2)). The LANDSAT Greenest Pixel was collected for some specific years and areas (Table 1-6).

Table 1-5 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 ⁸
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

Table 1-6 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

⁸ Obtained for each year from 2007 to 2010.

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 Remote Sensing Data

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. Figure 1-7 compares two satellite views, RapidEye (5 m-resolution) and Greenest Pixel (30 m-resolution), of a selective logging site in Asengeng Consolidated FMA (Forest Management Agreement), 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. On the other hand, the logging road is easily detected by Greenest Pixel.

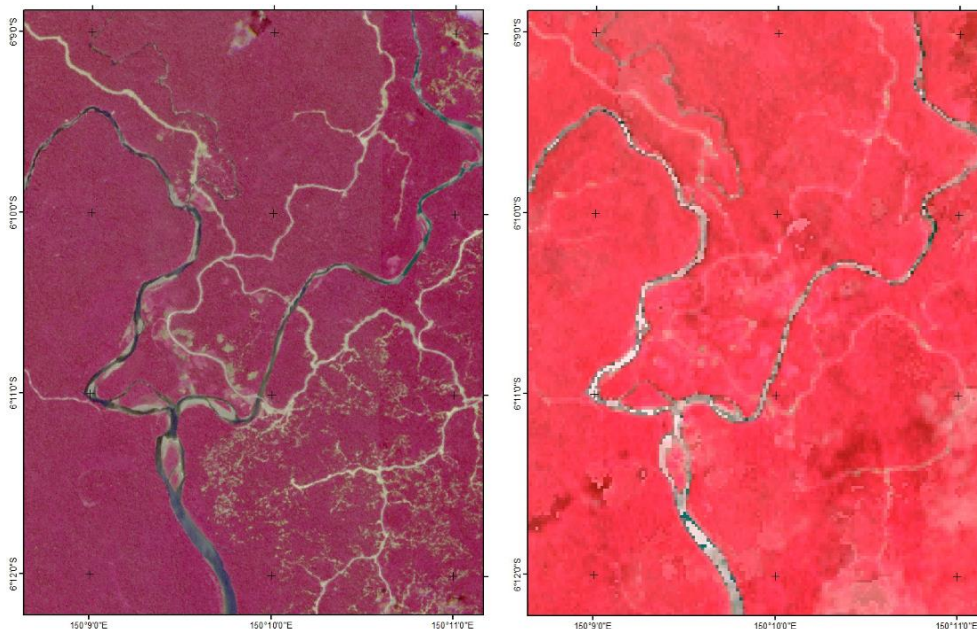


Figure 1-7 Satellite Views of a Selective Logging Site in Asengeng FMA 1

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

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 1-8 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 1-8 Right).

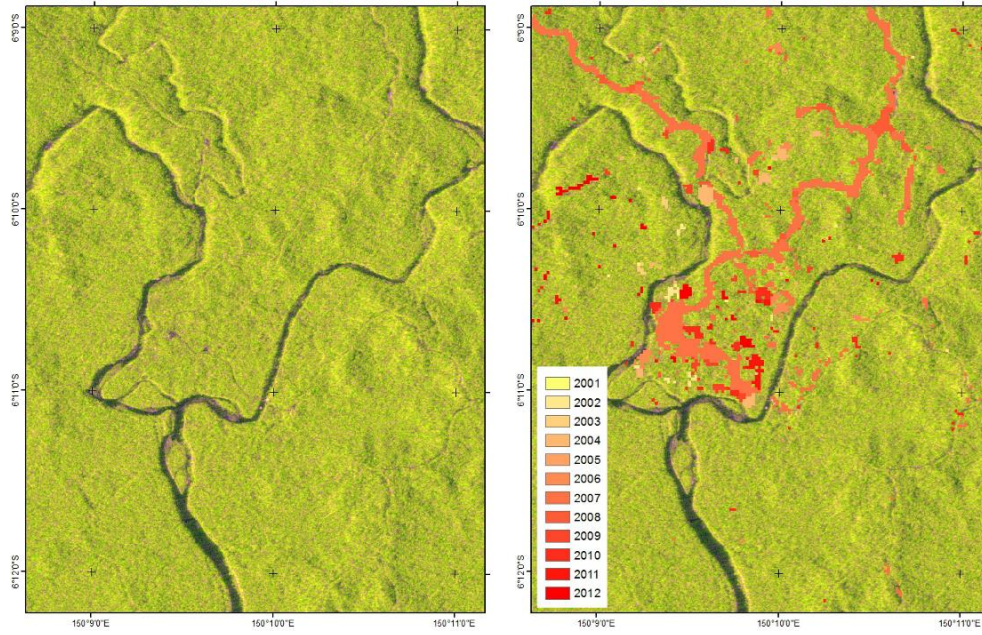


Figure 1-8 Satellite Views of a Selective Logging Site in Asengseng FMA 2
(Left) PALSAR-2 (10 m-resolution), year 2015; (Right) PALSAR-2 imagery plus Hansen's dataset

Forest degradation / deforestation caused by other drivers can be detected by Hansen's data in most cases (Figure 1-9).

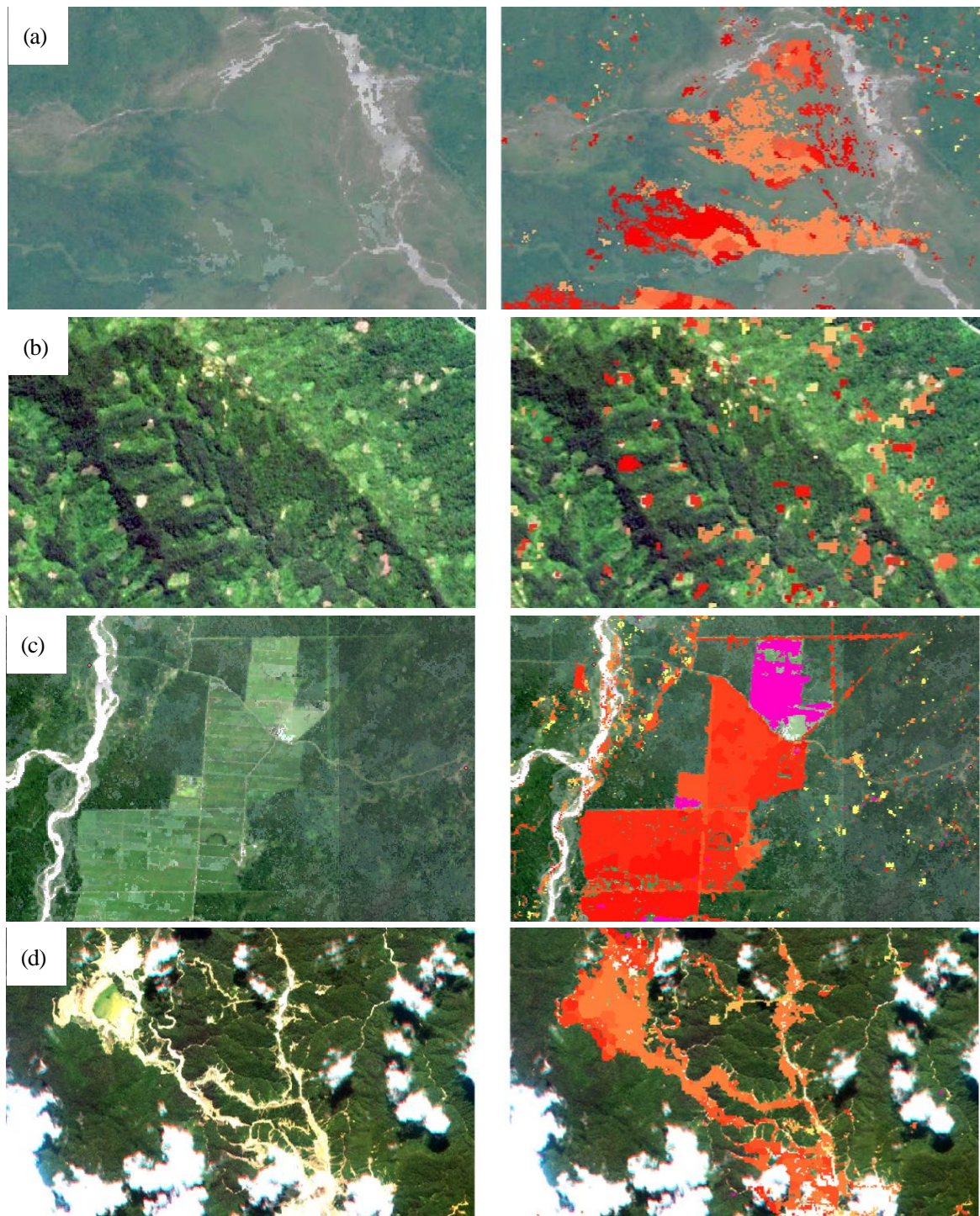


Figure 1-9 Detection of Vegetation Loss by Flooding (a), Subsistence Agriculture (b), Plantation Activity (c), and Mining (d)

(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 Earth⁹, etc., and checked what kind of drivers were observed and how frequently and how well they could be identified in the satellite imagery. 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)¹⁰ and Forest Clearance Authority (FCA)¹¹, 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.

The drivers were identified using the key-out method according to the rules shown in Figure 1-10. 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.

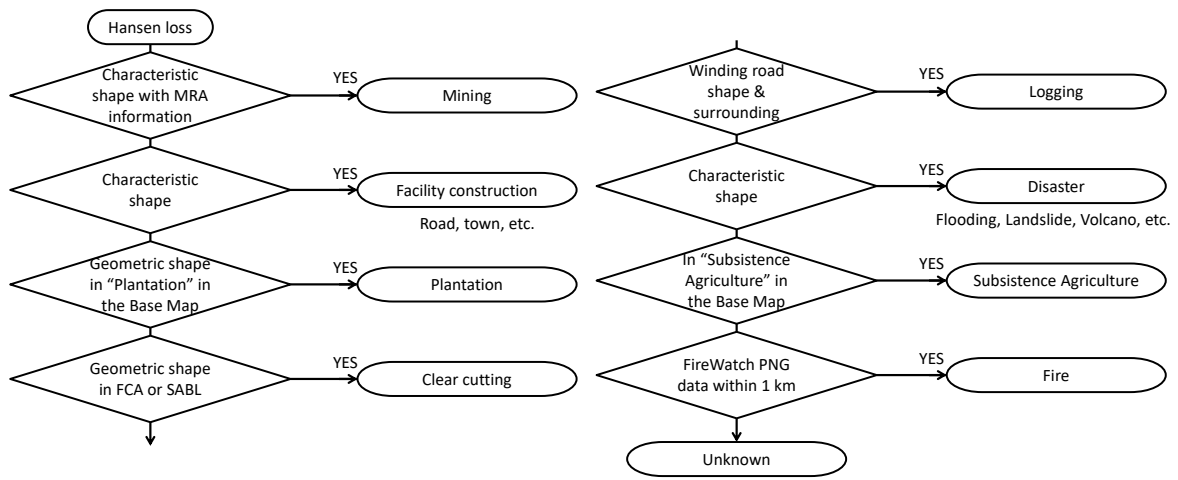


Figure 1-10 Rules Used to Identify Deforestation Drivers

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. 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).

⁹ 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.
¹⁰ Permission of development for agricultural purpose leasing customarily-owned land. The permission fixes the boundaries.
¹¹ Authority of forest clearance by developers within SABL boundaries. The authority fixes the boundaries.

According to the detection using Hansen Loss, deforestation areas over 20 hectares reached a total of 1,004 km² in the 13 years from 2001 to 2013. If deforestation areas less than 20 hectares are added, the total deforestation area reaches 8,108 km². 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.

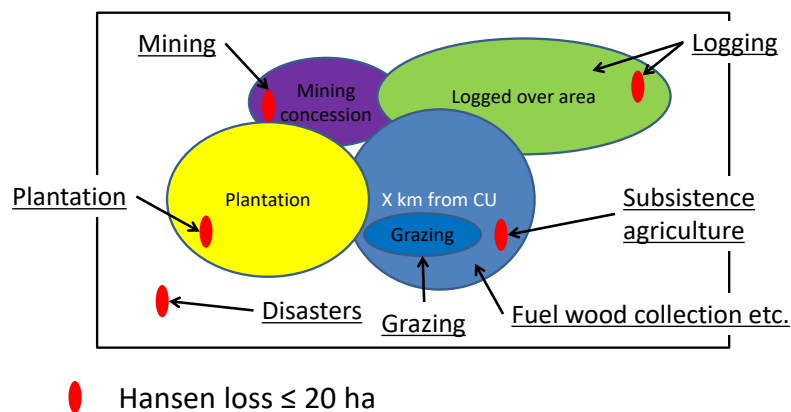


Figure 1-11 Automatic Detection of Deforestation and Forest Degradation (Schematic Image)

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.

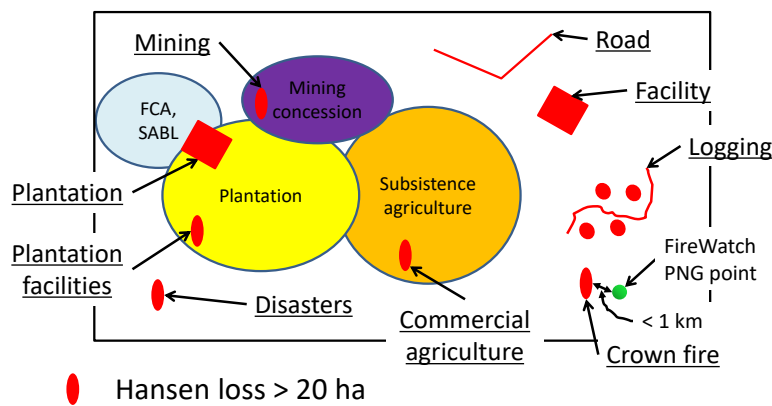


Figure 1-12 Detection of Deforestation over a Certain Size (Schematic Image)

Based on the above proposal, the Project team discussed 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.

This Project analyzed LANDSAT images from 2000, 2004, 2005, 2006, 2007, 2008, 2010, and 2014. 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, it was found that the areas where logging roads were constructed roughly matched the extracted areas of deforestation.

The results of analysis by CLASlite were compared with the field status. 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 is not recommended because CLASlite will not compensate the dedicated efforts.

1.3.3 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 1.3.2).

It was considered necessary to utilize indirect evidence of logging road information to estimate the distribution of selectively logged areas. Thus, road data from 2000, 2005, 2011 and 2015 were developed on the national level (refer to 1.6(4)).

It is assumed that collecting fuel wood, cattle grazing and utilizing understory vegetation are occurring within some distance from villages. The geospatial information of Census Unit¹² was used for specifying locations of villages.

The short-term expert team considered adding boundary data of mining activity obtained from the Mineral Resource Authority (MRA)¹³ for identifying drivers.

Regarding fire, 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.

1.3.4 Develop the manual on updating the Forest Base Map

The Project team shared its understanding of data conditions with the C/P, and discussions were held on policy and methods of updating forest cover maps through the activities described in 1.3.1 to 1.3.3 and 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).

¹² Point of national census operated every 5 years and location of villages

¹³ Government Agency established through the enactment of the Mineral Resources Authority Act 2005.

1.3.5 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 in 1.3.1. The Forest Base Map ver. 1.1 is shown in Figure 1-13. 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 1.3.2 and 1.3.3. Distribution of drivers of the Map is shown in Figure 1-14.

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)

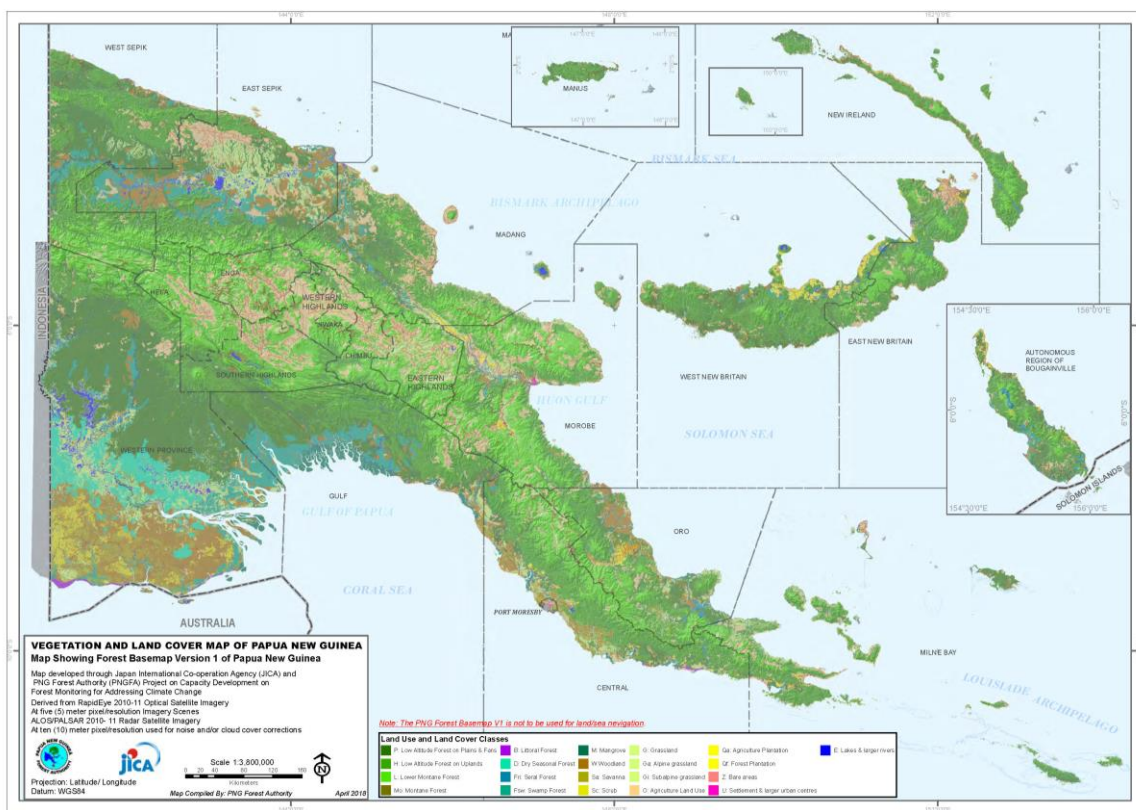


Figure 1-13 Forest Base Map 2012 (ver. 1.1)

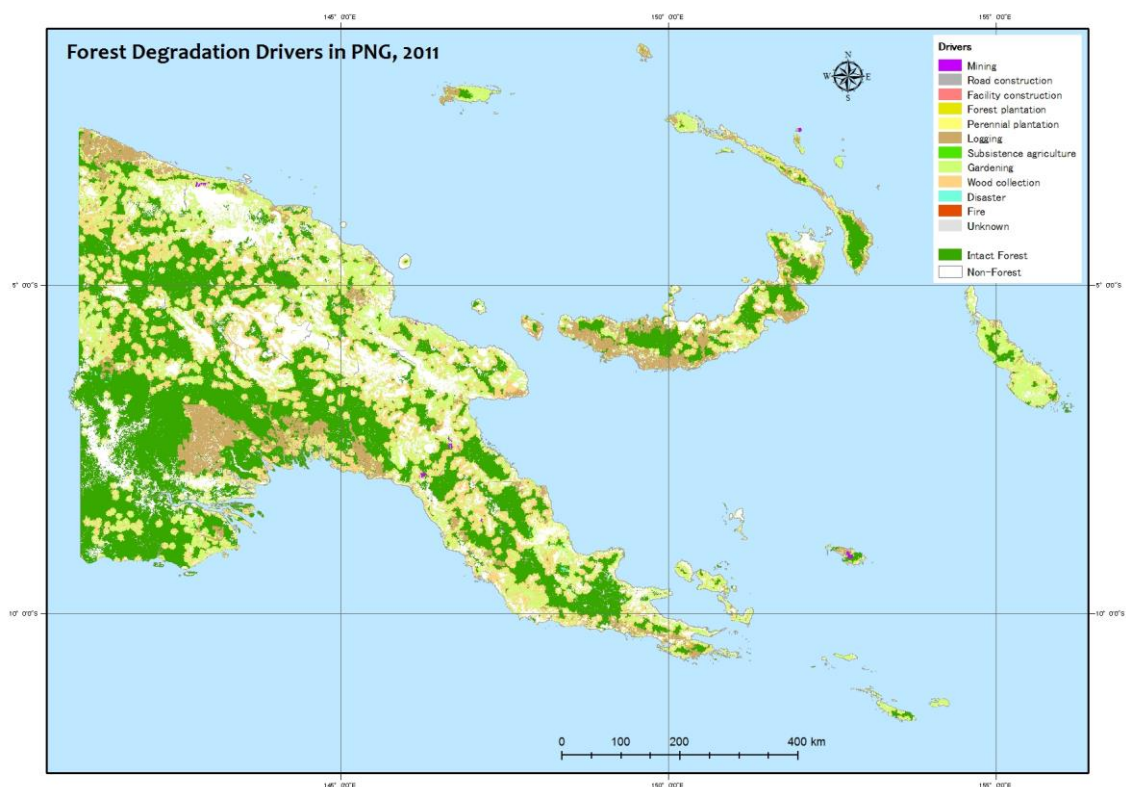


Figure 1-14 Distribution of Drivers of the Forest Base Map 2012 (ver. 1.1)

(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 1.3.1. Drivers of deforestation and forest degradation 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 1.3.1 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)

(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. Therefore, sample plots of Collect Earth data were overlaid on the Forest Base Map to compare these drivers’ information. 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.

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.

(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 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.

In the calculation using the Forest Cover Map 2015, the total forest carbon stocks of PNG in 2015 were 3,402.98 Mt. In this calculation using the Forest Cover Map for 2000, 2005 and 2011, the total forest carbon stocks of West New Britain Province was 192.51 Mt in 2000, which changed to 180.76 Mt in 2015, and that of West Sepik

Province 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.

1.4 Developing and Updating Information on Growing Stock in Forest

1.4.1 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.

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 1-15): province, forest cover type, tree crown size, Forest Zone, and catchment (watershed). The minimum base units of the Forest Base Map for the whole of PNG were updated with prepared data.

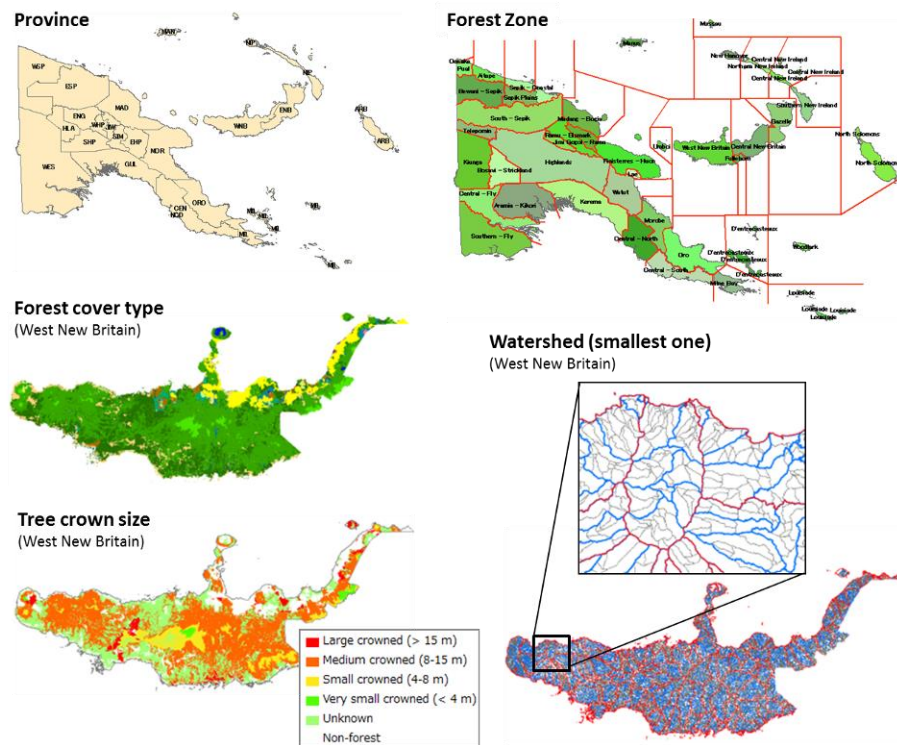


Figure 1-15 Information Used for Minimum Base Units of the Forest Base Map

The team decided to refer to the updated minimum base units of the Forest Base Map as Forest Monitoring Unit (FMU)¹⁴, 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.

1.4.2 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 short-term expert team fixed the model developed for an old version of Excel (Excel 5) to be compatible with the current version of Excel (Excel 2010) and examined the functions. However, the contents of PINFORM are not completely clear yet because there is a part protected by an unknown password.

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.

¹⁴ 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.

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.

(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). 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. 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 short-term expert team and the long-term experts had discussions with the C/P on the feasibility of integrating PINFORM into PNG-FRIMS 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 (refer to Annex 21). 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.

1.4.3 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: the PNG Resource Information System (PNGRIS)¹⁵, 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

¹⁵ 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.

implemented mostly between the 1980's and the present time; and Permanent Sample Plots (PSP), which is the result of an inventory survey in PSP implemented by FRI between the 1990's and 2000's.

The target of each survey is different. 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.

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. As a result of the examination of the merchantable timber volume to total volume ($DBH \geq 50$ cm) of FIPS, PNGRIS and PSP, it was assumed that the merchantable volumes of trees with a DBH of 50 cm or more in the FIPS survey and PNGRIS surveys were reliable. Furthermore, the results of the examination of the ratio of the timber volume of trees with $DBH \geq 50$ cm to those with $DBH 20 - 50$ cm in FIPS data and PSP data 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.

As the forest zone and vegetation types of each site of the FIPS survey and the vegetation types of each site of PSP survey were unknown, these were estimated from lists of existing tree species and those volume ratios of each site.

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 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.

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.

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 1.3.2 was verified. The NFI preliminary survey, conducted by PNGFA 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.

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. Therefore, the constraints data that form the PNG-FRIMS database were updated by processing the latest accessible data (Table 1-7). 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 16)

Table 1-7 Constraints Data

Constraints data	Data Description	Processed Data
Altitude	Altitude land over 2400m altitude.	Shuttle Radar Topography Mission (SRTM) 30 ¹⁶
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 ¹⁷
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. 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.

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

¹⁶ Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global, <https://lta.cr.usgs.gov/SRTM1Arc> (accessed on 03 April 2017)

¹⁷ University of Papua New Guinea, 2008. Papua New Guinea Resource Information System

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 Annual Logging Plans (ALPs) submitted by logging companies is one of the best sources of information to accurately grasp deforestation and forest degradation caused by logging activities. 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.

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 from July 2018. A list of the ALPs, Forest Working Plans (FWPs) and FCAs and the progress of the 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

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. 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 also used. Logging road information was compiled in 'Fact Sheet No.7 Digitized Road Information' (Annex 6).

(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. 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.

(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 are shown in Annex 27.

1.7 Develop a Prototype of Upgraded PNG-FRIMS

1.7.1 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.

1.7.2 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. 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.

1.7.3 Extension Functions of LAN-Map

Extension functions of LAN-Map are shown in Table 1-8.

Table 1-8 Extension Functions of LAN-Map

Function	Description
Job Request Function	There are three users of this function: clients, managers and cartographers. The application screens for each user are different.

Forest Volume Estimate Function	This function estimates forest volume at an area of interest digitized by the user.
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1.7.4 Portal Site for LAN-Map

Based on the basic design shown in 1.2, the short-term expert team developed a portal site that is a gateway to the LAN-Map.

Table 1-9 Functions of Portal Site for LAN-Map

Function	Description
Login Function	The access to the portal site needs a user name and password. 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.
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.
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.
System Administrator Function	The system administration has four functions: 'User management', 'Group list', 'Map management' and 'Group management'. The user management function defines the user name and password, and sets the group of each user. The group list function defines the group. The rights of users to view maps will be assigned by the group to which they belong. The map management function controls the map name and its URL delivered on the LAN-Map. The group management function sets one or more maps that each group can see.
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.

1.7.5 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, the C/P and JICA expert team examined the expected work and its expected effect for the Plantations Branch and Acquisition Branch. PNG-FRIMS has started publishing maps for both Branches.

- a) Plantation Map for the Plantations Branch
- b) Incorporated Land Group (ILG) Boundary Map for the Acquisition Branch

1.7.6 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).

1.7.7 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.

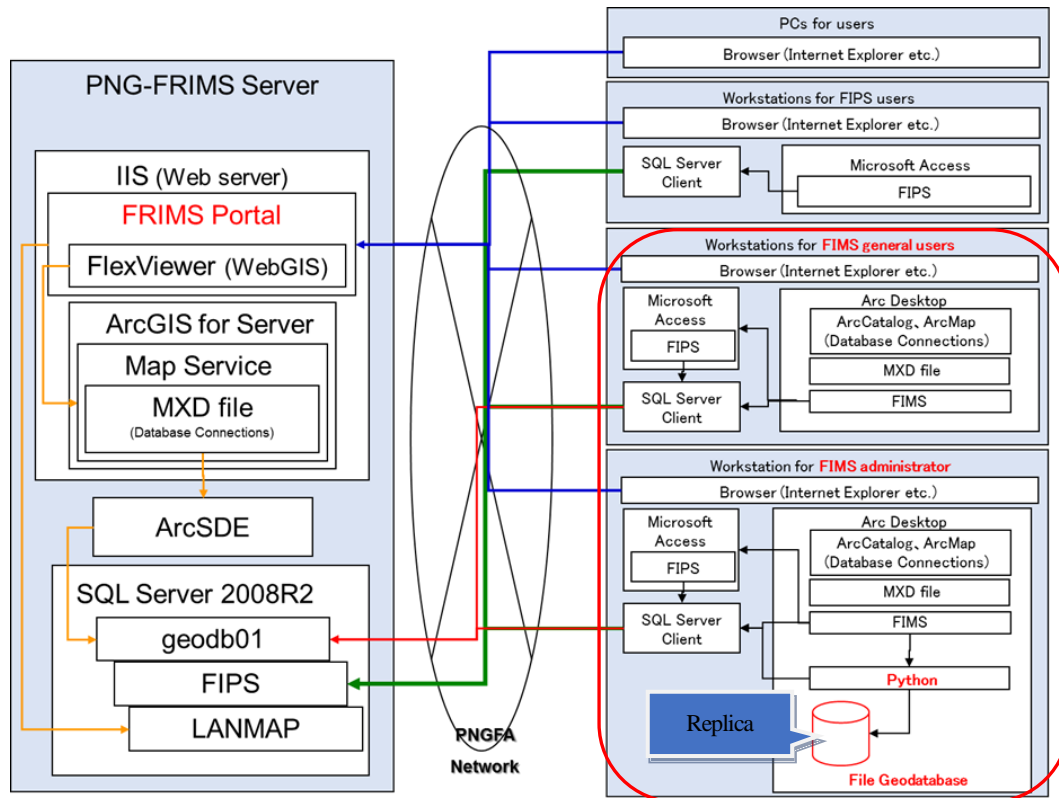


Figure 1-16 System Configuration Figure of PNG-FRIMS after Enhancement

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

Two kinds of forest vegetation maps became selectable in the login window. 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.

The AAC calculation module was integrated with FIMS as one of the functions for the Administrator. The following requirements became clear through the trial of the improved FIMS with the AAC calculation function. Therefore, the JICA expert team decided to develop the following functions.

- (i) A function to create an AAC record of each concession area and to show a breakdown of the AAC of each province
- (ii) A function to change the parameters to make a scenario of forest regrowth for each province in the future
- (iii) 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.

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

Use of the prototype of PNG-FRIMS developed in 1.7 was started on a trial basis from April 2014 sequentially.

1.8.1 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. According to the discussion with the C/P, LAN-Map has decided to adopt ‘All users can use the printing function on LAN-Map’ 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.

1.8.2 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 JICA expert team determined the reason for the issues, then modified the spatial operation calculation procedure and solved the issue of forest area overestimation (Annex 28).

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.

1.9 Develop a Work Manual of the PNG-FRIMS Operation

The manual on PNG-FRIMS was developed. The manual is composed of a main body, ‘PNG Forest Information Management System (PNG-FRIMS) Guidebook’ and four attachments: ‘PNG-FRIMS Installation Manual’, ‘FIMS User Guide’, ‘FIPS User Guide’, and ‘Simple Manual on LAN Map on PNGFA’s Intranet’ (Annex 7).

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 headquarters officers. These involved lectures, exercises and OJT. In addition, database training and RS / GIS training were held in Japan twice, in 2015 and 2017, for four trainees over two weeks in each training, for the purpose of learning database system construction technology and advanced RS imagery analysis technology. The technological fields in the training were (i) operation techniques for the PNG-FRIMS database; (ii) RS / GIS and forest monitoring; and (iii) biomass and carbon estimation. An overview of training content of each field is shown in Table 1-10. Details on the content and achievements of the training sessions are shown in ‘Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)’.

Table 1-10 Training Content of Each Field

(i) Operation Techniques for the PNG-FRIMS Database	(ii) RS / GIS Techniques	(iii) Biomass and Carbon Estimation Techniques
<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • 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 Synthetic Aperture Radar (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 	<ul style="list-style-type: none"> • Forest resource information analysis • Application of additional information into PNG-FRIMS • Calculation of forest biomass and carbon stocks • Land change modeling analysis • AAC calculation

<ul style="list-style-type: none"> • Maintenance of the ArcGIS Desktop license • AAC calculation • Installation and Operation verification of the updated FIMS 	<ul style="list-style-type: none"> degradation and their drivers into forest cover maps • Forest monitoring • Three -dimensional mapping with the GIS technology • Land change modeling analysis • Drone¹⁸ operation and analysis 	
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¹⁸ An uninhabited airborne vehicle (UAV) that enables autonomous aviation using on-board GPS and sensor.

Chapter 2. Output 2: Utilization of PNG-FRIMS for Forest Planning and Monitoring

Summary of Output 2: Development of FRIMS AAC function, supporting provincial forest plan, and consideration of drone utilization in logging monitoring

- As an expansion of the AAC calculation function in accordance with the actual situation of forest resource management in PNG, two potential functions were developed in addition to linkage with forest base map and the redefinition of the calculation method: (1) A function for calculating regrowth volume which is dependent on the incidence status of the logged over area; (2) A function for calculating the timber volume of potential production forests and expired forests.

Old Concept (before the Project)

$$AAC = \frac{(A_{total} - A_{logged}) * V_{standard}}{35 * 0.4}$$

Adjusting index

New concept (The Project's output)

$$AAC = \frac{\{(A_{net} - A_{logged}) * V_{standard} + V_{regrowth}\}}{35}$$

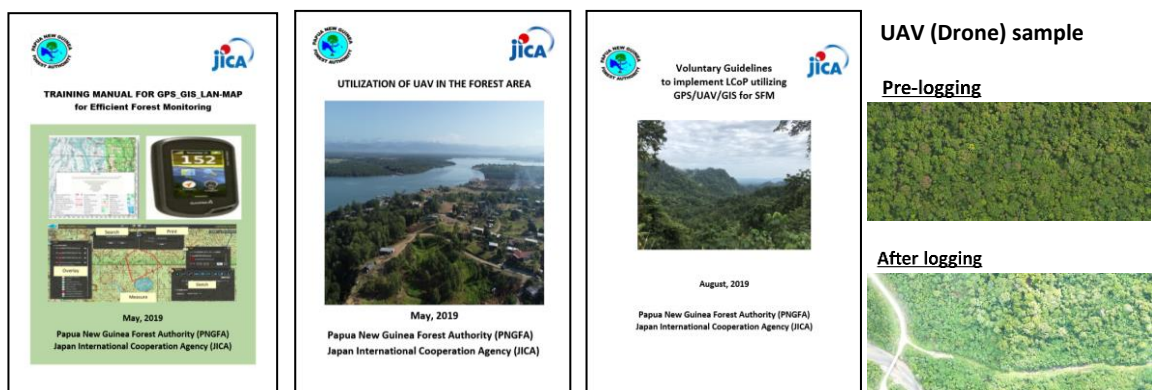
Redefining net production area Adding regrowth volume

Notice:
Formula calculates total volume of some concession by 35 years later after launching logging.

Abbreviation:

<i>A_{total}</i> : Total Forest Area (inc. constraints)	<i>V_{standard}</i> : Standard Volume of each forest type
<i>A_{net}</i> : Net Production Area (exc. constraints)	<i>V_{regrowth}</i> : Regrowth Volume of each forest type
<i>A_{logged}</i> : Logged Over Area in net production area	

- The use of drones as a forest monitoring tool was examined, and a proposal was prepared by organizing directions and challenges for the three themes (1) Natural Forest Monitoring, (2) Plantations, and (3) Forest Research (NFI: National Forest Inventory). In addition, trainings sessions were conducted to verify the potentials for practical use of drones, and the capability of C/P was improved.
- As a result of examining the potentials of utilizing PNG-FRIMS in PFP (Provincial Forest Plan) in cooperation with UNDP/FCPF, evaluations were made of (1) the use of the Forest Base Map, (2) AAC calculation, (3) tailor-made map creation using PNG-FRIMS, and (4) possible utilization of the Land Change Modeler.
- Comprehensive forest planning guidelines using PNG-FRIMS were prepared (Training Manual for GPS_GIS_LAN Map for Efficient Forest Monitoring, Utilization of UAV in the Forest Area, and Voluntary Guidelines to Implement LCoP utilizing GPS / UAV / GIS for SFM).



2.1 Review the Current Status of the Forest Planning System

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 (Activity 2.1.1 in the PDM).

The long-term experts and the C/P identified which issues 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 well as the following approaches.

- Enhancement of AAC calculation in PNG-FRIMS
- Promotion of Provincial Forest Plan (PFP) formulation
- Development of the capacity to monitor the forest resources in ground level

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 Global Positioning System (GPS) and GIS in forest monitoring in the field

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

2.2.1 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.

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.

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. 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.

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 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. 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).

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 2.3, and the Project workshop held on 1st August 2017 (refer to Annex 50) (Activity 2.6 in the PDM). The compiled results are shown in 2.2.3.

(2) Practical Training for Forest Monitoring Utilizing Drones

After considering the use of drones as a forest monitoring tool, a training was conducted to verify the possibility of practical application.

1) Training (1) held on 20-22 June 2018

In the scenario of plantation management at the Kuriva Plantation Site, 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.

2) Training (2) held on 23-27 June 2018

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. 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. 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. Checklist items for confirming the effectiveness of GPS and drone use were to be compiled afterwards by the long-term experts in the guidelines for LCoP.

3) Training (3) held on 18-22 and 24-27 February 2019

In response to previous study and workshops on the drone use, PNGFA aims to expand the use of drones at the sites. Therefore, PNGFA procured additional drones in the Project having as pilot site West Sepik Province and West New Britain Province. 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.

4) Training (4) held on 20-24 May 2019

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, in May 2019, a follow-up training of automatic flight data acquisition and orthographic image creation was held in the Amanab area of West New Britain, with case studies being summarized at the same time (Annex 30).

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

2.2.3 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, the method for utilizing PNG-FRIMS in a series of operations related to the forest management plans was arranged in the following points.

- Possible contributions to forest planning utilizing PNG-FRIMS
- Possibilities for utilizing PNG-FRIMS for logging operation monitoring system according to PMCP (1995) and LCoP (2015)
- Further possible effective utilization of PNG-FRIMS for logging operation monitoring system
- Possible utilizations of PNG-FRIMS for tasks at PNGFA other than logging operation monitoring system

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 2.2.1(2) and 2.2.2(2).

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

Using PNG-FRIMS to support the development of the next National Forest Plan (NFP) was defined as a Project activity. As a result of the review of the current status of the forest planning system, described in 2.1 (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).

2.4.1 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 felleable 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 felleable 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.

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. 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.

2.4.2 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). A manual for simulation of land use change utilizing Land Change Modeler was created based on trial simulations implemented before (Annex 10).

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.

(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 Forest Carbon Partnership Facility (FCPF). 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

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

As a result of activities shown in 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).

Chapter 3. Output 3: Preparation of Forest Resource Information for Addressing REED+

Summary of Output 3: Organization of the contributions made by PNG-FRIMS to REDD + (forest carbon emissions / removals calculation methods, etc.)

- With reference to the details of forest reference emission levels / forest reference levels submitted by PNG to the UNFCCC and the results of the technical assessment, the potentials for PNG-FRIMS to be utilized and make contributing toward improvements in the future was organized.
- In PNG, while timber production is an important industry, it is one of the main causes of increased carbon emissions due to forest degradation, and it is necessary to reduce the impact of logging so that timber production can be continually carried out. Therefore, a report was made that compiled the possibilities and challenges of the Volume Method for estimating forest carbon emissions/removals using logging information owned by PNG, which contributed to the formulation of an investment plan for the forest sector.

Net emissions	=	Activity Data	x	Emission Factor
Emissions from industrial timber production tCO ₂ e		Extracted volumes m ³		Biomass loss associated to timber extraction activities tCO ₂ e/m ³

Sources of degradation		Data (unit)	Documents
Logging infrastructure Factor	Forest clearance for roads	- L, W, Area (ha) - Merchantable volume (m ³)	- Setup logbook - Setup scaling sheet
	Forest clearance for log decks	- L, W, Area (ha) - Merchantable volume (m ³)	- Setup logbook - Setup scaling sheet
	Forest clearance for skid trails	- L, W, Area (ha) - Merchantable volume (m ³)	- NO RECORD - Setup scaling sheet
Logging Damage Factor	Felling	Felling deadwood	- NO RECORD
	Wasted log pieces	Stump, top, buttress (m ³)	- Post harvest assessment
Extracted Log Emission	Log extraction	Merchantable log volume (m ³)	Setup scaling sheet and DB

- Map-based forest carbon emissions / removals estimation, which is the standard method for setting the forest reference levels in other countries, was calculated on a trial basis in the two provinces.
- In terms of information that can be provided for REDD + activities, the methodology and data of the REDD+ project were organized. In addition, the potential contributions from PNG-FRIMS to activities other than calculating the forest reference level were organized (1) Support in Land Use Planning and Land Suitability Analysis; (2) Support in the Planning of Harvest Operations (using Reduced Impact Logging); (3) Support in the Development of Forest Plantation programs; (4) Support in the Regeneration of Degraded Zones; (5) Support in the Estimation of Carbon Benefits).
- In terms of technical inputs into meetings and activities organized by external organizations related to climate change, the potentials for utilizing FRIMS was reported at the meetings of PFP (Provincial Forest Plan), MRV-TWG and TLVS (Timber Legality Verification System).

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).

3.1.1 Examination of the Content of FREL / 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, 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.

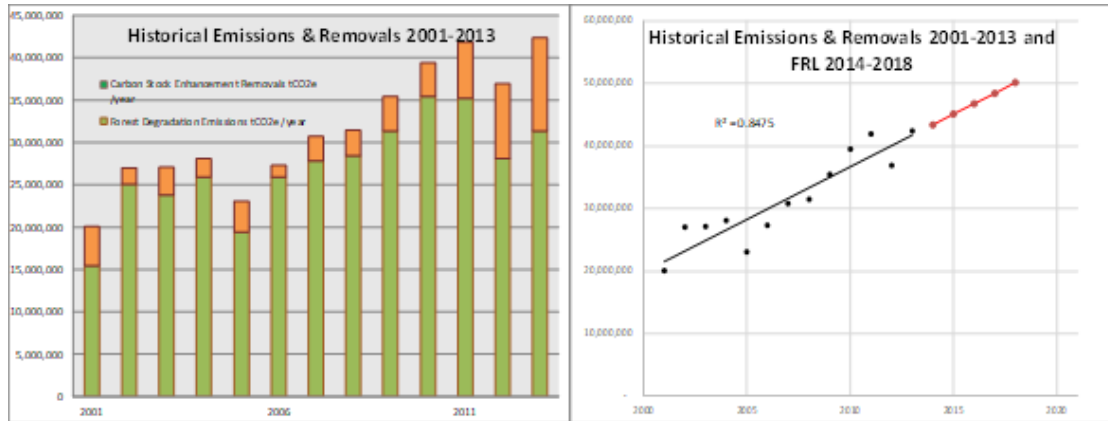


Figure 3-1 Chart / Graph of the Modified FREL / FRL Submitted to UNFCCC by PNG in May 2017

3.1.2 Examination of Calculation Method of Forest Carbon Emission / Removal Using PNG-FRIMS

The estimation of forest carbon emissions / removals, made using logging data owned by PNGFA, 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).

(1) 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, gardening¹⁹, 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

¹⁹ The activity that is called Gardening in PNG refers to the home garden and the burning for it, usually performed around Settlement.

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.

(2) 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.

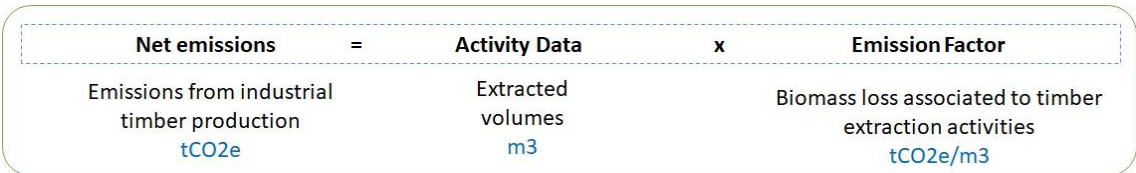


Figure 3-2: Overview of Volume Method Methodology (Pearson et al. (2014))

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.

(3) Estimation of logging emissions in PNG and possibility of use in FRL and Measurement, Reporting and Verification (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 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 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 3-2 Simulation Results of Total Logging Volume of PNG by Volume Method

Year	AD	Total EF	Total logging carbon loss (MtC)	Total logging emissions (MtCO _{2e})
	(Mm ³)	(tC/m ³)		
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.

(4) 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: (i) historical and projected emissions from logging, (ii) historical volume datasets, and (iii) 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 (SFM) 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 m³ 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).

3.1.3 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 and West Sepik provinces, 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 3-3).

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’.

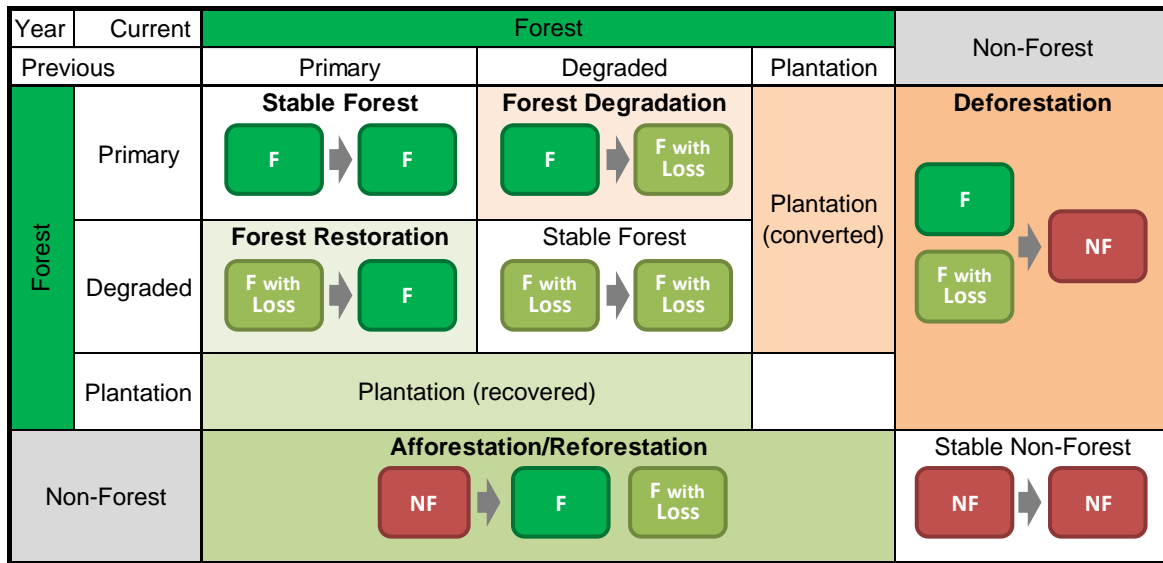


Figure 3-3 General Picture of Changing Type of Forest Cover Classes

(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 3-4 and Table 3-3 for Wes New Britain Province, and Figure 3-5 and Table 3-4 for West Sepik Province.

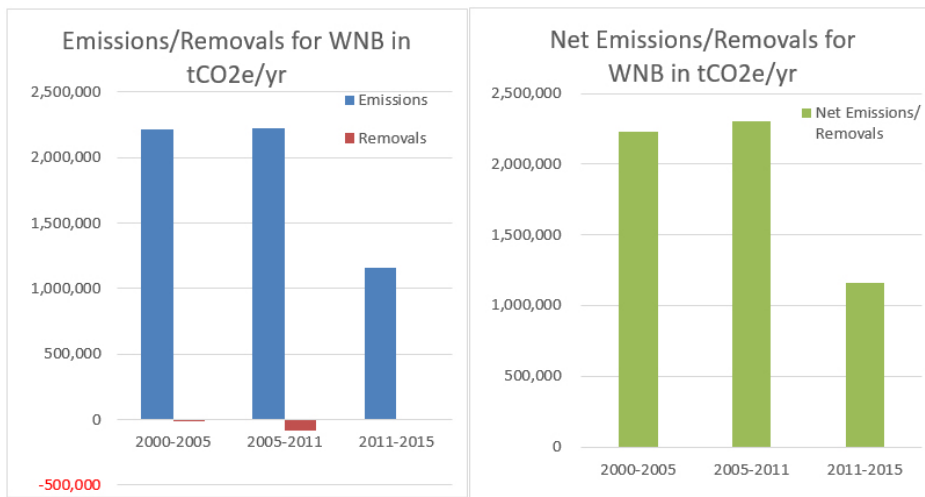


Figure 3-4 Annual Average of Carbon Emissions and Removals in West New Britain Province

Table 3-3 Annual Average of Carbon Emissions / Removals from 2000 to 2015 in

West New Britain Province

Terms	Amount of tCO ₂ /yr			
	Deforestation	Forest Degradation	Afforestation	Net Emissions/ Removals
	<i>Emissions</i>	<i>Emissions</i>	<i>Removals</i>	<i>Emissions/ Removals</i>
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

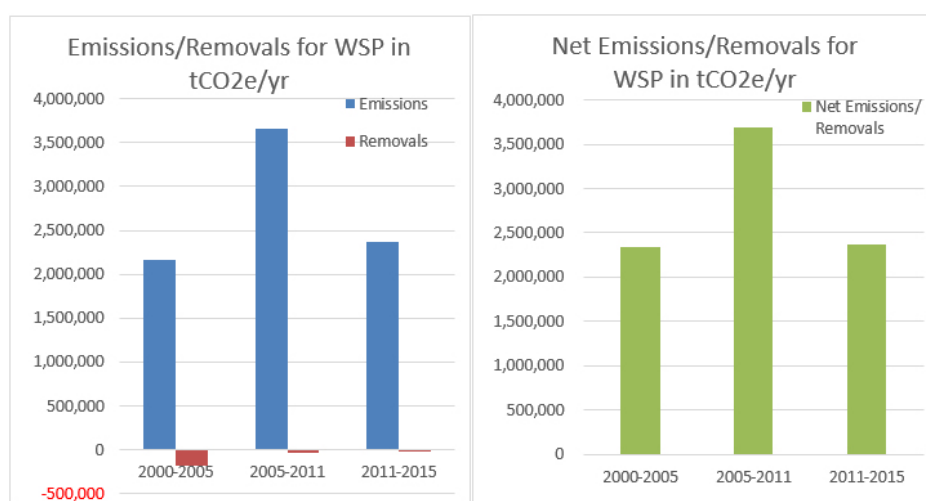


Figure 3-5 Annual Average of Carbon Emissions and Removals in West Sepik Province

Table 3-4 Annual Average of Carbon Emissions / Removals from 2000 to 2015 in West Sepik Province

Terms	Amount of tCO ₂ /yr			
	Deforestation	Forest Degradation	Afforestation	Net Emissions/ Removals
	<i>Emissions</i>	<i>Emissions</i>	<i>Removals</i>	<i>Emissions/ Removals</i>
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.

This analysis shows a large amount of net emissions and removals between 2005 and 2011 in West Sepik Province. 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.

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.

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 (i) to (iii) 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 Joint Coordinating Committee (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’.

3.2.1 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.

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 (refer to Annex 32 for details).

3.2.2 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 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).

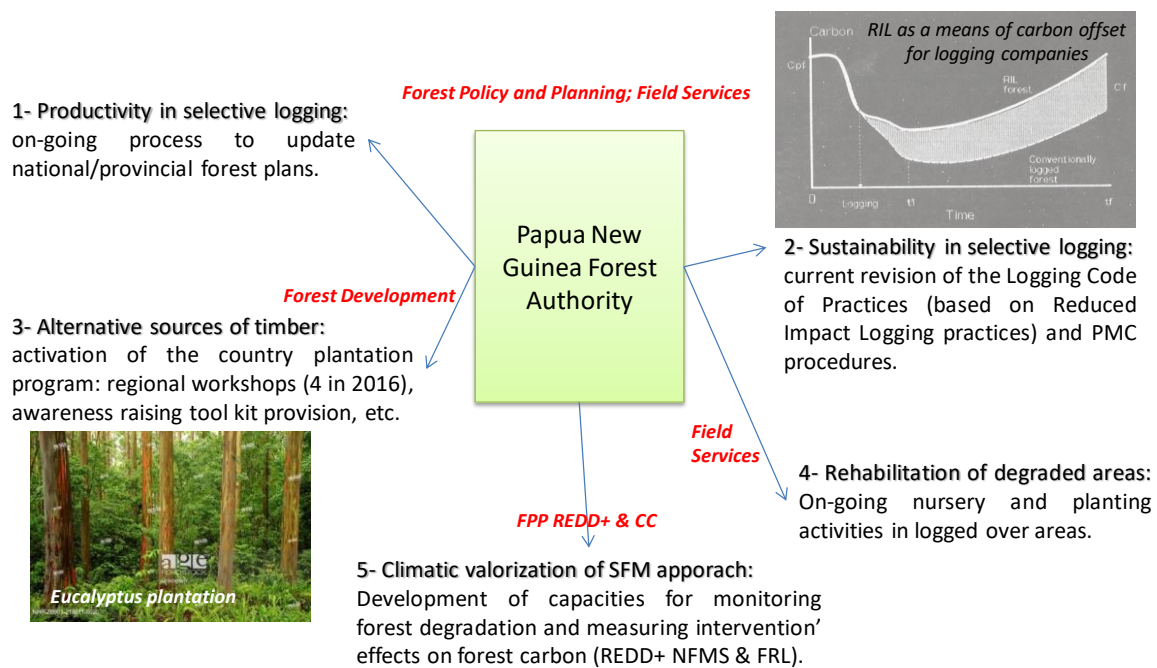


Figure 3-6 Contribution Activities for Sustainable Forest Management Using PNG-FRIMS (draft)

Activities that support to SFM using PNG-FRIMS (draft) were organized as shown in Table 3-5.

Table 3-5 Activities of Support for Sustainable Forest Management using PNG-FRIMS (draft)

Type of Support	Activity
(i) Support in Land Use Planning and Land Suitability Analysis	Planning of forest utilization concerning land potential and risk by PNGFA
(ii) Support in the Planning of Harvest Operations (using Reduced Impact Logging)	Planning of logging activities by timber logging companies and timber logging assessments by PNGFA
(iii) Support in the Development of Forest Plantation Programs	Development and management of afforestation plantations by PNGFA or timber logging companies
(iv) Support in the Regeneration of Degraded Zones	Nursery beds and afforestation in areas where forests have been degraded, which can be done by PNGFA or a logging company
(v) Support in the Estimation of Carbon Benefits	Monitoring of forest cover change and measurement of the effect of intervention activity

The content detailed above in (i) to (v) are also summarized as the PaMs proposal for SFM as a logical framework (refer to Annex 34 for details).

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.

PNG's REDD + activities are implemented based on the National REDD + Strategy (NRS); however, in the preparation for the Concept Note of the 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).

3.2.3 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).

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.

3.3 Provide Technical Input to Committees Related to Climate Change (Hosted by External Organizations)

3.3.1 Technical Support of PNGFA at Climate Change Related Meetings and Events Sponsored by an External Organization

(1) 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 on 17th March 2015, to introduce an overview of the Project (see Annex 52).

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 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 in June 2018 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.

3.3.2 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 3-6 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 3-7 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)	• Demographics	• Satellite images (e.g. Landsat/Sentinel)
• Hydrology	• Ethnographic tenure data	• LiDAR data (if available)
• Existing biological studies (recent)	• Land cadastre	• Initial land cover maps
• IUCN Red List and maps	• Existing socioeconomic studies (recent)	• Administrative boundaries
• CITES list	• Language background	• Other concessions' boundaries
• Key Biodiversity Area	• Cultural background	• Protected area boundaries
• National protected species list	• Ethno-botany studies	• Moratorium maps (if applicable)
• Protected areas	• Socioeconomic status and development needs	• Forest and state area maps
• Analysis of relevant environmental plans, policies and regulations	• Relevant official social and development plans, policies and regulations	• Land system maps
• History of forest disturbance		• Spatial planning maps
		• Physiographic regions

3.4 Conduct Training on Measurement and Reporting of Carbon Emissions and Removals from Forests

The training sessions on measurement and reporting of carbon emissions and removals from forests, as shown below, were implemented through lectures, discussions and workshops.

-
- International carbon offset frameworks
 - The REDD+ concept and possibility of REDD+ in PNGFA activities
 - Trial forest carbon emissions and removals calculation
 - Possibility of estimating carbon emissions from deforestation due to logging at the field level using PNG-FRIMS

The contents and achievements of these training sessions are shown in ‘Technology Transfer Plan & Achievement Final Report (July 2019 version) (Annex 44)’. 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.

Chapter 4. Lessons Learned and Recommendations

4.1 Lessons Learned in Project Management

4.1.1 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 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.

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').

4.1.2 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 Unmanned Aerial Vehicle (UAV)/Drone, Collect Earth,

Google Earth Engine, GLAD Alert²⁰, and JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST)²¹) 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.

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.

4.1.3 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.

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.

²⁰ An alert system that is updated every eight days for tree cover loss using Google Earth Engine.

²¹ JICA-JAXA Forest Early Warning System for deforestation of tropical forest developed by JICA and JAXA.

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.

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.

4.1.4 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.

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.

4.2 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.

4.2.1 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 CO₂ 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.

4.2.2 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.

4.2.3 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.

4.2.4 Quantitative Evaluation of Reduced Impact Logging and Examination and Construction of Regrowth Model of Secondary Forest

As mentioned in 4.2.1, 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.

4.2.5 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.

4.2.6 Practical Application of Estimates of Forest Carbon Emissions 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.