Second National REDD+ Forest Reference Level

Modified Submission for the UNFCCC Technical Assessment in 2023

Government of Papua New Guinea

January 2023

Executive Summary

Human activities are the major cause of greenhouse gas (GHG) emissions that are continuously emitted into the earth's atmosphere. The global scientific community has agreed that these anthropogenic GHG concentrations in the earth's atmosphere has had a negative impact on the earth by causing imbalances in the natural cycle of the earth's climate, leading to what is commonly known as climate change. Papua New Guinea (PNG) signed the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil in June 1992, to combat climate change. The UNFCCC was ratified by the Government of Papua New Guinea (GoPNG) in April 1993. Since then, the country has been committed to implementing the Convention.

According to PNG's Vision 2050[1], the country has made a massive commitment to be carbon neutral by 2050 and wishes to achieve 50% of it by 2030. The country has taken a global lead in seeking to combat climate change, particularly by proposing measures to realize the carbon abatement opportunity offered by preserving and sustainably managing tropical forests, that is, by introducing the pre-cursor to the concept of REDD+ into the international negotiations at UNFCCC 11th Conference of Parties (COP11) in Montreal in 2005. GoPNG through the Climate Change and Development Authority (CCDA) and PNG Forest Authority (PNGFA) have been putting much effort into the country's REDD+ readiness, with the support of international multilateral and bilateral development partners.

The UNFCCC has defined Forest Reference Emission Level/Forest Reference Level (FREL/FRL) as benchmarks for assessing each country's performance in implementing and reducing emissions and increasing removals associated with the implementation of REDD+ activities. The country submitted its 1st FRL to UNFCCC in January 2017. Technical Assessment by UNFCCC had been conducted throughout 2017 and the modified FRL was officially published by UNFCCC at early 2018.

With the support of the Food and Agriculture Organization of the United Nations (FAO), PNG has finalized its 2nd FRL. The projection methodology for the 2nd FRL is based on historical average with a reference period of 10 years (2009-2018) and FRL results period of 9 years (2019-2027). This decision was reached as a result of the broader stakeholder consultations.

Carbon pools covered in this 2nd FRL include above-ground biomass, and below-ground biomass. Litter, deadwood, and soil-organic carbon are not covered due to limited availability of data.

The REDD+ activities covered are deforestation, forest degradation, and carbon stock enhancement. Sustainable management of forest and conservation of carbon stocks (removals of forest remaining forest) are not covered. These two activities are different way

[1] The PNG Government in February 2010 published the National Strategic Plan (NSP), or "Vision 2050". This provides goals for transforming the PNG economy and society over a 40-year period. The NSP Task Force identified service delivery, wealth creation and human capital development as the core areas for attention.

to present the same Policies and Measures (PAMs). PNG will measure if they are resulted in the area increased of deforestation, forest degradation and carbon stock enhancement.

The activity data used is from the Collect Earth land use/land use change assessment conducted by the Papua New Guinea Forestry Authority (PNGFA) for the period 2000-2018 which was supported by FAO with funding from the FAO-Global Environment Facility-Capacity Building Initiative for Transparency and the Global Green Growth Institute through the NDC Partnership/ Climate Action Enhancement Package.

The emission factors used were tier 1 and tier 2. Tier 1 emission factors were taken from the 2006 IPCCC Guidelines for National GHG Inventories while the tier 2 emission factors were taken from different research carried out in the country's forest which includes Fox et al. Both the activity data and emission factors went through a wider stakeholder consultation process before the estimation of the 2nd FRL.

Considering PNG's HFLD (High Forest, Low Deforestation) status over the reference period, PNG proposes an upwards HFLD adjustment to the 2nd FRL. Since Green Climate Fund (GCF) scorecard for the result-based payment (RBP) is uncertain as valid at the moment, PNG considers the latest ART TREES 2.0 as the most reliable guidance for HFLD adjustments, namely, the FRL should not exceed HFLD-score multiply 0.05 of carbon stock.

The average historical emissions for the reference period (2009-2018) were 35,299,202 tCO_2 eq. The average total forest carbon stock in PNG corresponding to the year between 2009 and 2018 based on TREES2.0 was 14,748,195,755 tCO_2eq, therefore 0.05% of the total forest carbon stock suggests an allowable upwards adjustment of 5,219,378 tCO_2eq. As such, the calculated FRL (CO_2 emissions from deforestation, forest degradation, and carbon stock enhancement in PNG the results period (2019 to 2027)) has a value of 40,518,579 tCO_2eq.

PNG will continue to commit itself to achieve its targets set out in its Enhanced NDC 2020 to combating the effects of climate change to ensure the country contributes to fulfilling Paris Agreement goals. The country believes that, while fulfilling our development goals, every country can take responsibility, according to their capacities, doing what they can to make the earth is a safe place for its inhabitants.

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List of Acronyms

AGB	Above Ground Biomass
AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
ART	Architecture for REDD+ Transactions
BGB	Below Ground Biomass
BTR	Biennial Transparency Report
BUR	Biennial Update Report
CCDA	Climate Change and Development Authority
EF	Emission Factor
FAO	Food and Agriculture Organisation of the United Nations
FRA	Forest Resources Assessment
FRL	Forest Reference Levels
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GIS	Geographical Information System
GoPNG	Government of Papua New Guinea
IPCC	Intergovernmental Panel on Climate Change
LEAF	Lowering Emissions by Accelerating Forest finance
LULUCF	Land Use, Land Use Change and Forestry
MRV	Measurement, Reporting and Verification
NDC	Nationally Determined Contribution
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
PNG	Papua New Guinea
PNGFA	Papua New Guinea Forest Authority
PNGRIS	Papua New Guinea Resource Information System
QA/QC	Quality Assurance/Quality Control
REDD+	Reduced Emissions from Deforestation and Degradation and Conservation, Sustainable management of forests and Enhancement of Forest Carbon Stocks
tCO_2eq/year	Tonnes of Carbon Dioxide Equivalent per year
TREES	The REDD+ Environmental Excellence Standard
UNFCCC	United Nations Framework Convention on Climate Change

Chapter 1. Introduction

1.1. Brief General Country Circumstances

Papua New Guinea (PNG) is situated in the South West Pacific and comprises the eastern half of New Guinea including the islands of New Ireland, New Britain, Bougainville and 600 smaller nearby islands and atolls. PNG is largely mountainous, and much of it is covered with tropical rainforest—it is ranked as the third largest tropical forest area in the world after Amazon and Congo Basin. Terrestrial habitats range from extensive lowlands with rainforest, savanna, grassland, and fresh water swamps to upland montane rainforest and alpine grassland. PNG has a surface area of 462,840 km^2 (the largest Pacific Island state), a coastline of 5152 km^2 sheltered by 40,000 km^2 of coral reefs, and 820 km land border with the Indonesian province of West Papua[2].

PNG has a hot, humid tropical climate which is experienced all year round. Ocean temperature has a strong influence on average monthly temperatures. Changes in the temperature from season to season are small but are more noticeable around Port Moresby when compared to other areas in PNG. Port Moresby and other towns on the coast are quite hot in the summer months whereas temperatures are considerably cooler in the highland regions. PNG has a wet season from November to April and dry season from May to October. However, these seasons are only discernible in Port Moresby where most of the yearly annual rainfall is in the wet season. Other areas tend to experience rainfall all year round.

PNG is one of the least densely populated countries in the world with a population density of 19.4 persons per square kilometre. The 2011 Census of Population and Housing estimated a total residential population of 7.28 million. The population was forecast to be 8.98 million in 2020 with 24% of this population estimated to live in PNG's urban centres. Most people living in PNG are Melanesian, but some are Micronesian or Polynesian. While PNG's population continues to increase, the annual population growth rate has declined steadily since 2010 from 2.4% down to an estimated 1.9% growth rate in 2020.

PNG is the largest economy among the Pacific Islands which is dominated by natural resources, agriculture, forestry, and fishing. The economy is small, open, and export-orientated and is very dependent on commodity products, and economic growth is largely tied to foreign investment in the resources sector. The formal sector consists of extractive mining and petroleum industries, cash-crop agriculture production and a small import-substituting manufacturing sector. The informal sector is predominantly subsistence agriculture on which much of the PNG population derives their livelihood. While most of PNG's labour force is employed in the agriculture sector most of its export earnings is through the resources sector.

[2] World Bank, Global Facility for Disaster Reduction and Recovery GFDRR and Climate Investment Funds.2011.Climate risk and adaptation country profile for Papua New Guinea."

The resources sector is an influential factor in PNG's gross domestic product (GDP) and National accounts. In recent years PNG has experienced a steady GDP growth which reflects the performance of the resources sector. Lower liquefied natural gas (LNG) and oil prices, weakened demand and the COVID-19 global pandemic have collectively resulted in an estimated slowing of GDP growth in 2020. The economic forecast in the medium-term is positive with numerous new resource projects in the pipeline, such as the Papua LNG project, the Wafi-Golpu gold and copper mine, the P'nyang gas field and the Pasca A gas condensate field.

The rural region is generally a traditional village-based society which is dependent on subsistence and small cash-crop agriculture. Income is largely derived from growing and selling of coffee, cocoa, sugar, oil palm, rubber and fresh vegetables, and from harvesting of local crops. Sweet potato, banana, sago, taro, yams, cassava and sugar cane are the crops harvested while local livestock production include pigs, chickens, ducks, and occasionally fish.

Forestry sector is an important element of PNG's economy and to the overall socio-economic development of the country. According to the PNG's Forest Reference Level 2001-2013 (FRL) the country has a total area of about 46.1 million hectares, of which 77.89% (35.949 million hectares) is forest.

The same forest area (35.949 million hectares) was used for the REDD+ Technical Annex of the Second Biennial Update Report (BUR2) as well as this FRL2. This was provided by the PNG Forest Authority (PNGFA) and is different from the forest area contained in the Forest Resources Assessment (FRA) Report 2020 which is 35.795 million hectares. This is because after the REDD+ TA was submitted with the BUR2, PNGFA improved and updated the assessment result further including some of the errors correction (improvement with the availability of new satellite imageries) and change of category (Rubber plantation is categorized in Cropland after the initial assessment was under Forestland-Forest Plantation). PNGFA used the updated assessment result and database for the FRA 2020 but CCDA used the assessment result shared by PNGFA for the REDD+ TA in order to be consistent (before improvement and change of category).

There are 13 forest types in PNG comprising 12 natural forest types and man-made forest plantation. More than three-quarters of this forest is categorized as primary or as not being disturbed by human activities, whereas 11% is classified as disturbed by large scale logging, and 0.2% is disturbed by small scale logging using portable sawmill. Small scale temporary gardening cause 8% of forest disturbance.

The PNG government has taken the approach in revisiting all policies and plans against assumptions of sustainable growth and to manage the resources being exploited to sustain the economy hence, all polices have been developed for sustainable socio-economic growth of PNG and for climate change in particular, for both short term and long-term development. This includes the Vision 2050, Development Strategic Plan 2010-2030, National Strategy for Responsible Sustainable Development for Papua New Guinea, National Climate Compatible Development Management Policy, Climate Change (Management) Act and United Nations

Paris Agreement (Implementation) Act. More recent policies that were developed includes: PNG's Sustainable Development Goal 13 Roadmap 30 action by 2030; PNG's Enhanced NDC; and Climate change (Management) (Nationally Determined Contribution) Regulation.

PNG has taken a global lead in seeking to combat climate change, particularly by proposing measures to realise the carbon abatement opportunity offered by preserving and sustainably managing tropical forests, that is, by introducing the pre-cursor to the concept of REDD+ into the international negotiations at the 11th Conference of Parties (COP11) in Montreal in 2005. Since then, the Government of PNG (GoPNG) through the Climate Change and Development Authority (CCDA) and PNG Forest Authority (PNGFA) have been putting much effort into the country's REDD+ readiness, with the support of international multilateral and bilateral development partners.

PNG has institutionalized the preparation and submission of the National Communications, Forest Reference Level and Biennial Update Reports to the United Nations Framework Convention on Climate Change (UNFCCC). The mandated entity to prepare and communicate these documents as per the Climate Change (Management) Act 2015 is the CCDA. The responsible division within the CCDA structure is the Measurement Reporting & Verification (MRV) and National Communications division. Under this arrangement CCDA was able to prepare and submit PNG's 1st Forest Reference Level (FRL) in 2017. For the current 2nd FRL, CCDA has worked closely with the Agriculture, Forestry & Other Land Use Sub Technical Working Committee (AFOLU STWC) to compile the 2nd FRL.

1.2. Progress in Implementing REDD+ under the UNFCCC

PNG is leading the international negotiations on reducing emissions from deforestation and forest degradation (REDD+) after PNG and Cost Rica submitted the agenda to the UNFCCC COP in 2005. This concept of REDD+ was first recognized and accepted at the 2007 UNFCCC COP in Bali and later adopted under the Paris Agreement in 2015.

As part of PNG's involvement in its inception and development, GoPNG through the Climate Change and Development Authority (CCDA), PNG Forest Authority (PNGFA), line government agencies and other relevant stakeholders have made considerable effort in implementing the national REDD+ programme, with the support of international multilateral and bilateral development partners like UN-REDD Programme, Food and Agriculture Organisation of the United Nations (FAO), European Union (EU), United Nations Development Program (UNDP) and Japan International Cooperation Agency (JICA).

Through these technical and financial support, PNG was able to develop the 4 REDD+ elements as per decision 1/CP 16 in order to undertake REDD+ activities. This includes;

- National REDD+ Strategy (NRS);
- 1st REDD+ Forest Reference Level (FRL);
- National Forest Monitoring System (NFMS); and
- Safeguard Information System (SIS).

PNG established the NFMS containing the National Forest Inventory (NFI) and Climate Change and Forest Monitoring Web-portal, which were launched by the Prime Minister in 2016. PNG's 1st FRL was established using NFMS data and submitted to UNFCCC in 2017. The NRS was formulated in 2017 based on the NFMS data on deforestation and forest degradation driver. PNG submitted the 1st Biennial Update Report (BUR) including the REDD+ Technical Annex to UNFCCC in 2019 and the 2nd BUR including updated REDD+ Technical Annex in 2022. REDD+ Technical Annex is the report of REDD+ results against the FRL and PNG was 8th country in the world to submit REDD+ results through the first and second BURs. PNG's SIS was finalised and submitted to UNFCCC in 2021. This indicates the significant progress PNG has made towards REDD+ implementation.

Figure 1-1 PNG's REDD+ implementation status

Figure 1-2 FRL and REDD+ technical annex submissions

1.3. Objectives of Developing the National FRL

The 2nd FRL for PNG is prepared to achieve the following key objectives:

- To assess PNG's performance in implementing REDD+ activities to progress national policies (described in Chapter 9);
- For PNG to contribute to international mitigation efforts through REDD+ actions under the UNFCCC; and
- For PNG to access results-based payments (RBP) (according to UNFCCC decisions, results-based payments require a forest reference level) through the UNFCCC established international funding mechanism(s) such as Green Climate Fund (GCF) RBP Programme or other sources such as the LEAF Coalition ART/TREES, Verra, and Coalition for Rainforest Nations.

Chapter 2. Improvement in Comparison with Previous Submission

This document builds on the 1st FRL for the REDD+ submitted in 2017, and have been technically assessed by UNFCCC technical experts in 2018.

PNG retains the similarity to the 1st FRL document, and considered this as an update of the first submission, which is consistent with decision 12/CP.17. However, this submission also considers the improvement plan identified in the 1st submission, the suggestions of the UNFCCC technical assessment, and lesson learnt or experience on REDD+ implementation in PNG.

The 2nd FRL submission contains several improvements. In the 1st FRL submission, the methodology and results of Forest and Land Use Assessment were not explained in detail but they are included in the 2nd FRL submission. Uncertainty analysis of activity data was included in the modified 1st submission but uncertainty analysis of emission factors and aggregated uncertainty analysis were included in the 2nd FRL submission. In addition, the chapter to explain the NFMS was added (chapter 12).

Regarding the new Forest and Land Use Assessment (2016-2018), the basic methodology remains the same to keep consistency and compatibility with the past assessment data. Additionally new available i satellite imagery (e.g. Sentinel-1/2 and Planet Lab) were used as reference to improve the quality of the assessment, but the core parts of the assessment on historical forest and land use change assessment remain the same.

Regarding the construction methodology of 2nd FRL, although the data developed and used remain the same, the historical reference period, results period, and projection methodology were updated by referencing to the latest standard and guidance such as the GCF scorecard for the GCF RBP pilot programme, ART TREES2.0 etc (e.g. Forest Carbon Partnership Facility (FCPF) Methodological Framework). Projection methodology was updated from linear projection to historical average considering the trend of emissions and removals in recent years and referring to the requirement and recommendation of the latest standards and guidance.

Further details are explained in the relevant chapters in this document so please refer to the relevant chapters and sections as necessary.

Chapter 3. Consistency with GHG Inventory Reporting

The establishment of the PNG's 2nd FRL strived to maintain consistency with the latest Green House Gas (GHG) inventory for the land-use, land-use change and forestry (LULUCF) as contained in the 2nd BUR in order to meet the modalities for FRELs and/or FRLs in decision 12/CP 17. PNG's 2nd FRL and the latest GHG inventory for the LULUCF sector in the 2nd BUR used the same dataset and methodology but with some differences in included activities, carbon pools and GHGs.

The most significant difference between the GHG inventory for the LULUCF sector and 2nd FRL is the choice of inclusion/exclusion of the biomass regrowth of degraded forest that was degraded prior to 2000. The GHG inventory for the LULUCF and 2nd FRL were prepared using the same data of annual land use change assessment between 2000 and 2018 using Collect Earth tool (see Chapter 7 for detailed methodology). PNG included *deforestation*, *forest degradation* and *carbon stock enhancement* as REDD+ activities in the 2nd FRL. Biomass regrowth of the forest, which was degraded prior to 2000 was not included in *carbon stock enhancement* because it was not possible to identify repeated degradation in the forest already degraded and estimate the intensity of degradation. On the other hand, this was included in the GHG inventory for the LULUCF sector by using the growth factors for >20 years in the 2006 IPCC Guidelines.

For the forest degraded after 2000, stock difference of average biomass of primary forest and logged over forest in respective forest type was applied to estimate the carbon loss due to degradation and gains from subsequent recovery for both the GHG inventory for the LULUCF sector and 2nd FRL. Removal due to regrowth of degraded forest that was degraded prior to 2000 was 41,426,000 tCO_2eq/year in 2018. This was included in the GHG inventory for the LULUCF sector but not in the 2nd FRL and it caused significant differences with the net emissions reported.

In addition, the 2nd FRL did not include gases other than carbon dioxide (CO_2) because the lack of reliable data and also, they were likely insignificant for the activities included in the 2nd FRL. However, non-CO_2 gases (methane (CH_4) and nitrous oxide (N_2O)) were included in the GHG inventory for the LULUCF sector.

Litter and soil organic carbon were not included in the 2nd FRL due to lack of reliable data while they were included in the GHG inventory for the LULUCF sector using the 2006 IPCC Guidelines default values for purpose of completeness. Fuel wood gathering is not included in forest degradation in 2nd FRL due to lack of reliable data but it was included in the GHG inventory for the LULUCF sector.

These additional methodological differences slightly mitigate the large difference caused by inclusion/exclusion of biomass regrowth of degraded forest that was degraded prior to 2000. The overall difference of net emissions between the GHG inventory for the LULUCF sector and 2nd FRL was 10,427,130 tCO_2eq/year in 2018 (GHG inventory for the LULUCF sector; 14,612,000 tCO_2eq/year, while 2nd FRL; 25, 039, 130 tCO_2eq/year). The differences on

methodology between the GHG inventory for the LULUCF sector and 2nd FRL are listed in Table 3-1. Conform the quality principle of completeness for the LULUCF sector in BUR, all anthropogenic emissions and removals from managed land (full geographic coverage), all gases (including CH_4 and N_2O) and pools (including soils and litter) have to be included if country specific or default data are available using a tier 1 methodology according to decision 15/ CP.17 Annex I (II.B 4(d)). This is not a requirement for FREL/FRLs in which countries can include only emissions and removals of included activities, gasses and pools during the reference period.

Decision 12/CP.17 outlines that countries may take a step-wise approach to the development of FREL/FRLs, improving them over time by incorporating better data, improved methodologies and additional pools. Countries are also encouraged to update their FREL/FRLs periodically to take into account new knowledge, trends or any modification of scope and methodologies, as much as possible. PNG has been significantly improving its capacity on land use change assessment and availability of reliable spatial information and statistical data. PNG will continue improving its capacity and the differences between BURs and FRLs and is expected to diminish in the submission of Biennial Transparency Reports (BTR) and future FRLs.

Table 3-1. List of the differences on methodology between the GHG inventory for the LULUCF sector and 2nd FRL

	GHG inventory for the LULUCF sector	**2nd FRL**
Gas	CO_2, CH_4 and N_2O are included.	CO_2 is included.
Carbon pool	Above & blow ground biomass, litter and soil are included	Above & belowground biomass are included.
Activity	Removal due to forest regrowth of the degraded forest that was degraded prior to 2000 is included.	Removal due to forest regrowth of the degraded forest that was degraded prior to 2000 is not included.
	Biomass loss due to fuel wood removal is included	Fuel wood removal is not included in forest degradation

Chapter 4. PNG's National Forest Definition

4.1. Forest Definition

Prior to determining whether deforestation, afforestation or reforestation is occurring, and to define the areas within which degradation and the other REDD+ activities may occur, it is paramount that the forest has to be defined first. As part of the guidelines for submission of information on forest reference levels, country Parties should provide the definition of forest used.

Under the IPCC 2003 GPG the forest includes "*all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, subdivided into managed and unmanaged, and also by ecosystem type as specified in the IPCC Guidelines. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category*." The 2006 Guidelines make reference to *threshold values* for the forestland definition. This indicates that the IPCC anticipates countries to define their forest with quantitative thresholds.

PNG's national forest definition is "*land spanning more than 1 hectare, with trees higher than 3 meters and the canopy cover of more than 10 percent (%)*". This excludes land that is predominantly under agricultural or urban land use. This national definition was endorsed by the PNG National Executive Council in Decision #256 of Meeting #07/2014.

4.2. Forest Classification

Forestland in PNG is classified into Natural and Plantation Forest and subdivided based on the vegetation and plantations types. Vegetation type is classified based on the structural formation and described in PNG Resource Information System (PNGRIS) Publication No.4 (Hammermaster & Saunders, 1995). There are 12 natural vegetation/forest types in PNG forest. Montane coniferous forest is included due to the high conservation value of this specific forest type.

Table 4-1. Forest vegetation classification in PNG and their short description. Full description is available in Hammermaster & Saunders (1995).

Forest types	**Short description**
(a) Natural Forest	
Low Altitude Forest on Plains and Fans	below 1000 m
Low Altitude Forest on Uplands	below 1000 m
Lower Montane Forest	above 1000 m
Montane Forest	above 3000 m
Dry Seasonal Forest	restricted to southwest PNG in a low-rainfall area (1800-2500 mm)
Littoral Forest	dry or inundated beach
Seral Forest	river line, upper stream, river plains and volcano blast area
Swamp Forest	swamp area

Woodland	low and open tree layer
Savanna	low (< 6m) and open tree layer in low rainfall area with a marked dry season
Scrub	community of dense shrubs up to 6 m
Mangrove	along coastline and in the deltas of large rivers
Montane coniferous forest	high altitude forests dominated by coniferous species (Podocarpaceae)
(b) Plantation Forest	
Forest Plantations	Includes all species of Eucalyptus Plantation, Araucaria Plantation (Araucaria cumminghamii (Hoop Pine) and Araucaria hunstanii (Klinkii Pine)), Pinus Plantation, Acacia Plantation, Terminalia Plantation, Rubber Plantation and others not included above.

Moreover, natural forest types are divided into primary forest and disturbed forest as per the following definitions:

- Primary forests – Naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed.
- Disturbed forests – Naturally regenerated forest where there are clearly visible indications of human activities (FRA, 2015).

4.3. Definition of REDD+ Activities

In addition to the above, the definition for Deforestation and Forest Degradation are included as part of the REDD+ activities and is defined according to conversions between land-use types, as follows:

- Deforestation is the conversion from forest land to any non-forest land. Primary deforestation is the conversion of primary forest. Secondary deforestation is the conversion of degraded forest.
- Forest degradation is the conversion from primary forest to disturbed forest.
- Carbon stock enhancement is the conversion of any non-forest land to forest land.
- The sustainable management of forests and forest conservation concern the accumulation of carbon in forest land remaining forest land. These are not currently included in the scope.

The activity data were constructed to reflect only anthropogenic activities. This is true for both deforestation and forest degradation. This distinction between managed and unmanaged land was made according to the presence of logging roads, permanent roads & bridges, forest cover losses within proximity to villages and accessibility in terms of the topography. Where the forest cover loss was observed in inaccessible areas or far from villages/settlements and roads, these losses were not recorded or reported. Such observations were assumed to be due to natural disturbances (e.g.; volcanic activities,

landslides, cyclones). In summary, the deforestation and forest degradation emissions reflect anthropogenic emissions only.

Table 4-2. Land use categories, subtypes and subdivisions used in this assessment

IPCC Land use Category	Sub-type Category	Sub-division category
Forestland	Natural forest	Low altitude forest on plains and fans, Low altitude forest on uplands, Lower montane forest, Montane forest, Montane coniferous forest, Dry seasonal forest, Littoral forest, Seral forest, Swamp forest, Savanna, Woodland, Scrub, Mangrove
	Plantation forest	Eucalyptus, Araucaria, Pinus, Acacia, Terminalia, Teak, Rubber, Other Forest Plantation
	Subsistence Agriculture	Shifting, Permanent
	Commercial Agriculture	rice, spices, tea, sugar, coffee, palm oil, cocoa, coconut, cocoa/coconut, other
Grassland		herbland, rangeland, other
Wetland		river, lake, dam, nipa swamp[3], other swamp
Settlement		village, hamlet, large settlement, infrastructure
Otherland		bare, sand, rock
*No data		cloud, sea, other reasons

**This is an additional option apart from the six IPCC land use categories.*

[3] If the canopy cover of trees exceeds 10%, they are considered swamp forest.
Nipa swamps don't have trees but are dominated by Nipa palms which are classified under wetland

Chapter 5. Elements for Forest Reference Level

The elements include the set of REDD+ activities covered, the carbon pools, the GHGs included in the construction of the 2nd FRL, the results period and the scale. The information presented under each parameter are based on the availability of data for the LULUCF sector in PNG. All the information had been reviewed and validated by the national stakeholders and technical experts during the stakeholders' engagement process conducted in 2022. The national stakeholders comprise of representatives from government and private sectors, international development partners, academia, and Non-Government Organizations (NGO)/Civil Society Organizations (CSO).

5.1. Scope

5.1.1. REDD+ Activities

The REDD+ activities covered in the 2nd FRL include (1) deforestation, (2) forest degradation, and (3) enhancement of forest carbon stocks.

No activities on carbon stock enhancement were detected during the historical reference period (2000-2018) from the forest and land use assessment using Collect Earth. However, the government has set the policy for targeting of 800,000 ha tree planting. It is anticipated that tree planting would become one of the major REDD+ activities in the near future. Thus, carbon stock enhancement is included in REDD+ activities although it has been negligible amount of carbon removed by increase of forest area.

The REDD+ Activities not covered in the 2nd FRL are (4) Sustainable Management of Forests, and (5) Forest Conservation.

The sustainable management of forest and the conservation of carbon stocks both concern the accumulation of carbon in existing forests, especially forests managed through sustainable harvesting practices. But PNG currently does not have reliable and comprehensive information at national scale to measure those removals for international report. In addition, one of the most recent standards of REDD+ including measurement, ART/TREES2.0 excludes removals from forest remaining forest.

But this does not mean that PNG is not addressing sustainable management of forests and conservation of forest carbon stocks. These two activities are important for the country and PNG will address them and measure if they contribute to area decreased of deforestation and forest degradation, and enhancement of forest carbon stocks. These activities are actually just a different way to present the same Policies and Measures (PAMs). PNG will also make efforts to improve the capacity to measure removals from forest remaining forest.

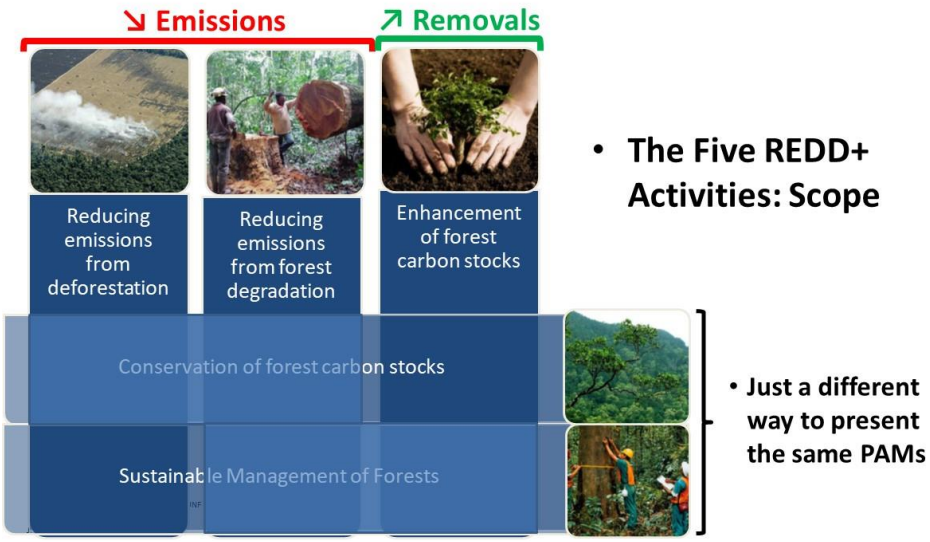


Figure 5-1. The Five REDD+ Activities: Scope (Source: Reference: South-South Learning: "The FRL Assessment Process in Asia and the Pacific"Pokhara, Nepal, April 2017)

5.1.2. Carbon Pools

The carbon pools covered in the 2nd FRL include (1) Above-Ground Biomass, and (2) Below-Ground Biomass.

Carbon pools not currently covered are (3) Litter, (4) Deadwood, and (5) Soil-organic carbon

Litter

According to the IPCC 2006 Guidelines, litter is treated identical as dead wood (see previous paragraph). However, IPCC 2006 Guidelines provides default values of carbon stock in Litter only for broadleaf deciduous and needleleaf evergreen forest for tropical region, while most of PNG forests are in different group (broadleaf evergreen). PNG has no country specific carbon stock value for litter to allow for reliable estimation.

The 2006 IPCC Guidelines default value of litter of broadleaf deciduous forest in tropical region is 2.1 tC/ha. This is 1.5% of average carbon stock in total living biomass of primary forests in PNG (144 tC/ha, Table 6-2) and not significant carbon pool. Since no reasonably reliable data for estimating carbon stock in litter is available in PNG and litter is insignificant carbon pool, it is not covered in the 2nd FRL. Country specific data will be available within 1-2 years as the national Forest Inventory progresses. By then litter will be included in national emission calculations.

Deadwood

According to the 2006 IPCC Guidelines, dead wood should be estimated at a tier 1 level for deforestation and carbon stock enhancement (land that is converted from forest land to any other land use and vice versa). For forest degradation (forestland remaining forestland), deadwood carbon stocks are assumed to be in equilibrium under tier 1 subsequently emissions are zero. However, 2006 IPCC Guidelines do not provide default values of deadwood carbon stock in forest because of the paucity of published data. PNG has no

country specific carbon stock value for dead wood to allow for reliable estimation. Since no reasonably reliable data is available to use in PNG, carbon pools in Deadwood is not covered in the 2nd FRL.

Dead wood is potentially a large carbon pool, particularly in disturbed forest, and may constitute 10-40% of aboveground biomass (Uhl & Kauffman 1990). Fox et al. (2010) estimated biomass of dead wood in PNG forests as 25% of aboveground living biomass at logged over forest and 10% of aboveground living biomass at primary forest from their observation.

National Forest Inventory currently under implementation in PNG includes the data collection of deadwoods. Within a couple of years, PNG will be able to accurately estimate the carbon stock of deadwood in Forest.

Soil organic carbon

McIntosh et al. (2016)[4] reported that up to 50–75% of PNG forest carbon could be held in the soil. Land use can have a large effect on the size of this pool through activities such as conversion of Forest Land to Cropland, where 20-40% of the original soil carbon stocks can be lost (IPCC 2006). Emissions from this carbon pool as the results of deforestation could be significant. According to the 2006 IPCC Guidelines soil organic carbon should be estimated at a tier 1 level for all considered REDD+ activities. However, PNG forest soil have not been classified into the soil types provide in 2006 IPCC Guidelines for their default values. It is currently not possible to estimate the emissions from soil organic carbon pool. On the other hand, it is possible to identify the soil type and climate of all the point where forest conversion occurred using Collect Earth tool. PNG has been rapidly accumulating the data set of soils under National Forest Inventory (NFI) and other studies. PNG does not cover soil organic carbon pool in the 2nd FRL; however, PNG will be able to include it within a few years once the NFI is completed.

5.1.3. GHG Considered

CO_2 is the only GHG included in the 2nd FRL. Non-CO_2 gases are not included in the 2nd FRL because the reliable data is lacking and also, they are likely insignificant. In principle, these would occur due to burning during the forest degradation, drainage of organic soils upon deforestation and mineralization of carbon after deforestation. About 3% of forest is affected by fire in PNG but the year in which the fire occurred and frequency are not known in most cases. There is no reliable data of distribution of organic soil and their drainage, which could cause CH_4 and N_2O emissions.

5.2. Scale

The dangers posed from climate change and the importance of forests in tackling this issue is a key concern for GoPNG. PNG has succeeded with other parties in having REDD+ embedded into Article 5 of the Paris Agreement as a positive measure for reducing GHG emissions within

[4] McIntosh, P.D.; Doyle, R.; Nimiago, P. 2016. Field guide for sampling and describing soils in the Papua New Guinea National Forest Inventory, 3rd edition.

developing countries. In line with this objective, PNG's political leadership called for tangible actions to be taken to reduce GHG emissions through REDD+ and put in place long term political visions, plans and strategies, most notably; the Vision 2050, Medium Term 3 Development Plan (MTDP) 2015-2018, the National Strategy for Responsible Sustainable Development (StaRS) and recently enacted Climate Change (Management) Act, 2015 to ensure this was achieved. PNG aims to address REDD+ at the national level where reducing emissions from the forest sector becomes an important policy priority.

As such, PNG has decided to develop its 2nd FRL at the national scale, where all REDD+ efforts will be monitored and measured using geographical information system (GIS) and remote sensing through the Satellite Land Monitoring Systems (SLMS) including the equipment and tools which have been introduced and built into the country's existing national agencies. This will effectively contribute towards the country's policy directions and act as a guide for its forest policies.

5.3. Data

PNG established the NFMS using a combination of remote sensing and ground-based forest carbon inventory approaches [5] to determine the extent of its current forest cover, the land use, land use-change, and associated carbon stock and the changes using a two-phase approach:

i. Remote Sensing data analysis (activity data) based on a systematic sampling method using Open Foris Collect Earth
ii. Ground based forest carbon inventory (emission factors) based on plot clusters on a random restricted sampling design

Remote Sensing data analysis (for activity data) is explained in detail in Chapter 7: Forest and Land Use Assessment: Method. The emission factors are explained in detail in Chapter 6: Emission and Removal Factors Estimates.

5.4. Construction Method

5.4.1. Guidance Reviewed

The construction of PNG's 2nd FRL and other reports such as REDD+ technical Annex and GHG inventory for the LULUCF sector were based on IPCC methodology. PNG used the 2006 IPCC Guidelines and Good Practice Guidelines for the LULUCF sector as a basis for estimating anthropogenic forest-related GHG and removals resulting from changes in carbon stocks in forest land converted to other land-use categories (Deforestation), forest land remaining forest land (Forest degradation) and non-forest land to forest land (Carbon stock enhancement)[6] . Forest land was stratified by forest type and type of disturbance. Historical

[5] Decision 4/CP.15
[6] see BUR section 2.4.4. for details on LULUCF

annual emissions were estimated using emission factors[7] appropriate to various forest strata, derived from scientific literature and the 2006 IPCC Guidelines, and activity data obtained through the Collect Earth assessment[8].

5.4.2. Reference Period

As a result of broader stakeholder consultations held recently it was agreed that the preferred reference period to use for PNG would be the period from 2009-2018 (10 years). The most reliable national land use data in PNG is available during the selected period. There might be some intervention of REDD+ activities to the GHG emission in LULUCF sector in very recent years. It is necessary to fully investigate the influence of REDD+ related policy and measures in recent years but this will take some time. PNG considers that the period from 2009-2018 is the most appropriate for the historical reference period for predicting future emissions under business-as-usual scenario.

5.4.3. Results Period

Basing on the national reporting schedules under UNFCCC requirements, a REDD+ results period of 2019-2027 (9 years) will be used to align the intervals of the 2nd FRL to the BTR reporting and PNG's Enhanced NDC 2020 review timeline. According to "Terms of reference for the pilot programme for REDD+ results-based payments[9]"; Annex XII: Scorecard, Section 2: Carbon Elements; Section 2b. REDD-plus Results reporting, REDD+ results reporting period get higher score if it is set with 5 years or less but 6 to 9 years is still acceptable.

[7] for details on EF refer to PNG modified FRL submission section 6.3
[8] for details on Collect Earth methodology see section 5.2.1
[9] https://www.greenclimate.fund/document/terms-reference-pilot-programme-redd-results-based-payments

Chapter 6. Emission and Removal Factors Estimates

PNG has been commencing ground-based forest carbon inventory since 2016 as the main component of its Multi-Purpose National Forest Inventory (NFI) to develop country specific emission factors with an aim to accurately estimate GHG emissions and removals in the LULUCF sector. The NFI methodology is built on the methods and capacity developed within the PNGFA over a number of years but with a wider scope in addressing forest management and biodiversity conservation in the country. (See chapter 12 for the information on the NFI)

Although it is anticipated that PNG is planning to use the results of the NFI for future FRLs, GHG inventories and REDD+ results reporting to improve the accuracy and reliability of the data and value, the survey and the analysis are still underway at the time of submitting 2nd BUR including the REDD+ technical annex. Therefore, the sub-sections below explain the current data used for 2nd FRL, based on the IPCC guidelines with some existing works in PNG (basically the same explanation in the emission factors section in the modified PNG national forest reference level submitted in 2017).

6.1. Forest Stratification

There are 12 vegetation types in PNG's natural forest, which is described in PNGRIS Publication No.4 (Hammermaster & Saunders 1995). For the Collect Earth assessment, "montane coniferous forest" was added because of the high conservation value of the specific forest type. Each forest type excluding Woodland, Savanna, Scrub and Mangrove were further stratified to three disturbance categories namely primary, logged over and forest disturbed by other than logging (e.g. fire, gardening). No commercial logging is conducted in Woodland, Savanna, Scrub and Mangrove. Consequently, these forest types were classified to only two disturbance categories namely; primary and forests disturbed by other than logging. In addition to natural forest, there are plantation forests with two disturbance categories (primary and disturbed other than logging). In total forest in PNG were stratified to 37 strata (Table 6-2).

6.2. Above Ground Biomass

Above Ground Biomass (AGB) of a unit forest area of each forest type and different type of disturbances needs to be estimated to calculate emissions from deforestation and forest degradation. Collecting such information is one of the major objectives of PNG's first NFI, which is currently under implementation. However, it will take another 2-3 years before the full information derived from the NFI become available. The review of existing information was conducted to identify the most appropriate aboveground biomass per unit area of each forest strata. The forest biomass information derived from small plot (e.g. 1 ha) in a specific forest was excluded from consideration because of the high local heterogeneity of PNG forest (Abe 2007, Vincent et al. 2015) and tropical rainforest elsewhere (Nascimento & Laurance 2002).

Fox et al. (2010) reported the average of above ground biomass of primary lowland tropical rainforest in PNG as 222.8 t/ha based on ten 1 ha permanent sample plots (PSP) managed by PNG Forest Research Institute. This is lower than any of ten lowland tropical rainforest studies (230 – 597 t/ha) in PNG summarised by Bryan et al. (2010a) and also lower than averages for tropical equatorial forest (Gibbs & Brown 2007: 328 t/ha; IPCC 2006: 350 t/ha; Lewis et al. 2009: 404 t/ha). Often well-developed large forests are preferred and selected for ecological studies, and consequently, AGB of study plots may be biased toward more productive forest. On the other hand, PSP plots are often located in proximity to roads or villages due to management reasons. They may have been subject to some degree of previous disturbance and it might cause lower carbon stock.

However, AGB estimated for 50 ha plot at Wanang lowland tropical rainforest in Madang Province is 210.7 t/ha (Vincent et al. 2015) and estimated for 3,000 ha lowland tropical rain forest of Makapa concession in Western province is 222.7 t/ha (Bryan et al. 2010b), generate estimates in agreement with Fox et al. (2010). Consequently, it is considered most appropriate to apply the average above ground biomass provided by Fox et al. (2010) to estimate carbon stock of the primary forest of five lowland tropical rainforest type (low altitude forest on plains and fans, low altitude forest on uplands, littoral forest, seral forest and swamp forest) in PNG.

For AGB of logged over lowland tropical rainforest in PNG, Fox et al. (2010) reported 146.0 t/ha as the average of 115 1-ha PSP plots across the country. This is also supported by Bryan et al. (2010b) reporting 152.9 t/ha at Makapa concession in Western province. It is considered most appropriate to apply the AGB for logged over lowland tropical rainforest reported in Fox et al. (2010) to logged forests of the five forests type (low altitude forest on plains and fans, low altitude forest on uplands, littoral forest, seral forest and swamp forest) in PNG. There is no information on ABG of the forests disturbed by anthropogenic activities other than commercial logging. This information will be available as NFI proceeds. In this 2nd FRL submission, the same AGB used for estimating carbon stock of logged over forest is also used for the forest disturbed by anthropogenic activities other than commercial logging for the five forest types of lowland tropical rainforest discussed above. These five forest types consist of 64% of PNG's forest.

PNG used the AGB > 10cm (106.3 Mg C/ha) and AGB <10cm (5.1 Mg C/ha), meaning AGB (111.4 Mg C/ha) for calculating primary lowland forest above ground biomass with a conversion value of 0.5, resulting in 222.8 t/ha.

Same for primary lowland forest (logged for other disturbance), the PNG team used AGB > 10cm (66.3 Mg C/ha) but also AGB <10cm (6.7 Mg C/ha), meaning AGB (73.0 Mg C/ha) with a conversion value of 0.5, resulting in 146.0 t/ha.

Then converted them back from biomass to carbon using the equation presented in section 6.4 to calculate carbon for each forest stratum (then using the 2006 IPCC default 0.47 conversion factor).

These data represent an average condition of degraded forests in PNG. Such an average condition results from an initial loss of carbon during a logging event and the regrowth of carbon during subsequent forest recovery. Using these data to build emission factors for forest degradation, as is undertaken below, results in estimating a net of losses from disturbance and gains from subsequent recovery.

The data represent logging in concessions primarily, and for small-scale logging activities may not be fully adequate. No high-quality information is currently available to estimate the degrading effects of small-scale activities, which is the data from large-scale logging activities were used instead. The impact of this simplification is deemed to be small, since small-scale logging accounts for only <1% of all logging by area.

6.3. IPCC Guidelines

Other than five forests type discussed in the above section, no sufficient information on AGB is available. IPCC Guideline (2006: Table 4.12) provides above ground biomass per unit forest area of each Global Ecological Zone described by FAO (2001). Global Ecological Zone and the PNG forest classification provided in PNGRIS (1995) are correlated well. Figure 6-1 shows similar distribution of montane vegetation and dry vegetation between the PNG Forest Base Map (PNGFA 2012) and Global Ecological zone (FAO 2001). The description of Ecological Zone in tropical climate is summarised in Table 6-1.

Table 6-1. Summary of Climate Domains and Ecological Zone (FAO 2001) relevant to PNG's environment.

Climate domain		**Ecological zone**	
Domain	**Domain Criteria**	**Zone**	**Zone Criteria**
Tropical	All months without frost; in marine areas, temperature >18°C	Tropical rain forest	Wet: ≤ 3months dry, during winter
		Tropical moist deciduous forest	Mainly wet: 3–5 months dry, during winter
		Tropical dry forest	Mainly dry: 5–8 months dry, during winter
		Tropical shrubland	Semi-arid: evaporation > precipitation
		Tropical desert	Arid: all months dry
		Tropical mountain systems	Altitudes approximately >1,000 meters, with local variations

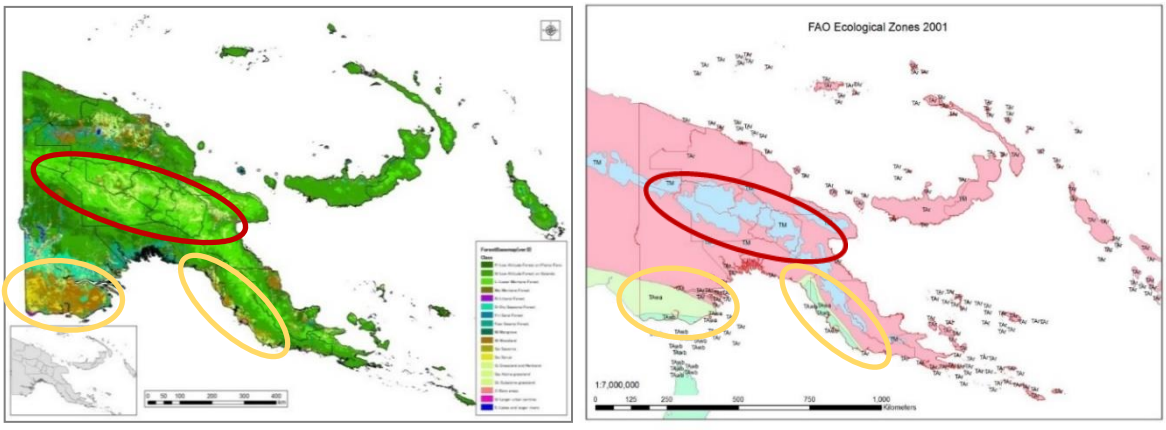


Figure 6-1. Correlation between PNG forest classification in Base Map (Left: PNGFA/JICA 2014) and Global Ecological Zone (Right: FAO 2001). Notes: The red ellipse shows the distribution of montane vegetation; the yellow ellipse shows the distribution of dry vegetation.

The default values of IPCC Guidelines for above ground biomass for associated Ecological Zone were applied to each of all other forest type as shown in Table 6-2. Root to shoot ratio and carbon fraction of the 2006 IPCC guidelines were also applied to estimate below ground biomass and carbon contents of above and below ground biomass (Table 6-2). Several carbon pools are not included in the scope of this FRL submission and appropriate values will become available as the NFI progresses. In the future, all the Emission Factors used in this FRL submission should be replaced with the country specific values obtained through the NFI, which is currently being implemented. After NFI is completed then PNG will be able to report near Tier 2-3 level of GHG inventory for the LULUCF sector.

Table 6-2. Above- and below-ground biomass calculations per unit area of PNG forest

Forest type	Human impact	Above-ground biomass			Below-ground biomass	
		Source	IPCC Ecological Zone	Dry matter (t/ha)	Dry matter (t/ha)	Root-to-shoot ratio
Low-altitude forest on plains and fans	Primary	Fox et al. (2010)	Tropical rainforest	223	83	0.37
	Logged			146	54	0.37
	Other disturbance			146	54	0.37
Low-altitude forest on uplands	Primary			223	83	0.37
	Logged			146	54	0.37
	Other disturbance			146	54	0.37
Littoral forest	Primary			223	83	0.37
	Logged			146	54	0.37
	Other disturbance			146	54	0.37
Seral forest	Primary			223	83	0.37
	Logged			146	54	0.37
	Other disturbance			146	54	0.37
Swamp forest	Primary			223	83	0.37
	Logged			146	54	0.37
	Other disturbance			146	54	0.37
Lower montane forest	Primary	2006 IPCC guidelines	Tropical mountain system	140	38	0.27
	Logged			92	25	0.27
	Other disturbance			92	25	0.27
Montane forest	Primary			140	38	0.27
	Logged			92	25	0.27
	Other disturbance			92	25	0.27
Mountain coniferous forest	Primary			140	38	0.27
	Logged			92	25	0.27
	Other disturbance			92	25	0.27
Dry seasonal forest	Primary		Tropical dry forest	130	36	0.28

	Logged			85	24	0.28
	Other disturbance			85	24	0.28
Woodland	Primary			130	36	0.28
	Other disturbance			85	24	0.28
Savanna	Primary			130	36	0.28
	Other disturbance			85	24	0.28
Scrub	Primary		Tropical shrubland	70	28	0.4
	Other disturbance			46	18	0.4
Mangrove	Primary		Tropical wet Mangrove	192	94	0.49
	Other disturbance			126	62	0.49
Forest plantation	Primary		Tropical rainforest (plantation)	150	56	0.37
	Other disturbance			98	36	0.37

For some of the forest types, the carbon stock in degraded forests had to be estimated as a percentage reduction from the primary forest carbon stock. The percentage reduction was estimated at 65.47% based on the measurements for low altitude forest on plains and fans.

6.4. Carbon stock in Forest land

The team calculated the carbon of each forest stratum, using the following formula:

$$C = A*[(B + (B*R))*CF]$$

Where:

A is the forest stratum area in hectares

B is the unit total living biomass in tons per hectare

C is the carbon stock in tons per hectare

R is the root-to-shoot ratio

CF is the carbon fraction (0.47 from 2006 IPCC guidelines)

6.5. Carbon stock in Non-Forest land

In line with the IPCC guidelines, the calculations of emissions from deforestation deduct the removals from post-deforestation regrowth in cropland and grasslands with trees. To approximate such removals in croplands and grasslands, IPCC default values are used since no country specific data on the biomass and the increment in biomass of land use other than forest is available in PNG.

The relative areas of different land-use types after deforestation are the starting point for calculating post-deforestation biomass and its growth. The IPCC guidelines include default

values for biomass and the growth duration, which allows to recover mean annual increments for these.

Table 6-3. Above-ground biomass and mean annual increment of cropland used for post-deforestation GHG removal.

Item	Coconut	Oil palm	Shifting cultivation	Permanent subsistence	Other
Relative area (%)	1	31	63	3	2
Above-ground biomass (t.d.m./ha)	196	136	45	45	45
Growth duration (years)	20	20	8	8	8
Mean annual increment in above-ground biomass (t.d.m./ha/year)	9.80	6.80	5.59	5.59	5.59

Source: Based on data from IPPC 2006, Tables 5.1 and 5.3.

Note: The average mean annual increment in living biomass 8.11 t.d.m./yr/ha, based on a weighted mean of the mean of the annual increments in above-ground biomass and a root-to-shoot ratio of 0.37.

The approach taken to determining removal factors for post-deforestation land use represents an approximation. In reality, the land uses have different growth rates for different time frames. The summary removal factor is applied regardless of the age of post-deforestation regrowth. In theory, applying this increment factors across a very longtime span (>50 years) could result in considerable carbon removals, potentially excluding biomass in some kinds of natural forests. In practice this will not occur because of the limited duration of the reference period and future accounting periods.

The expected duration of growth for shifting cultivation is given in the IPCC guidelines. The expected duration of growth for the other land uses was taken to correspond to 20 years in accordance with the default IPCC time horizon for conversion between land use types.

6.6. Calculation of Emission and Removal Factors

The emission factors for primary deforestation, secondary deforestation and forest degradation were calculated as follows:

Carbon stock = (above-ground biomass + below-ground biomass) x 0.47 (2006 IPCC guidelines)
Emission factor = (carbon stock before land use conversion – carbon stock after land use conversion) x 44/12 (2006 IPCC guidelines).

Table 6-4. Emission factors for deforestation of primary forest, deforestation of degraded forest and forest degradation.

Land use subdivision	Emission factors (tCO_2e/ha/yr)		
	Deforestation (primary forest)	Deforestation (degraded forest)	Forest degradation
Low-altitude forest on plains and fans	526.50	344.70	181.79
Low-altitude forest on uplands	526.50	344.70	181.79
Low montane forest	306.41	200.61	105.80
Montane forest	306.41	200.61	105.80
Montane coniferous forest	306.41	200.61	105.80

Dry seasonal forest	286.76	187.75	99.02
Littoral forest	526.50	344.70	181.79
Seral forest	526.50	344.70	181.79
Swamp forest	526.50	344.70	181.79
Savannah	286.76	187.75	99.02
Woodland	286.76	187.75	99.02
Shrub	168.89	110.57	58.32
Mangrove	493.01	322.78	170.23
Plantation forest	354.15	231.86	122.28

Note: $tCO_2e/ha/yr$ – tons of carbon dioxide equivalent per hectare, per year.

The removal factors for removals in carbon stock enhancement and post-deforestation regrowth are established as follows:

> *Removal factor = (increment in above-ground biomass + increment in below-ground biomass) x 0.47 (2006 IPCC guidelines) x 44/12 (2006 IPCC guidelines)*

For carbon stock enhancement, this calculation was carried out for plantations, since these were the only areas where conversion from non-forests to forests was observed. The removal factor amounts to 24.7 tCO2e/ha/yr, based on a default increment of 9.5m^3 merchantable volume/ha/yr, an average biomass conversion and expansion factor of 1.1 and a root-to-shoot ratio of 0.37, as per the 2006 IPCC guidelines.

For post-deforestation regrowth, the calculation was carried out drawing on the mean annual increment calculated above. Applying a mean annual increment is a simplification for two reasons. First, for some of the vegetation types considered, growth levels off after relatively a short period (eight years). Second, once that happens, the relevant areas of individual vegetation types should give greater weight for vegetation types with longer growth periods for establishing a weighted mean. Post-deforestation regrowth calculations may be refined in future iterations.

Values for post-deforestation land use types were derived from IPCC default values. The values of “cropping systems containing perennial species” were applied to two of PNG’s land use categories, “shifting cultivation” and “subsistence agriculture, permanent”. This match of categories was undertaken in a group discussion among sector experts from the CCDA and the PNGFA.

6.7. Calculation of Emissions and Removals

The emissions and removals are calculated as follows:

Emissions and Removals = Emission and Removal Factor x Activity Data

The emissions and removals to consider depend on the REDD+ activities.

For deforestation, the emissions from primary deforestation and from secondary deforestation, as well as the removals from post-deforestation regrowth need to be considered.

For forest degradation, the emissions from forest degradation are calculated using the equation above. The results represent the net of emissions from the logging event (or other degrading event) and removals from subsequent regrowth because the emission factors reflect average conditions of logged forests.

For carbon stock enhancement, only the removals from increment in plantations are considered. The emissions from clearing of vegetation present on lands before conversion to plantations are not covered. The error introduced by this simplification is expected to be small since plantations are established on grasslands that have largely herbaceous vegetation.

Chapter 7. Forest and Land Use Assessment: Method

PNG used the established NFMS and IPCC methodology to produce activity data for the 1st and 2nd FRL as well as the GHG inventory for the LULUCF sector in the 1st and 2nd BUR to be consistent over the time. PNG also has been working to improve the NFMS to be more transparent. The following sections provide the information of the remote sensing data analysis as a part of the established NFMS.

7.1. Overview of Assessment

Activity data used for the construction of the 2nd FRL were obtained from an annual historical time series analysis of LULUCF sector carried out by PNGFA using the same assessment methodology by Collect Earth for both the 1st and 2nd FRL.

Collect Earth is a forest monitoring tool that was developed by FAO under the Open Foris Initiative where software tools are open source and freely available online. Open-source software allows any party to verify the assessment conducted therefore improves the transparency of REDD+ process. One of the advantages of using Collect Earth software is that it can be customized according to the country's specific requirements or circumstances and when the software is modified there are regular updates of this online. The tool is linked to various application programs to enable the Collect Earth tool to operate functionally, i.e. Google Earth, Google Earth Engine and Bing Maps. The approach used for the Collect Earth is based on point sampling and the assessment used is detailed to capture the data for the six IPCC land use categories.

Activity data have been generated following IPCC Approach 3 for representing the activity data as described in the 2006 IPCC Guidelines (Volume 4, Chapter 3, Section 3.13), i.e., using spatially-explicit observations of land-use categories and land-use conversions over time, derived from sampling of geographically located points. Following this approach, a systematic grid sampling at national level was used to generate the national annual historical activity data for the entire area of the country.

7.2. Sampling Design and Unit

A systematic 0.04-degree (about 4.44 x 4.44 km) and 0.02-degree (about 2.22 x 2.22 km) grid consisting of a total of 25,279 points was established at the national level to generate the historical activity data. Each point was visually interpreted, and its information was entered into a database on Forest and Land use changes at the national level. The national level systematic sampling design allows estimating the variables of interest using accepted unbiased estimators, although it must be noted that the main drawback of systematic sampling is the absence of an unbiased estimator for the variance.

The spatial sampling unit from each point was defined as a 1 ha (100 m x 100m) plot, where an internal grid of 5 x 5 points (20m x 20m grid) is overlapped. Each point from the internal grid has weight coverage of 4%.

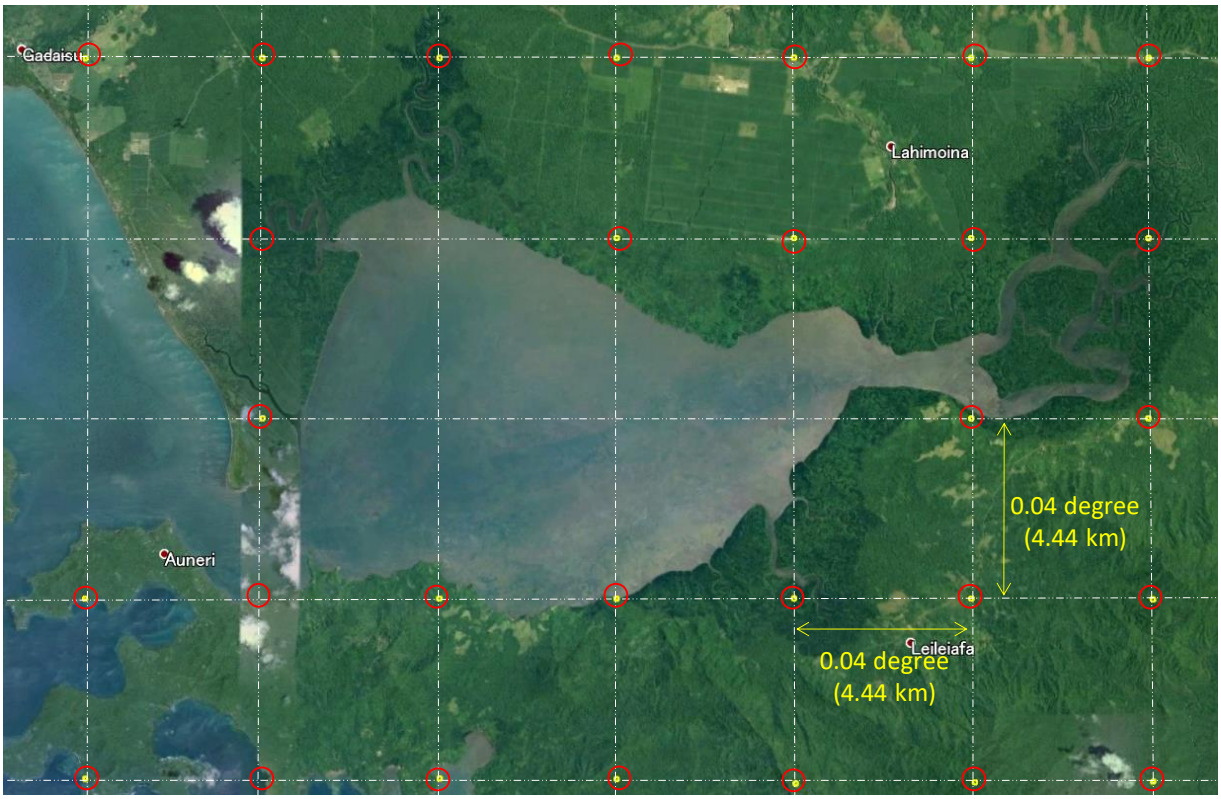


Figure 7-1. Image of the distribution of the assessment plots

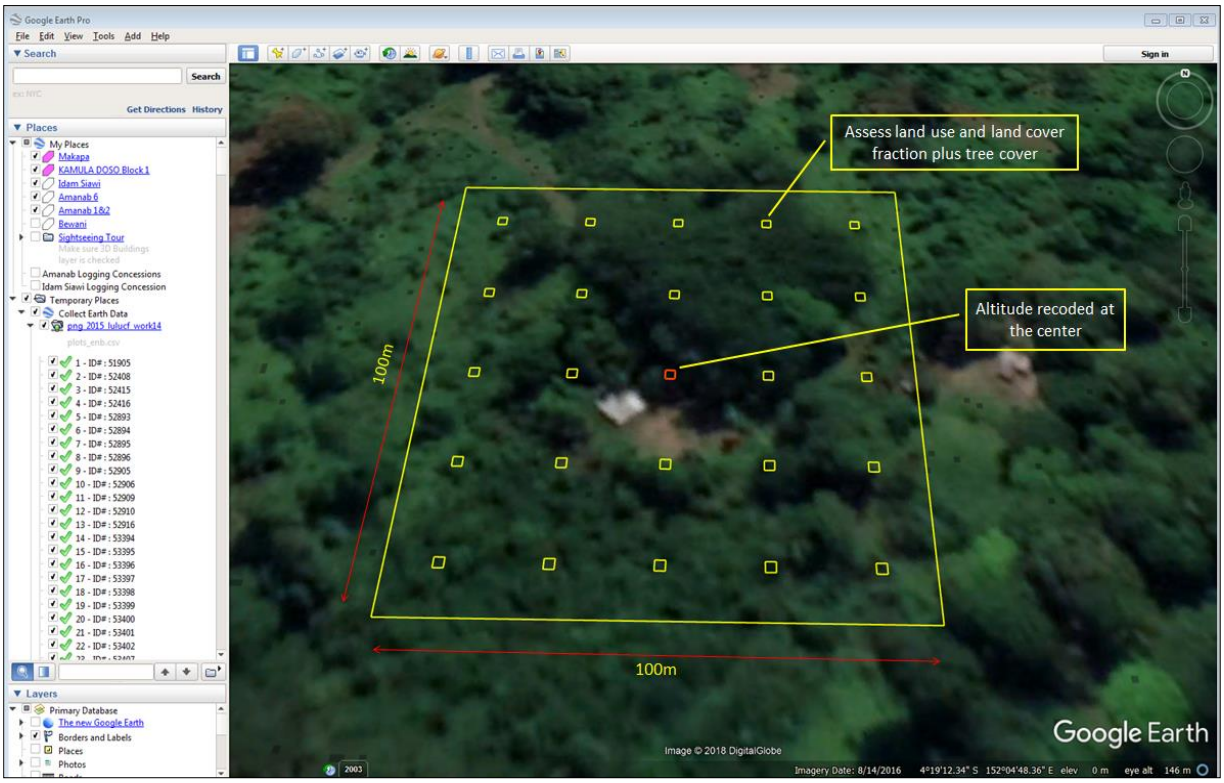


Figure 7-2. Image of the spatial sampling unit of the assessment plots

7.3. Reference Data to Use

The sampling approach for national historical activity data calculation based on systematic sampling has been designed and conducted using the high and medium resolution satellite image repository available through Google Earth, Bing Maps and Google Earth Engine as a visual assessment exercise. This imagery with the forms is designed to collect forest and land use change information on the points of the grid, which are automatically accessible through the Collect Earth tool. Google Earth Engine ensures the completeness of the series through Remote Sensing products from medium resolution imagery repositories between 2000 to 2018 (e.g. Annual TOA Reflectance Composite, Annual NDVI Composite, Annual Greenest-Pixel TOA Reflectance Composite, etc. from Landsat 5, 7 and 8).

Table 7-1 Satellite imagery used in the land use change assessment, source, type, year and purpose

Source	Imagery type	Resolution	Acquisition Year	Purpose
Google Earth	World-View, QuickBird, Ikonos, SPOT, etc.	High (0.5-2.5m)	2000-2018 (to date)	Land use and disturbance
Bing Maps	World-View, QuickBird, Ikonos, SPOT, etc.	High (0.5-2.5m)	2000-2005, 2007-2018 (to date)	Land use and disturbance
Planet Maps	Dove, Skyesat, RapidEye	Middle (3-5 m)	2018- 2018 (to date)	Reference data Accuracy assessment
Google Earth Engine	Landsat 7 (Annual Greenest Pixel)	Low (30m resolution)	1999-2013	Historical land use change
	Landsat 8 (Annual Greenest Pixel)		2014 -2018 (to date)	Check Current Situation
	Sentinel 2A/2B	Middle (10m)	2016- 2018 (to date)	Supplemental data Recent information

7.4. Assessment Procedure

The data collection process starts by launching the customized Collect Earth software on desktop computers with high-speed internet connections. Starting the Collect Earth automatically launches Google Earth, Google Earth Engine and Bing Map. This enables the systematic review of satellite images to assess land use and forest cover change. Data collection in this study is assessing the land use using the tools and materials described below:

(a) Collect Earth software is installed and opened, enabling the Google Earth to be automatically launched.
(b) Plot ID numbers located at the-side panel in Google Earth interface when double clicked automatically directs the screen to the sampling plot (Yellow Square) and the area of interest to be assessed. These sampling plots are used to quantify and characterize land cover within the plot area. For example, canopy cover percentage within the plot can be measured to apply the canopy cover threshold according to the Solomon Islands national forest definition.
(c) The cursor is placed inside the square plot and doubled-clicked, which opens the field form and activates Google Earth Engine and Bing Maps. Landsat 7 and 8 Annual Greenest Pixel are accessed through Google Earth Engine simultaneously.
(d) At the area of interest, the operator records information on the land characteristics and elements in a systematic and structured approach as they appear on the satellite image.

Once the assessment of the area of interest is completed, the operator is automatically directed to the next plot.

7.5. Data Collection Form

Figure 7-3 shows form (a) for recording information on the IPCC Land Use and Land Use Change and country specific sub-categories; form (b) the land cover elements to be measured; form (c) information on high resolution imagery; form (d) other sources of information used to support assessment; form (e) canopy cover measurement if land use is forest land; form (f) assessment of human impact type and year in a forest land category; form (g) information on logging concession if sampling plot falls within a boundary of a logging concession.

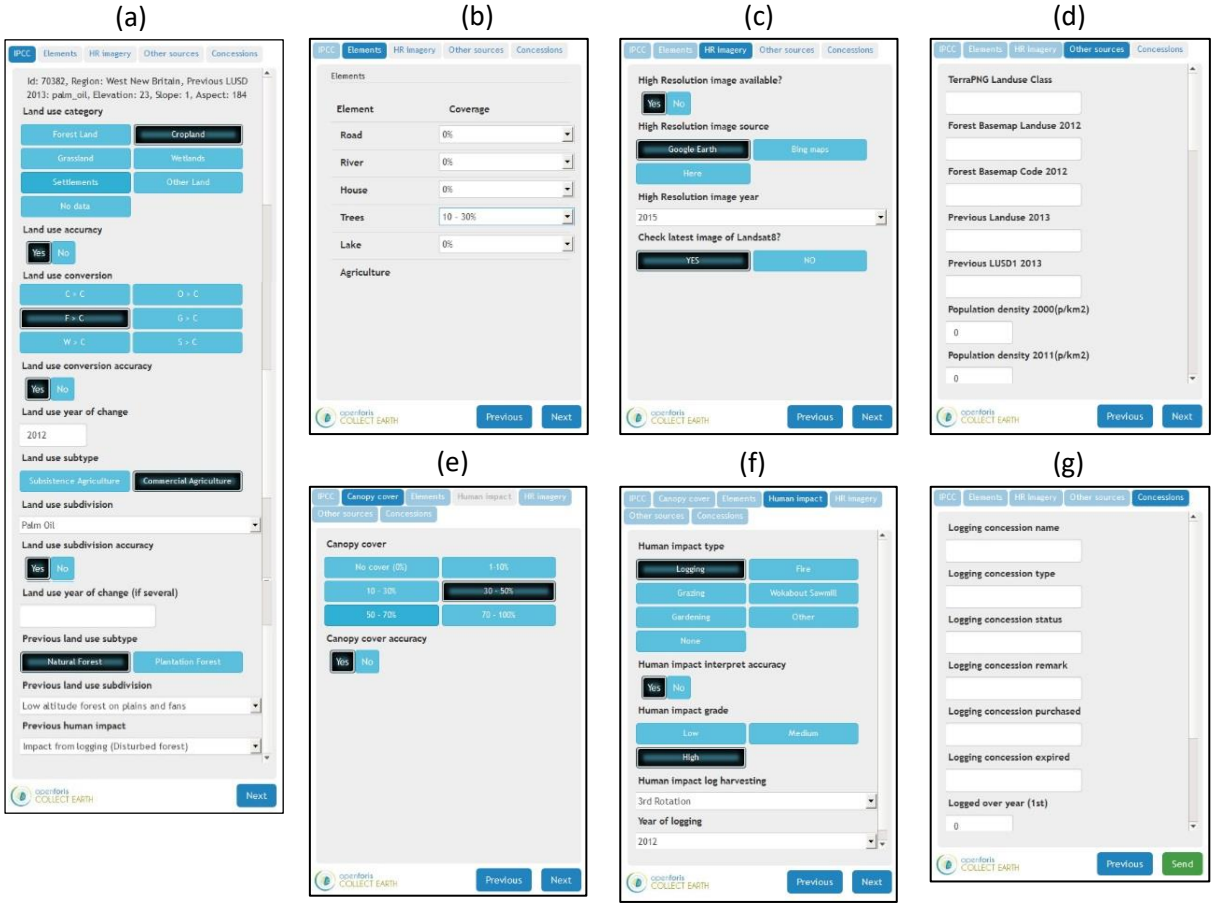


Figure 7-3. Illustration of the seven (7) PNG Collect Earth data collection forms

7.6. Land Use Assessment

The first step is to detect the 'key land elements' using medium to very high-resolution images. The key land elements are defined as a physical component of the land that characterize one or more land cover classes and/or land use categories.

Table 7-2. List of key land elements subdivided by land classes

IPCC Land Use Category	Land Key Elements
1. Forest land	Tree crown cover
2. Settlement	Building, paved roads and bridges
3. Cropland	Food crops
4. Wetland	Water, rivers, swamp, dam, lake
5. Grassland	Grasses, scrubs
6. Other Land	Rocky outcrop, barren land, sand

The second step is to determine the land use function of the land based on the spatial distribution of the key land elements and classify the land use. If the land class is complex (more than one land class in the area of interest) the hierarchical threshold criteria as described under Table 7-3 applies.

The final step is to determine if there is any land use change in the area of interest. The land use change is detected using Landsat 7 and 8 images using Google Earth Engine. Landsat 7 and 8 are enabled in Google Earth Engine once the sample plot is activated in Collect Earth. The operator uses Google Earth Engine with the different time series on Landsat 7 and Landsat 8 to determine the actual year of change from one land use conversion to another.

7.7. Hierarchical Rules to Apply

A single land use class is easier to classify however, it becomes challenging when there is a combination of two or more land use classes within the area of interest. This is where the hierarchical rules are applied to determine the land use.

The rules or assigned percentages are based on the land use definition which refers to the "description of the socio-economic function of the land", where a specific 'land use' is given preference over another when determining the 'land use' or 'land cover' type. This means that a plot with ≥10% coverage by 'settlement' is considered 'settlement' because the hierarchical rule determines that settlement takes precedence over forest, even if the plot has >10% forest cover and so forth. The hierarchical rules that apply are shown Table 7-3 below.

Table 7-3. Land use Hierarchical Rules

Priority	Land class	% Cover
1	Settlement	10
2	Cropland	20
3	Forestland	30
4	Grassland	30
5	Wetland	30

7.8. Land Use Classification

Under the six (6) IPCC broad land use categories (Forest land; Cropland; Grassland; Wetlands; Settlement; and Other land) there are two (2) levels of classes (sub-type and sub-division) that are used for the country specific sub-categories under this study as shown in Table 7-4. All PNG land is classified into 47 land use sub-division categories. Below are the short description of the land use categories and their sub-type categories.

Table 7-4. IPCC Land Use Categories, PNG Sub-type Category and Sub-division Category

IPCC Land use Category	Sub-type Category	Sub-division category
Forestland	Natural Forest	Low altitude forest on plains and fans, Low altitude forest on uplands, Lower montane forest, Montane forest, Dry seasonal forest, Littoral forest, Seral forest, Swamp forest, Savanna, Woodland, Scrub, Mangrove (12)
	Plantation Forest	Eucalyptus, Araucaria, Pinus, Acacia, Terminalia, Teak, Other Forest Plantation (8)
Cropland	Subsistence Agriculture	Shifting, Permanent, not sure (3)
	Commercial Agriculture	Tea, Sugar, Coffee, Oil palm, Cocoa, Coconut, Cocoa/Coconut, Rubber Other (8)
Grassland		Herbland, Rangeland, Other (3)
Wetland		River, Lake, Dam, Nipa Swamp[10], Other Swamp (6)
Settlement		Village, Hamlet, Large settlement, Infrastructure (4)
Other land		Bare soil, Sand, Rock (3)
*No data		Cloud, Sea, other reasons

*This is an additional option apart from the six IPCC land use categories.

Forest land has been classified into land use subdivision based on the vegetation type and plantations. Vegetation types have been classified based on the structural formation and described in the PNGRIS Publication No.4. There are 12 vegetation types in PNG forests. Full description of PNG vegetation types is available in Hammermaster & Saunders (1995). Lowland altitude forests below 1000m (on plains, fans and on uplands) contain a high presence of merchantable timber species and easily accessible landform than other forest types.

Table 7-5. Forest Vegetation Class used in the Collect Earth Assessment

Forest types	Short description
Natural Forest	
Low Altitude Forest on Plains and Fans	below 1000 m
Low Altitude Forest on Uplands	below 1000 m
Lower Montane Forest	above 1000 m

[10] If the canopy cover of trees exceeds 10%, they are considered swamp forest.
Nipa swamps don't have trees but are dominated by Nipa palms which are classified under wetland

Montane Forest	above 3000 m
Dry Seasonal Forest	restricted to southwest PNG in a low-rainfall area (1800-2500 mm)
Littoral Forest	dry or inundated beach
Seral Forest	river line, upper stream, river plains and volcano blast area
Swamp Forest	swamp area
Woodland	low and open tree layer
Savanna	< 6m and open tree layer in low rainfall area with a marked dry season
Scrub	community of dense shrubs up to 6 m
Mangrove	along coastline and in the deltas of large rivers
Montane coniferous forest	high altitude forests dominated by coniferous species (Podocarpaceae)
Plantation Forest	
Forest Plantations	Includes all species of Eucalyptus Plantation, Araucaria Plantation (*Araucaria cumminghamii* (Hoop Pine) and *Araucaria hunstanii* (Klinkii Pine)), Pinus Plantation, Acacia Plantation, Terminalia Plantation, Rubber Plantation and others not included above.

7.9. Disturbance Assessment

If the land use is classified as forest land, the next step is to assess if the forest is disturbed and identify the main drivers of change and key features as shown below:

Table 7-6. Forest Disturbance and key features used in the Collect Earth assessment

	Disturbed forest	**Key features**	**Remarks**
Man-made	Logged forest	Logging roads, etc	Easy to see
	Gardening	Isolated patches of temporary clearings at the edge of cropland areas	Challenging to see in Landsat
	Fire	Burnt forest	Challenging to see in Landsat
	Portable sawmill	Based on local knowledge	As above
	Mining	Mining concession and facilities	
	Petroleum	Development plan	
	Infrastructure	Roads and facilities	
	Others	Mining clearings & those not identified	As above
Natural	Flooding	River/sea coast	
	Landslide	Mountain slope	
	Eruption	Volcanic mountain	
	Frost	Highlands etc	
	Other		
No disturbance			
Unknown	Others	Mining clearings & those not identified	As above

7.10. Stratification by Disturbance

Natural forest types are divided into primary forest and disturbed forest as per the following definitions:

- Primary forests are densely populated old or matured native tree species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed.

- Disturbed forests are naturally regenerated forest where there are clearly visible indications of human activities (FRA, 2015). The disturbances are further subdivided into the following;
  - Commercial logging – refers to a large-scale logging operation with a permit or license within an acquired boundary of a forest area for a longer term of a contract or lease.
  - Gardening – refers to an activity isolated and unevenly distributed patches of forest clearings usually in a rural or remote setting. This includes isolated patches of temporary forest clearings often at the edge of cropland areas i.e. shifting cultivation.
  - Fire – refers to burning (human impact) within a forest area for instance slash and burn for gardening or hunting.
  - Portable sawmill – refers to a small-scale operation within a forest area.
  - Other – refers to other activities (mining, wood extraction, grazing etc.) which impacts a forest area.

The forest and land use change area were constructed to reflect only anthropogenic activities. This is true for both deforestation and forest degradation. This distinction between managed and unmanaged land was made according to the presence of logging roads, permanent roads & bridges, forest cover losses within proximity to villages and accessibility in terms of the topography. Where the forest cover loss was observed in inaccessible areas or far from villages/settlements and roads, these losses were not recorded or reported. Such observations were suspected to be due to natural disturbances (e.g; volcanic activities, landslides, cyclones).

The BUR2 however states that the distinction between managed and unmanaged lands has not been carried out yet and it is assumed that all land areas in PNG are managed. These discrepancies will be corrected in PNG's First Biennial Transparency Report to ensure that there is consistency with this 2nd FRL.

7.11. Quality Assurance/Control

The data goes through the quality assurance and quality control (QA/QC). The data is checked by the Saiku application, which is an analytical tool of Open Foris / Collect Earth package to analyse the data but also to identify error plots. In Saiku, the data can be filtered according to the operator's preference to display the information in tables or graphs, which can be also exported to Excel for further analysis. The error plots are re-assessed with guidance prepared by the Excel spreadsheet to check if the information or data provided is correct for these plots. The data goes through the cleaning process then a quality check is carried out on a certain percentage before the final analysis is conducted.

Another QA/QC was conducted by comparing Collect Earth data against Global Forest Change data (Hansen data) managed by University of Maryland (Hansen et al. 2013). All the plots were re-assessed where Hansen data showing a total of 200 ha and above tree cover loss within 1600 ha (4x4 km) around the plot in 2000-2018 but neither deforestation nor forest degradation was recorded by Collect Earth assessment. In most cases the difference between Collect Earth data and Hansen data occurred due to the lack of details of land cover interpretation of the Hansen data. For instance, harvesting and replanting of oil palm

plantation is reported as tree cover loss and gain in the Hansen data but it is considered Cropland remaining Cropland in Collect Earth assessment and therefore neither deforestation nor forest degradation. However, some of the missed deforestation and forest degradation could be identified and corrected through the QA/QC analysis. Also, all the plots were re-assessed where Hansen data shows 20ha or less tree cover loss within 1600 ha around the plot but deforestation or forest degradation was recorded in Collect Earth assessment. These QA/QC process ensure the reliability of the Collect Earth assessment data. The screenshot of customized Collect Earth with Hansen data is shown in Figure 7-4.

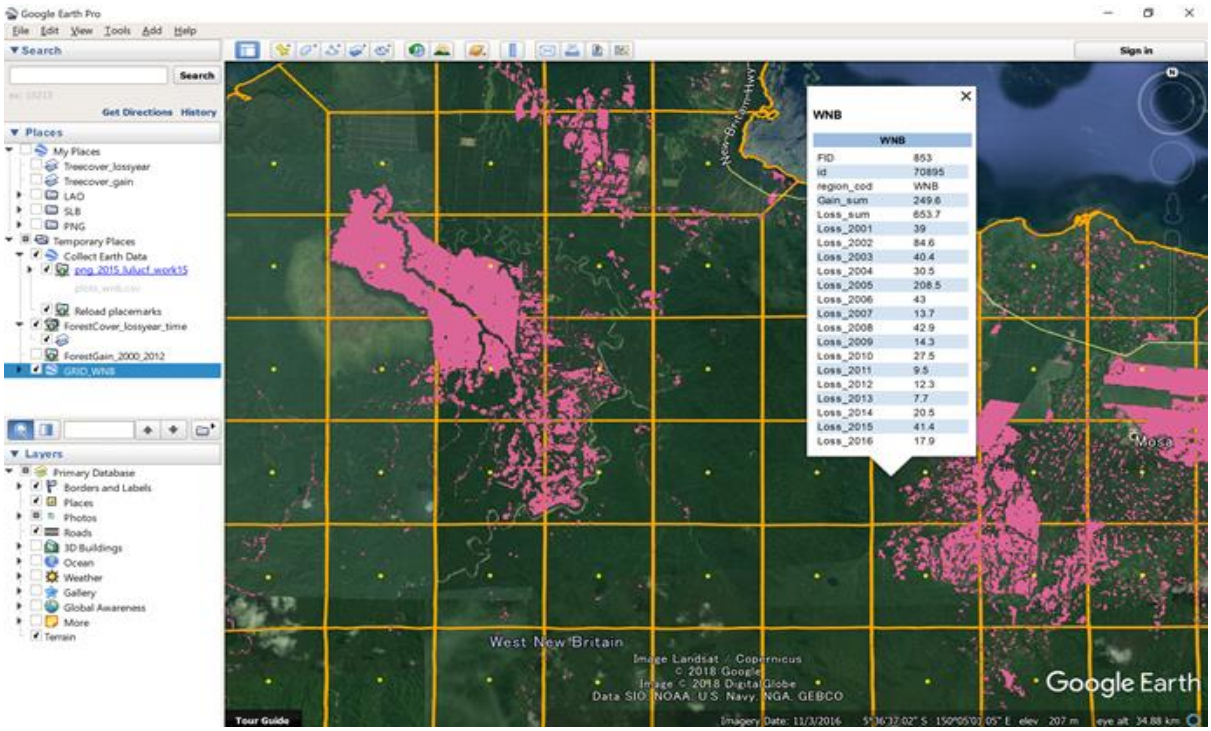


Figure 7-4. Linking revised Hansen Data with Collect Earth plots and grids (pink polygons are the Hansen data).

For national-level reporting, information must be transparent, accurate and consistent. Providing detailed classification and land definition descriptions must therefore be specific (accuracy) and reported over time (maintaining consistency). With deforestation, afforestation or reforestation all taking place in PNG, it is also important to start with defining the areas within which these activities occur or may occur: the forest.

Chapter 8. Forest and Land Use Assessment: Results

8.1. National and Provincial Land Use Status

About 35.949 million hectares (77.89% of the total land area) are forest land, and the remaining 10.2 million (22%) are for cropland, grassland, settlement, wetland and other land uses (Table 8-1). Cropland is the second major land use, with 5.2 million hectares (11.22%), followed by grassland (2.4 million hectares or 5.27%), wetland (2.1 million hectares or 4.61%), settlement (0.4 million hectares or 0.88%), and other (0.059 million hectares or 0.13%).

Table 8-1. PNG land use composition in 2018

Land use type	2018 (hectares)
Forest land	35,949,057.11
Cropland	5,179,577.88
Grassland	2,432,933.95
Wetlands	2,129,628.98
Settlements	404,290.72
Other land	59,277.17

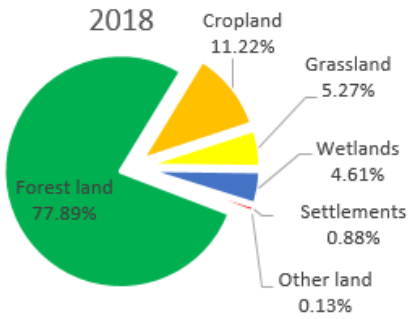


Figure 8-1. Land use in PNG (2018)

The six provinces with the highest proportion of forest areas are Gulf (91.4%, up by 0.2%), West Sepik (90.3%, 0.3 % drop), West New Britain (85%, 0.3% drop), Western (84.4%, 1% drop), Central (82.3%, 0.2% drop) and East New Britain (81.3%). Western Highlands (43.7%, up by 0.1%), Autonomous Region of Bougainville (40.7%), Jiwaka (30.7%, up by 0.2%) and Eastern Highland Province (28.6%) have more cropland than the other provinces (Figure 8-2). In general, provinces with higher population density have a higher proportion of cropland, and therefore a lower proportion of forest land.

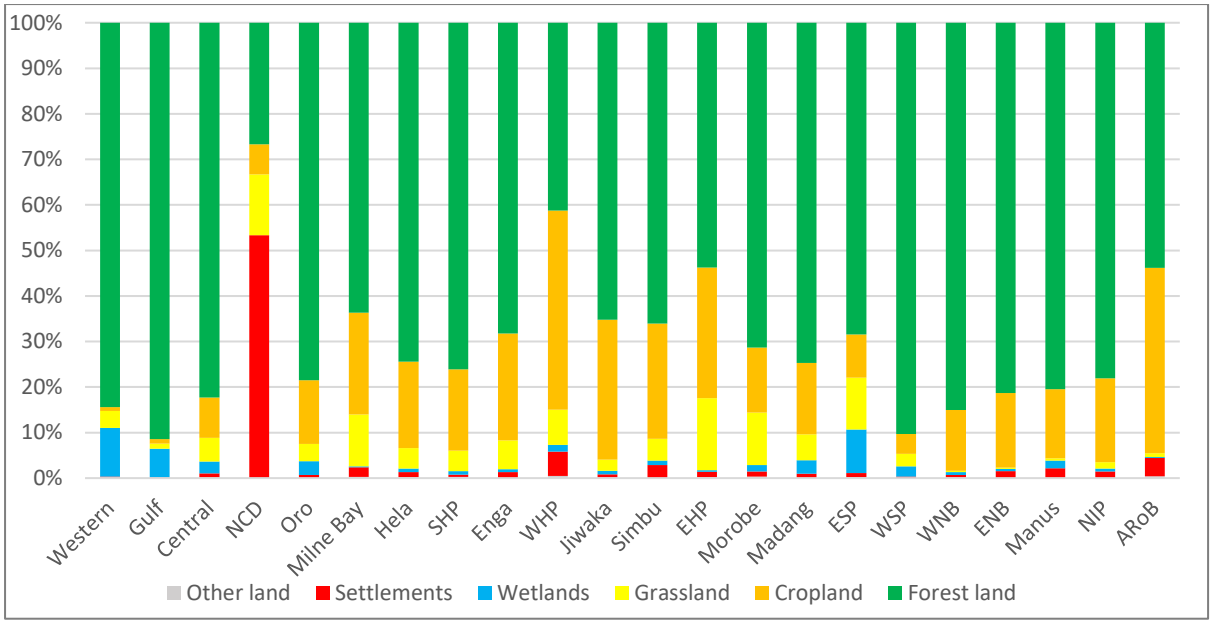


Figure 8-2. Land use by province[11]

8.2. Land Use and Altitude

There is a distinct relationship between land use and altitude in PNG (Figure 8-3). Forest occurs from the sea level up to 3,800 meters above sea level. Above 3,200 meters, the proportion of forest shrinks as elevation increases. Grassland is dominant between 3,500 and 3,800 meters, while other land (rock and bare soil) become dominant above 3,800 meters. PNG's highest peak (Mount Wilhelm) is 4,509 meters Agricultural activities are denser between 1,500 and 1,900 meters and prevalent in the hinterland highlands: Goroka (Eastern Highlands), Kundiawa (Simbu), Banz (Jiwaka), Mount Hagen (Western Highlands) and Mendi (Southern Highlands) are all located in this range. Agriculture activities are rarely seen above 2,800 meters. Almost all wetland is found below 100 meters.

[11] NCD: National Capital District, SHP: Southern Highlands Province, EHP: Eastern Highlands Province, ESP: East Sepik Province, WSP: West Sepik Province, WNB: West New Britain, ENB: East New Britain, AROB: Autonomous Region of Bougainville

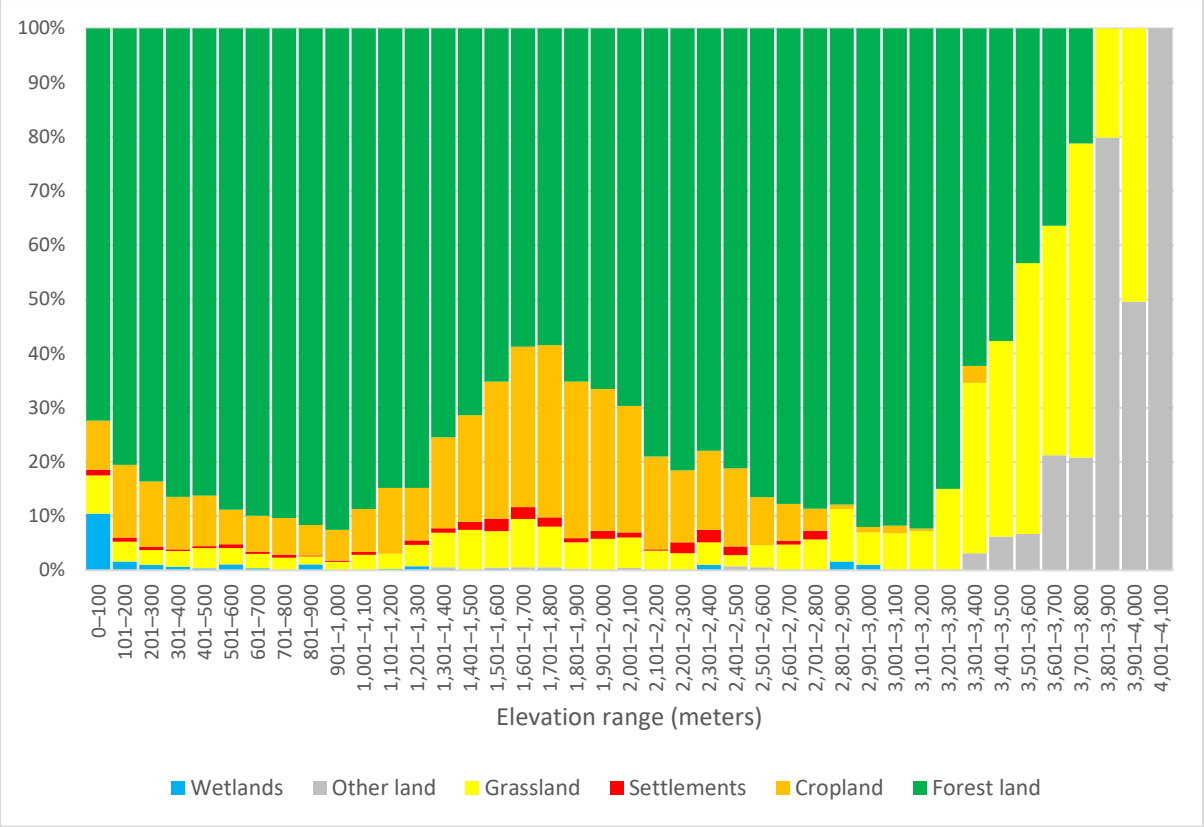


Figure 8-3. Land use by elevation range

8.3. Status of the Forest

8.3.1. Forest Composition

PNG has about 35.949 million hectares of forest, covering approximately 77.89% of total land mass (Table 8-2). More than 75.17% of the forest has not been disturbed by anthropogenic activities. The three most dominant forest types — low-altitude forest on uplands, low-altitude forest on plains and fans, and lower montane forest — comprise more than three-quarters of the country, at 30.91%, 24.77% and 22.29%, respectively. Table 8-2 shows areas of all forest types in the country.

Table 8-2. Forest cover in PNG, by forest type (2018)

Forest types	Area (hectares)	% of total PNG land
Low-altitude forest on plains and fans	8,891,397.12	24.76%
Low-altitude forest on uplands	11,105,600.28	30.93%
Lower montane forest	7,989,521.24	22.25%
Montane forest	390,815.19	1.09%
Montane Coniferous Forest	3,994.98	0.01%
Dry seasonal forest	2,349,347.02	6.54%
Littoral forest	146,226.24	0.41%
Seral forest	320,540.44	0.89%
Swamp forest	2,458,819.77	6.85%

Savanna	635,788.51	1.77%
Woodland	1,055,763.77	2.94%
Scrub	220,161.14	0.61%
Mangrove	281,849.67	0.78%
Eucalyptus plantation	17,636.99	0.05%
Balsa plantation	3,921.60	0.01%
Araucaria plantation	9,764.12	0.03%
Pinus plantation	7,808.67	0.02%
Acacia plantation	5,963.53	0.02%
Terminalia plantation	3,913.44	0.01%
Rubber plantation	11,697.05	0.03%
Total	**35,910,530.77**	**100.00%**

8.3.2. Distribution of Forest Types

PNG's major vegetation classification is based on altitude (Table 8-2). For example, three of its most dominant forest types are clearly classified by elevation rang. Low-altitude forest on plains and fans and low-altitude forest on uplands are below 1,000 meters, while lower montane forest is between 1,000 and 3,000 meters. The minor forest types are either confined to certain altitudinal range or sparsely distributed throughout. Mangrove, dry seasonal forest and littoral forest occur from the seashore up to 100 meters above sea level, while swamp forests are found up to 700 meters; woodland occurs only below 800 meters, while montane forest is found between 3,000 and 3,800 meters. Scrub, although concentrated from sea level up to 200 meters, is also sparsely distributed up to 3,500 meters above sea level (Figure 8-4).

Since altitude is one of the primary indices for vegetation classification in PNG, forest composition in the provinces is related to the altitude. Provinces in Highlands Region, for example, contain a higher portion of high-altitude forest types (Figure 8-4), while drier forest types (woodland, dry seasonal forest, savanna and scrub) are distributed in the southern part of the country, especially in Western Province, and at lower altitudes (Figure 8-4 and Figure 8-5).

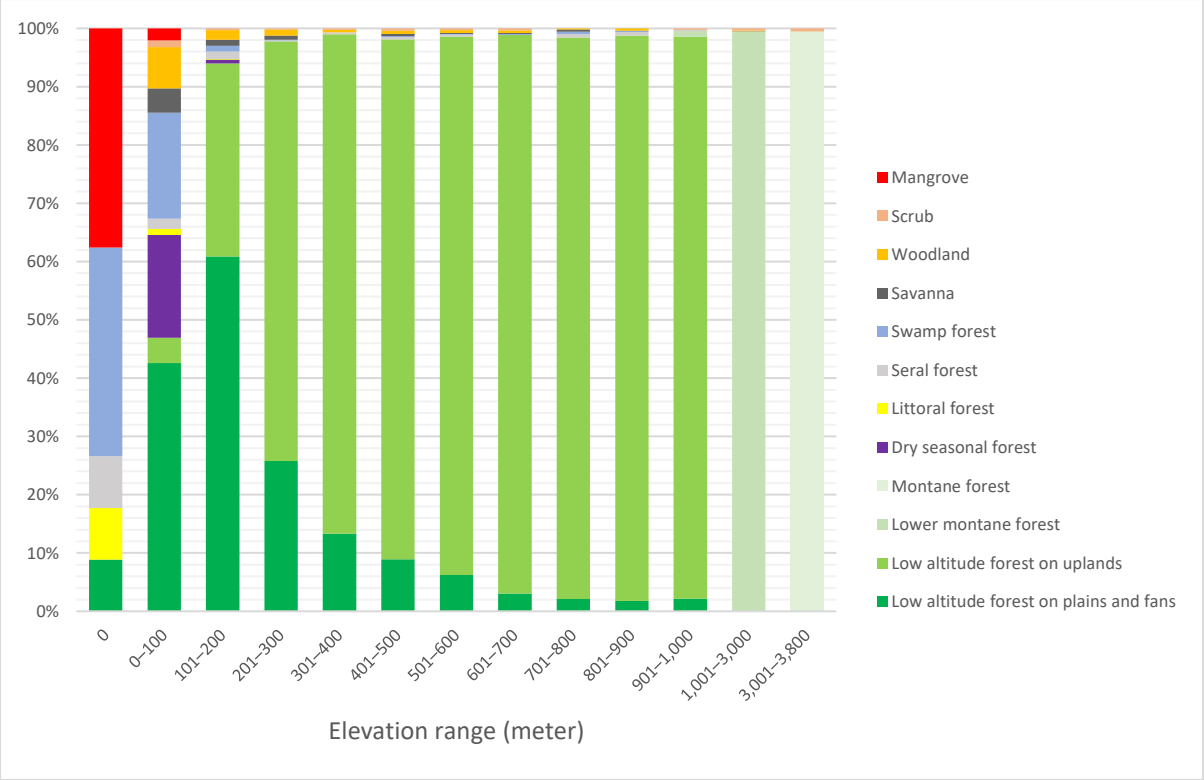


Figure 8-4. PNG forest types, by elevation range

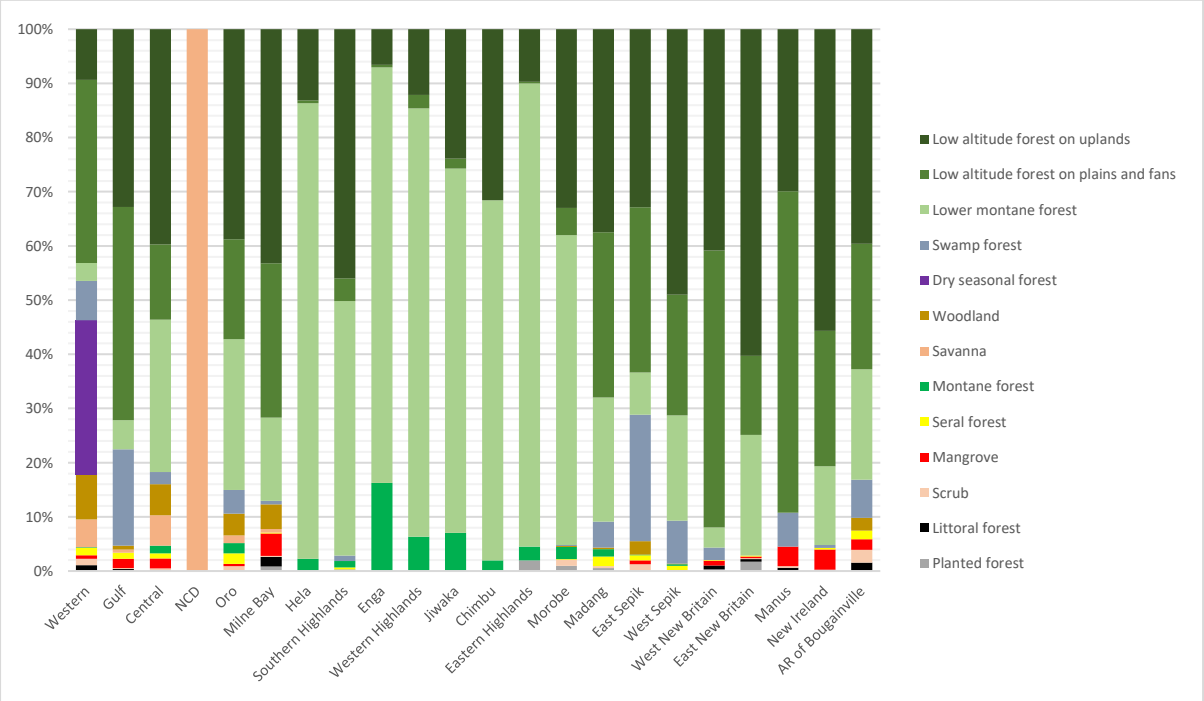


Figure 8-5. PNG forests, by type and province

8.3.3. Forest Disturbances

As at 2018, about 75.22% of PNG's total forest was undisturbed; 24.75% was disturbed through commercial logging, gardening fire, portable sawmill and other activities, with most of the disturbance caused by commercial logging and temporary agriculture (Figure 8-6). In the three most dominant forest types, the disturbed ratio varies. It is significantly higher (36.8%) than the national average (23.7%) in low-altitude forest on plains and fans due to commercial logging, while low-altitude forest on uplands and lower montane forest areas are less disturbed than national average (21.5% and 16.6%, respectively). The disturbed ratio is also higher than average for savanna and woodland, due to forest fire (Figure 8-6).

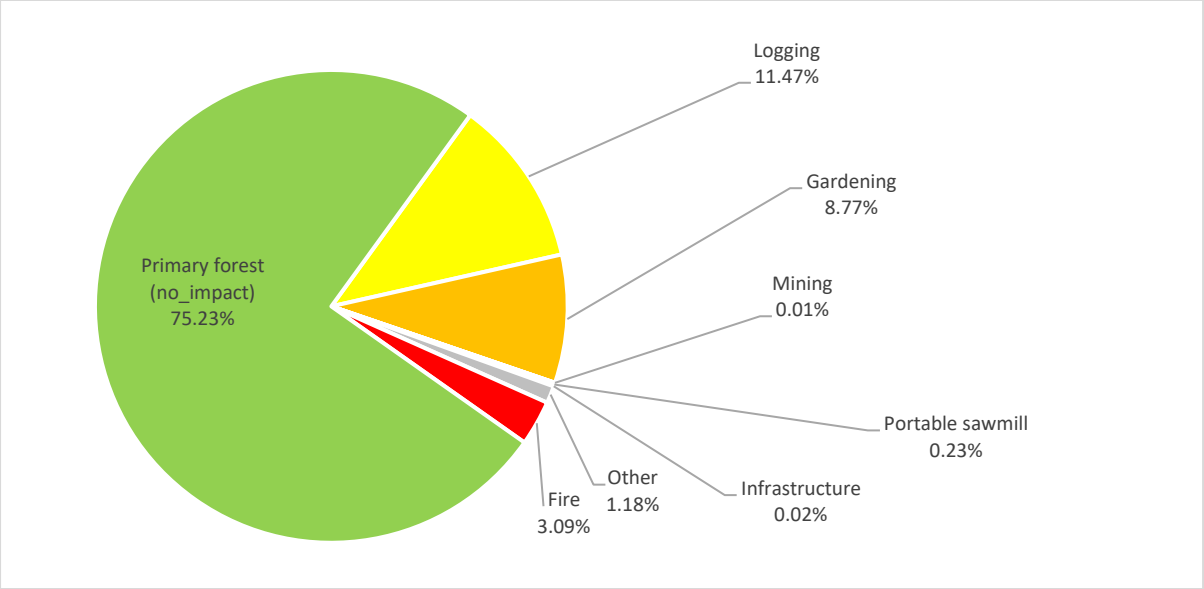


Figure 8-6. Manmade disturbances on forest land

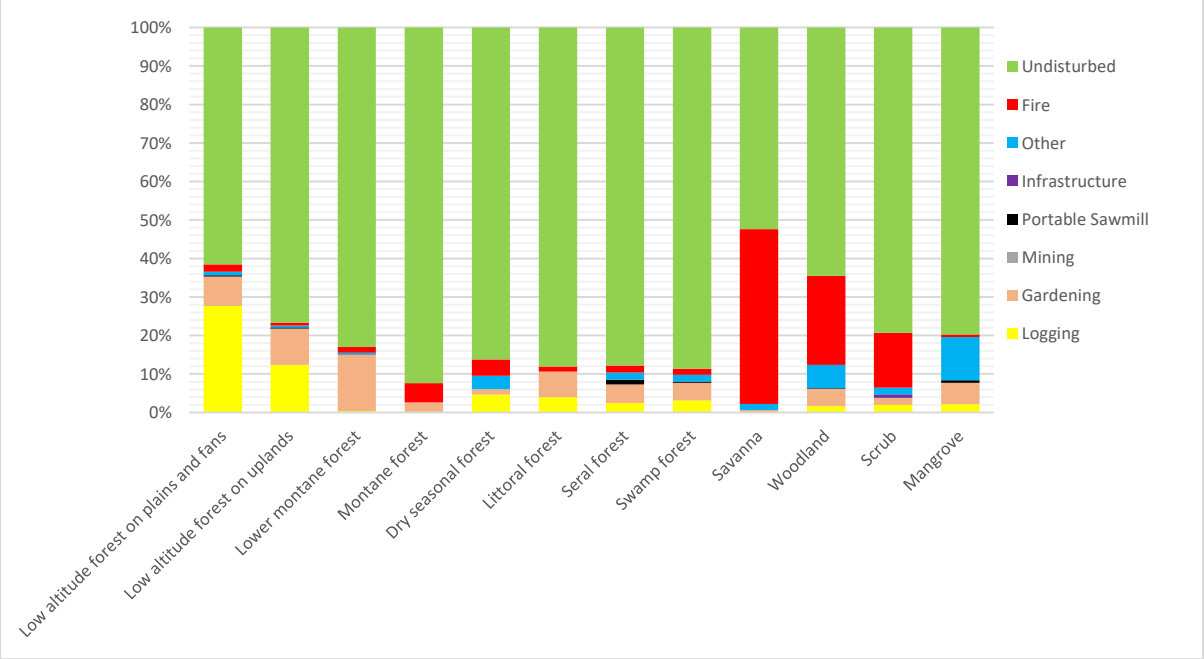


Figure 8-7. Forest disturbances, by forest type (2018)

Human impacts depend on the type of forest. Logging mostly occurs in low-attitude forest on plains, fans and uplands, particularly in the latter. Fire is prevalent in savanna, woodland and scrub forests. Gardening areas are isolated patches of temporary forest clearings. While gardening activities occur in all forest types, they are dominant in lower montane, low-altitude forests on uplands and low-altitude forests on plains and fans in order of abundance (Figure 8-7).

Elevation has a distinct relationship with anthropogenic activities on forest land (Figure 8-8). Although logging occurs from the seashore up to an elevation of 1,100 meters, it is more concentrated between 0 and 500 meters. Gardening activities occur across all elevations, becoming denser between 1,000 and 2,800 meters. Fire also occurs in all elevations but is prevalent between 2,700 and 3,400 meters. The dominance of grassland starts at 2,700 meters and the occurrence of fire also seems to follow this pattern (Figure 8-8).

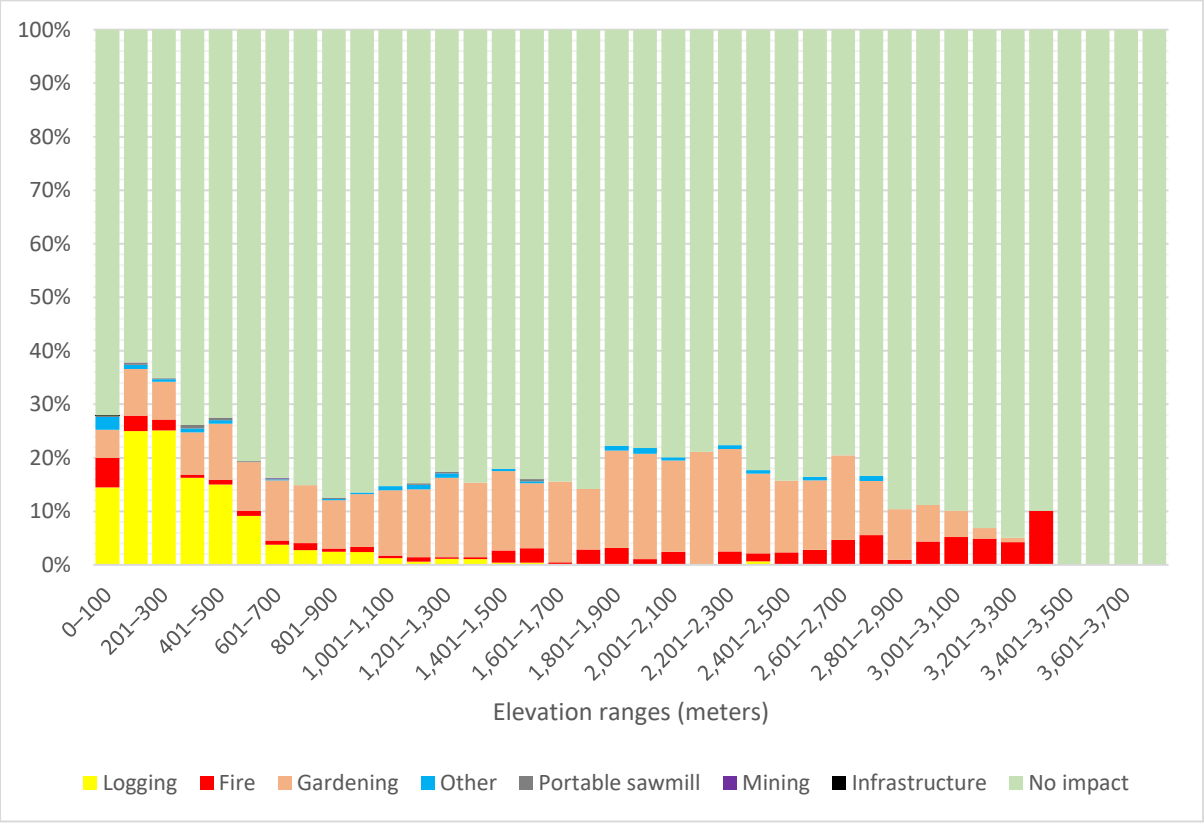


Figure 8-8. Forest disturbances, by elevation range (2018)

8.4. Cropland Status

PNG has a total cropland area of about 5.1 million hectares, which occupies 11.22% its land mass. Subsistence agriculture comprises both permanent and shifting and accounts for more than 88.2% of the total cropland area, followed by oil palm plantation (6.63%), coconut plantation (2.66%), coconut intercropped with cocoa (0.84%) and coffee plantation (0.57%) (Table 8-3). Large-scale monoculture commercial plantations are minor land use in PNG, with the exception of oil palm and coconut plantations (Table 8-3).

Table 8-3. Cropland in PNG, by subtype and subdivision (2018)

Subtype	Subdivision	Area (hectares)	%
Subsistence agriculture	Permanent	1,111,355.65	21.46
	Shifting cultivation	3,428,466.55	66.19
	Not sure	29,447.06	0.57
Commercial agriculture	Tea	2,954.99	0.06
	Coffee	29,471.54	0.57
	Palm oil	343,641.14	6.63
	Cocoa	13,795.90	0.27
	Coconut	137,986.19	2.66
	Other	19,613.36	0.38
	Cocoa/coconut	43,267.10	0.84
	Sugar	7,881.34	0.15
	Rubber	11,697.05	0.23
		5,179,577.88	**100**

8.5. Status of Land use other than Forest and Cropland

Land use other than forest and cropland includes settlement, grassland, wetland and other land (Table 8-4) and comprises about 10.91% of PNG's total land mass. Settlements cover about 0.88% of total land area; villages are the most dominant followed, by large settlements and infrastructure. Grasslands cover about 5.28% of the country's total land area. Herb land is most dominant, comprising about 77.6% of total grassland area. Wetlands cover about 4.62% of PNG's total land area. Other swamps include low-laying seasonal inundated areas comprising shrubby or vegetated areas, and are the most dominant wetland areas in PNG, followed by rivers. Other land — mainly rock, but also bare land and sand — is not significant in PNG, comprising just 0.13% of its total land area.

Table 8-4. Land use in PNG of non-forest and cropland (2018)

Land use	Subdivision	Area (ha)	%
Settlements	Village	239,455	59.23
	Hamlet	53,910	13.33
	Large settlement	55,991	13.85
	Infrastructure	54,933	13.59
	Subtotal	**404,290**	**100.00**
Grassland	Herb land	1,886,572	77.61
	Rangeland	111,187	4.57
	Others	433,210	17.82
	Subtotal	**2,430,971**	**100.00**
Wetlands	River	444,102	20.85
	Lake	253,549	11.91
	Dam	3,901	0.18
	Nipa swamp	190,816	8.96
	Other swamp	1,237,259	58.10
	Subtotal	**2,129,628**	**100.00**
Other land	Bare	20,559	34.68
	Sand	7,881	13.30

	Rock	30,835	52.02
	Subtotal	**59,277**	**100.00**
	Total	**5,024,168**	

8.6. Deforestation During 2001–2018

In total, about 351,633 hectares of forest was deforested between 2000 and 2018. This is at a rate of change of 0.05% of deforestation in 18 years, with an annual average of 18,585 hectares. About 99,199 hectares (0.27%) was deforested between 2000 and 2010. This increased rapidly over the next five years — when about 154,648 hectares (0.43%) was deforested — slowing down again between 2015 and 2018, when about 99,879 hectares (0.28%) of forest land was converted to other land use.

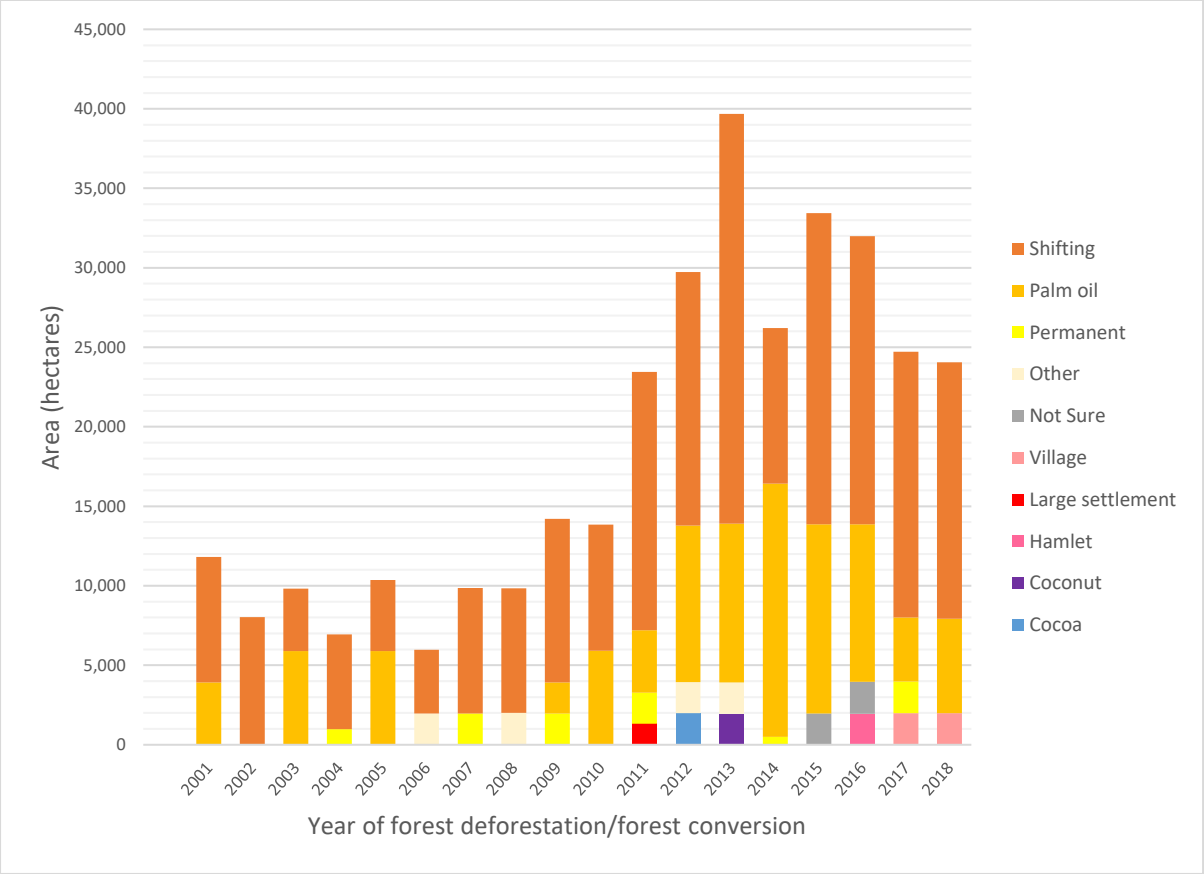


Figure 8-9. Annual deforestation in PNG

Overall, the main drivers of deforestation are shifting cultivation, followed by oil palm development (Table 8-5). Of the total forest converted, over 50% occurred in low-altitude forest on plains and fans (Figure 8-9), with oil palm plantation development and shifting cultivation the most significant causes of deforestation (Table 8-5). The highest rate of deforestation occurred in West Sepik Province, with more than double the deforestation in any other province, and most of oil palm plantation development occurred in West Sepik, West New Britain and East New Britain (Figure 8-10 and Figure 8-11).

Table 8-5. Forest converted to other land use, by forest type (2000–2018)

Forest types	Cropland (hectares)							Settlement (hectares)				Total
	Permanent	Shifting	Not sure	Palm Oil	Cocoa	Coconut	Other	Village	Hamlet	Large settlement	Hectares	%
Low-altitude forest on plains and fans	5,887	83,535	2,007	83,118	1,978	1,957	3,970	1,988			**184,440**	**52%**
Low-altitude forest on uplands		62,100		17,789			1,963	1,978			**83,830**	**24%**
Lower montane forest	1,479	60,848	1,959						1,953		**66,239**	**19%**
Dry seasonal forest		3,925									**3,925**	**1%**
Swamp forest	2,007	5,958									**7,965**	**2%**
Savanna										1,315	**1,315**	**0%**
Woodland		3,919									**3,919**	**1%**
Total	**9,373**	**220,285**	**3,966**	**100,907**	**1,978**	**1,957**	**5,933**	**3,966**	**1,953**	**1,315**		
%	**9,373**	**220,285**	**3,966**	**100,907**	**1,978**	**1,957**	**5,933**	**3,966**	**1,953**	**1,315**	**351,633**	**100%**

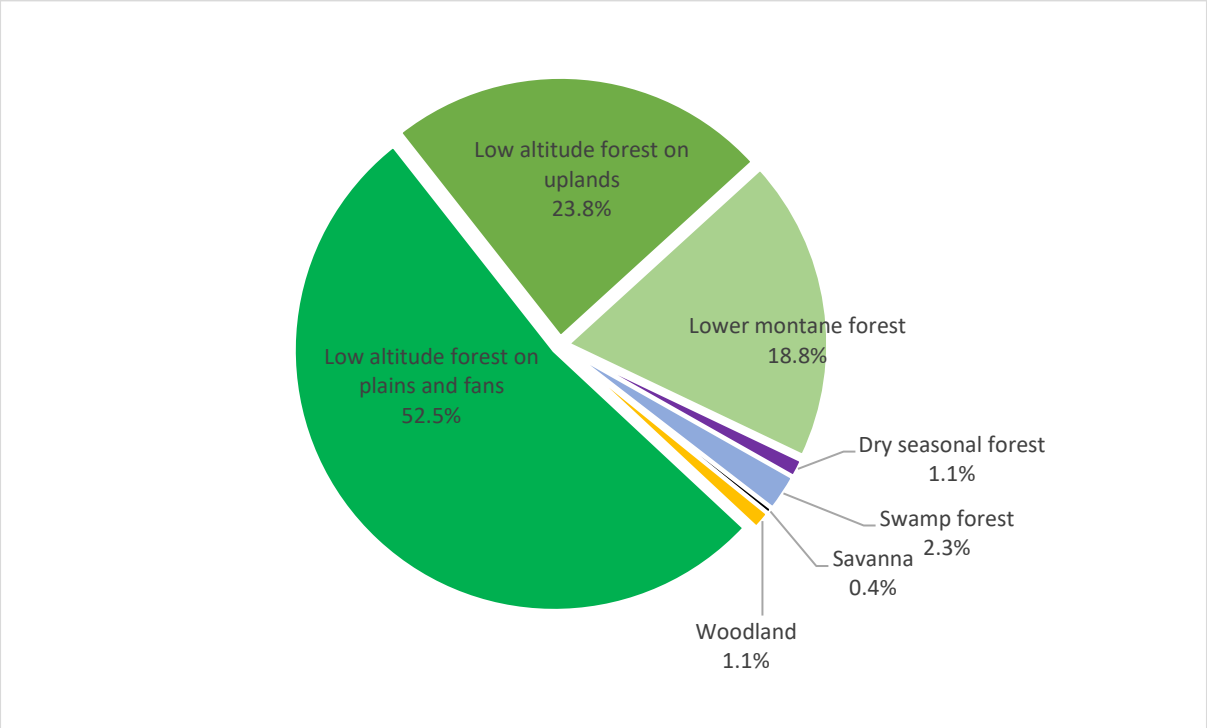


Figure 8-10. Forest converted to cropland, by forest type (2000–2018)

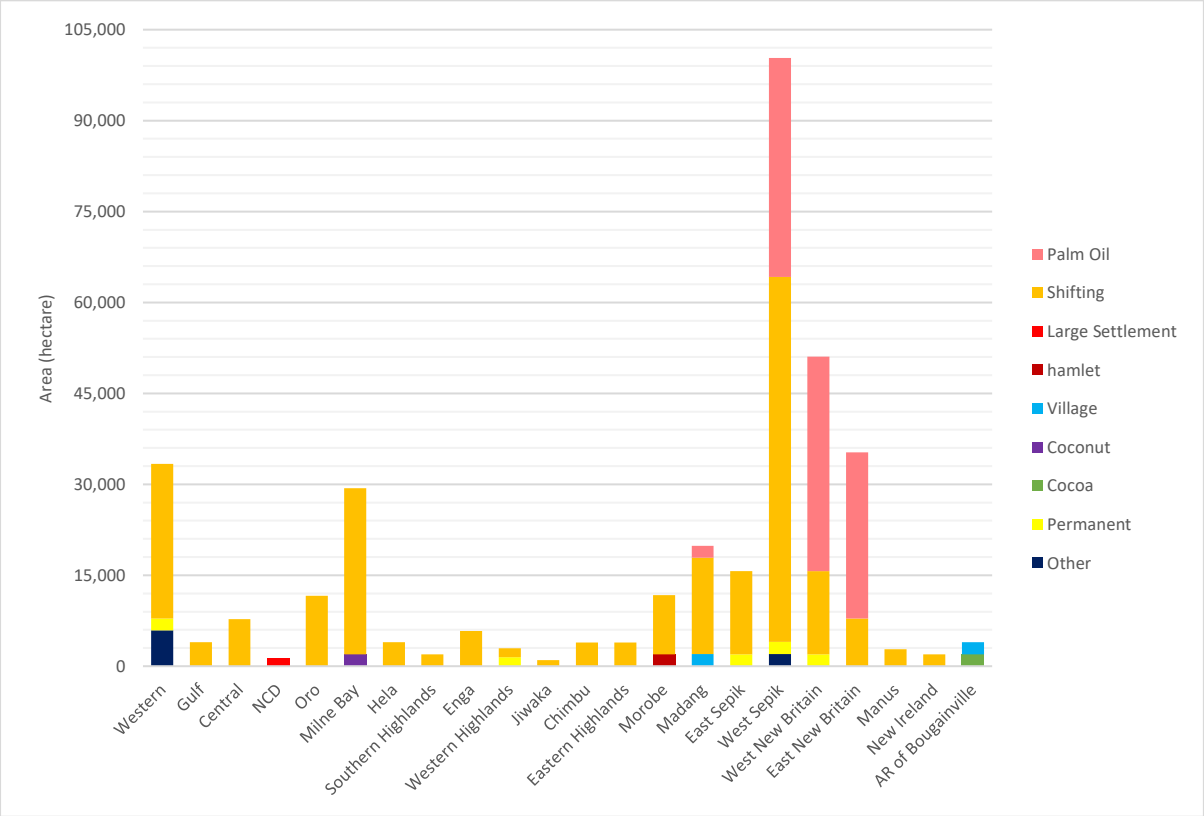


Figure 8-11. Forest converted to non-forest, by province (2001–2018)

8.7. Forest Degradation During 2001–2018

About 7.94% or 8.88 million hectares of forest in 2000 was disturbed or degraded in 18 years (Table 8-6). Forest degradation and disturbance increased steadily since 2000, peaking in 2010 and 2011 (Figure 8-12). It steadily decreased from 2015, falling below the annual average of 149,403 hectares by 2018.

Table 8-6. Forest area disturbed or degraded by human activities (2000–2018)

Forest disturbance status	Human impact					Total disturbed	Forest in 2018	
	Logging	Gardening	Portable sawmill	Other	Fire		Intact (hectares)	Total (hectares)
1999 or before (hectares)	1,602,846.0	2,915,295.6	77,629.6	373,642.8	1,059,598.7	6,029,012.7	27,064,207.09	35,949,057.11
2000–2015 (hectares)	2,191,887.0	136,554.0	1,961.0	37,701.0	21,562.0	2,389,665.0		
2016–2018 (hectares)	329,513.9	81,705.1	1,960.8	23,588.3	29,404.3	466,172.3		
Total forest disturbed	4,124,246.9	3,133,554.7	81,551.4	434,932.1	1,110,565.0	8,884,850.0		
% disturbed in 15 years (2000–2015)	6.09%	0.38%	0.01%	0.10%	0.06%	6.64%		

% disturbed in 4 years (2016–2018)	0.92%	0.23%	0.01%	0.07%	0.08%	1.30%		
% disturbed in 19 years (2000-2018)	7.01%	0.61%	0.01%	0.17%	0.14%	7.94%		
Annual rate of disturbance (%)	0.37%	0.03%	0.00%	0.01%	0.01%	0.42%		

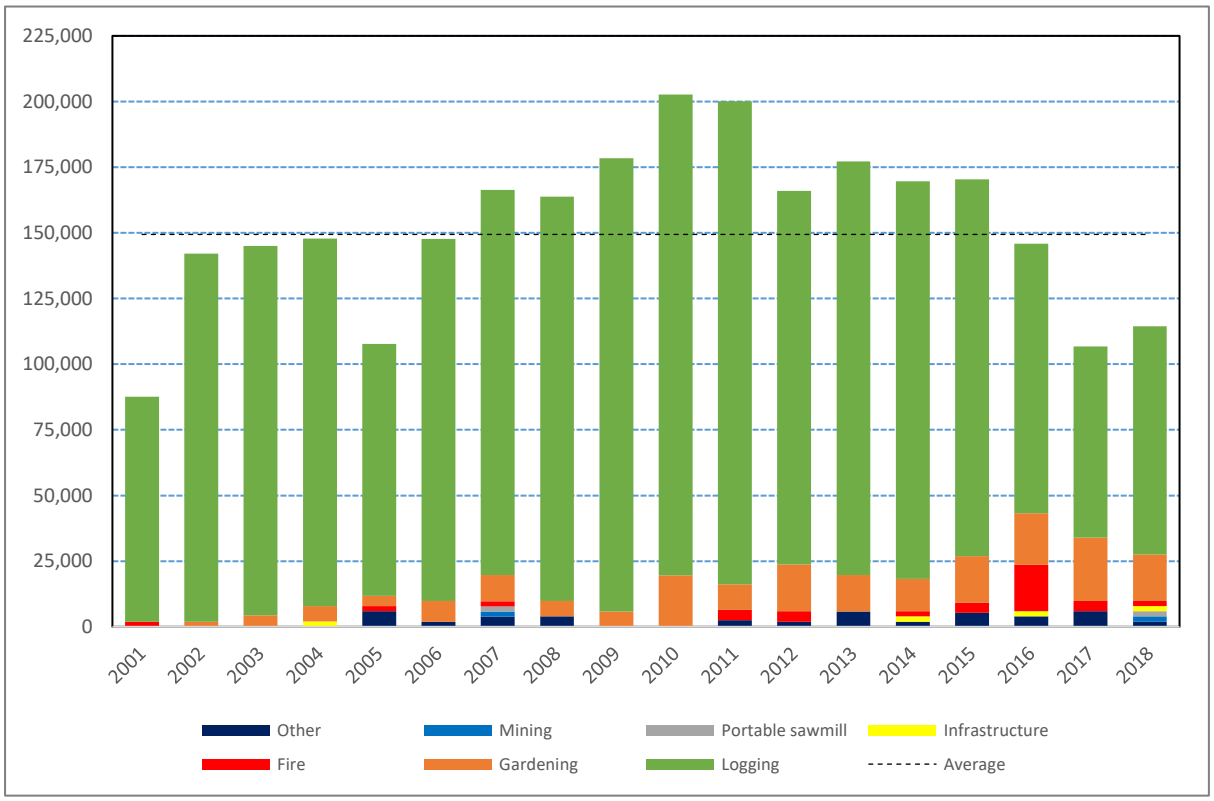


Figure 8-12. Annual forest degradation, by human impact type (2001–2018

Commercial logging was the major driver behind forest degradation or disturbance, responsible for about 46.3% of total degraded/disturbed forest between 2000 and 2018 (Figure 8-13). Commercial logging occurred mostly in low-altitude forest on plains and fans and low-altitude forest on uplands (see Appendix B for details). The top five province with high rates of logging during the 18-year period was Western, Gulf, West Sepik, West and East New Britain (Figure 8-13). Between 2016 and 2018, West Sepik Province had the highest rate (84,299 hectares) of disturbed forest through commercial logging, followed by West New Britain (54,972 hectares), New Ireland (44,747 hectares) and Western Province (43,179 hectares).

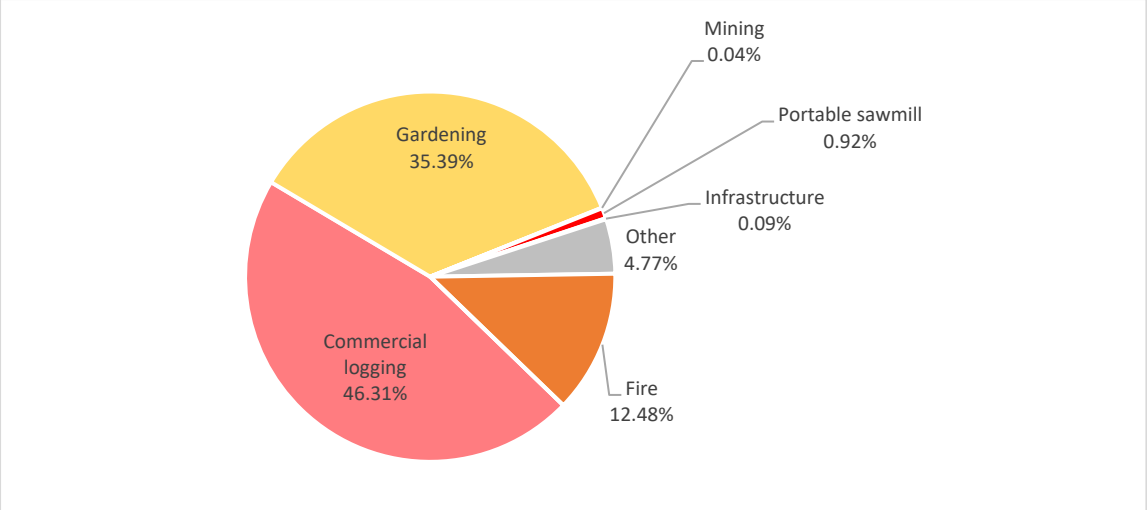


Figure 8-13. Human impact on forest land (2000–2018)

Chapter 9. National Circumstances on REDD+

9.1. Country Context on REDD+

PNG has taken a global lead in seeking to combat climate change by introducing the concept of REDD+ into international negotiations, part of which included the need to initiate discussions on the FREL/FRL specifically. PNG's REDD+ results reported in the 2nd BUR technical annex for the period of 2016-2018 were assessed against the technically assessed FRL (2017). The technically assessed FRL used regression model and a reference year of 2001-2013. This reporting was done for the purpose of completion of PNG's 1st FRL period which is from 2014-2018. The REDD+ results for 2014 and 2015 were reported in the REDD+ technical annex that was submitted with PNG's 1st BUR to UNFCCC. Then the REDD+ results for 2016-2018 were report in the REDD+ technical annex that was submitted with PNG's 2nd BUR.

Additionally, PNG also reported the REDD+ results against the Green Climate Fund (GCF) Reference Level in the REDD+ technical annex of the 1st and 2nd BUR which applies historical average + HFLD (High Forest, Low Deforestation) adjustments, reference periods of 2009-2013 (1st BUR) and 2009-2018 (2nd BUR) as well as a results periods of 2014-2015 (1st BUR) and 2016 to 2018 (2nd BUR). This was done for potential payment under the GCF result-based payment (RBP) Phase 2.

Prior to submitting 2nd BUR, PNG has made significant progress towards developing capacities to establish its national REDD+ architecture to be eligible to receive RBP through the UNFCCC. PNG has also significantly improved the NFMS. PNG developed its National REDD+ Strategy in 2017 which outlines the key action areas across the forest, agriculture, land and environment sectors. At the time of the 2nd BUR submission, PNG has successfully developed all four-design elements of the Warsaw Framework (NRS, NFMS, SIS, and FREL/FRL).

9.2. National Economic and Policy Attributing to GHG in LULUCF

Through the implementation of various REDD+ and mitigations policies since 2017 has seen evidential emission reduction results in the LULUCF sector. This has resulted in PNG being net zero emission statues in 2017 and has encourage PNG to take further action in having a PNG Carbon Market regulation in place to sustain the net zero actions here in PNG.

These are tremendous achievement for PNG in the Pacific and as Small Island Developing State, through the regulation in place it creates revenue opportunity for the Government as well the local landholders in the rural areas for PNG and encourage REDD+ practices in PNG this then maintains the zero emission statues for PNG.

Policy Environment

PNG's policy environment is centred on the long-term development strategy laid out in 2010 by the PNG Vision 2050. This is the blueprint document for all government policies/strategies and all sectors are required to align themselves with this framework. This policy is founded upon the country's National Constitutions and further incorporates its objectives within its 'Seven Pillars.'6 Pillar five (5) deals with the need for a Sustainable Development approach to all natural resources in PNG and specifies the need for measures to be adopted to increase both domestic and international/global resilience to the impacts of climate change and environmental destruction.
Vision 2050 also forms the basis for central national planning and for Medium Term Development Plans (MTDP) to be produced on a three yearly basis (to be extended to five years to fit with government terms). The most recent of these is the MDTP II (2015-18), which sets out an ambitious target for development that includes;

- Increasing the country's Human Development Index (HDI) rating in 2016-2017 towards PNG becoming one of the top 50 countries on the HDI by 2050; and
- Achieving this by and through becoming a world leader in responsible, sustainable development

These targets are linked closely to the National Strategy for Responsible Sustainable Development (StaRS) that was launched by the Prime Minister in 2014.

These most recent national development policies identify a shift in national planning away from strategies focused on economic growth through natural resource extraction to one that is based around a more sustainable development pathway. E.g., the StaRS establishes the development paradigm for the implementation of the Vision 2050 and its core pillars. It is a holistic approach to responsible sustainable development and is a national government consolidated approach in addressing significant sectors towards socio-economic development which are also financially supported through the national budget.

The key Guiding Principles within this policy document relating to Climate Change are incorporated into the concept of 'sustainable development' mentioned in MTDP II and include

principles such as biodiversity retention and ecosystem services (potential mechanism to support REDD+), resource and energy efficiency, low carbon and low emission, and precautionary approaches.

Sector-specific policies such as those within Climate Change, also address these broad objectives, e.g., the first National Climate Compatible Development Management Policy (NCCDMP) endorsed in 2013, includes a national-level Carbon Neutrality goal of 50% by 2030 and 100% by 2050. PNG's first ever Climate Change law, the Climate Change (Management) Act, 2015, gave prominence to the implementation of the NCCDMP entrenching these objectives within national legislation. Furthermore, it recently enacted the Paris Agreement (Implementation) Act 2016, which aims to 'domesticize' Article 5 of the Paris Agreement within the country's legal framework, ensuring REDD+ (and related activities) are enforceable within the country.

These changes in strategic direction are however operating in a challenging economic environment. The high reliance on extractive industry revenue has made the country vulnerable to changes in global commodity markets and with declining prices for oil and minerals the country has seen a rapid slowdown in growth and a significant drop in government revenue (of -20% in 2015). This latter element has led to significant efforts to reduce spending with major sector budgets being cut significantly in 2015 (37% cut in health, 36% cut in infrastructure, 30% cut in education8). Within this economic context significant shifts in economic policy appear unlikely, particularly those that would reduce the country's aim to access foreign investment and export revenue – a factor particularly relevant to log exports and large-scale agricultural investments. Thus, while PNG's log exports contribute under 10% of PNG's exports and large-scale commodity exports could provide the economic 'space' to reduce reliance on this revenue, the current global economic climate has made this situation unlikely.

9.4. PNG's NDC Submission on AFOLU

PNG prepared and submitted it Enhanced NDC in 2020 to the UNFCCC as part of its commitment to address climate change. The Enhanced NDC outlines PNG's mitigation contribution and adaptation actions that it plans to achieve by 2030. Under the mitigation contribution, targets have been established for the two largest GHG emitting sectors which are the Energy and AFOLU sectors.

The LULUCF GHG and Non-GHG targets are determined based on the sector's primary mitigation efforts as well as capacity needs to address the sector's monitoring capacity. There are options to improve monitoring and accounting to better address sustainable management of forests and conservation of forest carbon stocks, but current data does not allow for this, which PNG would like to improve on in the near future.

Actions noted within the NDC will transform the increasing emissions trend in the AFOLU sector into a downward trend over the next 10 years (by 2030) as shown in the Figure 9-1 below. PNG will reduce the area of annual deforestation and annual degradation by 25 percent against 2015 levels (equating to a reduction of 8,300 ha or annual deforestation and

43,300 ha of degradation), as well as increase the area of afforestation, reforestation, and ecosystem restoration. It will reduce 10,000 Gg CO_2 eq of the net emission from the LULUCF sub-sector by 2030. That is about 37,000 Gg CO_2 eq emission reduction compared to the business-as-usual scenario.

Activities/actions to reduce emissions include enhancement of land use planning and monitoring, promoting climate-friendly agriculture, strengthened monitoring of Forest Clearance Authority (FCA) permits, enhancement of timber legality, and promoting reforestation and ecosystem restoration. PNG will continue improving the monitoring capacity of LULUCF sector by enhancing its NFMS for more accurate monitoring of forest and land-use change, and assessment of GHG emissions in LULUCF sector.

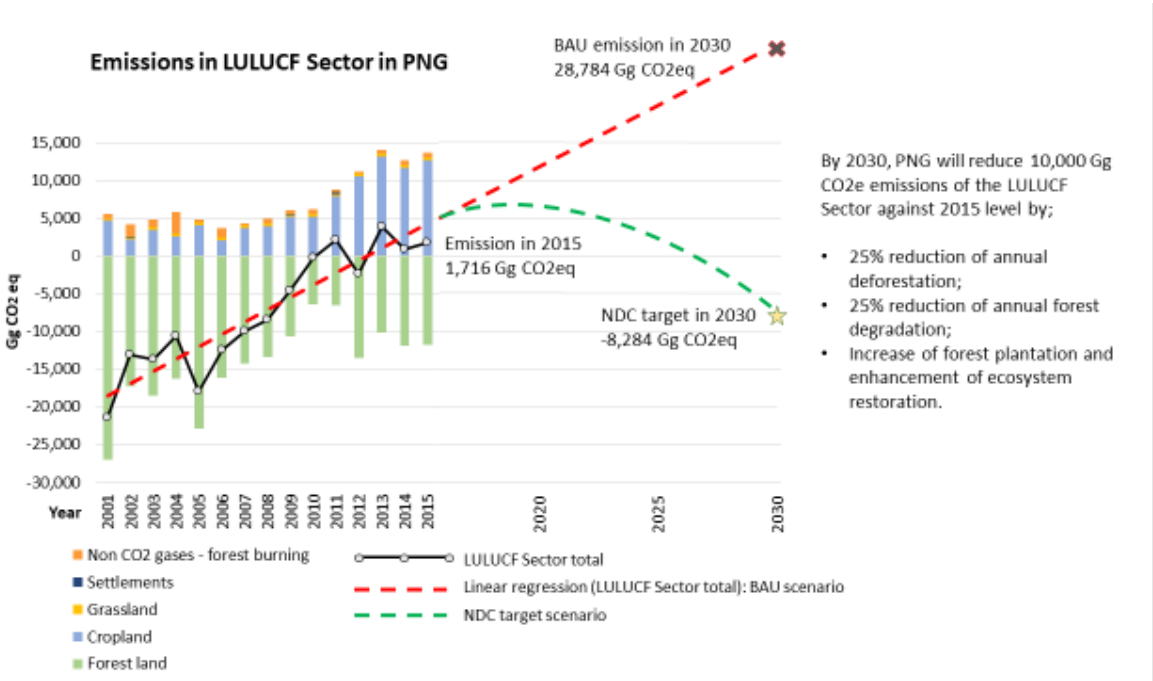


Figure 9-1 Enhanced NDC target for the LULUCF sector

9.3. Drivers of Deforestation and Forest Degradation

There are two main drivers of deforestation and forest degradation in PNG. They are commercial logging and family agricultures.

Commercial Logging:

This driver has had a significant impact on forest cover in PNG. Over 3.8m ha of forest has been identified as being degraded through logging and 8.4m ha of forest land are under current timber concessions. The sector has been a mainstay of the rural and national economy since the 1970's and the country has consistently been one of the most significant global exporters (see Figure 9-2).

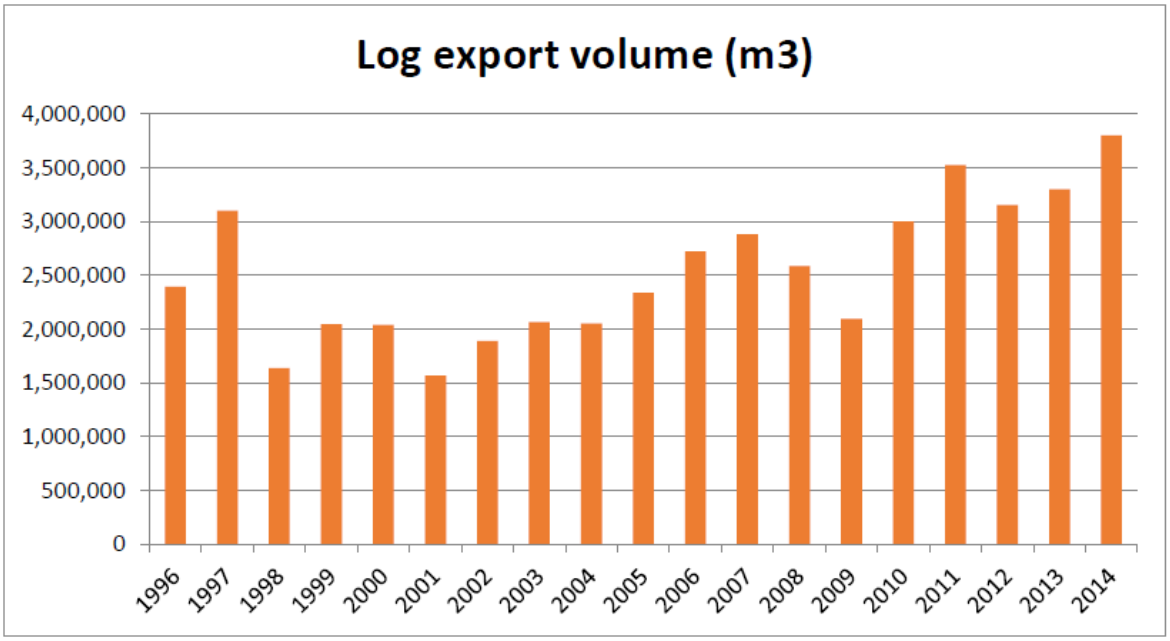


Figure 9-2. PNG annual log export volume 1996-2014 (Yosi 2015).

PNG timber industry is driven by a complex mix of international demand and domestic political and economic factors that have evolved over the past forty years. A number of efforts have been made to strengthen and reform the sector and while progress has been made, the line agencies responsible remain unable to deliver significant or rapid improvements. This is due to a lack of resources, technical capacity and the generally low levels of competency across logging companies, communities and provincial, district and local governments, as well as the challenging position that the regulator faces when being perceived as needing to deliver whilst not restricting economic opportunities.

The current Forestry Act was passed in 1991, which, accompanied with subsequent regulations, was intended to improve logging standards and mechanisms for acquiring and managing concessions. Following a pause in concession allocation the opening up of the new Forest Management Areas (FMA) through the 1991 Act led to a significant increase in the allocation of concession areas and production levels. This trend continued until the financial crash of 1998 which limited both demand and available finance for logging operations.

A steady recovery occurred over subsequent years linked also to a shift in destination markets from a predominantly Japanese market to a Chinese market. This shift was driven partially by higher import standards in Japan and rapidly increasing demand from a growing Chinese market. Production and exports were once again hit by the global financial crisis in 2009, although exports rebounded quickly to exceed previous levels. This increase has been driven by extraction from land areas under Special Agricultural Business Leases (SABLs) which, following amendments to the Forestry Act in 2003 and 2007, allow timber harvested and exported under Forest Clearance Authorities (FCA), free from the majority of safeguards put in place by the regulations of the Forestry Act. It is estimated that there are currently 4m ha of closed canopy forest in SABLs that would currently be available for harvesting.

Forestry legislation is also pivotal to the implementation of REDD+ by virtue of its nature and its mandate by law. All policy and programs developed within this sector have a direct

implication on the various aspects of REDD+ and MRV. In this context, the legal framework sets out clear objectives for its forest programmes under the National Forest Policy, the National Forestry Development Guidelines (NFDG) and the Forestry and Climate Change Framework for Action (FCCFA). These policies attempt to recognize and place emphasis on the need for forest inventories, forest plans to be drafted and monitoring of forest resources. Recently, certain forestry initiatives took a shift from the traditional view to a more sustainable approach that sought to meet certain international climate change benchmarks. In anticipation of the need to re-align its programs and activities with these benchmarks, they have sought to amend their existing Forestry Laws and Policies as well, with expected revisions to be completed in 2017.

Future Trends:

It is difficult to provide accurate predictions of the future direction of the PNG timber industry based solely on domestic policy. A log export ban set to come into force in 2020 combined with proposals to cancel 'undeveloped' SABLs, restrictions on foreign firms leading plantation development activities and the high operating costs and operational risks of working in PNG, have led some industry participants to expect a future decline in activity and revenues from the logging industry.

Such predictions are hard to fully justify particularly given the role that commercial forestry has played in delivering 'immediate development' and investment in rural PNG and its importance in local political processes. Cancellation of SABLs have been implemented and the proposals for a log export ban have been in place 2010 with its implementation date continually rolled back. International demand is similarly difficult to predict but with China's growth continuing – if decreasing in speed – and certification systems remaining in their infancy, a rapid drop in demand appears unlikely. Domestic supply, while increasingly limited within existing concession areas, also remains substantial with PNGFA having identified a further 8.4m ha of viable concession areas.

Based on these factors it is anticipated that without interventions to address the current situation and provide viable alternatives to either continuation of a business-as-usual scenario and the implementation of REDD+ activities current situation will continue. Indeed, there also remains the potential for a rapid increase in clearing as an unintended consequence of threats to cancel 'undeveloped' SABLs.

Family Agriculture:

This term has been used to capture both gardening and shifting cultivation activities in PNG and is also the preferred term used by the Department of Agriculture and Livestock (DAL). This driver has had a significant impact on forest cover in PNG, causing widespread deforestation with the active area estimated to cover over 3.2m ha. Shifting cultivation is crucial to the economy and food security of the country. Over 80% of food energy consumed is produced domestically, overwhelmingly from small scale shifting cultivation, with the value of imports needed to replace domestic production being estimated at over $900m. Similarly while local trade is minimal, it is growing, with market value estimated at $30m per annum in 1990.

The agricultural systems used are extremely diverse and any transition to larger, more permanent and efficient forms of production have been severely limited by:

- High levels of diversity across regions – there are over 350 different agricultural systems practiced in PNG making development of coherent agricultural strategies difficult to achieve.
- High transport costs – Transport systems are very limited in PNG and the costs of transporting goods from one area to another can be in excess of international transport

Chapter 10. National Forest Reference Level

10.1. FRL Development Process

The 2nd FRL preparation employs an institutional arrangement that involves various stakeholders as reviewers of the 2nd FRL report. PNGFA is one of the key stakeholders that is responsible for providing activity data on forest and land use change in PNG through the Collect Earth land use and land use change assessment. PNGFA also provides emissions factors for the different forest types in PNG through the NFI and the PSPs. The whole process is coordinated by CCDA through the MRV and National Communications Division.

The AFOLU technical working committee provides the required expertise on the development of the FRL to ensure that the entire process is in compliance with the UNFCCC requirements. The AFOLU TWC is comprised of representatives from governmental agencies, academic/research institutions, private sector (as appropriate), and NGOs/ CSOs who represent small-holders or vulnerable groups.

Data Sharing Arrangements

Data collection for the 1st FRL development was carried out on an ad-hoc basis. Using lessons learnt from the 1st FRL development and reporting, CCDA and PNGFA in the process of establishing a Memorandum of Understanding on data sharing and use for the development of future FRLs and BTR.

FRL Preparation team

The FRL preparation team is comprised of officers from CCDA and PNGFA. Planning and preparation are supported by FAO in close consultation with the stakeholders. It is crucial for CCDA to maintain the collaboration with all its key stakeholders for sustainability of the process.

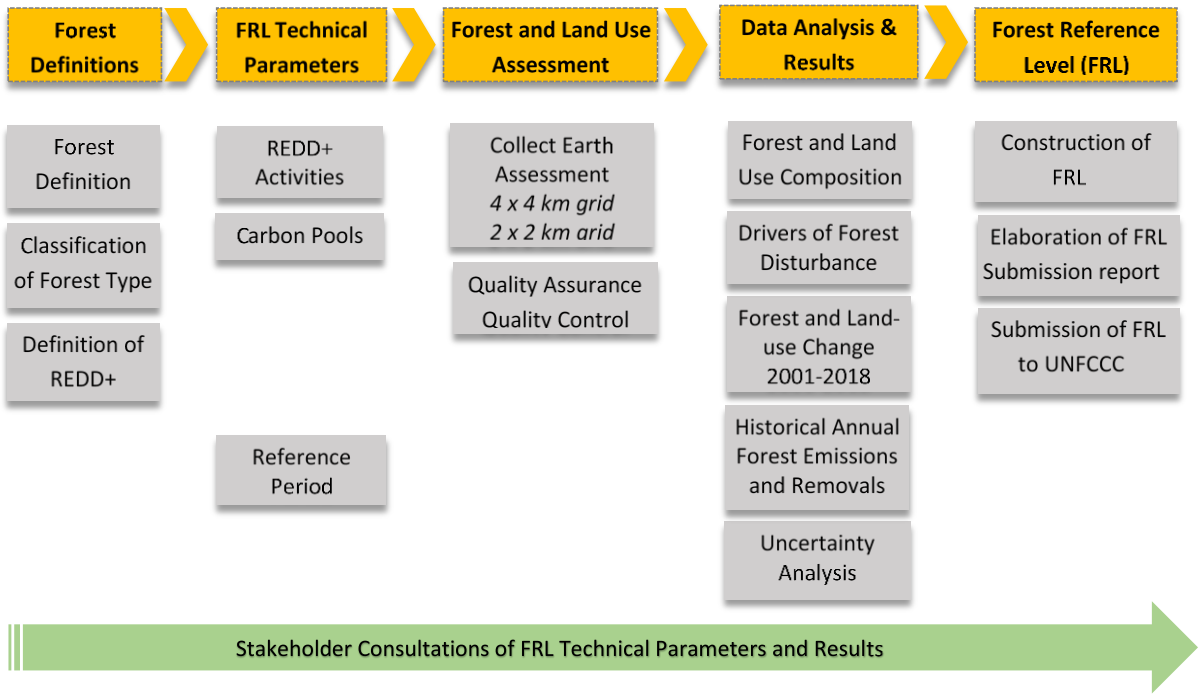


Figure 10-1. FRL development process

10.2. FRL Calculation

PNG's 2nd FRL is calculated using an historical average approach in accordance with standards, such as the GCF scorecard for the GCF RBP pilot programme, ART TREES2.0 etc.(e.g. FCPF Methodological Framework). The 2nd FRL is based on the average historical emissions for the period 2009-2018 as explained in "5.4.2. Reference period".

Considering PNG's HFLD (High Forest, Low Deforestation) status over the reference period, PNG proposes an upwards HFLD adjustment to its 2nd FRL. Since GCF scorecard for the RBP is uncertain as valid at the moment, PNG considers the latest ART TREES 2.0 is the most reliable guidance for HFLD adjustments, namely, the FRL should not exceed HFLD-score multiply 0.05 of carbon stock.

FRL (tCO_2e) = historical average emissions 2009-2018 + (HFLD-score x 0.05% carbon stock).

0.05 is the value defined by TREES 2.0 to calculate forest carbon stock. PNG did not incorporate this adjustment to FRL1 in 2017, as during the preparation phase (2016), neither the GCF scorecard for the GCF RBP pilot program nor the ART TREES had been established.

PNG submitted BUR1 with TA on REDD+ in April 2019 and also submitted concept note for GCF RBP (Results based Payments).

GCF RBP scorecard allows HFLD countries (PNG is a HFLD country) to adjust FRL and PNG adjusted FRL and reported REDD+ Results in the modified BUR2/TA. But GCF scorecard for the RBP is uncertain as valid at the moment, PNG considers the latest ART TREES 2.0 is the most

reliable guidance for HFLD adjustments https://www.artredd.org/wp-content/uploads/2021/12/TREES-2.0-August-2021-Clean.pdf

PNG follows TREES 2.0 and calculated HFLD Score every year and average of HFLD scores over the reference period (2009-2018), resulting in 0.71, which is higher than 0.5 threshold. HFLD-Score (0.71)* 0.05% carbon stock is added to the FRL (before adjustment).

The average historical emissions for 2009-2018 were 35,299,202 tCO_2 eq. The average total forest carbon stock in PNG corresponding to the year between 2009 and 2018 based on TREES2.0 was 14,748,195,755 tCO_2eq, therefore 0.05% of the total forest carbon stock suggests an allowable upwards adjustment of 5,219,378 tCO_2eq.

	Forest area	Forest cover	Deforestation rate	HFLD score	Carbon stock (AGB+BGB,
2009	36,134,329	78.32%	0.04%	0.74	14,909,772,990
2010	36,120,120	78.29%	0.04%	0.74	14,875,595,589
2011	36,106,267	78.26%	0.06%	0.72	14,837,101,237
2012	36,082,824	78.20%	0.08%	0.70	14,797,557,727
2013	36,053,081	78.14%	0.11%	0.67	14,763,630,387
2014	36,024,863	78.08%	0.08%	0.70	14,725,385,567
2015	35,991,296	78.01%	0.09%	0.69	14,688,488,498
2016	35,959,315	77.94%	0.09%	0.69	14,651,700,495
2017	35,934,596	77.88%	0.07%	0.71	14,629,150,517
2018	35,910,531	77.83%	0.07%	0.71	14,603,574,545

Ave. HFLD score reference period(2009-2018)
0.71
Ave. Carbon stock reference period(2009-2018)
14,748,195,755

Figure 10-2. PNG's HFLD score and Crediting Level

FRL (tCO2e) = historical average emissions 2009-2018 + (HFLD-score x 0.05% carbon stock).

= 35,299,202 + (0.71 x 0.05 x 14,748,195,755)

= 35,299,202 + 5,219,378

= 40,518,579

As such, the calculated FRL (CO_2 emissions from deforestation, forest degradation, and carbon stock enhancement in PNG in the period from 2019 to 2027) has value of **40,518,579** tCO_2eq/year.

10.3. The Forest Reference Level (FRL)

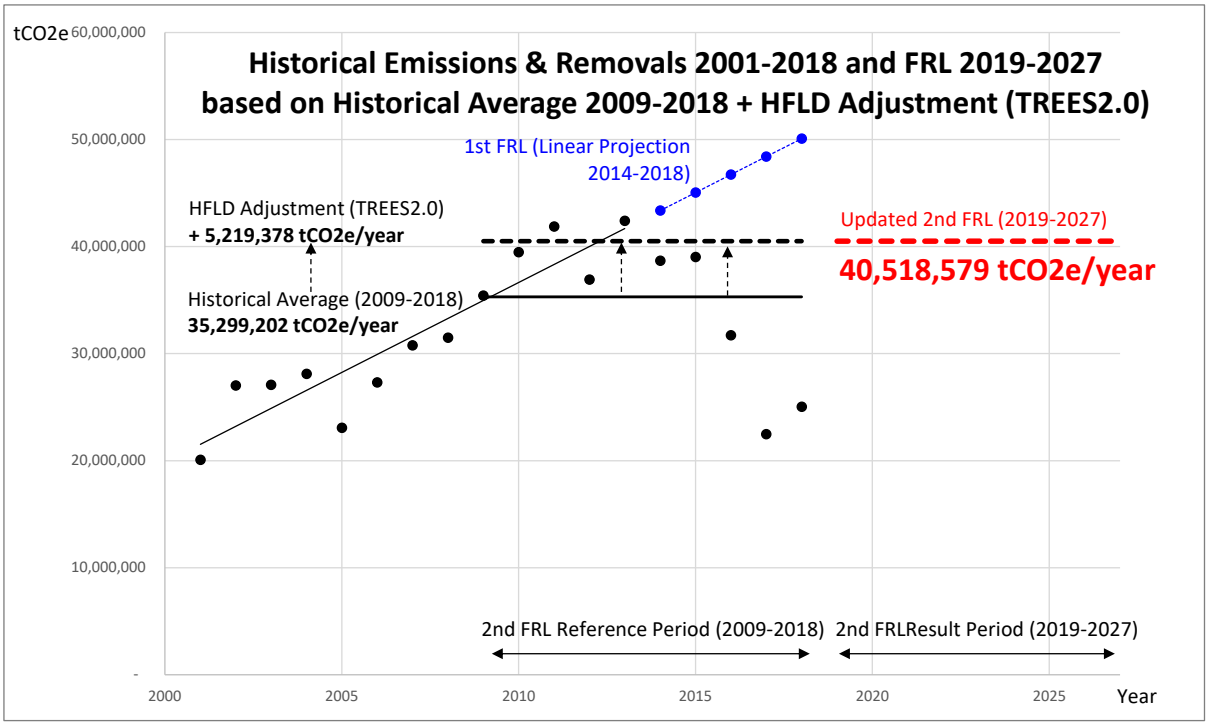


Figure 10-3. The Forest Reference Level for 2019 to 2027

Table 10-1. The Forest Reference Level for 2019 to 2027

Year	Total Emissions and Removals 2001-2018 (tCO_2eq/year)	Historical Average 2009-2018 (10years) (tCO_2eq/year)	HFLD Adjustment (based on TREES 2.0) (tCO_2eq/year)	Forest Reference Level (FRL) for 2019-2027 (tCO_2eq/year)
2009	35,420,964	35,299,202	5,219,378	40,518,579
2010	39,482,561	35,299,202	5,219,378	40,518,579
2011	41,862,863	35,299,202	5,219,378	40,518,579
2012	36,920,657	35,299,202	5,219,378	40,518,579
2013	42,401,717	35,299,202	5,219,378	40,518,579
2014	38,677,156	35,299,202	5,219,378	40,518,579
2015	39,024,003	35,299,202	5,219,378	40,518,579
2016	31,700,092	35,299,202	5,219,378	40,518,579
2017	22,462,875	35,299,202	5,219,378	40,518,579
2018	25,039,130	35,299,202	5,219,378	40,518,579
2019		35,299,202	5,219,378	40,518,579
2020		35,299,202	5,219,378	40,518,579
2021		35,299,202	5,219,378	40,518,579
2022		35,299,202	5,219,378	40,518,579
2023		35,299,202	5,219,378	40,518,579
2024		35,299,202	5,219,378	40,518,579
2025		35,299,202	5,219,378	40,518,579
2026		35,299,202	5,219,378	40,518,579
2027		35,299,202	5,219,378	40,518,579

Chapter 11. Uncertainty Analysis

The activity data and emissions factors used in the construction of PNG's 2nd FRL underwent both quantitative and qualitative uncertainty analysis. This has made it possible to identify opportunities for improvement.

11.1. Qualitative Uncertainty Analysis

In terms of activity data, several major sources of error in estimating past land-use trends from the Collect Earth exercise are expected.

- Classification error (random and systematic error)
- Sampling error (random error)

To reduce the uncertainty of "classification error", PNG defines the land use subdivision based on the existing classification system described in "Emission Factors" and "Historical land use" sections of the FRL report (see http://unfccc.int/8414). The stratification based on the carbon stock amount will be considered in future based on the progress and result of current ongoing national forest inventory.

The major potential sources contributing to uncertainty of the sampling assessment such as Collect Earth are the "sampling error" such as unrepresentative samples and variability resulting from the use of samples and the human error such as misinterpretation of historical land use and land use change and forest.

In terms of emission factors, there are also several most important error sources to be considered in estimating carbon stocks for PNG's land-use types. The set of emission factors used is taken from literature and only little direct information is available on the error. Nonetheless, PNG expects a set of typical errors to occur for the emission factors:

- Measurement error (random and systematic error) since the literature values were all derived from primary measurements, usually plot-based measurements where measurements can have error.
- Sampling error (random and systematic error) since the plot-based measurements that underlie estimates reported in literature and in the IPCC guidelines only sample the forests.
- There is representation error from using IPCC default values that might be imperfectly suitable for PNG's forests (systematic error).

- There is a representation error from approximating forest carbon stocks in all of PNG's forest types from literature values developed only for the most abundant types of forests (systematic error).
- There is model error from inferring on forest degradation carbon stocks from measurements in one type of forest only (systematic error).

11.2. Quantitative Uncertainty Analysis

Uncertainty analysis for Activity Data

In terms of activity data, the "sampling error" was estimated by using the spreadsheet developed by FAO for the Landuse Category and Conversion during 2001-2019 assessment (updated) by Collect Earth. The standard error of an area estimate is obtained as A*sqrt (pi* (1-pi)/(n-1)) (equation; taken from Chapter 3, volume 4 (AFOLU), of 2006 IPCC Guidelines, pp 3.33-3.34).

In Initial design stage, the sampling number was 25,279, as outlined in section 7.2 above, however through the assessment, 70 plots were identified and confirmed as "no data" (such as sea/outside-of-land, and cloud). Those data were excluded for the analysis (both previous assessment and new assessment). Therefore, the final sampling number is 25,279-70=25,029.

2009-2018 (FRL Reference Period 2: 10 years from the latest reported year: 2018)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, and Forest Degradation from 2009 to 2018 are respectively 0.74%, 2.41%, 15.71%, and 6.07%. After QA/QC process, it is confirmed that removals associated with Forest Restoration in this period are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	18,365.00	34,151,026.08	0.729	33,612,607.4	0.002801	129,238.7	± 253,307.8	± 0.74%
Stable Non-Forest	5,780.00	9,955,019.51	0.229	10,578,865.8	0.002648	122,160.6	± 239,434.8	± 2.41%
Deforestation	144.00	273,312.77	0.006	263,556.5	0.000475	21,900.7	± 42,925.3	± 15.71%
Forest Degradation	920.00	1,759,504.70	0.036	1,683,833.3	0.001181	54,493.0	± 106,806.3	± 6.07%
Forest Restoration	0.00		0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!

As references, the uncertainty analysis of the past reports was summarized below.

2001-2013 (FRL Reference Period 1-1: Original 1st FRL)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, and Forest Degradation from 2001 to 2013 are respectively 0.75%, 2.42%, 18.59%, and 5.70%. After QA/QC process, it is confirmed that removals associated with Forest Restoration in this period are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	18,320.00	34,066,149	0.727	33,530,246.0	0.002807	129,503.9	± 253,827.7	± 0.75%
Stable Non-Forest	5,747.00	9,892,213	0.228	10,518,467.5	0.002642	121,914.8	± 238,953.0	± 2.42%
Deforestation	101.00	193,569	0.004	184,855.6	0.000398	18,357.3	± 35,980.3	± 18.59%
Forest Degradation	1,041.00	1,986,932	0.041	1,905,294.0	0.001253	57,821.3	± 113,329.7	± 5.70%
Forest Restoration	0.00		0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!

2009-2013 (FRL Reference Period 1-2: For GCF RBP)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, and Forest Degradation from 2009 to 2013 are respectively 0.70%, 2.40%, 23.52%, and 8.53%. After QA/QC process, it is confirmed that removals associated with Forest Restoration in this period are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	18,892.00	35,150,366	0.749	34,577,151.1	0.002729	125,932.1	± 246,826.9	± 0.70%
Stable Non-Forest	5,785.00	9,964,856	0.229	10,588,017.1	0.002648	122,197.7	± 239,507.5	± 2.40%
Deforestation	63.00	120,926	0.002	115,306.0	0.000314	14,509.3	± 28,438.3	± 23.52%
Forest Degradation	469.00	902,715	0.019	858,388.9	0.000851	39,267.1	± 76,963.4	± 8.53%
Forest Restoration	0.00		0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!

2014-2015 (REDD+ Results Period 1 included in 1st BUR)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, and Forest Degradation from 2014 to 2015 are respectively 0.68%, 2.38%, 32.82%, and 14.31%. After QA/QC process, it is confirmed that removals associated with Forest Restoration in this period are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	19,146.00	35,653,390.98	0.759	35,042,035.5	0.002692	124,200.9	± 243,433.8	± 0.68%
Stable Non-Forest	5,848.00	10,085,782.43	0.232	10,703,323.1	0.002659	122,661.9	± 240,417.3	± 2.38%
Deforestation	32.00	61,784.18	0.001	58,568.1	0.000224	10,347.1	± 20,280.3	± 32.82%
Forest Degradation	183.00	337,905.46	0.007	334,936.4	0.000535	24,669.7	± 48,352.6	± 14.31%
Forest Restoration	0.00		0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!

2016-2018 (REDD+ Results Period 2 included in 2nd BUR)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, and Forest Degradation from 2016 to 2018 are respectively 0.69%, 2.37%, 29.44%, and 13.47%. After QA/QC process, it is confirmed that removals associated with Forest Restoration in this period are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	19,102.00	35,551,493.18	0.758	34,961,504.3	0.002699	124,507.5	± 244,034.7	± 0.69%
Stable Non-Forest	5,880.00	10,147,566.61	0.233	10,761,891.2	0.002664	122,895.3	± 240,874.9	± 2.37%
Deforestation	44.00	80,765.68	0.002	80,531.2	0.000263	12,130.2	± 23,775.1	± 29.44%
Forest Degradation	183.00	359,037.59	0.007	334,936.4	0.000535	24,669.7	± 48,352.6	± 13.47%
Forest Restoration	0.00		0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!

PNG also has been implementing landuse assessment by the wall-to-wall mapping method using TerraAmazon software adjusted to PNG situation (called TerraPNG). Although the assessment has been completed only for the base year of 2015, the relative comparison

between the results of sampling-based method (CollectEarth 2015) and wall-to-wall mapping method (TerraPNG 2015) has been conducted as the accuracy assessment of TerraPNG. The overall accuracy (agreement rate) of Forest/non-Forest was 89% and IPCC landuse category was 83%. It should be noted that Collect Earth sampling-based assessment is not always interpreting the landuse over the exact sampling point location, instead using the hierarchy rule for the plot (see section 7.7).

Uncertainty analysis for Emission Factors

In terms of emission factors, there is incomplete quantitative information available on error in estimating forest carbon stocks and emission factors. Those estimates of forest carbon stocks taken from Fox et al. (2010) are used for a bit more than half of PNG's forests and come with a quantification of sampling error. These sampling errors amount to around 20-30%, and for the exact value used from Fox et al, the sampling error amounts to 28.3% and 21.4% for degraded and primary forest respectively (see Table 3 in Fox et al, 2010, the values for lowland forest). There is no information on other error sources available there. Those estimates taken from the IPCC guidelines do not come with detail quantitative information on errors.

Based on the situation and understanding described above, the following causes were considered for the uncertainty analysis of Emission (and Removal) Factors.

a. Uncertainty of AGB due to the use of Fox et at. (2010) and IPCC default values (2006 IPCC guidelines)
b. Uncertainty of Root-to-Shoot ratios due to the use of IPCC default values (2006 IPCC guidelines)
c. Uncertainty of Carbon Fraction value due to the use of IPCC default values (2006 IPCC guidelines)

Estimation method for multiple uncertainties

After the uncertainty of each parameter is assessed, the total uncertainty of carbon stock was calculated through 'propagation of error approach' and by using the following generic equations given in the 2006 IPCC Guidelines.

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

$$U_{total} = \sqrt{U_1^2 + U_2^2 + \ldots + U_n^2}$$

Where:

U_{total} = the percentage uncertainty in the product of the quantities (half the 95 percent confidence interval divided by the total and expressed as a percentage);

U_i = the percentage uncertainties associated with each of the quantities.

EQUATION 3.2
COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

$$U_{total} = \frac{\sqrt{(U_1 \bullet x_1)^2 + (U_2 \bullet x_2)^2 + \ldots + (U_n \bullet x_n)^2}}{|x_1 + x_2 + \ldots + x_n|}$$

Where:

U_{total} = the percentage uncertainty in the sum of the quantities (half the 95 percent confidence interval divided by the total (i.e., mean) and expressed as a percentage). This term 'uncertainty' is thus based upon the 95 percent confidence interval;

x_i and U_i = the uncertain quantities and the percentage uncertainties associated with them, respectively.

Uncertainty of carbon stock for forest class

The following table shows the total uncertainty of carbon stock for each forest class estimated through the propagation of error approach. For AGB error for Fox et al. (2010), the values 18.8/66.3 = 28.3% and 22.7/106.3 = 21.4% in table 3 of Fox et al. were assigned for degraded and primary forest respectively. All the other values are based on the 2006 IPCC guidelines. "a" "b" "c" in the Table 11-1 refer to the explanation in the previous section (in page 61)

Table 11-1 Total uncertainty of carbon stock for each forest class

LU	STR	Land Use Subdivision	Global Ecological Zone	Source	tC/ha	tCO2/ha	Area(ha) 2013	a	b	c	Uncertainty (%)
Forest	Primary	Low altitude forest on plains and fans	Tropical rain forest	Fox et al. (2010)	305.5	526.5	5,817,288	21.4%	7.4%	2.7%	22.8%
		Low altitude forest on uplands			305.5	526.5	8,872,771	21.4%	7.4%	2.7%	22.8%
		Lower montane forest	Tropical mountain system	IPCC GL (2006)	177.8	306.4	6,671,087	30.0%	0.9%	2.7%	30.1%
		Montane forest			177.8	306.4	361,131	30.0%	0.9%	2.7%	30.1%
		Montane coniferous forest			177.8	306.4	3,995	30.0%	0.9%	2.7%	30.1%
		Dry seasonal forest	Tropical dry forest		166.4	286.8	2,064,756	30.0%	0.9%	2.7%	30.1%
		Littoral forest	Tropical rain forest	Fox et al. (2010)	305.5	526.5	130,533	21.4%	7.4%	2.7%	22.8%
		Seral forest			305.5	526.5	287,277	21.4%	7.4%	2.7%	22.8%
		Swamp forest			305.5	526.5	2,209,544	21.4%	7.4%	2.7%	22.8%
		Savanna	Tropical dry forest	IPCC GL (2006)	166.4	286.8	339,379	30.0%	0.9%	2.7%	30.1%
		Woodland			166.4	286.8	687,956	30.0%	0.9%	2.7%	30.1%
		Scrub	Tropical shrubland		98.0	168.9	178,511	30.0%	0.6%	2.7%	30.1%
		Mangrove	Tropical wet Mangrove		286.1	493.0	226,989	30.0%	5.6%	2.7%	30.6%
	Degraded	Low altitude forest on plains and fans	Tropical rain forest	Fox et al. (2010)	200.0	344.7	3,150,143	28.4%	14.9%	2.7%	32.1%
		Low altitude forest on uplands			200.0	344.7	2,272,738	28.4%	14.9%	2.7%	32.1%
		Lower montane forest	Tropical mountain system	IPCC GL (2006)	116.4	200.6	1,335,164	30.0%	0.9%	2.7%	30.1%
		Montane forest			116.4	200.6	29,684	30.0%	0.9%	2.7%	30.1%
		Montane coniferous forest			116.4	200.6	0	30.0%	0.9%	2.7%	30.1%
		Dry seasonal forest	Tropical dry forest		108.9	187.7	286,554	30.0%	0.9%	2.7%	30.1%
		Littoral forest	Tropical rain forest	Fox et al. (2010)	200.0	344.7	15,693	28.4%	14.9%	2.7%	32.1%
		Seral forest			200.0	344.7	33,263	28.4%	14.9%	2.7%	32.1%
		Swamp forest			200.0	344.7	255,234	28.4%	14.9%	2.7%	32.1%
		Savanna	Tropical dry forest	IPCC GL (2006)	108.9	187.7	296,410	30.0%	0.9%	2.7%	30.1%
		Woodland			108.9	187.7	369,765	30.0%	0.9%	2.7%	30.1%
		Scrub	Tropical shrubland		64.2	110.6	41,650	30.0%	0.6%	2.7%	30.1%
		Mangrove	Tropical wet Mangrove		187.3	322.8	54,860	30.0%	5.6%	2.7%	30.6%
	Plantation	Eucalyptus Plantation	Tropical rainforest (plantation)	IPCC GL (2006)	205.5	354.1	17,637	30.0%	14.9%	2.7%	33.6%
		Balsa Plantation			205.5	354.1	3,922	30.0%	14.9%	2.7%	33.6%
		Araucaria Plantation			205.5	354.1	9,764	30.0%	14.9%	2.7%	33.6%
		Pinus Plantation			205.5	354.1	7,809	30.0%	14.9%	2.7%	33.6%
		Acacia Plantation			205.5	354.1	5,964	30.0%	14.9%	2.7%	33.6%
		Terminalia Plantation			205.5	354.1	3,913	30.0%	14.9%	2.7%	33.6%
		Rubber Plantation			205.5	354.1	11,697	30.0%	14.9%	2.7%	33.6%
Non--Forest		Cropland	-	-	0.0	0.0	5,080,707	N/A	N/A	N/A	0.0%
		Grassland	-	-	0.0	0.0	2,436,667	N/A	N/A	N/A	0.0%
		Wetlands	-	-	0.0	0.0	2,128,512	N/A	N/A	N/A	0.0%
		Settlements	-	-	0.0	0.0	384,545	N/A	N/A	N/A	0.0%
		Other lands	-	-	0.0	0.0	55,352	N/A	N/A	N/A	0.0%

Uncertainty of Emission / Removal Factors

For the uncertainty analysis which will be estimated per REDD+ activity (e.g. Deforestation, Forest Degradation etc.), the land use subdivisions were stratified into simple strata; Forest (Primary), Forest (Degraded/Plantation) and Non-Forest. The uncertainty for each stratum was calculated by using a weighted value based on area proportion. The following table shows the uncertainty for each stratum.

Uncertainty in carbon stock/ha by stratum

Strata	Mean tCO_2/ha	Uncertainty (tCO_2/ha)	Uncertainty (%)
Forest (Primary)	441.7	52.1	11.8%
Forest (Degraded)	301.2	53.6	17.8%
Non-Forest	0.0	N/A	N/A

Strata Change and REDD+ Activity

		Current		
		Forest (Primary)	**Forest (Degraded)**	**Non-Forest**
Previous	Forest (Primary)	Stable Forest (SF)	Forest Degradation (DG)	Deforestation (DF)
	Forest (Degraded)	Forest Restoration (RS)	Stable Forest (SF)	Deforestation (DF)
	Non-Forest	Reforestation (RF)	Reforestation (RF)	Stable Non-Forest (SNF)

Emission/Removal Factors (tCO_2/ha)

		Current		
		Forest (Primary)	**Forest (Degraded)**	**Non-Forest**
Previous	Forest (Primary)	0.0	-140.5	-441.7
	Forest (Degraded)	140.5	0.0	-301.2
	Non-Forest	441.7	301.2	0.0

Emission/Removal Factor Uncertainty (%)

		Current		
		Forest (Primary)	**Forest (Degraded)**	**Non-Forest**
Previous	Forest (Primary)	0.0%	10.1%	11.8%
	Forest (Degraded)	10.1%	0.0%	17.8%
	Non-Forest	11.8%	17.8%	0.0%

Note: The calculation errors (figures) in the table above reported in 1st BUR were corrected in the 2nd BUR

Aggregated / Total Uncertainty Analysis

Based on the uncertainty assessment of Activity Data (AD) and Emission Factors (EF), the uncertainty of the emissions and removals through changes among the REDD+ activities using propagation of error approach. The following tables show the results of the calculation. EF Uncertainty does not have time series analysis so the same information is used for all the periods.

2009-2018 (FRL Reference Period 2: 10 years from the latest reported year: 2018)

	SF	SNF	DF	DG	RF	RS
AD Uncertainty	0.74%	2.41%	15.71%	6.07%	N/A	N/A
EF Uncertainty	N/A	N/A	10.07%	10.07%	10.07%	10.07%
Total Uncertainty	N/A	N/A	18.65%	11.75%	N/A	N/A

As references, the aggregated / total uncertainty analysis of the past reports was summarized below.

2001-20013 (FRL Reference Period 1-1: Original 1st FRL)

	SF	SNF	DF	DG	RF	RS
AD Uncertainty	0.75%	2.42%	18.59%	5.70%	N/A	N/A
EF Uncertainty	N/A	N/A	10.07%	10.07%	10.07%	10.07%
Total Uncertainty	N/A	N/A	21.14%	11.57%	N/A	N/A

2009-2013 (FRL Reference Period 1-2: For GCF RBP)

	SF	SNF	DF	DG	RF	RS
AD Uncertainty	0.70%	2.40%	23.52%	8.53%	N/A	N/A
EF Uncertainty	N/A	N/A	10.07%	10.07%	10.07%	10.07%
Total Uncertainty	N/A	N/A	25.58%	13.19%	N/A	N/A

2014-2015 (REDD+ Results Period 1 included in 1st BUR)

	SF	SNF	DF	DG	RF	RS
AD Uncertainty	0.68%	2.38%	32.82%	14.31%	N/A	N/A
EF Uncertainty	N/A	N/A	10.07%	10.07%	10.07%	10.07%
Total Uncertainty	N/A	N/A	34.33%	17.50%	N/A	N/A

2016-2018 (REDD+ Results Period 2 included in 2nd BUR2)

	SF	SNF	DF	DG	RF	RS
AD Uncertainty	0.69%	2.37%	29.44%	13.47%	N/A	N/A
EF Uncertainty	N/A	N/A	10.07%	10.07%	10.07%	10.07%
Total Uncertainty	N/A	N/A	31.11%	16.81%	N/A	N/A

Finally, the uncertainty in emissions from deforestation and emissions from forest degradation are combined by using the 2006 IPCC Equation 3.2. This results in the following uncertainty estimates:

	95% CI (%)
Uncertainty FRL (2009-2018)	**10.31%**

	95% CI (%)
Uncertainty FRL (2001-2013)	10.20%
Uncertainty FRL (2009-2013)	11.77%
Total uncertainty results (2014-2015)	15.69%
Total uncertainty results (2016-2018)	14.98%

Chapter 12. National Forest Monitoring System (NFMS)

12.1. Summary of NFMS and MRV Efforts to Date

In so far as the design of a NFMS for REDD+, PNG has managed to finalise the NFMS and submitted the 1st FRL to the UNFCCC for technical assessment in January 2017 (http://redd.unfccc.int/submissions.html?country=png). PNG's REDD+ efforts and readiness in the area of NFMS and FRL have been led by PNGFA, with close support and collaboration from CCDA and technical assistance from FAO and JICA. Alongside the technical support and development work, numerous stakeholder events on NFMS and FRL have been held to bring together all relevant parties. Information drawn from these meetings has informed the development of an NFMS Roadmap for PNG which has been implemented.

The capacity on forest monitoring of PNG using remote sensing technology has significantly improved in recent years with enormous advances made through the technical support from FAO under the UN-REDD Programme, EU funded NFI project and close collaboration with JICA project. One of the most significant achievements being the development of a forest monitoring GIS web-portal (https://png-nfms.org/portal/) through which numerous land use layers can be visualised. The GoPNG through PNGFA also completed national land use change assessments using the FAO developed Open Foris Collect Earth in 2015 and 2019.

Alongside this, PNG has undertaken a national-level Land Use, Land Use Change and Forestry (LULUCF) assessment by point sampling-based approach managed by PNGFA, a wall-to-wall approach through a system called TerraPNG, housed and managed within the CCDA. Full-time GIS operators are in place in both PNGFA and CCDA to ensure the sustainability of this support.

12.2. Operational NFMS and MRV system in PNG

PNG developed and has been improving NFMS including MRV (Measurement, Reporting and Verification) function using FAO developed Open Foris Tool (Collect Earth, Collect, Collect Mobile and Calc) as well as mapping function using TerraAmazon as TerraPNG. PNG developed the 1st FRL using the data from NFMS and submitted it to UNFCCC in January 2017. Technical Assessment by UNFCCC had been conducted throughout 2017 and the revised 1st FRL was officially published by UNFCCC at early 2018. The Reference Level shows the historical annual emissions from deforestation and forest degradation of 31,000 Gg CO_2 eq per annum, and it predicts an ongoing increase in the emissions levels. PNG had also prepared National REDD+ Strategy (NRS) and officially released it in 2017. The NRS[12] outlines the key action areas across the sectors and also uses information from the NFMS and FRL. All four design elements

[12] https://redd.unfccc.int/files/4838_1_papua_new_guinea_national_redd_2b_strategy.pdf

of the Warsaw Framework (NRS, NFMS, SIS[13], and FREL/FRL) were developed. PNG's SOI and SIS[14] were endorsed by the government in late 2020 and subsequently submitted to the UNFCCC in January 2021. The SOI describes the PNG's approach to the REDD+ safeguards and how they are addressed and intend to be respected through the monitoring of specific indicators.

PNG has made great progress on the REDD+ readiness and is now moving to its implementation and the results-based payment. As a base for implementation and monitoring, PNG had prepared GHG-Inventories and 1st and 2nd BUR with technical annexes on REDD+ and submitted the reports to UNFCCC in April 2019 and May 2022. Technical Assessment by UNFCCC had been conducted for 1st BUR and its Technical Annex on REDD+ from August to the end of 2019 followed by a technical assessment report which had been released by UNFCCC in early 2020. Technical assessment of the 2nd BUR and its REDD+ technical annex was conducted in October 2022 and PNG is expecting the first draft technical assessment report by early 2023.

Under the Cancun Agreement, NFMS should have two functions; "Monitoring" function to monitor REDD+ activities and "MRV" function to measure and report the performance of REDD+ activities to UNFCCC; which then undergoes verification. PNG established a robust domestic MRV system, which contains in-country verification using two different methods (point sampling and wall-to-wall mapping) with tools (Collect Earth and TerraPNG) hosted by different government organizations; PNGFA and CCDA.

As part of the monitoring function, PNG established and officially released PNG Climate Change and Forest Monitoring Web-Portal (http://png-nfms.org/portal/) in 2017 by Prime Minister to disseminate forest and land use information related to REDD+ to the public ensuring transparency of PNG REDD+ progress. This portal is recognized as an achievement by various government and private organizations in PNG to share the REDD+ related information in one single platform for the first time in PNG. Anybody and organizations can utilize this portal to promote the achievements related to REDD+ in PNG.

[13] https://redd.unfccc.int/uploads/4838_3_png_sis_framework.pdf
[14] https://redd.unfccc.int/submissions.html?country=png

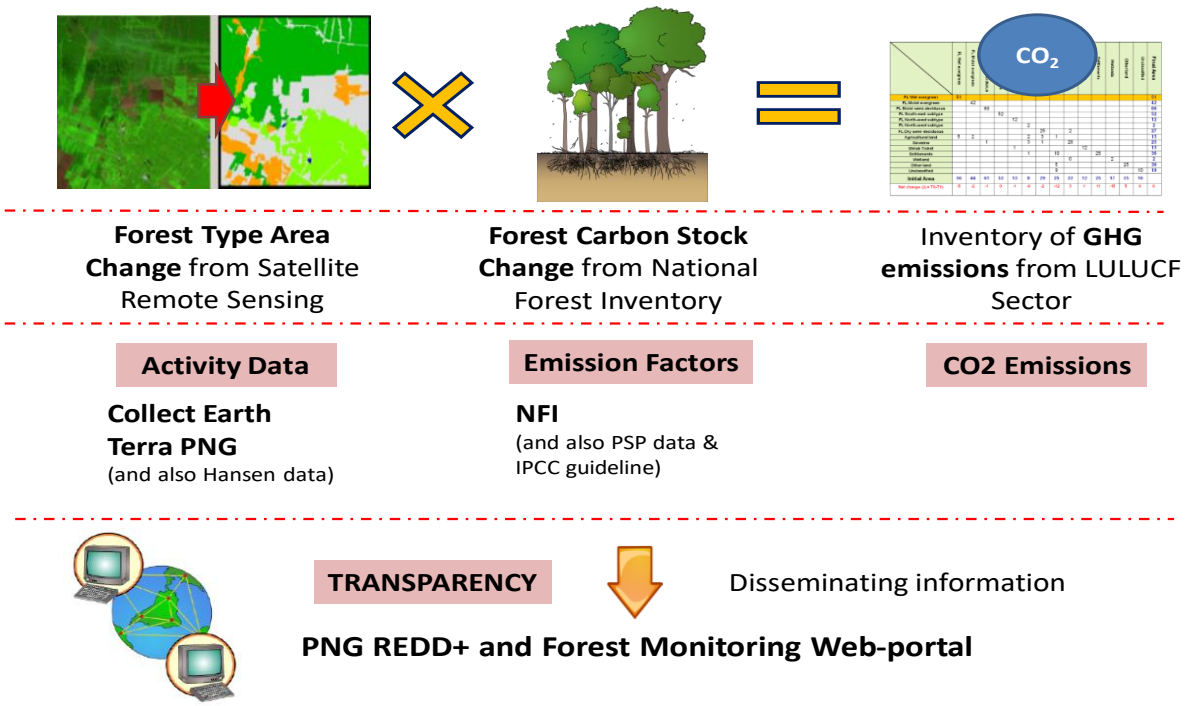


Figure 12-1. Papua New Guinea's NFMS for REDD+ under UNFCCC

PNG's REDD+ and Forest Monitoring Web-Portal was established for disseminating forest and land use information to public for ensuring the transparency of PNG REDD+ process. The web portal was developed jointly by CCDA and PNGFA. Other government agencies and private sectors (Conservation and Environmental Protection Authority, Mineral Resources Authority, National Statistics Office, etc) are responsible for providing all the necessary data needed for the web-portal. The web-portal is managed by CCDA who is responsible for publishing and updating the online information.

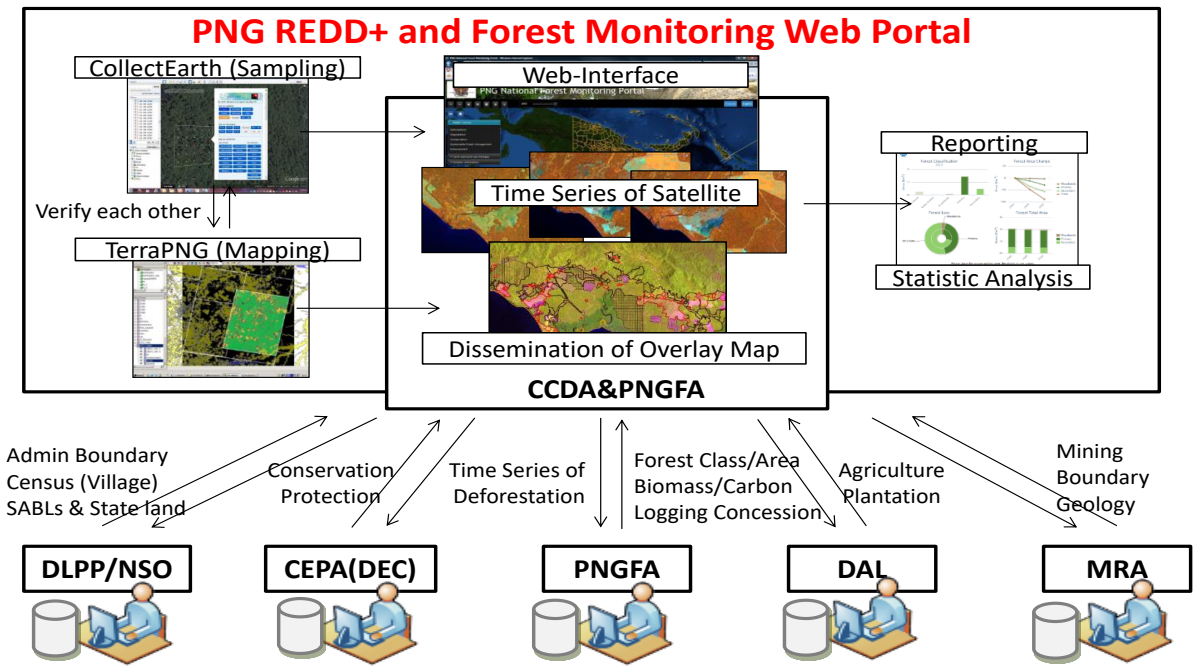


Figure 12-2. PNG REDD+ and Forest Monitoring Web-Portal (Source: CCDA)

After the Web-Portal was launched in 2017, PNG had made a lot of new achievements (products with publications) related to the forest and land use in PNG, such as “Forest and Land Use Change in Papua New Guinea 2000 - 2015”, which explains the results and method of Collect Earth assessment in PNG, which was used as a base data for FRL and BUR. There are also several new achievements related to REDD+ and land use in PNG initiated by CCDA with support of Forest Carbon Partnership Facility/United Nations Development Programme. The updating and enhancement of the Web-Portal were completed in 2021 and released as “PNG Climate Change and Forest Monitoring Web-Portal” in 2022.

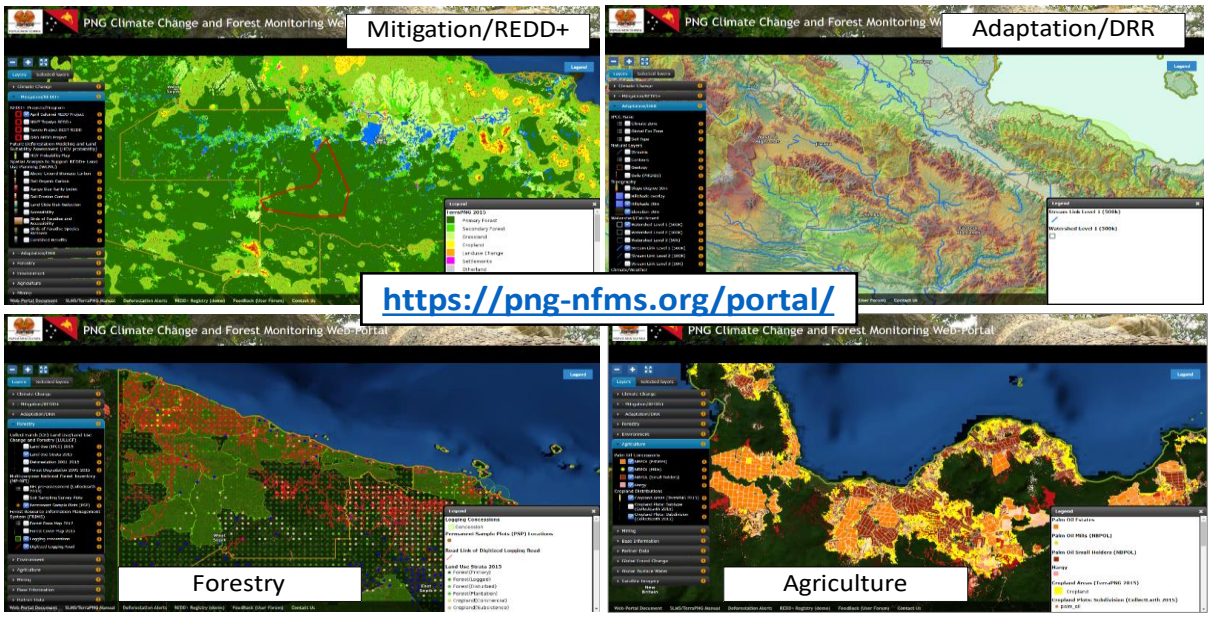
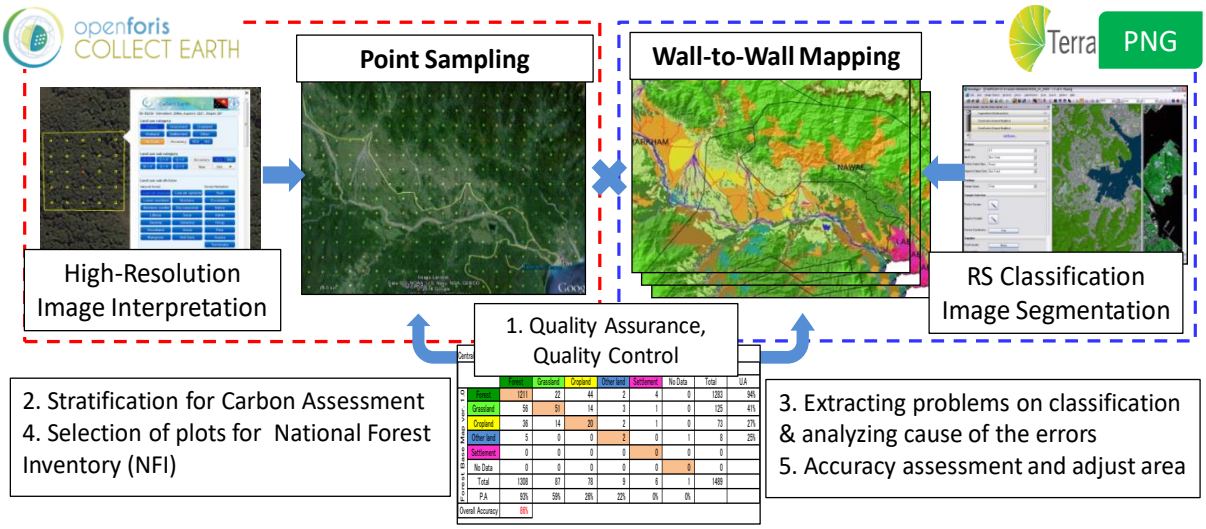


Figure 12-3. Updated PNG Climate Change and Forest Monitoring Web-Portal (Source: CCDA)

Regarding MRV system, PNG was the first country to use Collect Earth for LULUCF assessment and FRL and some of the other countries followed afterwards. On the other hand, many other countries use Wall-to-Wall mapping assessment. Based on the outcomes, challenges and lesson learnt from forest and land use change assessment in PNG 2000-2015, PNGFA organized the advantages and limitations of Collect Earth point sampling method compared with other methods (wall-to-wall mapping, such as TerraPNG). The overview of two different methods is illustrated in Figure below.



	Point Sampling	Wall-to-Wall Mapping
Spatial Coverage	Sampling Plots	Segmented polygons
Area Calculation	Statistical	Geographical
Boundary	No	Yes
Statistical Analysis	Ample	Limited
Driver Analysis	Ample	Limited

Figure 12-4. Collect Earth Point Sampling and Wall-to-Wall Mapping Method (Source: PNGFA)

In terms of "MRV", measurement frequency is annual based (by Collect Earth) and reporting is biannual based (for BUR). Such national reports need to be produced with great care, based on accurate and scrutinized data. The assessment and analysis require substantial time and resources. Consequently, there will be a considerable time lag before information such as deforestation is announced. In terms of "Monitoring", the needs to monitor the potential deforestation areas in the national protected areas, REDD+ project areas and logging constraints areas more frequently such as monthly or even weekly have been raised by the stakeholders including the government agencies, CSOs and academic institutions. Near-real-time information enable responsible authorities and organizations including the communities to take necessary measures against unplanned or unauthorized forest clearing, and prevent from further expansion.

Considering the situation above, the GoPNG decided to develop prototype PNG Deforestation Alerts and Monitoring System using the latest technologies with FAO assistance with affordable cost in the world and information existing in PNG, as a part of Monitoring Function under NFMS, to consider the potentials and issues/challenges for PNG. This new system is complementing the existing and potential systems in PNG, and collaboratively developed and managed by the several government organizations in PNG.

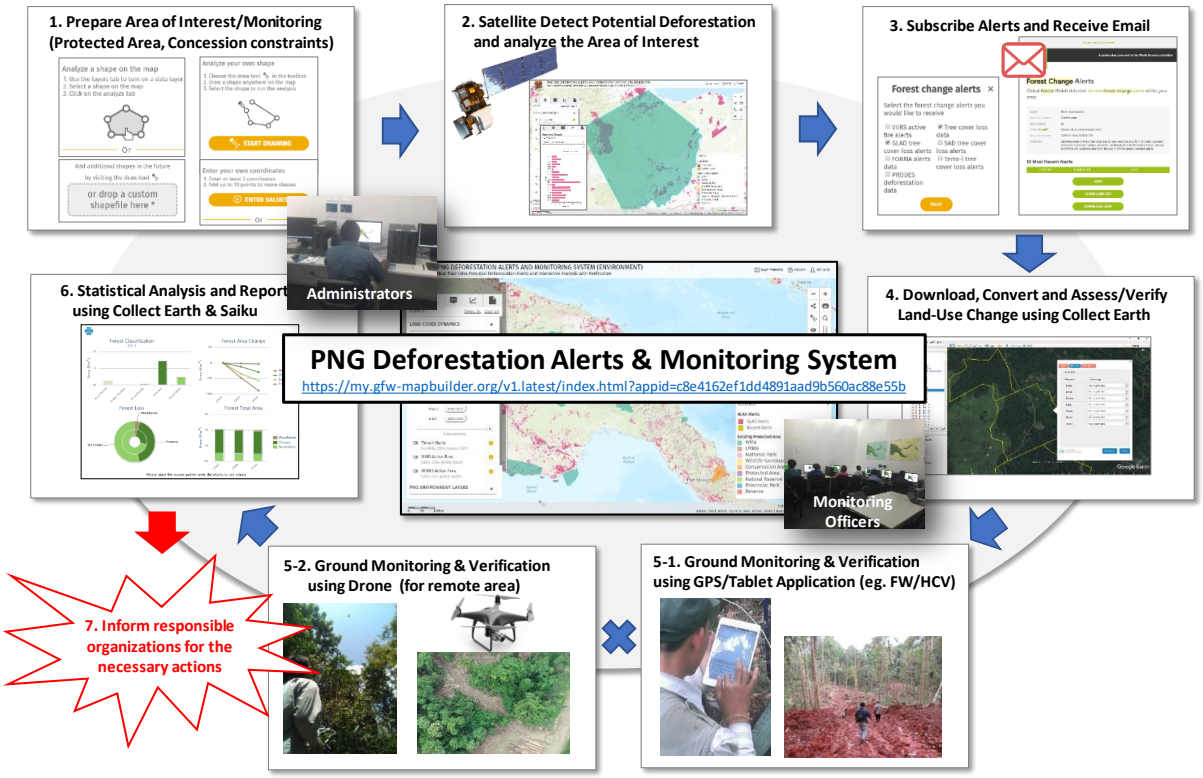


Figure 12-5. Indicative Work-Flow of PNG Near Real-time Deforestation Alerts and Monitoring System

PNG Near Real-time Deforestation and Degradation Alerts and Monitoring System will be oriented in a part of Monitoring function under NFMS. Figure 12-6 shows PNG Resource Information Network and the Deforestation Monitoring Alerts System. NFMS with this Deforestation Alerts system is contributing to implementation of Conservation / Environment Protection, Climate Change and Development, and Sustainable Forest Management, by collaborating with existing systems in PNG.

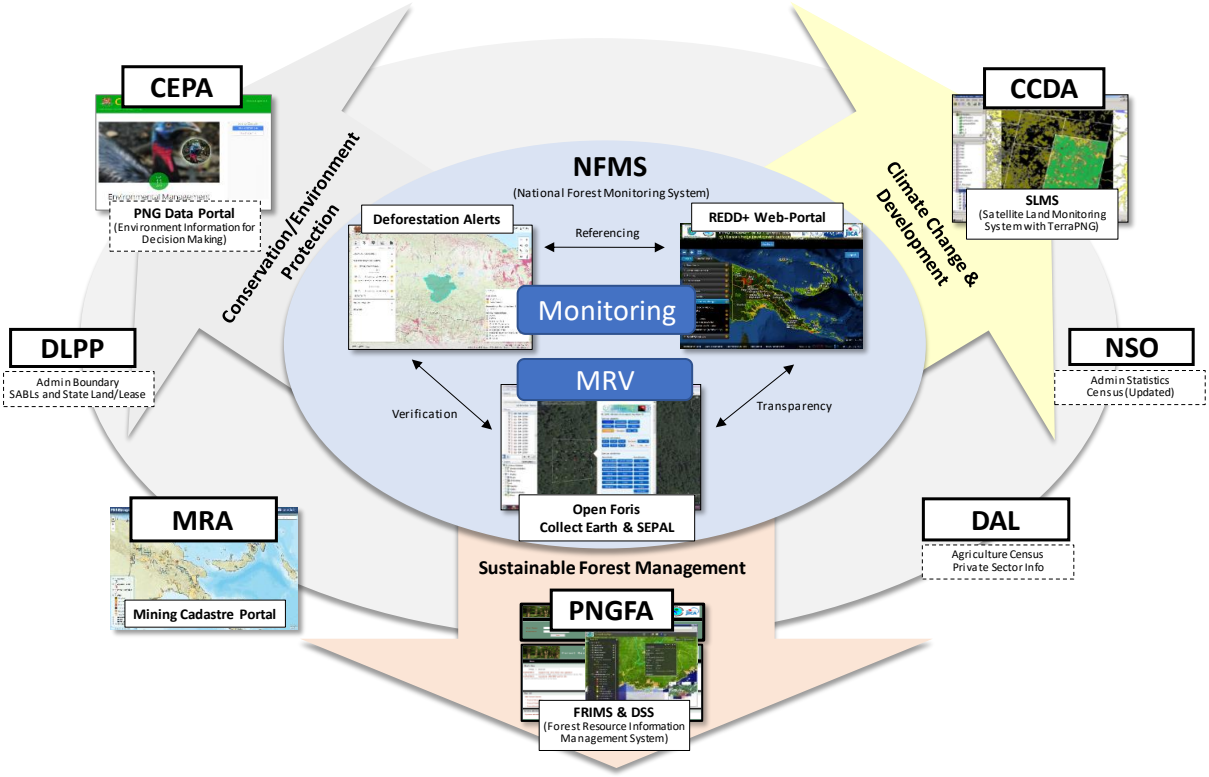


Figure 12-6. PNG Resource Information Network and National Forest Monitoring System

12.3. Multi-purpose National Forest Inventory

PNG launched a first-ever Multipurpose National Forest Inventory (NFI) in March 2016, along with the PNG Climate Change and Forest Monitoring Web-portal which has received national attention as the official endorsement was done by the Prime Minister of PNG. These initiatives aimed to enhanced the accuracy of GHG emissions estimation from forest and land use change meeting the requirements of Tier 3 emission factors (as prescribed by the IPCC for REDD+ Measurement, Reporting and Verification (MRV).

The NFI's methodology and approach was built on the methods and capacity developed within the PNGFA over a number of years. It was anticipated that the data generated by the NFI would significantly improve the accuracy of GHG estimations in the LULUCF sector and provide essential information related to the REDD+ (environmental and social) safeguards in PNG. The GoPNG and the EU had been financing this work with technical support from FAO. This program ended in 2019 with the main deficiencies observed in a number of areas related to the collection of flora and fauna biodiversity information and the development of detailed emission factors for different forest types as well as for different levels of forest degradation.

PNG Multi-Purpose National Forest Inventory Booklet
https://pngfa.gov.pg/images/articledocs/National_Forest_Inventory/NFI_Information_v3_Booklet_20180615_compressed.pdf
1st National Forest Inventory PNG: Field Manual
https://pngfa.gov.pg/images/articledocs/National_Forest_Inventory/PNG_Biophysical_Field_Manual_08_Feb_2018_FINAL_compressed.pdf

PNG's 1st Multi-Purpose NFI: Project Proceeding
https://pngfa.gov.pg/images/articledocs/National_Forest_Inventory/Proceedings_Feb_2018_compressed.pdf
Proceedings of the 2nd NFI Research Conference
https://pngfa.gov.pg/images/articledocs/National_Forest_Inventory/Proceedings_of_the_second_NFI_Research_Conference_compressed.pdf

Figure 12-7. Multi-purpose National Forest Inventory (source: PNGFA)

So far, only initial data has been derived from the total area earmarked. Information availability on land use and land use change will be a major step forward and a milestone achievement for the country. Based on this forest inventory and via input obtained from respective stakeholders, certain important measures relating to REDD+ such as the National Sustainable Land Use Policy (NSLUP), were developed which is a major advantage for the country.

The capacity on forest monitoring of PNG using remote sensing technology has improved significantly in recent years. However, a large information gap still remains. National scale information on carbon stock in the diverse forests subject to different disturbances is poorly known. Previous studies were too scattered and the estimation of average carbon stock in PNG forests were often contradictory. With the data derived from the NFI these deficiencies will be greatly improved in subsequent reporting periods.

12.4. Roles and Responsibilities for MRV of Results

The two key government organisations responsible for the measuring, reporting and verifying the results are CCDA and PNGFA. Other government departments provide auxiliary information for the REDD+ implementation. For example, Conservation and Environment Protection Authority (CEPA) is responsible for providing data on conservation and protected area; the Department of Agriculture and Livestock provides information on agriculture plantation area and type; and the information on administrative areas are provided by the National Statistics Office. Verification is implemented domestically through the stakeholders'

consultation process, particularly through technical working committee meetings and national consultation workshops.

Table 12-1. Stakeholders' responsibility for REDD+ MRV in PNG

MRV Components	Responsible Institutions/mechanism	Roles	Platforms use
Measuring	PNGFA[15]	• PNG Forest Authority (PNGFA) is responsible for providing activity data from the Collect Earth land use assessment for the estimation of emissions and removals in the LULUCF sector • PNGFA also contributes to the estimation of emissions and removals through Technical Working Committee (TWC) meetings and one-on-one meetings.	• Collect Earth • Saiku
	CCDA[16]	• Estimating CO_2 emissions and removals from deforestation, forest degradation and enhancement of forest carbon stocks in PNG based on the Collect Earth land use assessment. • Providing land use dynamic information on extent of forest cover, forest cover change, drivers, and other land use using TerraPNG wall-to-wall mapping system to support/complement Collect Earth point sampling.	• TerraAmazon/TerraPNG
Reporting	CCDA REDD+ and AFOLU/MRV Technical Working Committees	• Providing validation and other technical inputs for the national greenhouse gas inventories and REDD+ results submissions to the UNFCCC and ensuring the quality of the submissions.	Technical Working Committee meetings and workshops
	CCDA	• Reporting country's MRV progress and results to UNFCCC.	National Communication reports and Biennial Update Report (BURs) to UNFCCC

[15] See www.forestry.gov.pg
[16] See www.ccda.gov.pg

Verifying	UNFCCC assigned international experts (Team of Technical Experts, e.g. LULUCF international experts Others: • MRV/AFOLU and REDD+ TWCs (technical working committees) of CCDA. These committees comprise of domestic experts from the government and private sectors, academia, civil society organisations, and national consultants.	• Verifying the submissions from Parties, by appointing two LULUCF experts to assess the FRL submissions and the technical annexes.	UNFCCC International Consultation and Analysis of PNG's submitted FRL and BURs. National Stakeholders consultation i.e. TWC meetings and workshops

12.5. Existing System for Monitoring REDD+ Results

PNG has an operational and robust national REDD+ MRV System for monitoring and evaluating the REDD+ results achieved through the implementation of REDD+ activities (Deforestation and Forest degradation) to ensure that the results reported or claimed for the GCF RBP are maintained over the rest of the results period (2016-17-18) under the pilot programme. PNG is currently developing a REDD+ Registry with funding from its GCF REDD+ Readiness Project that will further enhance monitoring and evaluation of the REDD+ results reported. The REDD+ Registry System is closely related to BUR, Technical Annex (REDD+ Results Reporting) and FRL. The large part of information of those reports are produced from NFMS and the other systems in PNG and Data Management System (DMS) of REDD+ Registry System will be developed as enhancement of PNG's existing NFMS.

The cause of the emission reduction observed in 2016, 2017 and 2018 was due to the implementation of REDD+ related policies and measures by the Government of Papua New Guinea since 2009. When PNG's REDD+ registry is fully developed, a component of it will be dedicated to identifying and documenting the exact actions and policies that contributed to the emission reduction/REDD+ results reported.

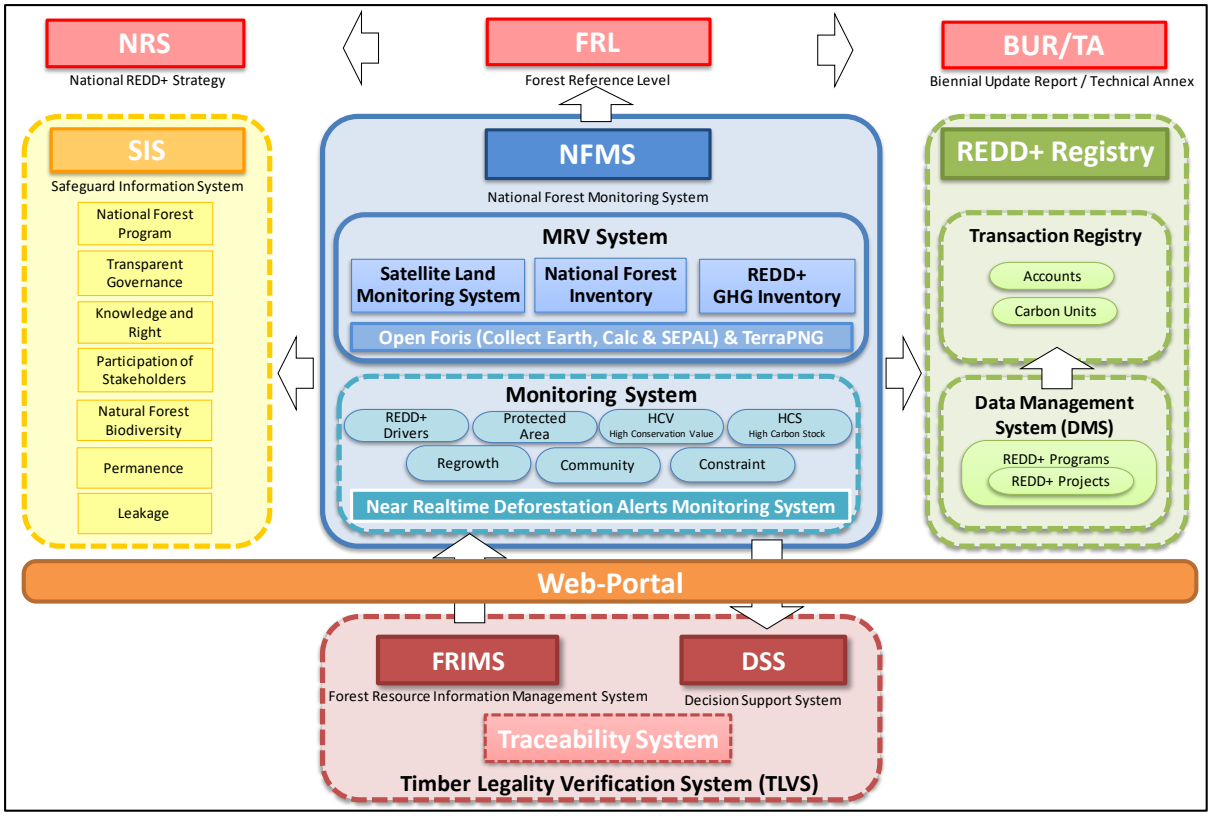


Figure 12-8. Planned workflow of REDD+ Registry System and NFMS and the other related systems in PNG

Chapter 13. Proposed Improvements

The table below summaries the progress of the improvement made against the TATR recommendations for the PNG's 1st FRL.

Table 13-1. Summary of Progress

No	TATR recommendations for 1st FRL	PNG's status in 2nd FRL	Future action
(a)	Improvement in the consistency of the FRL with the national GHG inventory, including the selection of methods, data and assumptions following the guidance provided in the relevant set of the IPCC guidelines.	PNG submitted *1st BUR in 2019 and 2nd BUR in 2022. The methodology and data used are consistent with the PNG's second Forest reference Level.	PNG to maintain the consistency in methodology and data in BTR reporting.
(b)	Inclusion of a detailed, step-by-step description of the FRL estimation procedure, including how activity data on land use and land-use change are derived from CE (e.g. information on the statistical methods to derive activity data from the CE assessments) to enable the reconstruction of the FRL.	PNGFA will publish a report in the first quarter of 2023 title "Forest and Land Use Change in Papua New Guinea 2016-2019" which will contain detail information on the methodology used to produce the activity. This will be the second volume publication, the first publication has the title *"Forest and Land Use Change in Papua New Guinea 2000-2015" which provides the information relating to PNG 1st FRL. Descriptions of FRL estimation using the historical average approach are available in the technical annexes of PNG 1st and 2nd BUR and is also described in this FRL submission.	PNG will continue to publish the reports on a periodic basis which will provide complementary information to future FRLs.
(c)	Correction of the errors in the remaining CE plots found with errors (6,868) according to the results presented by Papua New Guinea during the TA and inclusion of a summary of the QA/QC procedures applied that were presented during the TA.	PNG improved the QA/QC process as fully described in the publication by PNGFA titled "Forest and Land Use Change in Papua New Guinea 2000-2015".	To ensure overall transparency of the process, PNG will continue to prepare series of reports after every land use land use change assessment.

(d)	Use of crop-specific post-deforestation biomass growth rates for non-forest land uses, as presented by Papua New Guinea in the modified submission to estimate the emission factor for deforestation.	PNG continues to use crop-specific post-deforestation biomass growth rates.in 1st and 2nd BUR.	Country-specific biomass growth data to be developed.
(e)	Improvement of emission factors for forest degradation including through full implementation of the national forest inventory by: i. Accurate determination of the extent of forest regrowth included in the above-ground biomass carbon stocks in selectively logged forest. ii. Accurate determination of the losses in biomass carbon stocks in forest areas subject to disturbances other than logging. iii. Tracking of forest land subject to degradation and the inclusion of emissions and removals from forest degradation events subsequent to the first occurrence of degradation. iv. Use of the actual values of pre-disturbance forest biomass carbon stocks rather than those for primary forests in the estimation of emissions factors for gardening.	PNG progressed NFI but not completed thus the EF is yet to be improved since the submission of PNG's 1st FRL.	PNG will progress NFI to improve the accuracy of the EFs.
(f)	Use of the information on national circumstances and the drivers of deforestation and forest degradation presented to support the selection of the model used to construct the FRL, with a view to demonstrating its consistency with the national circumstances presented.	PNG applied historical average according to guidance from GCF and ART/TREES in the 2nd FRL compare to linear projection used in the estimation of PNG's 1st FRL.	PNG will continue to follow methodologies provided by future guidelines
(g)	Inclusion of the information clarifying the difference between the forest definition used for reporting to FAO and that used for the construction of the FRL.	PNG reported FRA 2020 using the same national forest definition and Collect Earth data that was used in the construction of FRL hence there is no discrepancies between FRA and FRL.	PNG to continue maintaining the consistency between FRA and FRL reporting.

(h)	Treatment of emissions from deadwood (i.e. the inclusion of this pool or the provision of more information on the justification for its exclusion).	PNG is yet to address this recommendation in the FRL	PNG will complete NFI to address the recommendation.
(i)	Inclusion of emissions from soil organic carbon.	PNG is yet to address this recommendation in the FRL	PNG will complete NFI to address the recommendation.
(j)	Monitoring of non-CO_2 gases from biomass burning and their potential inclusion, if considered significant.	PNG is yet to address this recommendation in the FRL	PNG will establish the methodology to monitor non-CO_2 gases from biomass burning in forest area.
(k)	Broadening of the scope of the FRL by assessment of the significance and inclusion of any other potentially significant activities excluded owing to lack of data, in line with the national GHG inventory.	Emissions and removals from all the activities are included in the FRL (refer to section 5.1.1 for further details)	N/A

* PNG 1st and 2nd BUR are accessible through this link: https://unfccc.int/documents/490259

* The publication Forest and Land Use Change in Papua New Guinea 2000-2015 can be downloaded from the link: https://pngreddplus.org/publications-and-reports/

Chapter 14. Capacity Building Needs

Following are prioritised capacity building needs for PNG which are expected to be addressed within the 2nd FRL period which is inclusive of the BTR reporting schedule.

i. Activity Data: Use of higher Tier 2 level uncertainty analysis of the FRL (Tier 2 Monte Carlo).
ii. Emission Factor: Enhancing Emission Factor by replacing IPCC default values with more reliable country specific data.
iii. Relevant methodology developed or adopted for assessing post-deforestation regrowth and associated emission reduction.
iv. Accounting of CO_2 emissions from carbon pools other than living biomass, namely deadwood, litter and soil organic carbon.
v. Monitoring of near-real time national scale forest carbon dynamics using space borne Lidar data such GEDI, etc.

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