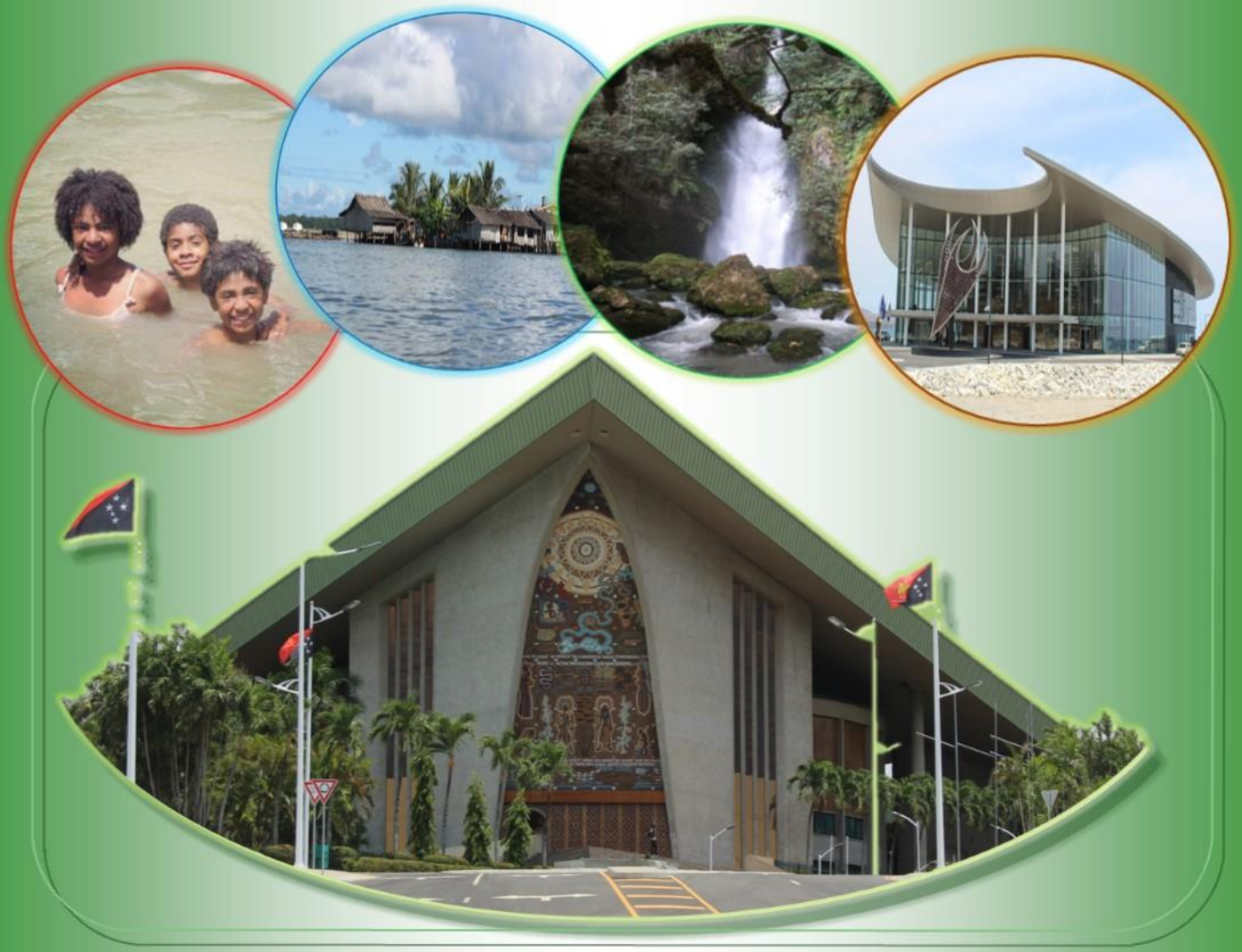
PAPUA NEW GUINEA'S FIRST BIENNIAL UPDATE REPORT

TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE



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Minister's Foreword

Hon. John Pundari, CMG, MP

After years of debate it has been scientifically proven that extreme climatic event is a direct cause of the increase in greenhouse gas (GHG) emissions driven by human activity with industrial processes, the burning of fossil fuels and the clearing of forests. Combating climate change is one of the most significant challenges our generation is facing. It is an unequivocal challenge and that any delay in reducing emissions significantly constrains opportunities to achieve lower stabilization levels and increases the risk of more severe climate change impacts.

The Paris Agreement is a milestone where 195 countries adopted the first-ever universal, legally binding global climate deal. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change events by limiting the global warming to the stabilization levels of well below 2^{o}C. Furthermore, the Sustainable Development Goals adopted by 193 member nations of the UN also includes Climate Action, SDG13, where there is a need to take urgent action to combat climate change.

As a responsible member of the international community, Papua New Guinea has ratified the Paris Agreement in 2016. PNG has also taken an extra step to pass in Parliament the Paris Agreement Implementation Act. In addition PNG has also agreed to the Sustainable Development Goals and has factored them into the National Goals.

PNG was the first country to submit its National Determined Contribution (NDC) where we will reduce our emission through the generation of electricity fully from renewable sources. Further mitigation options also included in the NDC are energy efficiency, reduction of emissions in the Oil and Gas sector and implementation of Reducing Emissions from Deforestation and forest Degradation and the role of Conservation, Sustainable Management of forest and Enhancement of Carbon Stocks. These initiatives are conditional to technology transfer and financial support from developed countries.

It therefore gives me great pleasure to present to you PNG's First Biennial Update Report (BUR1) which provides an update of the Second National Communication by describing our national circumstances, national greenhouse gas inventory, mitigation actions and their effects, as well as our finance, technology, and capacity building needs and support received.

Honorable John Pundari, CMG, MP
Minister for Environment, Conservation & Climate Change

Acknowledgement

The Government of Papua New Guinea through the Climate Change and Development Authority (CCDA) would firstly like to thank the Global Environment Facility (GEF) and United Nations Environment Program (UNEP) for funding and facilitating the development of PNG's BUR1.

CCDA is also grateful for the Technical Assistance the Japan International Cooperation Agency (JICA) provided in finalizing the GHG emissions estimations and in the final review and editions on the overall document.

CCDA also expresses our appreciation to the Food and Agriculture Organization (FAO) and European Union (EU) for providing Financial and Technical Assistance especially on the Agriculture, Forestry and Other Land-Use sector for the GHG Inventory Chapter including the REDD+ Technical Annex.

CCDA would also like to express our gratitude to those who provided data for the GHG inventory and were also involved in the reviewing of the document namely:

- Department of Agriculture and Livestock (DAL)
- PNG Forest Authority (PNGFA)
- Department of Petroleum and Energy (DPE)
- Conservation and Environmental Protection Authority (CEPA)
- National Statistical Office (NSO)
- Water PNG (WPNG)
- National Capital District Commission (NCDC)
- Private Companies
- Asia Pacific Energy Research Centre (APERC)

CCDA also thanks the following Provincial Governments for facilitating the data collection in their province:

- Eastern Highlands Provincial Government
- East New Britain Provincial Government
- West New Britain Provincial Government
- Madang Provincial Government
- Morobe Provincial Government

And finally, the project team for successfully delivering the project namely:

i. Ms Gwen Sissiou *(Project Director)*
ii. Mr Alfred Rungol *(Project Manager)*
iii. Mr Jason Paniu *(Compiler **Chapter 1**-Energy and Transport, **Chapter 2**-General Section and Energy Section, **Chapter 3**, **Chapter 5** and **Chapter 6**)*
iv. Ms Jacinta Kull *(Compiler **Chapter 1**-Climate &Weather , **Chapter 2**-IPPU Section and **Chapter 5**)*
v. Mr Larsen Daboyan *(Compiler **Chapter 1**-Land tenure systems and Agriculture, **Chapter 2**-Agriculture Section and **Chapter 5**)*

vi. Mr Morgan Kai *(Compiler **Chapter 1**- Forestry, **Chapter 2**-LULUCF Section and **Chapter 5**)*

vii. Mr Nathan Sapala *(Compiler **Chapter 1**-Fish resources, **Chapter 2**-LULUCF Section and **Chapter 5**)*

viii. Ms Priscilla Pep *(Compiler **Chapter 1**- Biodiversity, **Chapter 2**-Waste Section and **Chapter 5**)*

ix. Mr Erick Sarut *(Compiler **Chapter 1**-Population and Economy, **Chapter 2**-Waste Section and **Chapter 5**)*

x. Mr Paul Hasagama *(Compiler **Chapter 1** - Geographical Overview, **Chapter 4**, **Chapter 5** , **Chapter 7** and **Technical Annex/REDD+ Results**)*

xi. Ms Debra Sungi *(Compiler **Chapter 1**-Domestic Climate change policy and Institutional Arrangement for development of BUR & NC and **Chapter 5**)*

This report is dedicated to Late Ms Sherlyn Weplu and Late Mr Joe Neil Pokana. Their visions and drive in the field of climate change in Papua New Guinea have seen in various achievements for the Climate Change and Development Authority. Their impeccable leaderships in guiding and mentoring the team towards the completion of the BUR1 and REDD+ MRV for the GoPNG will always be valued and remembered.

Executive Summary

The Papua New Guinea Government submits PNG's first Biennial Update Report (BUR1) under the United Nations Framework Convention on Climate Change (UNFCCC). The report follows the BUR guidelines for developing countries according to paragraphs 39 to 42 of Decision 2/CP.17 and its Annex III.

This first BUR presents an overview of PNG's national circumstances relevant to climate change, summary results of the inventory of anthropogenic emissions by sources and removals by sinks for years 2000 through to 2015, and also presents information related to identified mitigation actions; constraints and gaps; the financial support received in relation to climate change activities and related financial, technical and capacity needs, including a description of support needed and received; information on national circumstances and institutional arrangements relevant to the preparation of national communications on a continuous basis; and information about the domestic MRV (measurement, reporting and verification).

This BUR also includes the Technical Annex referred to in decision 14/CP.19, paragraph 7, containing the results achieved from REDD+ activities by PNG.

1. National Circumstances

Papua New Guinea is located at 6 degrees South and 143 degrees east, occupying the eastern half of the island New Guinea which is north of Australia. The total land area is 46.9 million hectors with terrestrial habitats ranging from extensive lowlands with rainforest, savannah, grassland and freshwater swamps to upland montane rainforests and alpine grassland. The marine and aquatic environments appear equally divers. This is due to the country's tropical climate where the monthly rainfall ranges from 250mm-350mm with average monthly temperature ranging from 26^{o}C - 28^{o}C. However, the country's climate is changing due to effects of global warming.

According to the recent census held in 2011 the population was at 7.3 million with an average annual growth rate of 3.1 per cent since the last census held in the year 2000. About 88% of this population live in the rural areas based on traditional village structure while the remaining live in the urban areas. The country has two land tenure systems, the alienated system which adapts the European model where the state owns the land, and the customary system where the local indigenous people have ownership over the land. About 97 % of the land comes under the customary system.

PNG's economy is dominated by a large, labour-intensive agriculture sector and a capital-intensive mining and petroleum sector. According to the National Accounts 2008-2015, the level of Gross Domestic Product (GDP) increased from K31.5 billion (PNG Kina) in 2008 to K57.1 billion in 2015 representing an average annual growth of 9.4 per cent.

The rural population are smallholders where they get their income by growing and selling of coffee, cocoa, sugar, copra, oil palm, rubber, fresh vegetables and betel nut. They also grow local crops which provide 80 per cent of the calories they consume.

Of the 46.9 million ha of the country's total land area, about 36.1 million ha (77.8 per cent) is forest. There are 14 types of forest in PNG comprising 13 natural vegetation and a forest plantation. The disturbance of forest over the years has seen 11.9 per cent caused by large scale logging, 7.9 per cent caused by small scale temporary gardening and 0.2 per cent caused by small scale logging using portable sawmill.

PNG has a fisheries zone of 2.4 million km^2 which is the largest in the South Pacific. The country records an extensive and valuable fisheries sector ranging from inland river fisheries, aquiculture, coastal beche-de-mer and reef fisheries to the prawn trawl and large-scale deep-water tuna fisheries.

The electricity generation capacity of PNG has 797 MW from which about half of this generation is provided by the private sector to be used mainly in the mining sector. The total electricity output in 2015 was 4324 GWh, comprising hydro-electric (23 per cent), petroleum products (56 per cent), natural gas (11 per cent), and geothermal (10 per cent). Natural gas production increased in 2014 with the commencement of the LNG project. The total primary energy supply in 2015 was estimated to be 3,833 ktoe of which oil and petroleum products account for 49 per cent, natural gas 39 per cent and 12 per cent is from renewable energy sources. In the same year the final energy consumption was 1,587 ktoe of which 21 per cent was petroleum product while 21 per cent from other sources.

For the transport sector, the total number of vehicles including motor cycles was estimated at approximately 46,000 in 2010 or one vehicle per 147 people with a growth rate of less than 1 per cent over the past decade. There are 22 declared ports and a number of private port facilities to support specific industries such as mining, oil palm and logging. The marine traffic is mainly general/container cargo vessels and bulk carriers for petroleum, mineral and log exports. There are 21 national airports, one of which is an International Airport. A further 6 airports are certified in accordance with the International Civil Aviation Organization Annex 14 and PNG Civil Aviation rules. There are about 259 registered planes in the country.

Domestic Climate Change Policy

The Government of PNG (GoPNG) has developed both long term and short term policy that addresses climate change. For long term policies the Vision 2050 which was developed in 2010 captures Environment Sustainability and Climate Change as one of the seven pillars for socioeconomic growth so that PNG can be a Smart, Wise, Fair, Healthy and Happy Society by 2050. In achieving the Vision 2050 the PNG Development Strategic Plan (DSP) 2010-2030 was also developed in 2010 outlining broad frameworks, targets and strategies and are to be implemented in 5 years intervals through the Medium Term Development Plans (MTDP). The National Strategy for Responsible Sustainable Development (StaRS) for PNG was then developed after the 2012 national elections and is the policy shift in long term planning to guide the government's position to attain: 1. the establishment of a responsible sustainable development paradigm; 2. to be a middle-income country by 2030; and 3. to be one of the top 50 countries on the Human Development Index by 2050.

Building on from the long term policies and as the country's action to address climate change issues, GoPNG established the Office of Climate Change and Development in 2010 then further

developed the National Climate Compatible Development Policy (NCCDP) in 2014. To ensure certainty and continuity of the NCCDP, GoPNG passed the Climate Change (Management) Act in 2015 which also saw the establishment of the Climate Change and Development Authority. Straight after the adoption of the Paris Agreement, GoPNG passed the United Nations Paris Agreement (Implementation) Act in 2016. Although prior to the COP 21 PNG also played some leading contributions under the UNFCCC process.

Institutional Arrangement for the development of the Biennial Update Report and National Communications

CCDA is responsible for the overall coordination and management of the Biennial Update Report (BUR) and National Communication (NC). Therefore CCDA in cooperation with its stakeholders consisting of the private sector, the non-government agencies, development partners and government agencies develop the BUR and NC elements. This has seen the completion of the INC, the SNC and the current BUR1.

2. GHG Inventory

The total net Green House Gas emissions in 2015 amounted to 15,193 Gg CO_2 eq compared to the emissions in 2000 which was -14,179 GgCO_2 eq. Therefore, PNG went from a net sink in 2000 to a net source in 2015.

Emissions from the Energy Sector amounted to 11,806.28 Gg CO_2 eq in 2015 an increase of 5,532.37 Gg CO_2 eq when compared to 2000. In 2015 the three largest emitting activities were Energy Industries which contributed 35 per cent followed by fugitive emissions of natural gas which contributed 27 per cent and Transport which contributed 17 per cent.

Emissions from the Industrial Process and Product Use amounted to 35.29 Gg CO_2 eq in 2015 an increase of 1.38 Gg CO_2 eq when compared to 2000. 58 per cent of the emissions were from Medical Use of N_2O while 42 per cent was from Lubricant Use.

Emissions from the Agriculture sector amounted to 796 Gg CO_2 eq in 2015, an increase of 114 Gg CO_2 eq (16.72 per cent) when compared with the year 2000. Direct and indirect emissions from managed soils contributed 58 percent of the total sector emissions in 2015, followed by enteric fermentation and manure management that contributed together 41 percent and biomass burning of crop residue contributed 1 percent of the total sectoral emission.

The Land use and Land Use Change and Forestry sector (LULUCF) has been one of the most significant sector in PNG with both the highest removals and emissions among all sectors. LULUCF sector historically acted as a sink. However the sector has evolved into a smaller sink over time due to the decrease in forest lands over time. The net removals from the LULUCF sector amounted to 1,716.46 Gg CO_2 eq in 2015 compared to 21,635.94 Gg CO_2 eq in 2000 which is a total decrease of removals amounting to 19,919.48 Gg CO_2

Emissions from the Waste sector amounted to 872.5 Gg CO_2 eq in 2015, an increase of 354 Gg CO_2 eq when compared to 2000. Waste water treatment and discharge contributed 70.6 per cent followed by 28.7 per cent from Solid Waste disposal and 0.7 per cent from Biological Treatment of solid waste.

3. Mitigation Actions

At the International level, PNG has committed in its Nationally Determined Contribution that the country's electricity will be generated fully from renewable sources by 2030. Other mitigation options include energy efficiency, energy efficient vehicles, reduction of emissions in the Oil and Gas sector and implementation of REDD+ activities under the UNFCCC. However, these actions are conditional to financial and technical assistance.

For domestic mitigation policies the National Climate Compatible Development Management Policy outlines three policies for the mitigation component.

i. Carbon Neutrality by 2050;
ii. Land Use and Forestry Sector Emissions Abatement; and
iii. Green Economic Growth

Under the LULUCF sector the main mitigation action is from REDD+ where the National REDD+ Strategy (NRS) 2017-2027 outlines three action areas and under each action area are actions to be undertaken as well as the lead agencies. The first action area is to Strengthen Land-Use and Development Planning, the second action area is Strengthen Environmental Management, Protection and Enforcement and the third action area is Enhanced Economic and Sustainable Livelihoods.

Under the Agriculture sector the, the NCCDMP identifies two mitigation actions although they have not yet been implemented. The first action is to Reduce GHG emissions through improved agricultural practices and the second action is to protect agricultural land from urban and suburban encroachment.

Under the Energy sector, PNG's vision 2050 outlines the country's goal to provide 100 per cent power generation from renewable energy sources. This is also elaborated in the NDC. Energy Efficiency is another mitigation action under this sector which is outlined in the NCCDMP and National Energy Policy although there is not much done in terms of implementation. Oil Search Limited, which is an oil company operating in the country has taken its own initiative to reduce its emissions in 2016 by 33% against the 2009 baseline.

Under Transport the three mitigation actions for road transport identified in the NCCDMP and also elaborated in the National Transport Strategy are; to promote clean fuel technology; a regulation to set standards for GHG emissions from vehicles; and economic incentives for fuel efficient vehicles. However, these actions have not yet been implemented. For the Air and Marine transport, PNG is a member of the International Civil Aviation Organization and International Marine Organization so any resolution relating to climate change mitigation will be implemented in the country. One of the actions is the Carbon Offsetting and Reduction Scheme.

Under the Industrial Process and Product Use sector, the country has signed the Kigali Amendment which aim is to phase out HFCs by 2050. CEPA, the implementing agency of the Montreal Protocol have drafted a regulation on Ozone Depleting Substances and Synthetic Green House Gas which will replace the Environment (Ozone Depleting Substances) Regulation 2007.

Under the Waste sector, for the domestic solid waste, a project was implemented by JICA in collaboration with CEPA and NCDC was focused on rehabilitating the largest open pit dump, improvement of the collection system, and the development the Solid Waste Management master plan. While for the industrial waste, an Oil Palm company, New Britain Palm Oil Limited, is implementing two projects which utilize methane produced from oil palm waste to generate electricity.

There are six quantitative mitigation projects, all of which are under the energy sector, and are as follows;

i. Renewable energy from Geothermal Power project
ii. Renewable energy generated from methane capture (Kumbango)
iii. Renewable energy generated from methane capture (Mosa)
iv. Facilitating Renewable Energy & Energy Efficiency Applications for Greenhouse Gas Emission Reduction
v. EU-GIZ Adapting to Climate Change and Sustainable Energy (ACSE) Program
vi. RE generated from Biomass Project

4. Information on the description of Domestic MRV

PNG's has an operational MRV system in place for REDD+. Hence, the current institutional arrangement focuses primarily on REDD+. MRV for other mitigation actions that were outlined in PNG's NDC, National Goals and Policies will be established when the necessary mitigation projects are develop and operational in the country. The different systems will be integrated into a single platform in order to meet the measurement, reporting verification requirement under UNFCCC.

5. Constraints, Gaps and Capacity Needs

As a Non-Annex I country, PNG faces challenges when implementing climate change activities in the country. Below is a list of constraints, gaps and capacity needs faced in implementing climate change activities which may be addressed through technical and financial support.

Constraints

- Data sensitivity
- Limited budget to carry out climate change activities
- Geographical situation of the country
- Ineffective institutional arrangement

Gaps

- Unavailability of data from data source
- Inaccurate and inconsistent data
- No established monitoring system to monitor climate change activities in the country.

Capacity Needs

- Understanding of 2006 IPCC guidelines
- Mitigation analysis knowledge and skills
- Vulnerability need assessment knowledge and skills

6. Financial and Technical Support Received for Climate Change Activities

Over the years PNG has received either technical or financial support to implement climate change activities in the country. The following are organizations and Governments that have provided either technical or financial support to PNG:

- Adaptation fund;
- AusAid;
- Asian Development Bank;
- European Union;
- Deutsche Gesellschaft für Internationale Zusammenarbeit;
- Green Environment Fund;
- Italy Government;
- Japan International Cooperation Agency;
- United Nations Development Programme;
- United Nations Environment Programme;
- UN Food and Agriculture Organization;
- UN Habitat;
- UN-REDD programme;
- USAID;
- World Bank

7. Technical Annex

The technical annex presents the REDD+ results (results measured against the technically assessed FRL) achieved by PNG between 2014 and 2015 which was 9,003,314 tCO_2e .The REDD+ activities that were accounted for in the period 2014 to 2015 include deforestation, forest degradation and enhancement of forest carbon stock. The emission reductions come mainly for reduced degradation. PNG reports zero (0) removals from carbon stock enhancement in the historical reference period (2001-2013) and 2014-2015.

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List of Acronyms and abbreviations

ADB	Asian Development Bank
AFOLU	Agriculture Forestry and Other Land-use
ANG	Air Niugini
APERC	Asia Pacific Energy Research Centre
AUSAID	Australian Agency for International Development
BoM	Australian Bureau of Meteorology
BUR	Biennial Update Report
CBIT	Capacity Building Initiative for Transparency
CBO	Community Based Organization
CCDA	Climate Change Development Authority
CCDS	Climate Change Development Strategy
CCMA	Climate Change (Management) Act
CEPA	Conservation and Environment Protection Agency
CfRN	Coalition for Rainforest Nations
CO_2eq	Carbon dioxide equivalent
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Civil Society Organizations
DAL	Department of Agriculture and Livestock
DLPP	Department of Lands and Physical Planning
DMPGM	Department of Mineral Policy and Geohazards Management
DNPM	Department of National Planning and Monitoring
DPE	Department of Petroleum and Energy
DoH	Department of Health
DOM	Dead Organic Matter
DPLGA	Department of Provincial and Local Government Affairs
DSP	Development Strategic Plan
ENSO	El Niño-Southern Oscillation
EU	European Union
FAO	United Nations Food and Agriculture Organisation
FCPF	Forest Carbon Partnership Facility
FPDA	Fresh Produce Development Agency
FREL	Forest Reference Emission Level
PNGFRI	Papua New Guinea Forest Research Institute
FRL	Forest Reference Level
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Giga gram
GHG	Greenhouse Gas
GHGi	Greenhouse Gas inventory
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GVA	Gross Value Added
GWh	Gigawatt hours
ha	Hectare

ICAO	International Civil Aviation Organization
IFRC	International Federation of Red Cross and Red Crescent Societies
IMO	International Marine Organization
IOM	International Organization for Migration
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
IPPU	Industrial Processes and Other Product Use
JICA	Japan International Cooperation Agency
K	Kina, monetary unit of Papua New Guinea
KCA	Key Category Analysis
km	Kilometer
km^2	Square kilometers
ktoe	Kilo-tonne of oil equivalent
LB	Living Biomass
LLG	Local Level Government
LNG	Liquefied Natural Gas
LULUCF	Land use, Land-Use Change and Forestry
MEPSL	Minimum Energy Performance Standards and Labelling
MMS	Manure Management Systems
MND	Mahonia Na Dari Research, Education & Conservation
MP-NFI	Multi-Purpose National Forest Inventory
MRA	Mineral Resources Authority
MRV	Monitoring, Reporting and Verification
MW	Megawatt
NBPOL	New Britain Palm Oil Limited
NC	National Communication
NCCDMP	National Climate Compatible Development Management Policy
NCDC	National Capital District Commission
NDA	National Designated Authority
NDC	National Disaster Centre
NEC	National Executive Council
NFA	National Fisheries Authority
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NGO	Non-Government Organization
NRS	National REDD+ Strategy
NSO	National Statistical Office
NWS	National Weather Services
OCCD	Officer of Climate Change and Development
PACAM	Pacific American Climate Fund
PGRD	Partners for Global Research & Development
PNG	Papua New Guinea
PNGCLMA	Papua New Guinea Centre for Locally Managed Areas Inc
PNGFA	Papua New Guinea Forest Authority
POME	Palm Oil Mill Effluent
PPL	PNG Power Limited
PSP	Permanent Sample Plots
QA/QC	Quality Assurance and Quality Control
RE	Renewable Energy
REDD+	Reducing Emissions from Deforestation and forest Degradation and the role of

	Conservation, Sustainable management of forest and enhancement of carbon stocks
SIS	Safeguard Information System
SLMS	Satellite Land Monitoring System
SPC	Pacific Community
STaRS	National Strategy for Responsible Sustainable Development
SWDS	Solid Waste Disposal Site
t	Tonne
TNC	The Nature Conservancy
TWC	Technical Working Committee
TWG	Technical Working Group
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITECH	University of Technology
UPNG	University of Papua New Guinea
USAID	United States Agency for International Development
USP	University of South Pacific
WB	World Bank

Chapter 1. National Circumstances

1.1. Geographical Overview

Papua New Guinea (PNG) is located in the South Pacific and lies 6 degrees South and 143 degrees East on the Global Positioning System. PNG comprises the eastern half of the island of New Guinea, located just north of Australia. It is a geomorphologically diverse country in the South-West Pacific Ocean and contains four large provincial islands and over 600 smaller islands expanding over 800,000 square kilometres (km^2) of ocean. The total land area of the country is 46.9 million hectares (ha), with 5,152 kilometres (km) of coastline and 40,000 km^2 of coral reefs. PNG's Economic Exclusion Zone (EEZ) is 2.4 million km^2 in extent, and is one of the largest and more productive in the Western and Central Pacific Ocean.

The country is located on the boundary between the northward moving Australian continental plate, and the northwest moving Pacific plate, which makes it one of the tectonically active areas in the world. The main islands are characterized by block-faulted, folded, and mountainous interiors. The highest peak is Mt. Wilhelm in the Simbu Province, which rises to 4,510 meters (m) above sea level. The deltaic flood plains provide the largest areas of lowlands especially along the south coast, where freshwater swamplands are common. Important rivers are the Sepik River, flowing about 1,130 km to the north coast, and the Fly River, which is navigable for 800 km in the southwest. The smaller islands of PNG are also areas of extreme topographic contrast and generally feature mountain ranges rising directly from the sea or from narrow coastal plains.

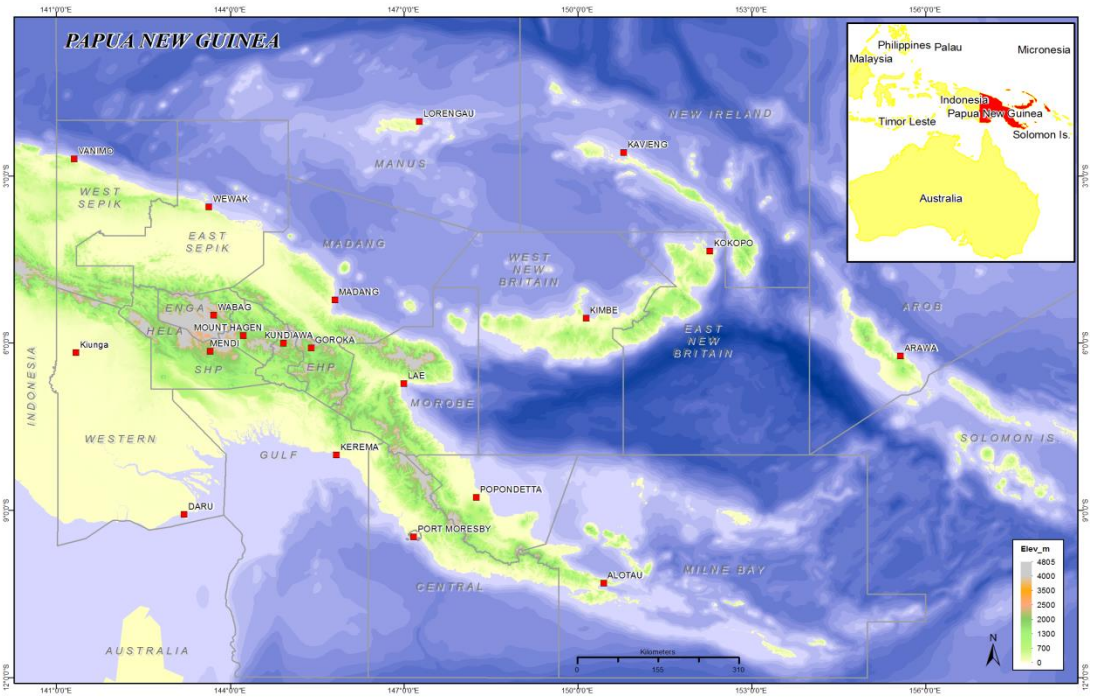


Figure1-1 Map of Papua New Guinea

1.2. Biodiversity

PNG is remarkably diverse in terms of landscapes, ecosystems, and collectively with West Papua constitutes the third largest expanse of tropical rainforest on the planet after the Amazon and Congo forests (Brooks el al, 2006). PNG covers less than 1 percent of the world's land mass and is recognized as one of the mega-diverse countries of the world. PNG host six percent of the world's most biologically diverse ecosystems (Convention on Biological Diversity Fifth National Report, 2017). Many of these organisms are endemic, that is, they are found only in PNG or on the island of New Guinea.

The flora of PNG is rich and varied, with habitats ranging from tidal swamps at sea level to alpine conditions. In low-lying coastal areas, various species of mangroves form the main vegetation, together with the beautiful casuarina, sago, and palm. Most of the country is covered by tropical and savanna rain forest, in which valuable trees such as kwila and cedar are found. Orchids, lilies, ferns, and creepers abound in the rain forests. There are large stands of pine at elevations of 910 to 1,220 m. At the highest altitudes, mosses, lichens, and other alpine flora prevail.

PNG also harbors a rich array of animals including an estimated 150,000 species of insects, 314 species of freshwater fishes, 352 species of amphibians and 335 species of reptiles, 813 species of birds, and 298 species of terrestrial mammals. Overall approximately a third of the species are endemic to PNG and more than 70 per cent are endemic to Papuasia.

1.3. Climate and weather

PNG is known for its tropical climate which is influenced by its location in the Pacific Warm Pool, between the equator and Tropic of Capricorn. Its location lies within the Intertropical Convergence Zone and to a lesser extent the South Pacific Convergence Zone. According to the Koppen-Geiger Classification, PNG is classified as 'Af climate' whereby hot, humid tropical climate is experienced all year round, which is greatly influenced by the West Pacific Monsoon and the El-Nino Southern Oscillation (ENSO).The coastal plains have an average temperature of 32°C, the inland and mountain areas average 26°C, and the higher mountain regions, 18°C. Relative humidity is quite high in PNG and ranges between 70 and 90 per cent.

Dry season is experienced from June to September, and wet season from December to March, which in these months tropical cyclones can hit PNG. A research by the Australian Bureau of Meteorology (BoM) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (BoM and CSIRO;2011:2) has found that in the 41-year period between 1969 and 2010, 23 tropical cyclones passed within 400 km of Port Moresby, an average of less than one cyclone per season. Over this period, cyclones occurred more frequently in neutral phases of the ENSO. Sometimes these cyclones cause heavy damage in terms of flooding and landslides. Western and northern parts of PNG experience the most precipitation, since the north- and westward-moving monsoon clouds are heavy with moisture by the time they reach these more distant regions.

According to Figure 1-2, average monthly rainfall for PNG ranges from 250mm – 350mm with average monthly temperature ranging from 26°C - 28°C. Annually, many areas receive more

than 3000 mm, but a few, like Port Moresby, lie in a rain shadow and receive 1190mm or less (BoM and CSIRO;2011:2). The rainfall and temperature data are taken from the World Bank Group.

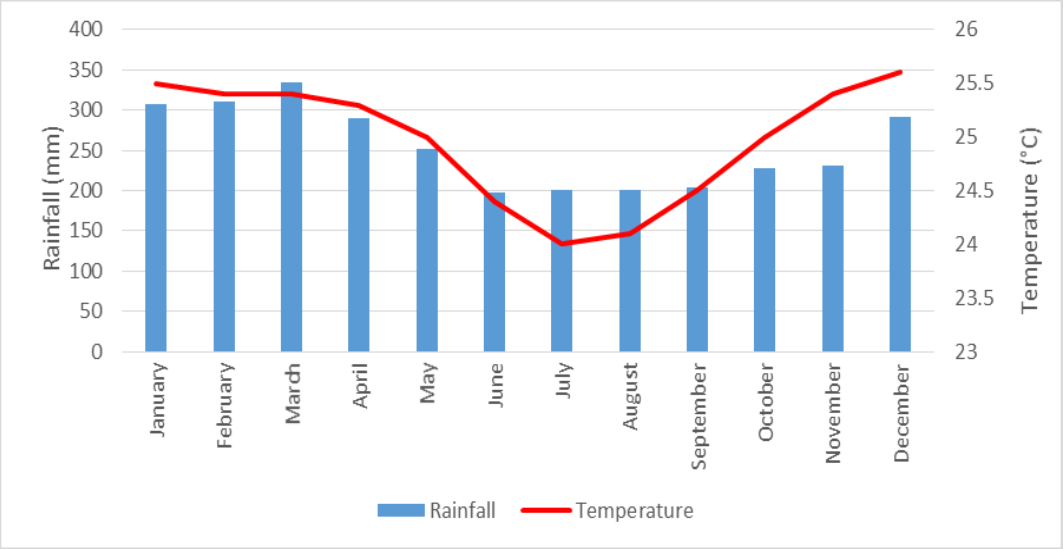


Figure 1-2: Average Annual Rainfall and Temperature for Papua New Guinea 1901 – 2015 (*Source: World Bank Climate Change knowledge portal)*

The El-Nino, is very much experienced in the Southern and Mainland than the Northern Region. But the recent 2015-2016 El Nino event had a significant impact on PNG. The drought and frosts impacted many rural villagers between mid-2015 and late 2016, with the impact continuing in early 2017 in some areas. The National Weather Service on 7 August 2015 declared the country were to be experiencing a severe El Nino event, which was forecasted to continue for 8–10 months with reduced rainfall in all parts of the country. The previous El Nino disaster occurred 18 years ago from 1997 to 1998. The National Disaster Centre estimated that 2 million people were affected and that the operation of food distribution by the World Food Program cost up to $12.6 million. The Provincial Disaster Centre of Chimbu Province reported 24 people confirmed dead as a result of prolonged drought in the Highlands region (IFRC, 2015). Papua New Guinea's drought has ranked eighth in aid group CARE's top 10 most under-reported crises in the world for 2016.

The future climate of PNG is projected to change. According to CSIRO there is a high confidence that over the course of the 21st century:

- The surface air temperature and sea-surface temperature are projected to continue to increase;
- Annual and seasonal mean rainfall is projected to increase;
- The intensity and frequency of days of extreme heat are projected to increase;
- The intensity and frequency of days of extreme rainfall are projected to increase;
- Ocean acidification is projected to continue; and
- Mean sea-level rise is projected to continue

1.4. Population

It has been difficult to develop a long-term trend in population in PNG. This is mainly because of the fact that censuses have been conducted only for a relatively short period. Censuses were

conducted in 1966, 1971, 1980, 1990, 2000 and latest in 2011. The population of PNG has grown from 3.8 million in 1990 to 7.3 million according to 2011 Census. This is a 40 per cent increase with an average annual growth rate of 3.1 per cent since the 2000 population census. In absolute numbers a total of 2,084, 538 persons were added to the population during the last 11 years.

Most of the population lives in rural communities based on the traditional village structure and dependent on subsistence farming supplemented by cash cropping. The 2000 and 2011 censuses identified that around 12 per cent of the PNG population lives in urban areas. Around 39 per cent in the Highlands region and 26 per cent in the Momase region, while Southern and Islands regions make up 20 per cent and 15 per cent of the population, respectively. A report from the National Statistical Office (NSO) identified that the annual growth in population increased by 2.2 per cent from 1980, and by 3.1 per cent from 2000 (NSO, 2011). The Highlands and Islands regions have annual growth higher than the national average. Gender ratio (number of males to every 100 females) was found by the NSO to remain steady at 108, as reported in the 2011 census. The report also identified average household size is 5.3 persons which is a slight increase from 5.2 reported in the 2000 census.

Of the 22 provinces, Morobe province contains 9.3 per cent of the country's total population, reporting a total population count of 674, 810 persons in the 2011 census. Eastern Highlands and Southern Highlands (minus Hela Province) are the two most populated provinces with population in excess of half a million. Significant increase in the population is noted mostly for provinces in the Highlands and Islands region. However, this is not the case for the provinces in Momase region where population growth rate is comparatively lower. Table 1-1 contains the population distribution for PNG across its provinces and includes urban and regional data.

Table 1-1: Regional population distribution across PNG provinces in 2000 and 2011 (Source: National Statistical Office)

	Census Years									
	2000					2011				
	Urban	% Urban	Rural	Total Populatio	% Rural	Urban	% Urban	Rural	% Rural	Total Population
Papua New Guinea	622,160	12%	4,568,626	5,190,786	88%	854,951	12%	6,420,373	88%	7,275,324
Southern Region	313,409	30%	728,411	1,041,820	70%	441,838	30%	1,014,412	70%	1,456,250
Western Province	24,373	16%	128,931	153,304	84%	30,517	15%	170,834	85%	201,351
Gulf Province	5,124	5%	101,774	106,898	95%	5,885	4%	152,312	96%	158,197
Central Province	-	0%	183,983	183,983	100%	-	0%	269,756	100%	269,756
National Capital District	254,158	100%	-	254,158	0%	364,125	100%	-	0%	364,125
Milne Bay Province	9,888	5%	200,524	210,412	95%	11,857	4%	264,655	96%	276,512
Northern Province	19,866	15%	113,199	133,065	85%	29,454	16%	156,855	84%	186,309
Highlands Region	102,044	5%	1,871,952	1,973,996	95%	151,310	5%	2,703,564	95%	2,854,874
Southern Highlands Province	22,607	6%	337,711	360,318	94%	28,049	5%	482,196	95%	510,245
Hela Province	8,824	5%	177,123	185,947	95%	39,279	16%	210,170	84%	249,449
Enga Province	4,208	1%	290,823	295,031	99%	5,041	1%	427,004	99%	432,045
Western Highlands Province	27,877	11%	226,350	254,227	89%	32,830	9%	330,020	91%	362,850
Jiwaka Province	-	0%	185,798	185,798	100%	-	0%	343,987	100%	343,987
Chimbu Province	12,217	5%	247,486	259,703	95%	15,547	4%	360,926	96%	376,473
Eastern Highlands Province	26,311	6%	406,661	432,972	94%	30,564	5%	549,261	95%	579,825
Momase Region	151,535	11%	1,281,897	1,433,432	89%	176,523	9%	1,691,134	91%	1,867,657
Morobe Province	92,953	17%	446,451	539,404	83%	102,111	15%	572,699	85%	674,810
Madang Province	28,547	8%	336,559	365,106	92%	35,971	7%	457,935	93%	493,906
East Sepik Province	20,257	6%	322,924	343,181	94%	24,471	5%	426,059	95%	450,530
West Sepik Province	9,778	5%	175,963	185,741	95%	13,970	6%	234,441	94%	248,411
Islands Region	55,172	7%	686,366	741,538	93%	85,280	8%	1,011,263	92%	1,096,543
Manus Province	5,874	14%	37,513	43,387	86%	8,882	15%	51,603	85%	60,485
New Ireland Province	11,274	10%	107,076	118,350	90%	16,725	9%	177,342	91%	194,067
East New Britain Province	23,840	11%	196,293	220,133	89%	36,750	11%	291,619	89%	328,369
West New Britain Province	14,184	8%	170,324	184,508	92%	22,923	9%	241,341	91%	264,264
Autonomous Region of Bougainville	-	0%	175,160	175,160	100%	-	0%	249,358	100%	249,358

1.5. Land tenure systems

Papua New Guinea has a land mass covering approximately 46.9 million ha. There are two land tenure systems in the country, the Alienated System and the Customary System, with each having different characteristics in relation to land management and its use. The Alienated Land tenure system is premised on the European model where the state owns the land and decides on the development and the entire management of the land, whereas the customary land tenure system embraces the local indigenous people to have ownership over the land and the decision power on the management of the land and its use rests with the local land owners (Armitage, 1998). About 97 per cent of land is owned by the local indigenous people while the remainder is owned by the state.

Many of the pressures for change in land management are common to both systems. However, control of the tenure system is a major hurdle for change: the traditional system provides for shared control by owners while the Alienated Land Tenure system delegates control to an external authority - the State. Therefore, the change from a traditional to a market economy is inevitable in which many traditional landowners recognize the need for a strengthening of the Customer Land Tenure system to effectively manage the external pressures in a manner which is acceptable and beneficial to the local land owners.

1.6. Economy

PNG has an abundance of natural resources including large reserves of minerals, extensive forestry and fishery assets, significant agricultural land and many beautiful locations with potential for ecological and cultural tourism. Despite the potential of these resources, PNG's economic performance has fallen short of expectations. Following a relatively stable macroeconomic performance in the first decade after independence, PNG experienced a series of macroeconomic crises in the 1990s.

PNG's economy is dominated by a large, labour-intensive agricultural sector and a capital-intensive mining and petroleum sector (consisting mostly of Crude Oil, liquefied natural gas (LNG), gold, copper, and silver extraction). The formal sector consists of enclave extractive mining and petroleum industries, forestry, fishing, cash-crop agriculture production and a small, import-substituting manufacturing sector. The informal sector, on which roughly 85 per cent of the population derives their livelihood, is largely subsistence agriculture. Figure 1-3 shows the 2015 share of Gross Value Added (GVA) at basic prices (per cent) by each sector.

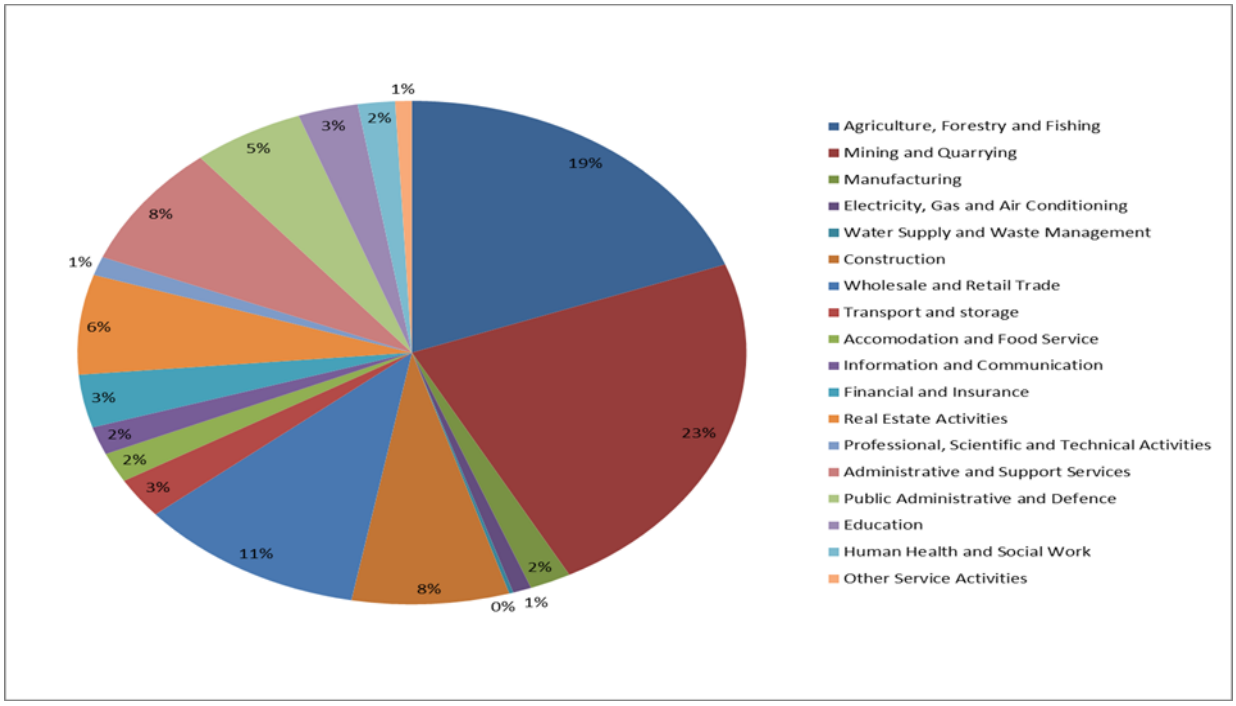


Figure 1-3 2015 Economic profile of PNG (Source: Papua New Guinea National Accounts 2008-2015)

According to the National Accounts 2008-2015, the level of Gross Domestic Product (GDP) increased from K 31.5 billion (PNG Kina) in 2008 to K57.1 billion in 2015. This represents an average annual growth of 9.4per cent. GDP growth has slowed down at 0.7per cent, value of K57.1 billion in 2015 from 2014. Progressively, over the period from 2008 to 2015, overall PNG economy experienced positive economic growth annually with a highest increase of 21.1per cent in 2010, followed by 18.9per cent in 2014, 11.3per cent in 2008, and 10.0per cent in 2011. The lowest increase was in 2015 with 0.7per cent. Figure 1-4 describes PNG's Constant and Current GDP from 2008 to 2015.

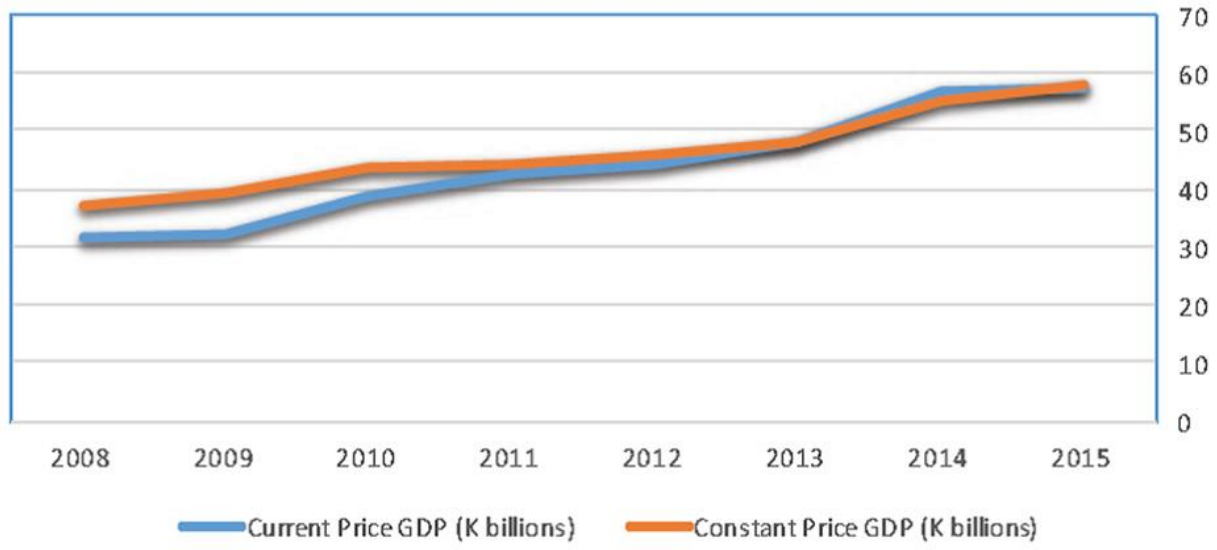


Figure 1-4 PNG's Constant and Current GDP from 2008-2015 (source: National Accounts 2008-2015)

Development Challenges

PNG has reached an important economic crossroad. The commencement of LNG production and exports marks an end to the large foreign direct investment inflows that fuelled a period of construction-led growth. What has emerged is a significantly more resource-dependent economy with modest growth of the job-intensive non-mineral sector. With a number of new resource projects in the pipeline, it is possible that this dependency will grow further over the coming decade. As the current sharp unexpected drop in global oil and other commodity prices demonstrates, managing the volatility associated with this resource dependence will be increasingly important for maintaining macroeconomic stability. To ensure growth is sustainable, a number of adjustments to economic policy are needed.

1.7. Agriculture

PNG is well endowed with land; however only 30 per cent is suitable for agriculture development because of the mountain ranges, high rainfall, long dry seasons, and excessive cloud cover in several areas.

Coffee, cocoa, sugar, copra, oil palm, rubber, fresh vegetables, and betel nut are grown by smallholders and provide income for 80 per cent of the population. Smallholder production of tree crops comprises 70 per cent of total output for the sub-sector. Total production from commercial plantations has been on a decline since the 1980s because of rising labour and overhead costs, and fluctuating world prices. Promoting smallholder agriculture system is the key to growth of the sub-sector.

Subsistence gardeners cultivate about 0.01 to 0.1 ha of land, and smallholder farmers cultivate less than 5 ha units. Most gardens are planted with crops continuously for one or two years then fallowed for 5-15 years to allow development of soil fertility. Garden sites are cleared of vegetation by slash and burn method, without land cultivation and use of purchased input. Crops grown are sweet potato, banana, sago, taro, yams, cassava, and sugarcane. Among the livestock raised are pigs, chickens, ducks, and occasionally, fish in ponds. Locally grown food provides 80 per cent of calories consumed by rural people (Ministry of Agriculture and Livestock, 2001).

Intensive agriculture is practiced among 20 per cent of rural people living in productive environments with high population densities. They continuously cultivate the land, and use land improvement practices such as composting, mounding, drainage, legume rotation, tree fallowing, soil retention barriers. Where alternative livelihood opportunities are limited, agricultural production is intensified through shorter fallow periods, extension of cropping periods, and planting of crops which do not require much inputs such as sweet potato, taro, cassava and bananas. Such practices could in the long run lead to soil degradation which will affect their only source of livelihood. These farmers need assistance to improve agricultural production practices, management and increase their productivity.

Current practices in managing plantations can have a negative impact on the environment. Chemicals such as pesticides, oil for processing and production ensure higher productivity, but these inputs could spill into the water system or rivers or environment and affect fishing and

biodiversity. Monoculture cropping encourages growth of harmful insects and micro-organisms which can cause epidemics of infestation. Development projects need to be assessed on environmental impact, and mitigating measures should be included in the plan.

1.8. Forestry

PNG's definition of forest is derived from the definition approved by the National Executive Council (NEC) in 2014 and is, "Land spanning more than 1 hectare, with trees higher than 3 meters and the canopy cover of more than 10 percent".

PNG together with West Papua (Island of New Guinea) represents one of the largest areas of intact tropical forest in the world. According to the PNG's Forest Reference Level 2001-2013 (FRL) the country has a total area of about 46.9 million ha, of which 77.8 per cent (36.1 million ha) is forest. There are 14 types of forest in PNG comprising 13 natural vegetation types and a forest plantation. Among those, three forest type (low altitude forest on plain and fans, low altitude forest on uplands, lower montane forest) amount to more than three-quarters of forest in PNG. Plantation forest (various plantations species; mono-type or mixed) account for only 0.1 per cent of PNG forest.

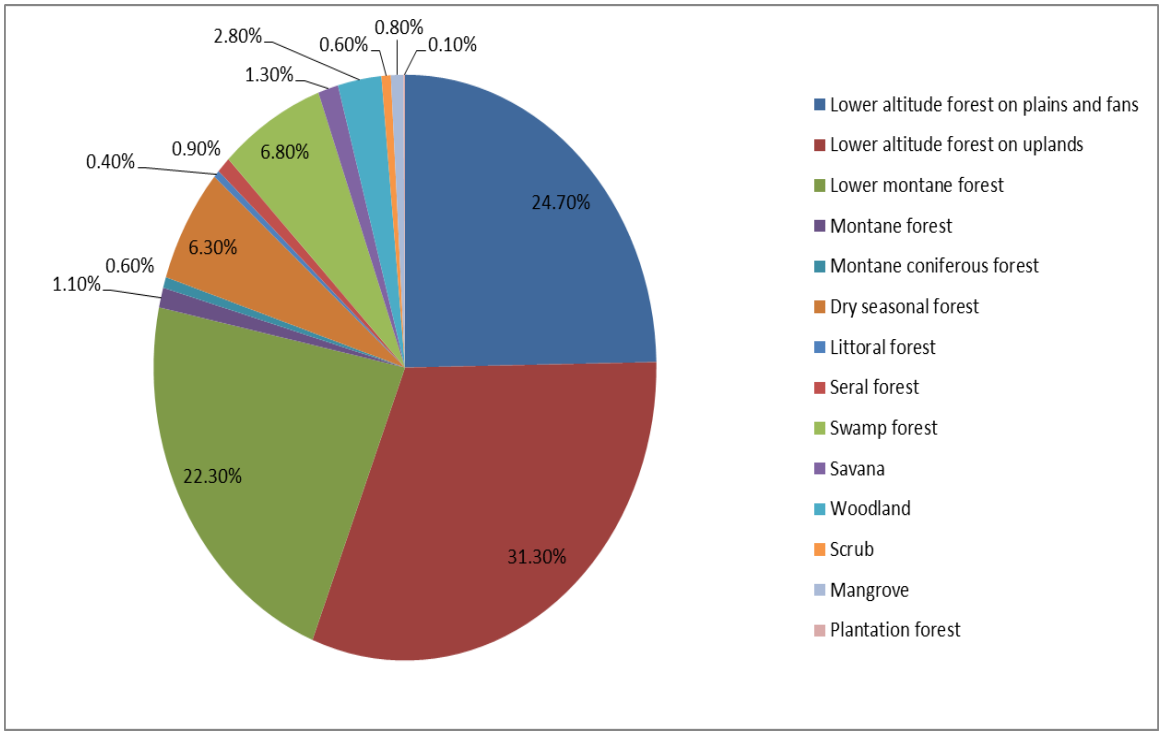


Figure 1-5 Distribution of forests by forest type (source: Papua New Guinea's Forest Reference Level 2001-2013)

More than three-quarters of this forest is categorized as primary or as not being disturbed by human activities, whereas 11.9 per cent is classified as disturbed by large scale logging and 0.2 per cent is disturbed by small scale logging using portable sawmill. Small scale temporary gardening cause 7.9 per cent of forest disturbance.

PNG's forest is critical to the livelihoods of its people and to its economy. Papua New Guinea's forests provide access to clean water and suitable agricultural land for PNG's predominantly

rural population. Forest resources also help to protect key infrastructure, people and crops from natural disasters like flash flooding and landslides. Forests also play a direct role in supporting the livelihoods of rural communities, with more than 500 species of wild-growing plants identified as being used for food. The value of annual bush meat from the forest that is consumed is estimated to be equivalent to $26 million if alternative meats had to be sourced (Sherman, 2008).

1.9. Fish resources

According to the National Fisheries Authority (NFA), PNG's fisheries zone of 2.4 million km^2 is the largest in the South Pacific which includes an extended reef system, numerous islands and an extensive coastline. The country records an extensive and valuable fisheries sector ranging from inland river fisheries, aquaculture, coastal beche-de-mer and reef fisheries to the prawn trawl and large-scale deep-water tuna fisheries. The range of participants covers artisanal community to medium sized domestic prawn and tuna long line operators to large international purse seine fleets in the deep-water tuna fishery.

NFA also estimates its total market value of PNG catch is at K350 to K400 million on average although information on the true value of artisanal fisheries is difficult to obtain and cyclical factors and commodity price movements, especially tuna, because huge value swings from year to year. NFA believes that there is significant potential to increase the economic value and returns to PNG of these fisheries through better management and development programs. The importance of fisheries to the local markets and subsistence economy is also of major importance to the PNG people.

1.10. Energy

Improved economic performance has led to an increase in the demand for electricity. Its supply is critical for further economic growth and development. There are eight power plants and 58 substations in PNG, with the largest power plant located in Central Province.

PNG has 797MW of electricity generation capacity. About half of this generation is provided by the private sector to be used mainly in the mining sector. Papua New Guinea's primary source of energy is from hydro schemes providing just under half of all electricity generation capacity while around one-third of electricity capacity is provided by diesel generators. Gas, geothermal and biogas generation represent most of the balance with the bulk of this energy used for mining. Diesel is dominant in off-grid applications. The total electricity output in 2015 was 4324 GWh, comprising hydro-electric (23 per cent), petroleum products (56 per cent), natural gas (11 per cent), and geothermal (10 per cent).

Natural gas production increased in 2014 with commencement of the LNG project, but most of the natural gas is exported. In 2015, the natural gas production was 8,427 kiloton of oil equivalent (ktoe) with 6,939 ktoe exported. Most crude oil produced in PNG is also exported, and to meet domestic demand crude oil is imported. The total primary energy supply in 2015 was estimated to be 3,833 ktoe of which oil and petroleum products account for 49 per cent, natural gas 39 per cent and 12 per cent is from Renewable Energy sources (Hydro and Geothermal).

A total of 614 ktoe of Crude Oil, comprising of both imports and domestic production was refined in 2015 producing about 609ktoe of petroleum products. From this, 229ktoe was naphtha, 36Ktoe jet kerosene, 264 ktoe gas/diesel oil, 68Ktoe fuel oil, 6Ktoe LPG and 5Ktoe other products.

In 2015 the total final energy consumption was 1,587 ktoe of which 79 per cent was petroleum product while 21 per cent was from other sources. The transport sector was the largest energy consuming sector with 711 ktoe followed by the manufacturing industries and construction subsector with 637ktoe and the other subsectors with 239 ktoe.

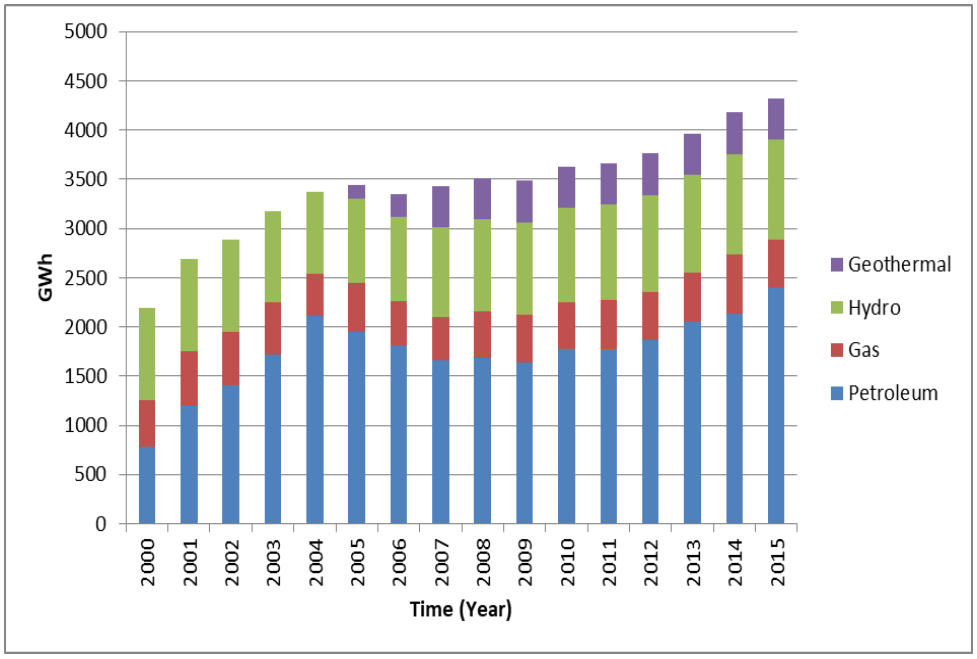


Figure 1-6 Electricity generation by source (Source: APEC Energy Balance Table)

Papua New Guinea has a vast amount of renewable energy sources including hydro, geothermal, biomass, wave, solar and wind. This is able to meet the electricity demand in the country. However, currently only hydro, geothermal and biogas are being utilized. Hydro has been utilized since the 1990s and currently has an installed generation capacity of 432MW. Utilization of geothermal began in 2005 and has an installed generation capacity of 56MW. Biogas has also been recently utilized and has an installed generation capacity of 7MW.

1.11. Transport

a. Road Transport

The total number of vehicles including motor cycles was estimated at approximately 46,000 in 2010, or one vehicle per 147 people. Official statistics on the total number of vehicles in PNG are poor due to the fragmentation of responsibility for vehicle licensing since devolution of responsibility to provincial governments. Growth over the past decade appears to have been low, less than 1 per cent which is below the growth rate in population and appears to be at variance with common observation. This total will

also include cars owned by businesses, public agencies and taxis, so that vehicle ownership by private households and village groups will be even lower, possibly only 50 per cent of the total. This is a very low level of motor vehicle ownership in comparison with other Pacific states and internationally.

The extent of use in vehicles is difficult to ascertain due to the relatively few roadside traffic counts. Historical data on traffic composition counts shows that heavy vehicles account on average for one third of the traffic on rural highways, although this can vary between 20 and 50 per cent. Passenger motor vehicles account for about 20 per cent of traffic with a typical range of variation between 10 to 30 per cent, government vehicles with a range of 10 to 15 per cent, and private vehicles 65 per cent with a typical range between 55 to 75 per cent.

b. Maritime and Inland Water Transport

There are 22 declared ports, of which 16 are operated by PNG Ports Corporation, either directly or through agents. Other than the declared ports, there are a number of private port facilities on the PNG coast, mainly established to support specific industries, such as mining, oil palm and logging. There are a large number of minor port facilities, including small wharves, jetties, ramps and landings.

Total cargo grew at 3.8 per cent over the 2005-2009 periods, international cargo at 3.0 per cent and coastal cargo at 5.3 per cent. In 2010, the total ship calls at the declared ports were 6,330. From this a total of 6.8 million revenue tons of cargos was handled, of which 60 per cent was international cargo. The total twenty foot equivalent unit containers, including empty ones, handled was 265,000.

Papua New Guinea is comparatively well served by international shipping lines mainly in north-south services between Asia and Australasia. There are approximately 3,000 voyages per year and 300 voyage rotations between PNG, the Australian east coast ports and Asia. The traffic is mainly general/container cargo vessels and bulk carriers for petroleum, mineral and log exports.

c. Air Transport

Port Moresby International Airport is currently the only airport in PNG supporting international regular scheduled passenger services. The international airport and a further 20 national airports are operated by the National Airports Corporation. A further 6 airports are certified in accordance with the International Civil Aviation Organization Annex 14 and PNG Civil Aviation Rules; these include three airports associated with mining and oil & gas and three ex-national airports now operated by provincial governments. There are also a large number of smaller airports, ranging in strip length from as long as 1,700m down to small rural airstrips as short as 450m. The number currently listed as “active” from provincial data sources is 424.

There are about 259 registered planes. Air Niugini (ANG) and Airlines PNG operate domestic services primarily based in Port Moresby. ANG flies point-to-point services to 11 main domestic airports. Airlines PNG operates first and second level services using

mainly Dash-8, competing against ANG but also serving smaller airports from hubs. The largest third level operator is Mission Aviation Fellowship, a church-sponsored airline, based in Mount Hagen, with a fleet of 16 mainly DHC-6, Cessna 206 and GA8 Airvans with which it serves remote rural airstrips throughout PNG.

The main international carrier is the government-owned ANG which operates the bulk of international services and routes. ANG currently operates B767-300AR and Fokker F100 aircraft on its international services.

1.12. Domestic Climate Change Policy

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 developments. An overview of the climate change policies in PNG is as below.

a. Long term Policy: Vision 2050 and the Development Strategic Plan (DSP) 2010-2030

The Vision 2050 captures the relevant elements which was shaped by the PNG National Constitution and gave birth to the seven pillars which are:

- Human Capital Development, Gender, Youth and People Empowerment;
- Wealth Creation;
- Institutional Development and Service Delivery;
- Security and International Relations;
- Environmental sustainability and climate change;
- Spiritual, Cultural and Community Development; and
- Strategic Planning, Integration and Control.

PNG Vision 2050 (Vision 2050) is the country's unified strategic vision for socioeconomic growth that aims to build a "Smart, Wise, Fair, Healthy and Happy Society." Vision 2050 identifies the main challenge of socioeconomic growth to shift an economy, dominated by the mining and energy sectors, which together represent over 80 per cent of PNG's export revenue, towards agriculture, forestry, fisheries, eco-tourism and manufacturing by 2050.

The current theme of this new development roadmap is to shift the country's socio-economic growth away from the current emission- intensive growth strategy towards a more sustainable path that is able to leverage PNG's competitive advantages, natural wealth and significant human capital into the future.

Systematically hierarchal implementation of any plan derives all actions from a master blue print; such is the Papua New Guinea Development Strategic Plan 2010-2030 (DSP). The DSP is the 20 year long term development blueprint created to achieve Vision 2050 through broad frameworks, targets and strategies.

b. National Strategy for Responsible Sustainable Development for Papua New Guinea (StaRS)

After the 2012 national election the formation of the government under the Alotau Accord instructed for a review of the DSP 2010-2030 and the subsequent three year Medium Term Development Plan 2011-2015. This was to ensure that all developments are truly strategic and must be align with Vision 2050 which lead to the development of the National Strategy for the Responsible Sustainable Development (StaRs). The StaRS offers a new development paradigm. It builds on the gains made by Vision 2050 and the current DSP 2010-2030 and prescribes a new development road map that incorporates these elements that make for a growth strategy that is truly strategic, futuristic and appropriate for the future. The StaRS is the policy shift in long term planning to guide the actions of current and future governments to position PNG towards attaining the following goals: being a leader in the promotion and establishment of the responsible sustainable development paradigm; be a prosperous middle-income country by 2030; and be among the top 50 countries on Human Development Index by 2050

It introduces three enabling dimensions that are essential for transitioning from the brown driven growth to inclusive green growth. The dimensions are: national green growth plan to create enabling conditions; green growth main streaming mechanisms to enable opportunities are explored through existing economic activities; and green growth policy instruments to tap specific opportunities within spatial and resource systems.

c. The National Climate Compatible Development Management Policy (NCCDMP)

Based on the country's sustainable and inclusive growth strategy, the government of PNG established the Office of Climate Change and Development in 2010 under the NEC Decision 54. PNG's commitment to developing an inclusive green economy by sustainably leveraging its natural resources is demonstrated in the establishment of the sustainable development policy in critical resource sectors such forestry, agriculture, fisheries, mining and energy. In 2014 the NEC endorsed The National Climate Compatible Development Management Policy (NCCDMP) which was derived from a highly intensive stakeholder consultation process. The NCCDMP gives structure and impetus to the role of the different stakeholders within the country.

d. Climate Change (Management) Act

The Climate Change (Management) Act 2015 was endorsed under the NEC Decision 19 of 2015. The endorsement of the Act then sees the establishment of the Climate Change and Development Authority (CCDA). The Act gives certainty and continuity of the NNCCDP in PNG and sets the country on a path to low carbon economy. It establishes the basis for the creation of Institutions, Legal Frameworks and Financing to move towards a low carbon economy. As an Act it provides an overarching legal framework for regulating climate change activities in the country and principally advocates consultations with relevant stakeholders.

e. United Nations Paris Agreement (Implementation) Act

The United Nations Paris Agreement (Implementation) Act was passed in Parliament in 2016 following the adoption of the Paris Agreement. The Act gives effect to the implementation of

the States obligation under the Paris Agreement through the Nationally Determined Contribution (NDC).

f. PNG and the UNFCCC

PNG has been an active member of the UNFCCC since it became a signatory to the Convention in 1992 then ratified it in 1993 to contribute in partnership with the global community to address the adverse effects of climate change and global warming. In 1997 PNG signed the Kyoto Protocol and later ratified the Protocol in 2000. Though it wasn't mandatory for non-Annex I Parties to reduce their GHG emissions, PNG was willing to do so voluntarily. Then in 2009 in support of the Copenhagen Accord, the PNG Government made a commitment to the UNFCCC to reduce its GHG emission by 50% by 2030 and 100% or become carbon neutral by 2050. In 2015 PNG was part of the 195 countries that adopted the Paris Agreement.

PNG has also played some leading contributions under the UNFCCC process;

i. PNG was a founding member of the Coalition for Rainforest Nations (CfRN) in 2005
ii. PNG and Costa Rica were the first countries to introduce the Reducing Emissions from forest Deforestation and forest Degradation concept in 2005 on behalf of the CfRN by submitting the document on Reducing Emissions from Deforestation in Developing Countries.
iii. PNG plays a key role in adopting the Bali Roadmap in 2007
iv. PNG becomes co-chair with Japan of partnership secretariat in 2010
v. REDD+ financing included in Durban platform, 2011
vi. PNG played a key role in the Doha decision
vii. Adoption of the Warsaw Framework, 2013, on Reducing Emissions from Deforestation and forest Degradation and the role of Conservation, Sustainable management of forest and enhancement of carbon stocks which PNG was very instrumental to include Loss and Damage
viii. Adoption of the Lima Plan of Actions which also included Intended Nationally Determined Contributions (INDC)
ix. PNG was the first country to submit its Nationally Determined Contribution (NDC) in 2016

1.13. Institutional Arrangement for Development of the Biennial Update Report and National Communication

CCDA is the National Designated Authority (NDA) that has been assigned responsibility to implement the UNFCCC and the Paris Agreement in collaboration with line agencies. CCDA's objective is ''to provide a coordination mechanism at the national level for research, analysis and development of the policy and legislative framework for the management of climate change within the Government's National Strategy on Climate-Compatible Development" (NEC Decision No 55/2010).

As per the structure given, CCDA as the single body is responsible for the overall coordination and management of the Biennial Update Report (BUR) and National Communication (NC)

preparation process. Its' main responsibility is to provide the overall coordination for the preparation of BURs and NCs, with key tasks being to:

- ✓ Plan and conduct all coordination and consultation activities with governmental and, if appropriate, non-governmental stakeholders;
- ✓ Identify all institutions and teams that will be involved in the preparation of the BUR or NC, and establish any formal working arrangements required;
- ✓ Allocate responsibilities for all components of the BUR and NC, ensuring there is a clear lead for each section, and establish a formal approval process;
- ✓ Develop and monitor a timeline and schedule for BUR or NC preparation, including specific milestones and dates for deliverables

CCDA is also responsible for the following BUR and NC elements:

- ✓ Identify constraints and gaps, and related financial, technical and capacity-building needs, including a description of support needed and received;
- ✓ Keep any management committees and working groups informed of progress and emerging issues;
- ✓ Develop and implement Quality Assurance and Quality Control strategies for the entire BUR and NC;
- ✓ Manage the overall budget for the preparation of the BUR and NC;
- ✓ Compile and integrate all sections of the BUR and NC into a cohesive document;
- ✓ Develop and maintain an archiving system to ensure institutional memory and to fully and systematically document all the activity data and the methods used;
- ✓ Collect and maintain statistical records;
- ✓ Conduct an evaluation exercise to identify key lessons learned and areas for improvement;
- ✓ Consider results of the International Consultation and Analysis (ICA) process.

CCDA, in cooperation with its stakeholders which consist of the private sector, the non-governmental agencies, development partners and the government agencies, has completed and submitted to UNFCCC secretariat the Initial National Communications (February, 2002) of PNG, the Second National Communication (December, 2015) and is currently working on its Third National Communication.

In 2016 the Government of PNG and United Nations Environment Programme (UNEP) signed the agreement on implementation of the BUR Project. UNEP acts as the GEF Implementing Agency for the project and assists CCDA for the entire project length to implement the activities set forth and to monitor and supervise the project on behalf of the GEF. The project has a governance structure, aligned with UNEP rules and guidelines.

Chapter 2. GHG Inventory

2.1. National GHG inventory arrangements

CCDA has been tasked with managing the preparation of the National GHG inventory in addition to the preparation of the BUR1. Key functions include the identification of data source under each sector, collection and compilation of activity data and emission factors for each sector and estimation and reporting of GHG emissions by sources and removals by sinks.

Since there are existing sector lead agencies for each sector, CCDA has involved them in the GHG inventory process. Their main purpose was to provide activity data and to some extent emission factors for CCDA to estimate the emissions. However, not all lead agencies have the required data so other organizations including private companies were also included.

As shown in Figure 2-1, for the Energy Sector the Department of Petroleum and Energy (DPE) was involved but the data used was from the energy balance table compile by the Asia Pacific Energy Research Centre (APERC) by using the Oil and Natural Gas data provided by the DPE. For the Industrial Process and Product Use sector, two private companies were involved where one is a N_2O distributor and another is a Lubricant distributor. For the Agriculture, Forestry and Other Land Use Sector, the Department of Agriculture and Livestock, lead agency for agriculture sector, and the PNG Forest Authority, lead agency for the forestry sector were involved. And for the Waste Sector, three government agencies namely Water PNG, National Statistical Office and the National Capital District Commission were involved.

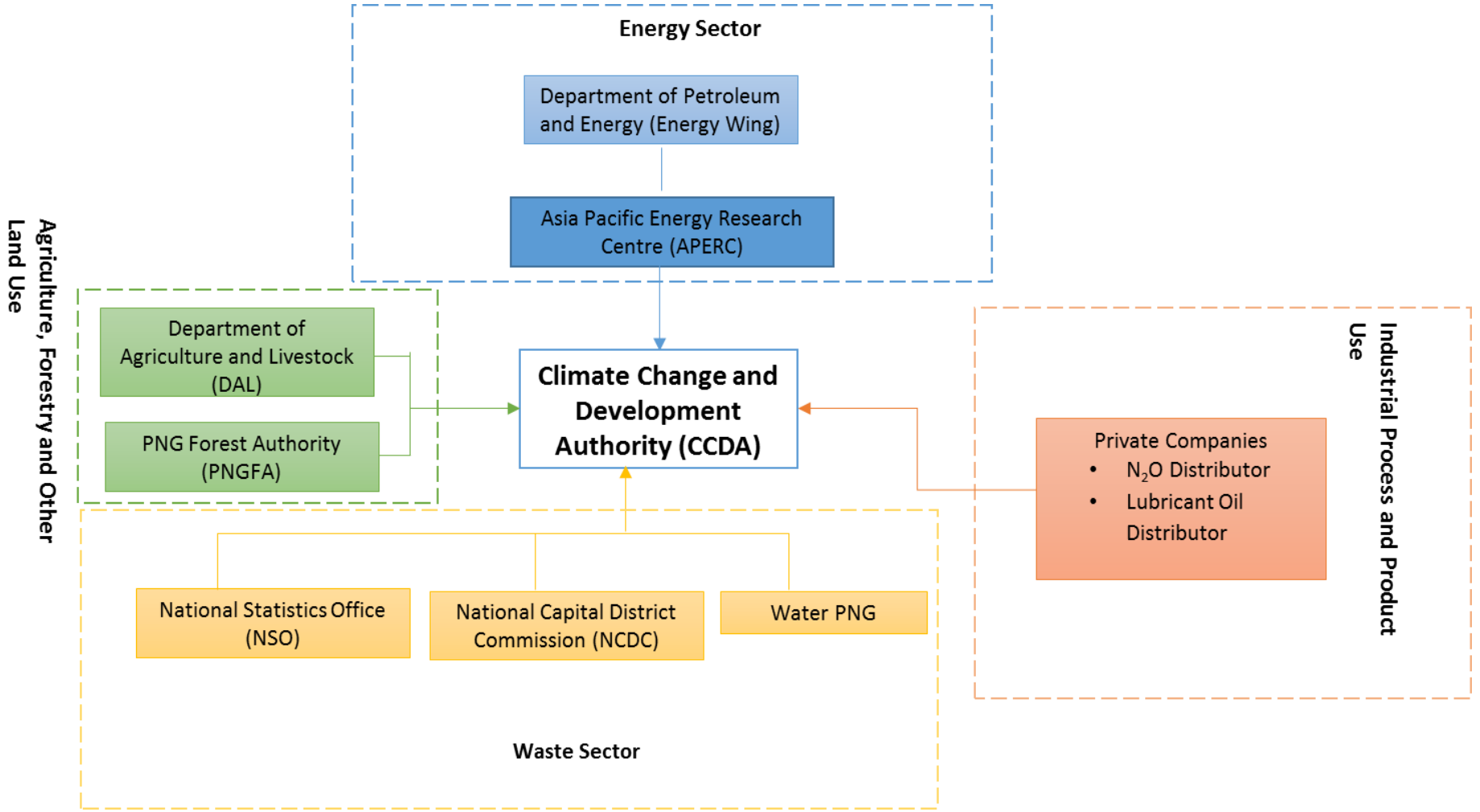


Figure 2-1: National system for inventory planning, preparation and management.

The GHG inventory preparation schedule, as shown in Table 2-1, took 5 years beginning in 2014 and ending in 2018. Although the UNEP BUR1 project began in early 2016, the data collection process had already started in 2014 and took almost 4 years to complete. The estimation and finalization of emissions and removals took about 14 months and the presentation of results was done in October 2018 during the BUR1 Consultation Workshop.

Table 2-1: GHG inventory preparation schedule

Activities	2014												2015												2016												2017												2018									
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10
Identifiy key source categories of emissions																																																										
Gather available data from national sources to fill inventory data gaps and identify and develop methods for overcoming inventory data gaps if there is no available data																																																										
UNEP First Biennial Update Report and Third National Communication Inception																																																										
Undertake national GHG inventories for the year 2000 to 2015 and describle preparation procedures																																																										
Finalization of GHG estimates																																																										
Organize workshop for presentation and discussion on the results obtained from the GHG Inventory (Consultation Workshop)																																																										

2.2. Methodology

2.2.1. Reporting Guidelines and IPCC Guidelines

PNG has followed the National communications guidelines and the BUR guidelines as contained in decision 17/CP.8 and decision 2/CP.17, respectively. The 2006 IPCC Guidelines for National Greenhouse Gas Inventories were used to estimate emissions and all sectors of removals for the BUR1 inventory.

2.2.2. Methods and Global warming potentials (GWP) used

Emissions and removals from most categories of the BUR1 inventory have been estimated with Tier 1 methods with exception of some categories in the LULUCF, and waste sectors which were estimated using the Tier 2 method. The BUR1 inventory uses the global warming potentials as contained in the Second Assessment Report (SAR) of the IPCC.

Table 2-2: Method and emission factors used in the GHG inventory

	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6	
	method	EF	method	EF	method	EF	method	EF	method	EF	method	EF
1 ENERGY												
1A Fuel Combustion Activities												
1A1 Energy Industries	1	D	1	D	1	D						
1A2 Manufacturing Industries and Construction	1	D	1	D	1	D						
1A3 Transport	1	D	1	D	1	D						
1A4 Other Sectors	1	D	1	D	1	D						
1A5 Non-Specified												
1B Fugitive Emissions from Fuels	1	D	1	D	1	D						
1C Carbon Dioxide Transport and Storage												
2 INDUSTRIAL PROCESSES AND PRODUCT USE												
2A Mineral Industry												
2B Chemical Industry												
2C Metal Industry												
2D Non-Energy Products from Fuels and Solvent Use	1	D										
2E Electronics Industry												
2F Product Uses as Substitutes for Ozone Depleting Substances												
2G Other Product Manufacture and Use					1	D						
2H Other (please specify)												
3 AGRICULTURE, FORESTRY AND OTHER LAND USE												
3A Livestock			1	D	1	D						
3B Land	1, 2	D, CS										
3C Aggregate Sources and Non-CO2 Emissions Sources on Land			1	D	1	D						
3D Other												
4 WASTE												
4A Solid Waste Disposal			2	D								
4B Biological Treatment of Solid Waste			1	D	1	D						
4C Incineration and Open Burning of Waste												
4D Wastewater Treatment and Discharge			1	D	1	D						

The following notation keys have been used to specify the method applied:

D (IPCC default)	T2 (IPCC Tier 2)	CS (Country Specific)
T1 (IPCC Tier 1)	T3 (IPCC Tier 3)	OTH (Other)

Use the following notation keys to specify the emission factor used:

D (IPCC default)	CS (Country Specific OTH (Other)
CR (CORINAIR)	PS (Plant Specific)

2.2.3. Years covered

The BUR Guidelines require GHG inventory data for 4 years before year of submission, but PNG has made efforts to include GHG emissions/removals of the time series from 2000 to 2015 in order to be consistent with the REDD+ Technical Annex.

2.2.4. Activity data and emission factors

Various sources were used for activity data such as data provided from government agencies, companies, in addition to international sources such as the FAO. Most emission factors and other parameters used in the estimation were taken from the 2006 IPCC Guidelines.

2.3. Emission and removal trends

2.3.1. Overview

Total GHG emissions in 2015 amounted to 15,193 Gg (giga gram) CO_2eq with LULUCF, and 13,477 Gg CO_2eq without LULUCF. In 2000, the emissions were -14,179 Gg CO_2eq with LULUCF and 7,475Gg CO_2eq without LULUCF. This represents an 80% increase of emissions without LULUCF from 2000 to 2015. There is some fluctuation in the national total emissions/removals due to the LULUCF sector influence on the total GHG emissions.

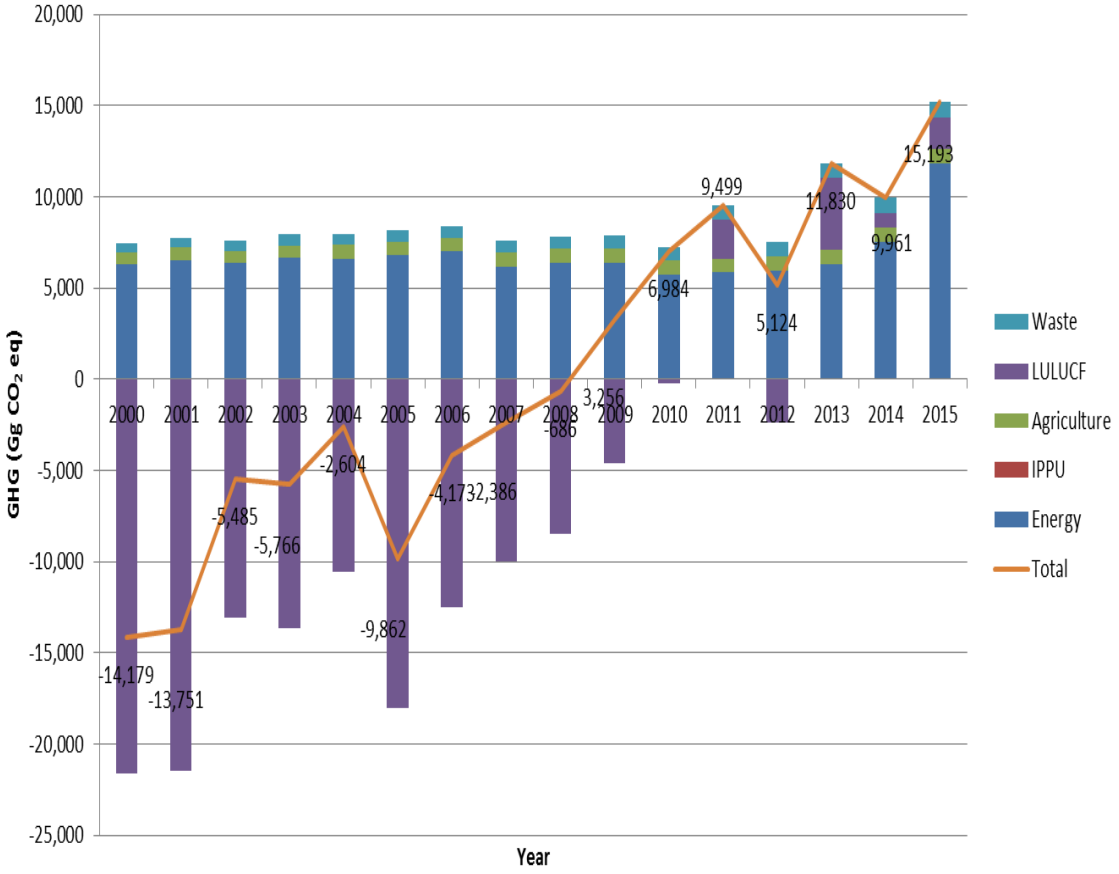


Figure 2-2: Time-series of total GHG emissions and removals

Table 2-3: Trend of GHG emissions and removals (2000-2015)

	unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Energy	Gg $CO_{2\ eq}$	6,274	6,536	6,342	6,631	6,603	6,826	6,984	6,185	6,385	6,367
IPPU	Gg $CO_{2\ eq}$	1	1	1	2	3	3	3	3	3	3
Agriculture	Gg $CO_{2\ eq}$	682	681	676	698	764	695	725	733	744	796
LULUCF	Gg $CO_{2\ eq}$	-21,654	-21,508	-13,064	-13,682	-10,583	-18,015	-12,538	-9,984	-8,518	-4,633
Waste	Gg $CO_{2\ eq}$	518	539	560	586	609	630	653	676	701	724
Total with LULUCF	Gg $CO_{2\ eq}$	-14,179	-13,751	-5,485	-5,766	-2,604	-9,862	-4,173	-2,386	-686	3,256
Total without LULUCF	Gg $CO_{2\ eq}$	7,475	7,757	7,579	7,916	7,979	8,154	8,365	7,598	7,833	7,890

	unit	2010	2011	2012	2013	2014	2015
Energy	Gg $CO_{2\ eq}$	5,701	5,837	5,929	6,296	7,507	11,806
IPPU	Gg $CO_{2\ eq}$	3	3	3	2	2	2
Agriculture	Gg $CO_{2\ eq}$	788	769	791	812	787	796
LULUCF	Gg $CO_{2\ eq}$	-255	2,117	-2,398	3,898	817	1,716
Waste	Gg $CO_{2\ eq}$	748	772	798	822	847	872
Total with LULUCF	Gg $CO_{2\ eq}$	6,984	9,499	5,124	11,830	9,961	15,193
Total without LULUCF	Gg $CO_{2\ eq}$	7,239	7,382	7,521	7,932	9,143	13,477

Of the non LULUCF sectors, in 2015 the energy sector contributed 87.5 per cent to total GHG emissions, followed by the waste sector (6.5 per cent), agriculture (5.9 per cent) and IPPU (0.2 per cent). In 2000, the energy sector contributed 83.9 per cent to total GHG emissions, followed by agriculture (9.1 percent), waste sector (6.9 per cent), and IPPU (0.01 per cent). Energy consumption and production of natural gas has increased rapidly from 2000 to 2015, resulting in an 88.2 per cent increase of the energy sector emissions.

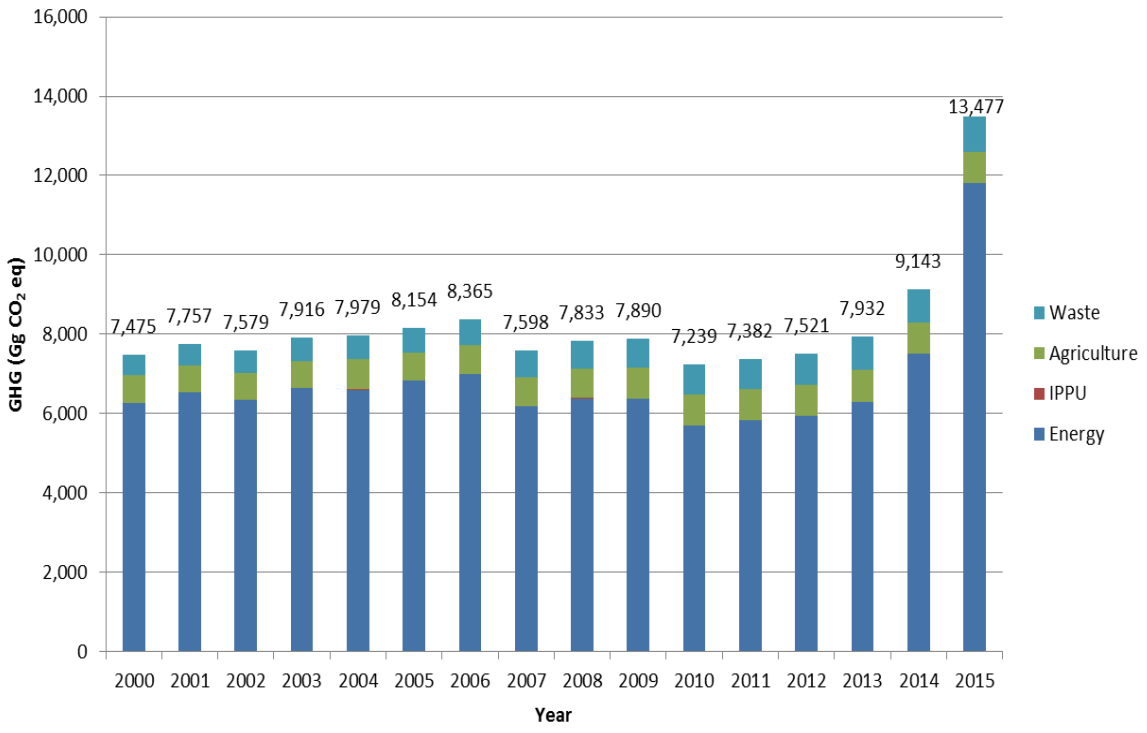


Figure 2-3: Time-series of non LULUCF emissions

In 2015 CO_2 contributed 59.8 per cent to total GHG emissions, followed by CH_4 (35.2 per cent), and N_2O (4.9 per cent), without LULUCF. In 2000 CH_4 contributed 47.3 per cent to total GHG emissions, followed by CO_2 (45.7 per cent), and N_2O (7.0 per cent). The increasing trend of CH_4 emissions from production and upgrading and the increasing trend of CO_2 emissions from energy industries in the energy sector is largely attributable to the change in ratio of emissions.

Table 2-4: Total GHG emissions and removals by gas

	unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (without LULUCF)	Gg CO_2	3,419	4,120	4,308	4,696	4,912	4,896	4,752	4,620	4,731	4,752
CO_2 (with LULUCF)	Gg CO_2	-18,629	-17,963	-10,451	-10,026	-8,560	-13,548	-9,100	-5,719	-4,401	-405
CH_4 (without LULUCF)	Gg CO_2	3,535	3,108	2,740	2,658	2,431	2,685	3,018	2,373	2,482	2,474
CH_4 (with LULUCF)	Gg CO_2	3,810	3,509	3,921	3,382	4,445	2,984	3,934	2,620	2,911	2,839
N_2O (without LULUCF)	Gg CO_2	521	530	532	563	636	572	595	605	619	663
N_2O (with LULUCF)	Gg CO_2	640	704	1,045	878	1,511	702	992	712	805	822
Total (with LULUCF)	Gg CO_2	-14,179	-13,751	-5,485	-5,766	-2,604	-9,862	-4,173	-2,386	-686	3,256
Total (without LULUCF)	Gg CO_2	7,475	7,757	7,579	7,916	7,979	8,154	8,365	7,598	7,833	7,890

	unit	2010	2011	2012	2013	2014	2015
CO_2 (without LULUCF)	Gg CO_2	4,941	5,073	5,262	5,604	6,288	8,061
CO_2 (with LULUCF)	Gg CO_2	4,034	6,918	2,572	8,989	6,407	9,211
CH_4 (without LULUCF)	Gg CO_2	1,646	1,676	1,599	1,654	2,198	4,750
CH_4 (with LULUCF)	Gg CO_2	2,100	1,866	1,802	2,012	2,686	5,144
N_2O (without LULUCF)	Gg CO_2	653	632	661	673	657	667
N_2O (with LULUCF)	Gg CO_2	850	715	750	829	868	838
Total (with LULUCF)	Gg CO_2	6,984	9,499	5,124	11,830	9,961	15,193
Total (without LULUCF)	Gg CO_2	7,239	7,382	7,521	7,932	9,143	13,477

2.3.2. Table 1/Table 2 of Decision 17/CP8 for the most recent year

Total GHG emissions by subsector are provided in Table 2-5 below.

Table 2-5: GHG emissions for 2015

	Net CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Other halogenated gases with CO_2 eq. conversion factors	Other halogenated gases without CO_2 eq. conversion factors
	(Gg)			CO_2 equivalents (Gg)				(Gg)
Total National Emissions and Removals	9,210.74	245.04	2.71	0.00	0.00	0.00	0.00	0.00
1 ENERGY	8,059.23	175.90	0.17					
1A Fuel Combustion Activities	7,959.19	0.48	0.17					
1A1 Energy Industries	4,119.87	0.12	0.02					
1A2 Manufacturing Industries and Construction	1,444.99	0.06	0.06					
1A3 Transport	1,937.59	0.24	0.09					
1A4 Other Sectors	456.73	0.06	0.00					
1A5 Non-Specified	NE	NE	NE					
1B Fugitive Emissions from Fuels	100.04	175.43	0.00					
1B1 Solid Fuels	NO	NO	NO					
1B2 Oil and Natural Gas	100.04	175.43	0.00					
1B3 Other Emissions from Energy Production	NE	NE	NE					
1C Carbon Dioxide Transport and Storage	NO							
1C1 Transport of CO2	NO							
1C2 Injection and Storage	NO							
2. INDUSTRIAL PROCESSES AND PRODUCT USE	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2A Mineral Industry	0.00	0.00	0.00					
2B Chemical Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2C Metal Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2D Non-Energy Products from Fuels and Solvent Use	1.40	0.00	0.00					
2D1 Lubricant Use	1.40							
2D2 Paraffin Wax Use	0.00	0.00	0.00					
2D3 Solvent Use								
2D4 Other (please specify)	0.00	0.00	0.00					
2E Electronics Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2F Product Uses as Substitutes for Ozone Depleting Substances	0.00	0.00	0.00	0.00	0.00		0.00	0.00
2G Other Product Manufacture and Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2G1 Electrical Equipment					0.00	0.00	0.00	0.00
2G2 SF6 and PFCs from Other Product Uses					0.00	0.00	0.00	0.00
2G3 N2O from Product Uses			0.00					
2G4 Other (please specify)	0.00	0.00		0.00			0.00	0.00
2H Other (please specify)	0.00	0.00	0.00					
3 AGRICULTURE, FORESTRY AND OTHER LAND USE	1,150.12	33.85	2.11					
3A Livestock		14.91	0.06					
3A1 Enteric Fermentation		8.01						
3A2 Manure Management		6.90	0.06					
3B Land	1,150.12	0.00	0.00					
3B1 Forest Land	-11,855.41	0.00	0.00					
3B2 Cropland	12,647.58	0.00	0.00					
3B3 Grassland	323.36	0.00	0.00					
3B4 Wetlands	NE	0.00	0.00					
3B5 Settlements	34.59	0.00	0.00					
3B6 Other Land	NO	0.00	0.00					
3C Aggregate Sources and Non-CO2 Emissions Sources on Land	0.00	18.94	2.05					
3C1 Biomass Burning	0.00	18.94	0.56					
3C2 Liming	0.00							
3C3 Urea Application	0.00							
3C4 Direct N2O Emissions from Managed Soils			1.33					
3C5 Indirect N2O Emissions from Managed Soils			0.14					
3C6 Indirect N2O Emissions from Manure Management			0.03					
3C7 Rice Cultivations		0.00	0.00					
3D Other	0.00	0.00	0.00					
3D1 Harvested Wood Products	IO							
4 WASTE	0.00	35.28	0.42					
4A Solid Waste Disposal		11.92	0.00					
4B Biological Treatment of Solid Waste		0.14	0.01					
4C Incineration and Open Burning of Waste	0.00	0.00	0.00					
4D Wastewater Treatment and Discharge		23.22	0.41					

2.3.3. Key category assessment

Key category analysis was carried out as described in the 2006 IPCC Guidelines, for both with and without LULUCF sector. Thirteen categories are identified as key without LULUCF, 12 were identified as key with LULUCF. The results of the key category assessment are shown below (key categories in yellow).

Table 2-6: Key category assesment results without LULUCF

crf code	category name	gas	2015 emissions	absolute value of 2015 emissions	Level assessment	cumulative total
1.A.1:	1A1 Energy Industries	CO_2	4,119.87	4,119.87	30.57%	30.57%
1.B.2.b.iii.2	Gas Production	CH_4	2,394.52	2,394.52	17.77%	48.34%
1.A.3	1A3 Transport	CO_2	1,937.59	1,937.59	14.38%	62.71%
1.A.2:	1A2 Manufacturing Industries and Construction	CO_2	1,444.99	1,444.99	10.72%	73.44%
1.B.2.a.iii2	Production and Upgrading	CH_4	555.61	555.61	4.12%	77.56%
4D	Wastewater Treatment and Discharge	CH_4	487.68	487.68	3.62%	81.18%
1.A.4:	1A4 Other Sectors	CO_2	456.73	456.73	3.39%	84.57%
3C4	Direct N2O Emissions from Managed Soils	N_2O	411.00	411.00	3.05%	87.62%
1.B.2.b.iii.5	Gas Distribution	CH_4	353.58	353.58	2.62%	90.24%
4A	Solid Waste Disposal	CH_4	250.26	250.26	1.86%	92.10%
3A1	Enteric Fermentation	CH_4	168.30	168.30	1.25%	93.35%
1.B.2.b.iii.3	Gas Processing	CH_4	155.18	155.18	1.15%	94.50%
3A2	Manure Management	CH_4	144.83	144.83	1.07%	95.57%
1.B.2.b.iii.4	Total Gas Transmission and Storage	CH_4	131.06	131.06	0.97%	96.54%
4D	Wastewater Treatment and Discharge	N_2O	128.21	128.21	0.95%	97.50%
1.B.2.b.i	Gas Venting	CH_4	77.00	77.00	0.57%	98.07%
1.B.2.a.ii	Oil Flaring	CO_2	42.77	42.77	0.32%	98.38%
3C5	Indirect N2O Emissions from Managed Soils	N_2O	41.96	41.96	0.31%	98.70%
1.B.2.b.ii	Gas Flaring	CO_2	33.21	33.21	0.25%	98.94%
1.A.3	1A3 Transport	N_2O	27.61	27.61	0.20%	99.15%
1.B.2.b.iii.3	Gas Processing	CO_2	20.11	20.11	0.15%	99.30%
3A2	Manure Management	N_2O	18.99	18.99	0.14%	99.44%
1.A.2	1A2 Manufacturing Industries and Construction	N_2O	17.85	17.85	0.13%	99.57%
1.B.2.a.i	Oil Venting	CH_4	15.83	15.83	0.12%	99.69%
3C6	Indirect N2O Emissions from Manure Management	N_2O	8.69	8.69	0.06%	99.75%
1.A.1	1A1 Energy Industries	N_2O	6.09	6.09	0.05%	99.80%
1.A.3	1A3 Transport	CH_4	5.06	5.06	0.04%	99.83%
4B	Biological Treatment of Solid Waste	N_2O	3.31	3.31	0.02%	99.86%
4B	Biological Treatment of Solid Waste	CH_4	2.99	2.99	0.02%	99.88%
1.A.1:	1A1 Energy Industries	CH_4	2.45	2.45	0.02%	99.90%
1.B.2.a.iii2	Production and Upgrading	CO_2	1.90	1.90	0.01%	99.91%
3C1	Biomass Burning	CH_4	1.46	1.46	0.01%	99.92%
2D1	Lubricants Use	CO_2	1.40	1.40	0.01%	99.94%
1.A.4:	1A4 Other Sectors	CH_4	1.30	1.30	0.01%	99.94%
1.A.2:	1A2 Manufacturing Industries and Construction	CH_4	1.21	1.21	0.01%	99.95%
1.A.4	1A4 Other Sectors	N_2O	1.14	1.14	0.01%	99.96%
1.B.2.b.iii.2	Gas Production	CO_2	0.91	0.91	0.01%	99.97%
1.B.2.b.iii.5	Gas Distribution	CO_2	0.89	0.89	0.01%	99.98%
2G3	N20 From Medical Use	N_2O	0.80	0.80	0.01%	99.98%
3C1	Biomass Burning	N_2O	0.71	0.71	0.01%	99.99%
1.B.2.a.ii	Oil Flaring	CH_4	0.55	0.55	0.00%	99.99%
1.B.2.b.ii	Gas Flaring	CH_4	0.45	0.45	0.00%	99.99%
1.B.2.a.ii	Oil Flaring	N_2O	0.21	0.21	0.00%	100.00%
1.B.2.a.iii.3	Oil Transport	CH_4	0.18	0.18	0.00%	100.00%
1.B.2.b.ii	Gas Flaring	N_2O	0.16	0.16	0.00%	100.00%
1.B.2.a.i	Oil Venting	CO_2	0.10	0.10	0.00%	100.00%
1.B.2.a.iii.3	Oil Transport	CO_2	0.09	0.09	0.00%	100.00%
1.B.2.b.i	Gas Venting	CO_2	0.05	0.05	0.00%	100.00%
1.B.2.b.iii.4	Total Gas Transmission and Storage	CO_2	0.01	0.01	0.00%	100.00%
1.B.2.a.i	Oil Venting	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.a.iii2	Production and Upgrading	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.a.iii.3	Oil Transport	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.b.i	Gas Venting	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.b.iii.2	Gas Production	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.b.iii.3	Gas Processing	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.b.iii.4	Total Gas Transmission and Storage	N_2O	0.00	0.00	0.00%	100.00%
1.B.2.b.iii.5	Gas Distribution	N_2O	0.00	0.00	0.00%	100.00%

Table 2-7: Key category assessment results with LULUCF

crf code	category name	gas	2015 emissions	absolute value of 2015 emissions	Level assessment	cumulative total
3B2	Cropland	CO_2	12,648	12,647.58	32.510%	32.510%
3B1	Forest land	CO_2	-11,855	11,855.41	30.473%	62.983%
1.A.1:	1A1 Energy Industries	CO_2	4,120	4,119.9	10.590%	73.573%
1.B.2.b.iii.2	Gas Production	CH_4	2,395	2,394.5	6.155%	79.728%
1.A.3	1A3 Transport	CO_2	1,938	1,937.6	4.980%	84.708%
1.A.2:	1A2 Manufacturing Industries and Construction	CO_2	1,445	1,445.0	3.714%	88.422%
1.B.2.a.iii2	Production and Upgrading	CH_4	556	555.6	1.428%	89.851%
4D	Wastewater Treatment and Discharge	CH_4	488	487.68	1.254%	91.104%
1.A.4:	1A4 Other Sectors	CO_2	457	456.7	1.174%	92.278%
3C4	Direct N2O Emissions from Managed Soils	N_2O	411	411.0	1.056%	93.335%
3C1	Biomass burning - FL	CH_4	395	394.89	1.015%	94.350%
1.B.2.b.iii.5	Gas Distribution	CH_4	354	353.6	0.909%	95.258%
3B3	Grassland	CO_2	323	323.36	0.831%	96.090%
4A	Solid Waste Disposal	CH_4	250	250.26	0.643%	96.733%
3C1	Biomass burning - FL	N_2O	171	171.45	0.441%	97.174%
3A1	Enteric Fermentation	CH_4	168	168.3	0.433%	97.606%
1.B.2.b.iii.3	Gas Processing	CH_4	155	155.2	0.399%	98.005%
3A2	Manure Management	CH_4	145	144.8	0.372%	98.377%
1.B.2.b.iii.4	Total Gas Transmission and Storage	CH_4	131	131.1	0.337%	98.714%
4D	Wastewater Treatment and Discharge	N_2O	128	128.21	0.330%	99.044%
1.B.2.b.i	Gas Venting	CH_4	77	77.0	0.198%	99.242%
1.B.2.a.ii	Oil Flaring	CO_2	43	42.8	0.110%	99.352%
3C5	Indirect N2O Emissions from Managed Soils	N_2O	42	41.96	0.108%	99.459%
3B5	Settlements	CO_2	35	34.59	0.089%	99.548%
1.B.2.b.ii	Gas Flaring	CO_2	33	33.2	0.085%	99.634%
1.A.3	1A3 Transport	N_2O	28	27.6	0.071%	99.705%
1.B.2.b.iii.3	Gas Processing	CO_2	20	20.1	0.052%	99.756%
3A2	Manure Management	N_2O	19	19.0	0.049%	99.805%
1.A.2	1A2 Manufacturing Industries and Construction	N_2O	18	17.8	0.046%	99.851%
1.B.2.a.i	Oil Venting	CH_4	16	15.8	0.041%	99.892%
3C6	Indirect N2O Emissions from Manure Management	N_2O	9	8.69	0.022%	99.914%
1.A.1	1A1 Energy Industries	N_2O	6	6.1	0.016%	99.930%
1.A.3	1A3 Transport	CH_4	5	5.1	0.013%	99.943%
4B	Biological Treatment of Solid Waste	N_2O	3	3.31	0.008%	99.951%
4B	Biological Treatment of Solid Waste	CH_4	3	2.99	0.008%	99.959%
1.A.1:	1A1 Energy Industries	CH_4	2	2.5	0.006%	99.965%
1.B.2.a.iii2	Production and Upgrading	CO_2	2	1.9	0.005%	99.970%
3C1	Biomass Burning	CH_4	1	1.5	0.004%	99.974%
2D1	Lubricants Use	CO_2	1	1.4	0.004%	99.978%
1.A.4:	1A4 Other Sectors	CH_4	1	1.3	0.003%	99.981%
1.A.2:	1A2 Manufacturing Industries and Construction	CH_4	1	1.2	0.003%	99.984%
1.A.4	1A4 Other Sectors	N_2O	1	1.1	0.003%	99.987%
1.B.2.b.iii.2	Gas Production	CO_2	1	0.9	0.002%	99.989%
1.B.2.b.iii.5	Gas Distribution	CO_2	1	0.9	0.002%	99.992%
2G3	N20 From Medical Use	N_2O	1	0.8	0.002%	99.994%
3C1	Biomass Burning	N_2O	1	0.7	0.002%	99.995%
1.B.2.a.ii	Oil Flaring	CH_4	1	0.5	0.001%	99.997%
1.B.2.b.ii	Gas Flaring	CH_4	0	0.4	0.001%	99.998%
1.B.2.a.ii	Oil Flaring	N_2O	0	0.2	0.001%	99.998%
1.B.2.a.iii.3	Oil Transport	CH_4	0	0.2	0.000%	99.999%
1.B.2.b.ii	Gas Flaring	N_2O	0	0.2	0.000%	99.999%
1.B.2.a.i	Oil Venting	CO_2	0	0.1	0.000%	100.000%
1.B.2.a.iii.3	Oil Transport	CO_2	0	0.1	0.000%	100.000%
1.B.2.b.i	Gas Venting	CO_2	0	0.0	0.000%	100.000%
1.B.2.b.iii.4	Total Gas Transmission and Storage	CO_2	0	0.0	0.000%	100.000%
1.B.2.a.i	Oil Venting	N_2O	0	0.0	0.000%	100.000%
1.B.2.a.iii2	Production and Upgrading	N_2O	0	0.0	0.000%	100.000%
1.B.2.a.iii.3	Oil Transport	N_2O	0	0.0	0.000%	100.000%
1.B.2.b.i	Gas Venting	N_2O	0	0.0	0.000%	100.000%
1.B.2.b.iii.2	Gas Production	N_2O	0	0.0	0.000%	100.000%
1.B.2.b.iii.3	Gas Processing	N_2O	0	0.0	0.000%	100.000%
1.B.2.b.iii.4	Total Gas Transmission and Storage	N_2O	0	0.0	0.000%	100.000%
1.B.2.b.iii.5	Gas Distribution	N_2O	0	0.0	0.000%	100.000%
3B4	Wetlands	CO_2	0	0.00	0.000%	100.000%
3B6	Other land	CO_2	0	0.00	0.000%	100.000%
3D1	HWP	CO_2	0	0.00	0.000%	100.000%
3C1	Biomass burning - GL	CH_4	0	0.00	0.000%	100.000%
3C1	Biomass burning - crop residue	CH_4	0	0.00	0.000%	100.000%
3C1	Biomass burning - GL	N_2O	0	0.00	0.000%	100.000%

2.4. Sectors

2.4.1. Energy

2.4.1.1. General breakdown of emissions in the sector

Emissions from the energy sector amounted to 11,806.28 Gg CO_2eq in 2015, an increase of 5,532.37 Gg CO_2eq (88.2 per cent) when compared to 2000. The Energy Industries contributed 35 per cent to the total sector emissions in 2015, followed by fugitive emissions from natural gas (27 per cent), transport (17 per cent). 68 per cent of total sector emissions are CO_2, while CH_4 contributed 31 per cent and N_2O 0.4 per cent.

Energy industries has been the main emitting subsector from 2000 to 2015 and this was mainly from electricity generation. The emissions increased slightly from 2000 to 2004 due to the increase in demand for electricity then remained constant from 2005 to 2013 and increased rapidly from 2014 to 2015 due to the increasing demand for electricity especially for the operation of the LNG project. Emissions from transport increased rapidly from 2007 to 2015 as the transportation activities increased. Emission from fugitive emissions in the oil sector decreased between 2000 and 2015 as the production of oil decreased while fugitive emissions from the gas sector increased due to the increase in production of natural gas (LNG project) especially in 2015. As for the other subsectors and the manufacturing industries and construction, the emissions remained quite constant between 2000 and 2015.

Emissions have been estimated for all categories except those that are not occurring in PNG or are not estimated due to data limitations. Categories reported as not occurring includes energy industries (except electricity), fugitive emissions from coal mining and handling, all categories under the carbon dioxide transportation and storage. Categories reported as not estimated or as an aggregate include:

- Under manufacturing industries and construction, emissions from pulp, paper and print, from food processing, beverage and tobacco, from mining and quarrying, and from wood and wood products are reported as an aggregate due limited data;
- Under manufacturing industries and construction, emissions from construction are reported as not estimated due to a paucity of data;
- Under transportation, emissions from road transportation, civil aviation and navigation for both domestic and international bunkers are reported as an aggregate due to limited data (railways are not occurring); and
- Under other sectors, emissions from commercial/institutional, residential, agriculture, forestry, fishing and fish farms are reported as an aggregate due to limited data.

As to activity data, data has been obtained from the Energy Balance Table which was compiled by the Asia Pacific Energy Research Centre (APERC) from 1990 to 2016.

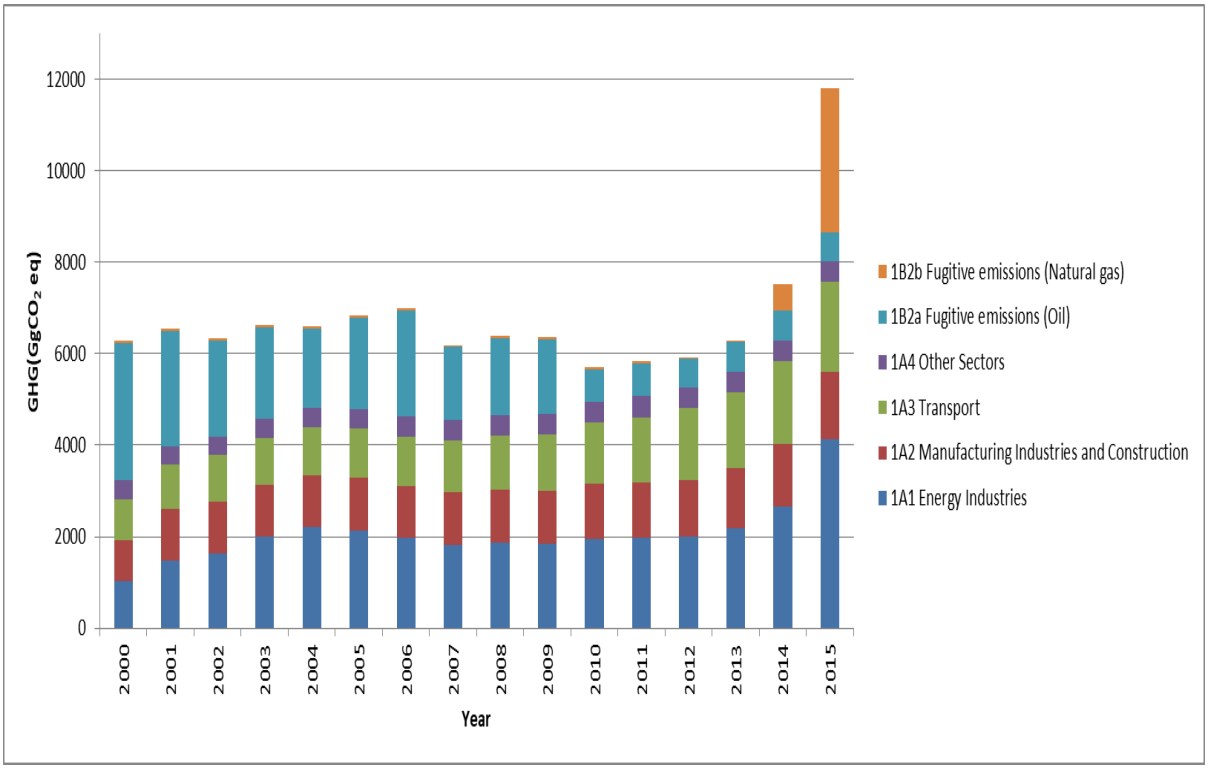


Figure 2-4: Time-series of total GHG emissions from the energy sector by category

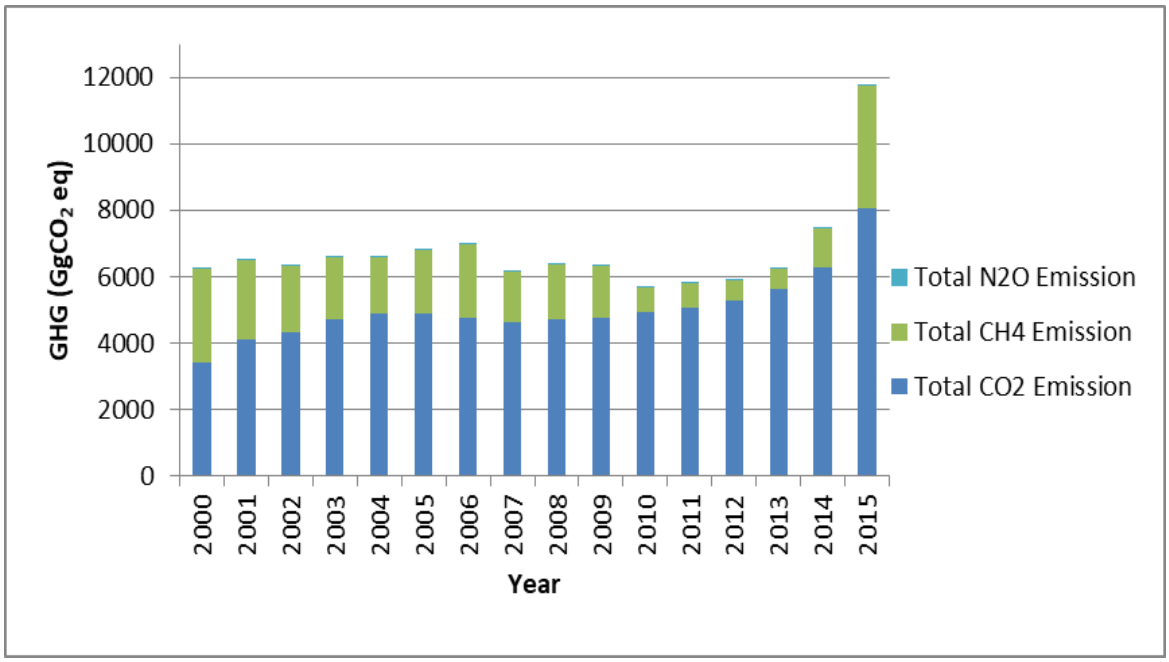


Figure 2-5: Time-series of total GHG emissions from the energy sector by gas

Reference versus Sectoral Approaches for Estimating the CO_2 Emissions Level

The estimate of CO_2 emissions showed that the estimations using reference approach balances with the estimation from the sectoral approach. In 2004 and 2015 there were high discrepancies of 23% and 15%. Respectively in 2004, it was due to the statistical discrepancy in crude oil data

while in 2015 it was due to the statistical discrepancy in Natural Gas data. For the other years the discrepancy of GHG level ranged from 0% to 7%.

Figure 2-6 below shows the estimated emissions using the reference approach and sectoral approach.

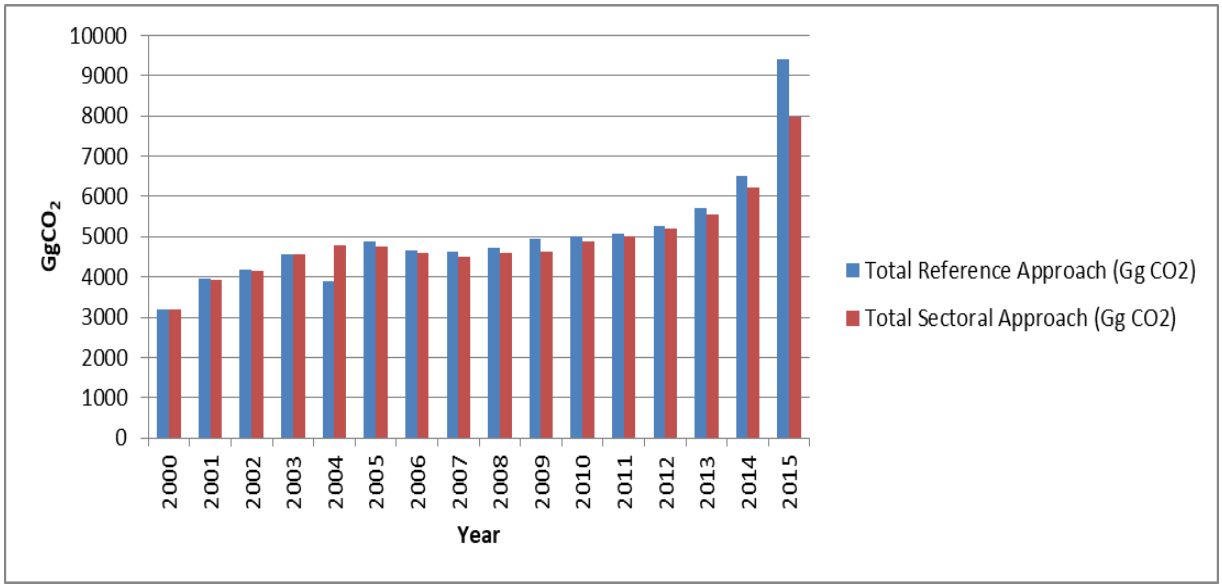


Figure 2-6: Time-series of reference versus sectoral approach

2.4.1.2. Tiers, Methods, source of activity data, emission factors

GHG emissions presented in the GHG emissions inventory were estimated using Tier 1 method of IPCC 2006 Guidelines with default value emission factors. The activity data was taken exclusively from the Energy Balance Table developed by the APERC and converted from one energy unit (ktoe) to another (TJ). All GHG estimations were carried out using Microsoft Excel Spread Sheets.

2.4.1.3. Improvements made, challenges, areas for further improvement in the future

The Second National Communication (OCCD, 2015) included aggregate emission estimates from the energy sector that were based on fuel import statistics, but not disaggregated into separate categories. Further, emissions estimated were only provided for the year 2000. BUR1 has made significant improvements in the coverage of categories and years in the estimates of the energy sector emissions, primarily based on improved energy consumption data from the APERC that includes all years between 2000 and 2015.

In this inventory the Energy Sector has the following challenges:

- Lack of a national energy balance table;
- Inability to disaggregate activity data into specific categories; and
- Lack of country specific emission factors

This may be improved by contacting the relevant stakeholder to check whether there is available data.

2.4.2. Industrial Process and Other Product Use (IPPU)

2.4.2.1. General breakdown of emissions in the sector

Emissions from the IPPU sector amounted to 35.29 Gg CO_2 eq in 2015, an increase of 1.38 Gg CO_2 eq (4.07 per cent) when compared to 2000. N_2O from Medical Use contributed 58 per cent and Lubricant Use contributed 42 per cent to the total sector emissions in 2015.

The change in the emissions total for IPPU Sector when compared to PNG's Second National Communication is due to major adjustments with the categories covered in the IPPU sectors. The previous National Communications were done on project basis, thus at the end of the projects, there was not a proper system in place for technology and information transfer of the data by the consultants to the current officers undertaking the inventory, therefore, resulting in the current inventory to be repeated.

PNG has only a few manufacturing companies, which are mostly based in Lae, Morobe Province and Port Moresby. There is less availability of industry data in the country. However, the recommended stakeholders have been visited by CCDA and have collected IPPU data basing on targeted data from questionnaires developed from the 2006 IPCC guidelines.

The emissions from the sector cover two categories; Non- Energy Products from Fuels and Fossil Fuels (Lubricant Use) and Other Product Manufacture and Use (N_2O for Medical Use). Lubricant Use emission accounts for application of lubricants used in transportation and industry in forms of oil types. Emission from N_2O for Medical Uses accounts from anaesthetic use, analgesic use and veterinary use. Figure 2-7 shows the breakdown of gases in IPPU sector and the trend of emissions for the time series.

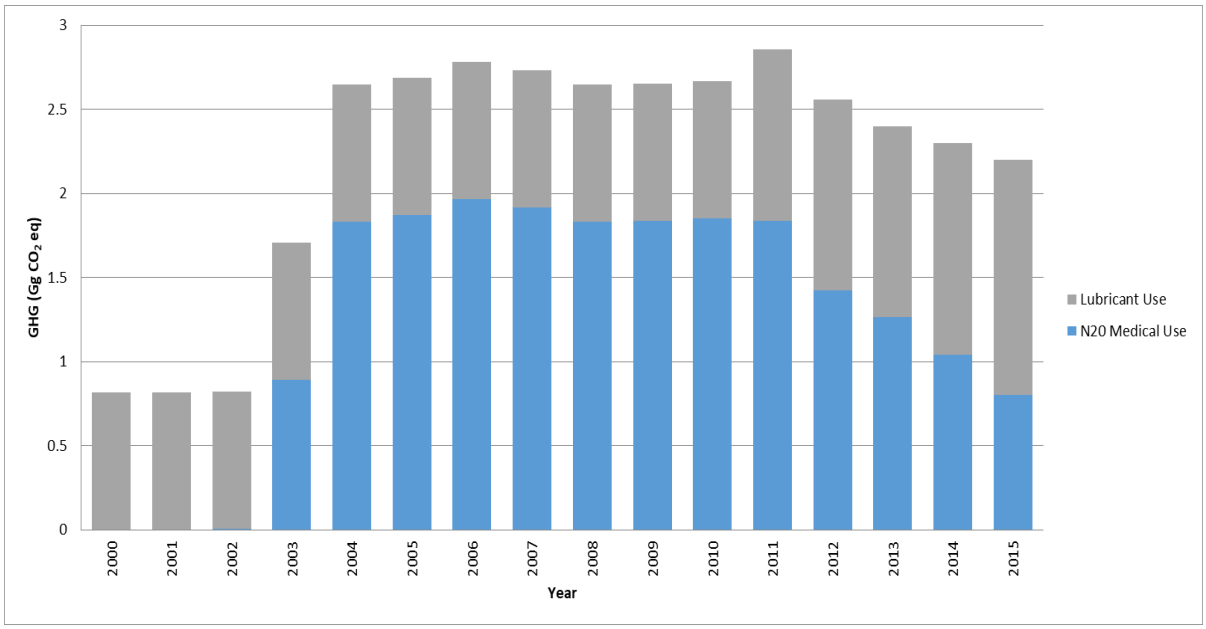


Figure 2-7: Time-series of total GHG emissions from the IPPU sector

2.4.2.2. Tiers, Methods, source of activity data, emission factors

The emissions from the IPPU sector were estimated using Tier 1 method of 2006 IPCC Guidelines for National Greenhouse Gas Inventories with default value emission factors. The activity data were collected from the private sector. All GHG estimations were carried out using the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Software and Microsoft Excel Spread Sheets.

2.4.2.3. Improvements made, challenges, areas for further improvement in the future

It has been reported in the INC and SNC that the most important category from the IPPU sector was CO_2 emissions from cement production. The INC and SNC assumed that clinker was being produced domestically. However, from data collection exercises for the BUR1, the CCDA discovered that clinker is not produced in PNG but it is being imported from Japan along with cement. Therefore, in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, emission from cement production was not estimated. The category is now reported as NO.

The two categories (Lubricant use and N_2O medical use) estimated for the BUR1 were not included in the SNC.

All emissions have not been estimated for all categories except those that are not occurring in PNG or are not estimated due to data limitations.

Plans for major improvements for the IPPU sector are underway and with the help of JICA through the Project for enhancing capacity to develop a sustainable GHG inventory system for PNG (2017 to 2021) IPPU team aims to have at least a complete inventory to which it abides by the TACCC good practice approach.

2.4.3. Agriculture

GHG emissions from the agricultural sector are generally linked to the management of agricultural soils, livestock, rice production and biomass burning. The main agricultural sources of GHG emissions are the following:

- enteric fermentation, part of the digestive process for many ruminants such as cattle, sheep and goats, which produces methane (CH_4) emissions;
- soil nitrification and denitrification, which produces nitrous oxide (N_2O) emissions;
- manure decomposition, which produces both methane and nitrous oxide emissions.

In general, GHG emissions from agriculture are influenced by a number of factors such as farm management practices and trends in the number of ruminant animals.

2.4.3.1. General breakdown of emissions in the sector

Emissions from the Agriculture sector amounted to 796 Gg CO_2 eq in 2015, an increase of 114 Gg CO_2 eq (16.72 per cent) when compared with the year 2000. Direct and indirect emissions from managed soils contributed 58 percent of the total sector emissions in 2015, followed by enteric fermentation and manure management that contributed together 41 percent and biomass burning

of crop residue contributed 1 percent of the total sectoral emission. Figure 2.8 shows the trend of increasing emissions over time.

The following emitting categories with associated gas were included in the estimation:

- Enteric fermentation (CH_4)
- Direct and indirect manure management (CH_4 and N_2O)
- Burning of crop residues (CH_4 and N_2O)
- Direct and indirect emissions from managed soils (N_2O)

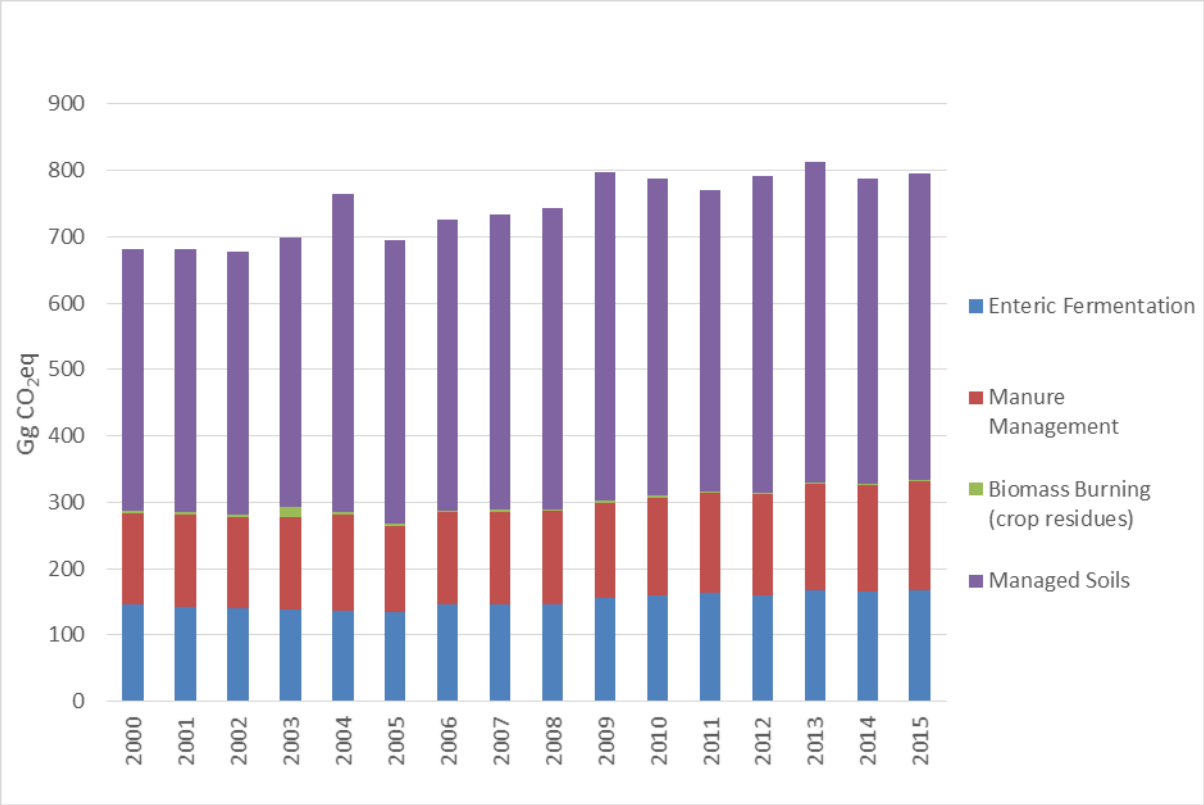


Figure 2-8: Time-series of emissions from the Agriculture sector by category

The main emitting category was managed soil, composed mainly by organic and synthetic fertilizers. In general, the increasing trend in emissions from agriculture since 2000 has been mainly driven by national economic growth and the increased demand for agricultural commodities which led to a large number of agriculture and livestock development initiatives in the country. The government of Papua New Guinea (GoPNG) has prioritised its focus to revive the primary industry (agriculture) into a core driver in boosting the economy development growth. Indeed, livestock population has increased during the last years as well as the cultivation of cash crops such as coffee, palm oil, tea, cocoa, copra and others, in line with the new agriculture policy reform.

GHG emitting categories with limited availability of activity data for calculation such as liming and urea application were not included in the GHGI estimation. The category rice cultivation was assumed to be not source of methane since cultivated in upland and without the irrigation practice of flooding.

Figure 2.9 shows the trend of emissions by gas. The figure shows that N_20 emissions are gradually increasing except for the last two years and are significantly larger than the emissions from CH_4.

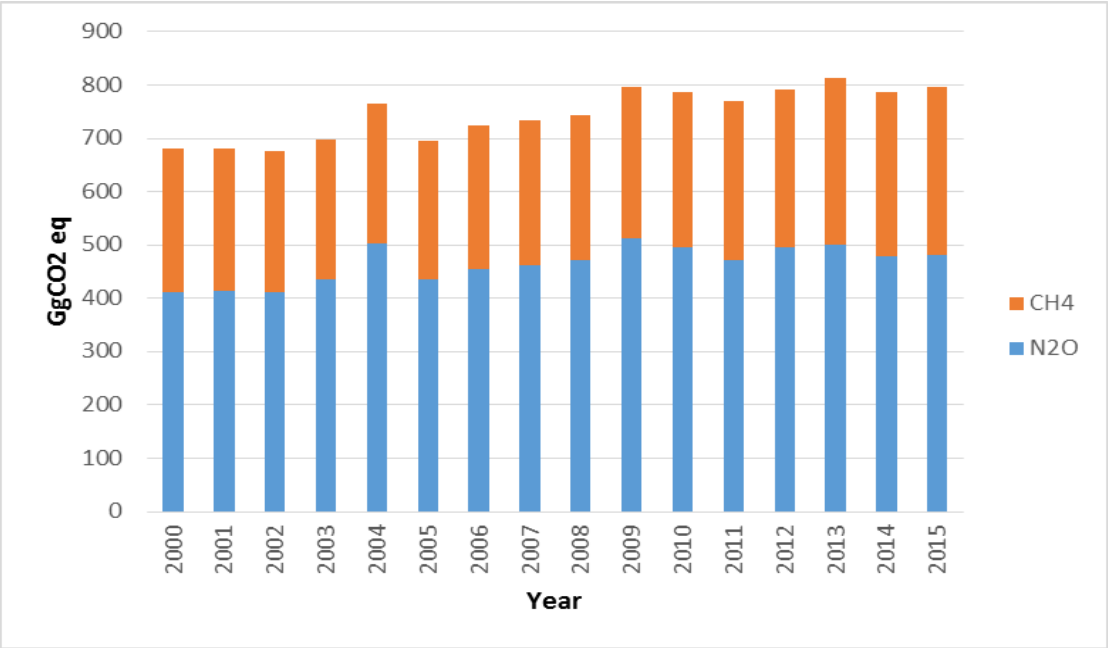


Figure 2-9: Time-series of GHG emissions from the Agriculture sector by gas

2.4.3.2. Tiers, Methods, source of activity data, emission factors

GHG emissions for the agriculture sector have been estimated using Tier 1 method of the IPCC 2006 Guidelines, except for the category burning of agricultural residues for which IPCC 1996 Revised Guidelines was used. This was because estimations were carried out using NAI tables (MS Excel Spread Sheets) that in certain cases are not compatible with the changed methodologies provided in the IPCC 2006 Guidelines.

The use of the 2006 IPCC Guidelines was to ensure that the GHG emission estimates were as much as transparent, complete, consistent and accurate (TCCCA) through time and comparable with those inventories produced in other countries with similar national circumstances.

Default emission factors and other parameters were taken from IPCC 2006 Guidelines when possible. In order to improve transparency, quality of the inventory and ultimately to help the QA/QC processes, all key methodological steps, assumptions and relevant information used in the calculation and on data sources were reported in the documentation box located below each worksheet of the NAI table.

The inventory was prepared using data from a combination of sources namely national and international institutions. During the inventory data collection, priority was given to data that have been generated in the country. In cases where the required data were not available in the country, the data from international organizations such as FAO were used.

The activity data values used for the categories enteric fermentation and manure management were country specific. Data on mules, asses and buffaloes were not reported since the amount of these

animal species is not relevant in the country. Up to 80 per cent of the livestock data were collected or provided by the National Department of Agriculture and Livestock (DAL) through the four regional offices. The remaining 20 per cent were collected or provided by the private sector, particularly the private agriculture business industries.

In the context of the manure management, the availability of information on different manure management systems (MMS) used in the country as well as on the fraction of the manure in MMS was very limited. For the latter, default parameter in the IPCC 2006 Guidelines were used. Some expert judgment was also necessary to complete the estimation of GHG emissions for this category.

Activity data for other categories such as managed soil were taken from FAOSTAT Database because data were not available at a national level.

Data on cultivated areas of organic soil has been taken from the Collect Earth assessment and are the same data used in the LULUCF sector.

Emissions from rice cultivation were considered zero because experts stated that, in general, rice fields in the country are not flooded or are cultivated in uplands. In fact, methane emissions are produced when rice fields are flooded during cultivation.

Emissions produced by the burning of agricultural crop residues have been calculated only for three crops: rice, sugarcane and corn according to the data from FAOSTAT.

Livestock data collected by the country were available on hard copy only. FAO provided support to the country to digitalize the data, facilitating then their analysis as well as the archiving.

As per the quality assurance (QA) procedure, national livestock data were compared with data of FAOSTAT Database and numerous differences were highlighted. FAOSTAT data derived from questionnaires compiled directly by the countries and discrepancies between these two data sources will require further investigation. A summary of collected activity data and relative sources and gaps are reported in Table 2-8 below.

Table 2-8 A Summary of collected activity data and relative sources and gaps is reported

Category codes	GHG source/sink category	Data type	Data source	Gaps and constraints
3A1-3A2	• Enteric fermentation • Manure management	• Animal population • MMS • Fractions of manure in MMS	• DAL • Private sector (Trukai Industries , Ramu Agri - Industry Limited, Zenag Chickens, Niugini Table Birds, Rumion (Leron) Piggery and New Britain Palm Oil Limited)	• Large difference with FAOSTAT livestock figures • Unavailability of data from national data providers • Data collection design
3C1	• Biomass burning (crop residues)	• Crop production • Harvested area	• FAOSTAT	• National data availability
3C2-3C3	• Urea application and Liming	• Urea and Lime application	None	• National data availability
3C4-3C5	• Direct and indirect N_2O emissions from managed soils	• Fertilizer consumption • Crop production	• FAOSTAT • PNGFA (Collect Earth) (for Cultivation OS)	• Fertilizer consumption data
3C6	• Indirect N_2O emissions from manure management	Same as 3A-1/2	Same as 3A-1/2	Same as 3A-1/2

3C7	• Rice cultivation	• Rice harvested area • Irrigation management • Crop length	• FAOSTAT • Expert judgment	• Information on irrigation management. • Harvested areas

2.4.3.3. Improvements made, challenges, areas for further improvement in the future

Many improvements have been done compared to the GHGI conducted for the SNC submitted to UNFCCC in 2015. Some emitting categories not reported before have been considered for the estimation and others improved (managed soils, burning crop residues and rice cultivation) and the whole time series from 2000 to 2015 has been calculated.

Improvements in terms of accuracy of activity data collected and consistencies in the time series have been done and all main regions of the county were covered. In addition, the methodology applied, including the choice of activity data, emission factors and other relevant parameters, have been clearly documented, with a consequent increase of transparency of the overall process.

The previous GHGI was conducted on a project base approach under a project management unit (PMU); only certain pilot areas were considered and consequently the whole picture of the country in terms of emissions for this important sector was not provided. The GHGI process for the first BUR of PNG has been institutionalized by CCDA and delivered by its staff. Technical support from international organization such as FAO enhanced the capacity of the compilers to understand and use the methodologies, tools and software to be used for the preparation of the GHGI.

Data collection for the agriculture sector was a major challenge to the inventory compilers due to unavailability of data and proper data management systems in place, despite large evidence of agriculture activities occurring in the country. The other challenge encountered was data accessibility from the private agriculture business industries due to their data confidentiality company policies, which became a constraint in collecting reliable data needed for GHGI. Accessing reliable data from one province to another was difficult due to geographical and transport constraints. Reaching the various locations to collect data involved a lot of cost and that was seen as a barrier that hindered effective and reliable data collection. Moreover, the absence of a national policy on data management for all sectors through the responsible agencies in managing relevant data is a real limit for the inventory compilers.

Despite of the constraints and challenges, the CCDA officers in collaboration with the DAL using the funding and technical support from the FAO and UNEP successfully covered almost all sector emissions categories. Nonetheless, there is still room for improvement of the estimation of emissions from the agricultural sector. In particular, big effort should be dedicated to the collection of all data related to manage soils such as synthetic or organic fertilizers that for this inventory have been taken from FAOSTAT. Awareness and consultation workshops as well as agreed technical support to data providers are necessary for the development of a national statistical system from which the GHGI can benefit.

This activity has been an opportunity to not only improve the accuracy and comprehensiveness of emission estimates, but also to improve the management systems designed to carry out all phases of the inventory. It is indeed an on-going and iterative process which requires regular contact with

technical experts and data providers. In this context, the forthcoming CBIT project will be a great opportunity to face and address all these challenges.

2.4.4. LULUCF

The Land Use Land-Use Change and Forest (LULUCF) sector contains the emissions and removals from carbon stock changes due to land use and forest management. The land use categories to be estimated are forest land (3B1), cropland (3B2), grassland (3B3), wetlands (3B4), settlements (3B5), and other land (3B6). Non-CO_2 emissions from biomass burning (3C1) are also included under this sector. The following chapters provide the details on the general emissions and removals of the sector, the methodologies and data and the future improvements to the sector.

2.4.4.1. General breakdown of emissions in the sector

The LULUCF sector in PNG is one of the biggest sectors among all sectors and historically acted as a sink. The sector has evolved into a smaller sink over time due to a decrease in forest lands over time. In the years 2011, 2013, 2014 and 2015 the LULUCF sector was a net source. Since on average the sector is responsible for more than half of all the total emissions[1], it is also the greatest source.

Most of the emissions in LULUCF sector in PNG occurred when forest was degraded or deforested (forest land converted to other land use). Annual area of forest degradation (primary forest becoming degraded forest) increased more than two-fold from 2001 (87,618 ha) to 2011 (200,052 ha) then slightly decreased in subsequent years (Figure 2-10). Area of deforestation also significantly increased during the reporting period. Average annual area of deforestation between 2011 and 2015 (30,667 ha) was more than three times higher than the average between 2001 and 2005. Logging was the major driver of forest degradation responsible to 90% of the degradation occurred during the reporting period. Almost the entire (99.3%) of deforestation was due to land use conversion from forest land to cropland. Subsistence agriculture is the most significant (69.8%) driver of deforestation during the reporting period followed by oil palm plantation development (24.4%).

[1] GHG emissions in 2015 from the LULUCF sector amounted 13,574 Gg CO_2 against 13,462 Gg CO_2 for all other sectors

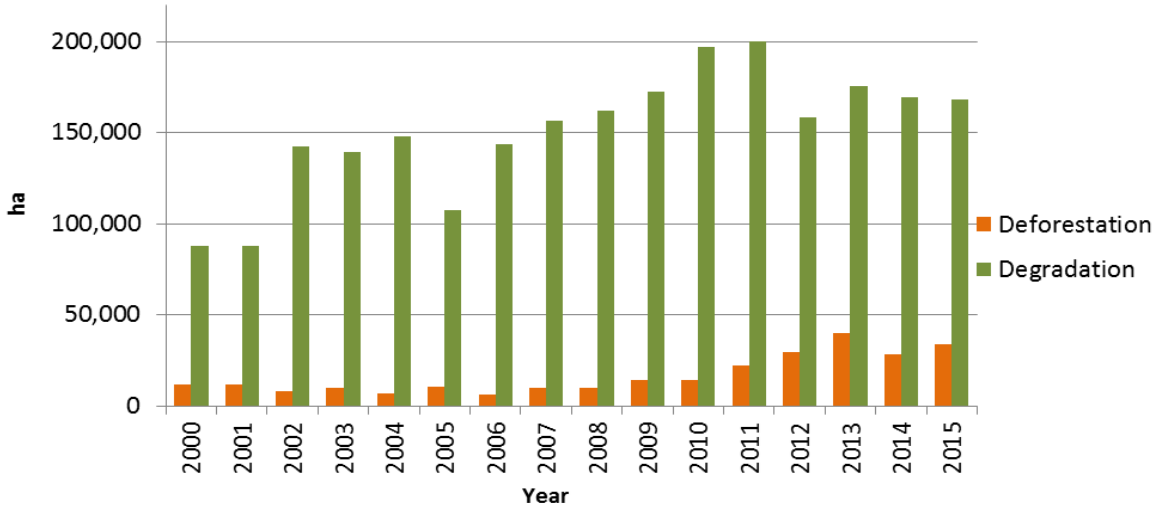


Figure 2-10: Annual area of deforestation and forest degradation in PNG

The net emissions from the LULUCF sector amounted to 1,716.46 Gg CO_2 eq in 2015 compared to -21,653.94 Gg CO_2 eq in 2000 which is a total decrease of removals amounting to 23,370.40 Gg CO_2 eq. Removals are decreasing since these are applied to the area of degraded forest directly taken from the Collect Earth assessment, for which each next year an area deforested is lost. For forest that is degraded during the reference level period, the consistency with FRL is maintained since the net of losses from disturbance and gains from subsequent recovery are reflected in the emission factor, reflecting long term average carbon loss.

Gross emissions from LULUCF, which are mainly coming from cropland (forest land converted to cropland), amounted to 13,574.04 Gg CO_2 eq in 2015 and are almost 3 times higher than the emissions in 2000, which amounted to 5,434.83 Gg CO_2 eq. Figure 2-11 showcases the trend of increasing emissions and decreasing removals over time.

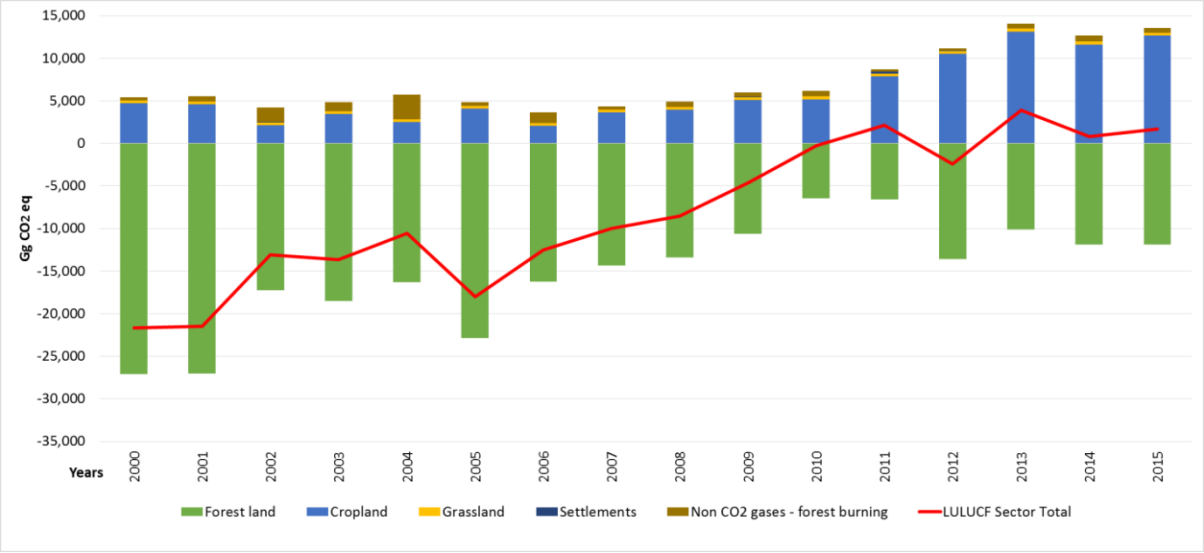


Figure 2-11: Time-series of total GHG emissions and removals from the LULUCF sector by category

The category cropland contributed 93 per cent to the total sector gross emission in 2015, followed by the category Non-CO_2 gas with 4 per cent and the category grassland with 3 per cent. Emissions from settlements are less than 1% of the total gross emissions. Non-CO_2 gases include biomass burning in forest land. Biomass burning of crop residues is accounted in agriculture. Most emissions in forest land, cropland and grassland are from losses of above ground and below ground biomass and all removals in forest land are from gains of below and above ground biomass. In the case of a land conversion from forest land to any other land, emissions are also estimated for loss of dead organic matter. Emissions from organic soils are estimated for grassland, cropland and for degraded forest lands. There was no deforestation on organic soils, so therefore those emissions are zero

Figure 2-12 shows the total net emissions/removals by gas. The figure shows that CO_2 turned from a net sink into a net source between 2000 and 2015 and that they are significantly larger than the emissions from CH_4 and N_2O. From the absolute emissions and removals in 2015 in the LULUCF sector 75 per cent are CO_2 gas from forest land use and land use change, whereas 17 per cent is CH_4 and 8 per cent is N_2O gases from forest burning.

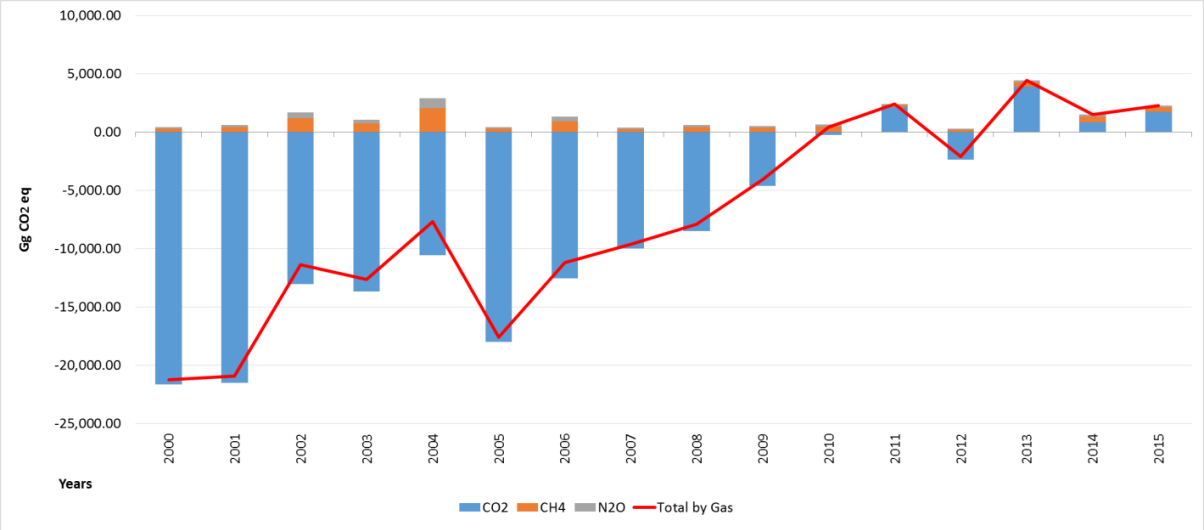


Figure 2-12: Time-series of total GHG emissions from the LULUCF sector by gas

The GHG inventory includes emissions from deforestation that are accounted under forest land converted to cropland and settlements. The main driver of deforestation is agriculture land use.

The inventory also includes emissions from forest degradation which is accounted under the category forest land remaining forest land. The emission calculations are based on multiplying degradation area from primary forest to degraded forest by the difference of carbon stocks between primary forest and degraded forest. The emission calculation corresponds to a modified version of the IPCC methodology, volume 4, chapter 2 (equation 2.15 and 2.16[2]). Therefore it is assumed that implicitly the estimation also includes losses from timber and fuel wood harvest and disturbances,

[2] In the case of a forest land remaining forest land a modified version of the equation 2.16 ($\Delta C_{CONVERSION} = \sum_i \{(B_{AFTER_i} - B_i) \times \Delta A_{TO\_OTHERS_i}\} \times CF$) is used where B_{AFTER_i} and B_{BEFORE_i} represent respectively the carbon stock in the degraded land and the carbon stock in the primary intact forest land

which is mainly driven by commercial logging. The same methodology has also been applied in the REDD+ technical annex.

Emissions and removals have been estimated for all categories except those that are not occurring in PNG or are not estimated, mainly due to data limitations. Land converted to forest land, land converted to grassland, land converted to wetlands, land converted to other land did not occur in PNG during the reporting period.

Emissions in living biomass and dead organic matter of grassland remaining grassland, wetlands remaining wetlands and settlements remaining settlements are not estimated since they are not mandatory to report its carbon stock change at tier 1.

Emissions from organic soils have been estimated for degraded land in forest land, cropland and grassland. They were not occurring for other remaining land uses, such as wetlands, settlements and other land. The amount of peatlands as part of organic soils has not been analysed so far.

The carbon stock changes in mineral soils have not been estimated and should be included at tier 1 for cropland remaining cropland and all land use conversions. It had not been estimated due to a lack of country specific data. Carbon pools for which the tier 1 assumption of no carbon stock change or instant oxidation was used are:

- Dead organic matter and mineral soil in forest land remaining forest land;
- Dead organic matter in land converted to cropland;
- All the carbon pools for grassland remaining grassland, wetlands remaining wetlands and settlements remaining settlements;
- And harvested wood products.

2.4.4.2. Tiers, Methods, source of activity data, emission factors

GHG emissions/removals were estimated mostly using a Tier 1 method and using approach 1 for land representation of the IPCC 2006 Guidelines. Only for emissions in living biomass after forest conversions and forest degradation the Tier 2 method was used.

GHG estimations were out carried using the 2006 IPCC worksheets with modification where appropriate and final estimates reported with the UNFCCC reporting sheets. Emissions/removals in forest land remaining forest land (except for degradation, see further) and cropland remaining cropland have been estimated using the gain-loss method (default tier 1 method[3]). The tier 2 method was used when estimating emissions and removals in living biomass[4] due to immediate conversions and degradation in forest land remaining forest land and dead organic matter[5] in conversion categories. Emissions from organic soils and biomass burning in forest land have also been estimated using the default tier 1 method. Emissions from harvested wood products are considered zero, since instantaneous oxidation is assumed.

[3] IPCC 2006 Guidelines, equation 2.7
[4] IPCC 2006 Guidelines, equation 2.15 and equation 2.16
[5] IPCC 2006 Guidelines, equation 2.23

Activity data were taken from the land use and land use change assessment (Collect Earth) conducted by PNG Forest Authority (refer Technical Annex of this report for methodology details). The same activity data and estimation methods have also been used for PNG Forest Reference Level for REDD+. The activity data from the land use assessment are used to estimate above ground biomass, below ground biomass, dead organic matter and soil organic carbon from organic soil for all land use categories. The area burned was taken from the FAOSTAT database[6].

PNG stratified the land according to the six IPCC Land use categories for preparing the land representation. Forest land and cropland were further disaggregated into subcategories, see Table 2-9. The Collect Earth survey was customized so that activity data where classified by their carbon stocks in function of the ecological characteristics and agricultural land uses. IPCC ecological zones, i.e. tropical wet, tropical moist, dry and montane forests, were used as forest strata to which also mangroves and plantations were added. Except for plantations, all strata were sub-categorized into primary and degraded/logged forest types. The difference between primary forest and degraded forest was made based on visual interpretation in Collect Earth[7]. For croplands, subcategories are oil palm, coconut, cocoa, tea, and coffee, shifting cultivation and permanent crop systems.

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. However, primary forests are assumed under very little human disturbances. Therefore it is assumed that primary forests are in equilibrium and it also assumed that their net removals are close to zero.

Table 2-9 Land categories by land cover and use types of the GHG inventory

Categories	**Land use stratification**
Tropical rain forest	Primary forest, Degraded forest
Tropical dry forest	Primary forest, Degraded forest
Tropical shrubland	Primary forest, Degraded forest
Tropical mountain system	Primary forest, Degraded forest
Mangrove	Primary forest, Degraded forest
Plantation	Deforested, Degraded
Cropland	Oil palm, coconut, cocoa, tea, and coffee, shifting cultivation and permanent crop systems
Grassland	No further stratification
Wetlands	No further stratification
Settlements	No further stratification
Other land	No further stratification

The results generated from Collect Earth are set of annual land use change matrices between 2000 and 2015. High resolution imageries before 2000 are limited and therefore an approach 1 was

[6]FAOSTAT Burned area for humid tropical forest (area code 168, item code 6796) and Burned area other forest (Area code 168, item code 6797)

[7] Use of high resolution imagery, ab Bing Maps and with combination of use of the Google Earth Engine platform looking at Landsat 7 and 8 for change detection

applied for land representation. Nevertheless, annual land area changes like approach 2 have been used to estimate immediate loss due to forest land conversion and forest degradation.

Mostly default emission factors and some country specific factors have been used. Forest growth factors in Table 2-10 have been taken from the IPCC 2006 guidelines for degraded forest which were considered more than 20 years old. Primary forests are mostly undisturbed, and therefore a growth rate of zero has been applied. This is a conservative assumption since much of the primary forest may continue to sequester carbon; a global comparison study from 2008 suggests undisturbed old forests absorb significant quantities of carbon (Luyssaert et al 2008). PNG's SNC did not use a zero value and as a result estimated removals in forest land remaining forest land to amount up to 180 million tCO_2. The average annual growth rate of regrowth on cropland is consistent with the FRL submission.

National forest carbon stocks and root to shoot ratios in table 2-11 have been derived from literature (Fox et al. 2010) and completed with defaults from the IPCC Guidelines (2006). The carbon fraction selected from IPCC 2006 Guidelines is 0.47 tC /t d.m. Long term stock factors for the two major perennial crops, croplands for oil palm and cocoa and coconut have been taken from the IPCC 2006 Guidelines (table 5.3) and are consistent with the product of the annual increment and maturity cycle (years). Other crop types, such as tea and coffee have not been included yet separately and this is justified since their area is insignificant compared to the two major crops.

PNG will update most emission factors for forestlands when data from the NFI will become available and will be included in BUR2.

Table 2-10 Average annual growth rates by forest types

Categories	Land use stratification	Average annual growth rates (t d.m. ha^{-1} yr^{-1})
All types	Primary	zero
Tropical rain forest	Degraded forest	3.4
Tropical dry forest	Degraded forest	2
Tropical shrubland	Degraded forest	2
Tropical mountain system	Degraded forest	1
Mangrove	Degraded forest	9.9
Plantations	Plantations	5
Regrowth cropland		8.11[8]

Table 2-11 Average annual above ground biomass and ratio of below and above ground biomass

Categories	Land use stratification	Ratio below and above ground (-)	Average annual above ground biomass (t d.m. ha^{-1})
Tropical rain forest	Primary forest	0.37	223
Tropical dry forest	Primary forest	0.28	130

[8] Based on an average growth rate from different perennial crop types (consistent with the value calculated in the FRL)

Tropical shrubland	Primary forest	0.4	70
Tropical mountain system	Primary forest	0.27	140
Mangrove	Primary forest	0.49	192
Tropical rain forest	Degraded forest	0.37	146
Tropical dry forest	Degraded forest	0.2.8	85
Tropical shrubland	Degraded forest	0.4	46
Tropical mountain system	Degraded forest	0.27	92
Mangrove	Degraded forest	0.49	126
Plantations	Deforested	0.37	150
Plantations	Degraded	0.37	98
Cropland	By Crop types	see table 2-12	see table 2-12
Grassland	No further stratification	-	16.1[9]
Wetlands	No further stratification	-	zero
Settlements	No further stratification	-	zero
Wetlands	No further stratification	-	zero

Table 2-12 Average long term carbon stocks and mean increment for the crop types to calculate gains and losses in croplands

Categories	Average long term carbon stock (t dm ha^{-1})	Mean increment (tonnes C ha^{-1} yr^{-1})
Oil palm	136	6.8
Cocoa and coconut	196	9.8

2.4.4.3. Improvements made, challenges, areas for further improvement in the future

This report compared to the previous SNC has updated the estimates from using the revised 1996 IPCC Guidelines to the new IPCC 2006 Guidelines. The SNC included aggregate emission and removal estimates from the LULUCF sector. In this report more disaggregated information is provided on activity data, coverage of categories and years in the estimate of GHG compared to the SNC.

PNG used a new land use assessment to estimate the activity data by using a sample based approach. The land use assessment carried out with the FAO tool, Collect Earth, provides consistent land use and land use change data for the entire country which improves considerably the time-series consistency compared to the SNC. The national forest categories in the SNC did not match IPCC categories under the 2006 IPCC Guidelines, therefore the new land use assessment categories where made consistent. Further check with relevant national institutions and data providers is necessary to improve the quality of the activity.

This GHG inventory did not include estimations of GHG emissions from high carbon organic soils and carbon stock changes in mineral soils. In order to accurately estimate the amount of GHG emission from organic soils, including peatlands, areas of drained and rewetted soils are required. To obtain

[9] IPCC 2006, chapter 6, table 6.4, tropical, moist & wet, includes above and below ground biomass for non-woody biomass

this information the country needs to collect more information on the location of the soils and the historical and current land use of those soils. In order to estimate mineral soils, the country would also need more information on historical land use.

Continuous capacity building is necessary for PNG to further sustain and build on the current dataset and, in particular to enable to move from an approach 1 to an approach 2, in order to track converted and managed lands over time (20 years default or less).

The estimation of carbon stock gains in forest land remaining forest land is based on the default gain-loss method. It is important to improve over time through further stratification of the forest land use by its level of disturbance, age, etc. and to allocate losses from harvest and disturbances by forest land use using country specific data sources.

Current data collected on areas of non-forest land are imprecise and verification of the estimates with other remote sensing products or ground measurement can increase the precision of the estimates. There is also need to improve estimates on cropland and grassland management practices through field surveys.

Capacity building is on-going on data collection to establish PNG's first NFI, which is a multipurpose inventory and will generate estimates for living biomass, dead wood, litter and soil carbon (PNGFA 2018).

Some other challenges are:

- Collect country specific data on fuel wood
- Collect country specific data on forest and grassland burning (with PNGFA UPNG)
- Disaggregate managed and unmanaged forest and revise growth rate factors for different forest types and disturbance conditions
- The inclusion of other carbon pools apart from living biomass and organic soils such as, litter, deadwood, mineral soils and harvested wood products.

A table of data needs and future improvements by each reporting subsector is given in Table 2-13.

Table 2-13 Summary of data needs and future improvements by each reporting subsector

GHG source/sink category		Data type[10]	Data source	Notes/assumptions to data	Future Improvement
3B1	Forest land	Forest land area and area change and disturbed, organic drained soils, forest growth factors, volume of fuelwood and timber harvest	PNGFA (Collect Earth), published literature source and FAOSTAT	Growth factors are default taken from the IPCC guidelines	- C stock values from NFI (PNG) - Historical area data (before 2000) - distinguish different levels of disturbed forest - gains and loss at

[10] Parameters in italic are not used / available in PNG

					more spatial explicit level
3B2	Cropland	Cropland area and area change, Forest carbon stock values for biomass and dead organic matter, organic drained soils, *Mineral soil management factors*	PNGFA (Collect Earth), national literature study	Litter stocks are a default taken from the IPCC guidelines	-C stock values from NFI (PNG) (including vegetation of deforested lands, long term carbons tocks of perennial crops) - define management practices for cropland - verify cropland area by subcategory with ground survey
3B3	Grassland	Grassland area and area change, Forest carbon stock values for biomass and dead organic matter, Organic drained soils *Mineral soil management factors*	PNGFA (Collect Earth)	No land use changed to grasslands occurred	-C stock for woody and herbaceous biomass - define management practices for Grassland
3B4	Wetlands	*Peatland extraction, wetland area and area, area of organic drained soils* *Mineral soil management factors*	Not Estimated	No Land use change to wetlands occurred – LB and DOM not estimated	-C stock values from NFI (PNG) - Identifying high organic soils and peat land area - estimate non-CO2 from drained organic soils - identifying flooded land
3B5	Settlements	Settlement area and area change, Forest carbon stock values for biomass and dead organic matter, organic drained soils *Mineral soil management factors*	PNGFA (Collect Earth)		-C stock values from NFI (PNG) - spatial explicit (e.g. LiDAR) data to track forest to settlement - urban biomass waste

					- Urban tree cover
3B6	Other land	Other land area and area change, Forest carbon stock values for biomass and dead organic matter, *Mineral soil management factors*	PNGFA (Collect Earth)	No land use change to other lands occurred- LB and DOM not estimated	- C stock values from NFI (PNG)
3C1	Biomass burning	Land area burned, crop residues burned	FAOSTAT	Burning in forest land only	-Use Fire dataset on hotspot areas (GIS data) (UPNG)
3D1	Harvested Wood Products	Volume of wood	NA	Tier 1 assumption: instant oxidation	-volumes of wood production, import and export

2.4.5. Waste

2.4.5.1. General breakdown of emissions in sector

Emissions from the waste sector amounted to 872.5 Gg CO_2 eq in 2015, an increase of 354 Gg CO_2 eq (60.88 per cent) when compared to 2000. Wastewater treatment and discharge contributed 70.6 per cent to total sector emissions in 2015, followed by solid waste disposal (28.7 per cent), biological treatment of solid waste (0.7 per cent). 87.1 per cent of total sector emissions are CH_4 and 15.1 per cent are N_2O.

The emissions of the waste sector have increased in the whole time series (2000-2015) as seen in Figure 2-13. The increase is influenced by population growth, development, consumption rate and rural-to-urban drift. Waste management in PNG remains a poorly managed sector with much improvement needed in the short and long term. Limited activity data were available to carry out GHG emission estimations for the waste sector. Most of the GHG emission estimates were done based on assumptions and expert judgement

Emissions have been estimated for all categories except those that are not estimated due to data limitations. Categories that are occurring in PNG but are reported as not estimated include incineration and open burning of waste and others.

Given the paucity of data, emissions estimates from the waste sector comprised of CH_4 emissions from solid waste disposal sites, and both CH_4 and N_2O emissions from biological treatment of solid waste, especially composting and domestic waste water treatment.

In the solid waste disposal sites, the sub sector which emissions are estimated is from the unmanaged waste disposal sites at which municipal solid waste are disposed. Most solid waste from households and commercial sites within the 22 towns/cites in PNG are disposed in aggregate quantities at open air dump sites located at the periphery of the town/ city through a road side pickup system.

In the water waste treatment and discharge, the sub sector which emissions are estimated is from the domestic waste water treatment and discharge. Emissions from this category are mainly driven by population growth.

In the biological treatment of solid waste, the sub category which emissions are estimated is from composting. Municipal solid waste such as food waste, garden and park waste and wood are used as composts in the gardens in rural areas of PNG. Most of these wastes are not disposed at the SWDS in rural areas.

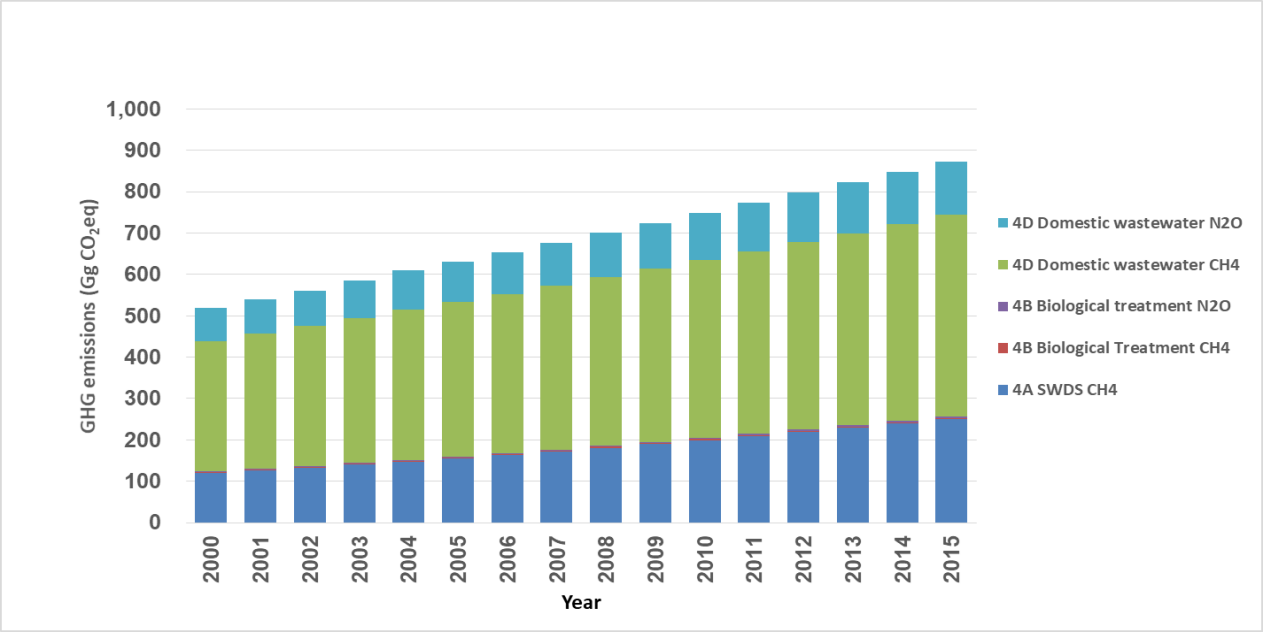


Figure 2-13: Time-series of total GHG emissions from the waste sector by category

In terms of emissions by gas, the most emitting gas is CH_4 and then followed by N_2O.

2.4.5.2. Tiers, Methods, source of activity data, emission factors

The GHG emissions of waste sector were mainly estimated using the Tier 1 method of 2006 IPCC Guidelines with default values and default emission factors, with the exception of solid waste, which was estimated by Tier 2 method. The activity data were provided by the National Statistical Office (NSO), Conservation and Environment Protection Authority and the National Capital District Commission (NCDC). Some activity data were also obtained from the FAOSTAT. All the GHG estimations were carried out using MS Excel Spread Sheets.

The National Statistical Office in PNG provided information on total population of the national census conducted for PNG in years 1980, 1990, 2000 and 2011. PNG conducts national population census every after 10 years.

All SWDS in PNG are considered unmanaged disposal sites (open air dump sites). But SWDS in Port Moresby (Baruni Landfill) was rehabilitated in 2015.The dump site is now converted to semi-aerobic landfill site. National Capital District Commission (NCDC) and Conservation and Environment Protection Authority (CEPA) have provided data on the municipal solid waste disposed at the Baruni

landfill site in Port Moresby from 2015 to 2016. Data provided by NCDC was used as representational data to estimate emissions from twenty-two (22) provinces of PNG. Waste generation rate for each provinces were determined depending on population size. Thus, estimations were made for whole time series (2000-2015).

2.4.5.3. Improvements made, challenges, areas for further improvement in the future

GHG estimates for the waste sector in the Second National Communication only captured CH_4 emissions from the SWDS and domestic wastewater of the year 2008 only.

In this inventory, GHG emissions estimates from the waste sector comprised of CH_4 emissions from the SWDS both CH_4 and N_2O emissions from biological treatment of solid waste (composting) and domestic wastewater treatment and discharge. GHG emissions are estimated from 2000 to 2015 time series.

A major constraint faced in conducting this inventory has been the lack of activity data. Challenges encountered in this inventory are:

- Lack of data on land filled waste, composted waste, incinerated/open burned waste, waste composition, parameters for methane estimation for landfills, industrial waste data, population data by domestic waste water treatment method, industrial wastewater data;
- Lack of country specific emission factors;
- Limited information on waste management systems in PNG

These challenges would be addressed with the assistance of the stakeholders. The stakeholders responsible in handling different waste categories would be consulted to find out on availability of data and information on waste management systems in PNG.

Chapter 3. Mitigation Actions

3.1. Introduction

This chapter provides an overview of the actions taken by Papua New Guinea in addressing the mitigation of anthropogenic GHG emissions. It begins with the International commitments followed by the domestic mitigation policies and descriptive tables of quantitative mitigation projects in the country.

3.2. International Commitments

Papua New Guinea submitted its Nationally Determined Contribution (NDC) in March 2016. Under the NDC the main contribution will be the replacement of fossil fuelled electricity generation with renewable energy sources. Further mitigation options outlined in the NDC includes energy efficiency options, energy efficient vehicles in the transport sector, reduction of emissions in the Oil and Gas sector and implementation of REDD+ activities under the UNFCCC to reduce emissions and enhance removals from the Forestry and Land Use sector. However, these actions are fully conditional where external financial and technical support will be needed.

Implementation of the mitigation contribution will be through the Climate Change (Management) Act 2015 and the United Nations Paris Agreement (Implementation) Act 2016 together with the sectoral agencies. However, similar to other Non-Annex I Parties PNG still lacks the capacity as such Capacity Building is also outlined in the NDC for the implementation and monitoring of the mitigation contribution.

3.3. Domestic Mitigation Policies

3.3.1. National Climate Compatible Development Management Policy (NCCDMP)

The National Climate Compatible Development Management Policy (NCCDMP) is the Government's blue print to achieve a vision in building a climate-resilient and carbon neutral pathway through sustainable economic development for Papua New Guinea. The strategy in achieving Climate-Compatible Development in PNG is through the combination of economic development with climate change mitigation and adaptation. For the mitigation component there are three policies;

i. Carbon Neutrality by 2050: PNG is climate compatible by 2050

ii. Land Use and Forestry Sector Emissions Abatement: GHG emissions mitigated in the land use, land use change and forestry (LULUFC) sector

iii. Green Economic Growth: Development is climate-compatible through efficient, low GHG emissions infrastructure and technology.

In achieving these, the NCCDMP has identified mitigation actions that will be implemented in the relevant key sectors. It also outlines the roles of the National, Provincial and Local Government.

The CCDA plays a coordinative role by making sure that these actions are implemented by line government departments and agencies, Provincial and Local Government, development partners and the private sector.

3.3.2. Sectorial Mitigation Policies

3.3.2.1. Land Use, Land Use Change and Forestry (LULUCF)

The LULUCF sector in PNG was previously a net sink; however this has decreased over the years due to the decrease in forest lands. The Main factors are from deforestation and degradation of the forest. According to Papua New Guinea's National REDD+ Forest Reference Level a total of 261,528ha of forest was deforested from 2000 to 2015. While a total 2,427,987ha of forest was degraded which are ten times higher than the area deforested in the same period. The main driver of forest degradation is commercial logging while the main drivers for deforestation are shifting cultivation and oil palm plantation.

Therefore the country's main mitigation action in this sector is from Reducing emissions from Deforestation Forest Degradation and the role of conservation, sustainable management of forest and enhancement of forest carbon sticks (REDD+). PNG will be taking a national approach through policies and measures that will be implemented through the national and subnational government system. Although, any project targeting the voluntary carbon market is required to follow guidelines link to the national REDD+ development process and UNFCCC guidelines.

The National REDD+ Strategy (NRS) 2017-2027 outlines three action areas and under each area are actions to be undertaken as well as the lead agencies within the period. Specific details of these actions will be developed further through the REDD+ Finance and Investment Plan which is still under development and should be completed by early 2019.

The first action area outlined in the NRS is Strengthened Land-Use and Development Planning. Under this action area the two actions to be implemented are: Strengthened and Coordinated National Level Development and Land Use Planning (lead agencies are Department of National Planning and Monitoring (DNPM) and Department of Lands and Physical Planning (DLPP)); and Integrated Subnational Planning (lead agencies are DNPM and Department of Provincial & Local Government Affairs (DPLGA)).

The Second Action Area is Strengthened Environmental Management, Protection and Enforcement. Under this area there are four actions which are: Strengthening climate change legislation, financing and management (lead agency is CCDA); Strengthening forest management and enforcement practices (lead agency is PNGFA); strengthening conservation and environmental management (lead agency is CEPA); and Strengthening access to information and resource mechanisms (multi-stakeholder action).

The Third Action Area is Enhanced Economic Productivity and Sustainable Livelihoods under which there are two actions to be implemented which are: Development of a sustainable commercial agriculture sector (lead agencies are DAL and DNPM); and Strengthened food security and increase productivity of family agriculture (lead agencies are DAL and Fresh Produce Development Agency (FPDA)).

3.3.2.2. Agriculture

The Agriculture sector contributed about 5.8% of the total emissions (excluding LULUCF) in 2015 but regardless of the high mitigation potential, further mitigation effort can be achieved. This is because most of the country's focus has been on adaptation due to the impacts of climate change on this sector. The NCCDMP identifies two mitigation actions in this sector, although they have yet to be implemented. The first action is to Reduce Green House Gas Emissions through improved Agricultural Practices which involves the establishment of educational programs and incentives to promote agricultural cultivation and livestock best management practices that reduces greenhouse gas emissions and that allow the sequestration potential of agricultural activities to be realized. The second action is to protect agricultural land from urban and suburban encroachment and involves the establishment of strategies to promote redevelopment and compact new development that will minimize the conversion of forest and grassland for urban and suburban use.

3.3.2.3. Energy

The Energy Sector is the largest net emitting sector in PNG emitting about 87.7% of the total emissions (excluding the LULUCF) in 2015. When broken down into subsector emission, energy industries contribute the highest as seen in 2015 which contributed about 35% of the total sectoral emissions. As such the country has made some ambitious goals as outlined in the Vision 2050 which is to provide 100 per cent power generation from renewable sources. This is also elaborated in the country's Nationally Determined Contribution although it being conditional due to the financial capacity.

On a per technology basis, the renewable Energy Plan intends to deliver the following:

(i) For geothermal, the Gazelle grid is poised to be extended and cover West New Britain Province. An additional 95 MW should be added to the Gazelle grid by 2030 and another 110 MW to the Ramu Grid by 2050;
(ii) Increase hydropower capacity by 1483 MW by 2030 and further 3 680 MW by 2050 for the Pom and Ramu grids;
(iii) Deliver additional 62 MW biomass power to Ramu grid by 2030 and a further 34 MW by 2050;
(iv) Add 30MW wind power capacity for Pom and Ramu grids by 2030 and a further 20 MW by 2050;
(v) Add new 65 MW solar power capacity by 2030 and pursue the achievement of a further 35 MW by 2050;
(vi) Develop the first 5 MW Ocean energy facility for the economy by 2022, which is to be connected to the Pom grid.

Energy Efficiency is also seen as an important mitigation action in this sector which has also been elaborated in the NCCDMP and National Energy Policy. However, not much has been done in terms of implementation. There is currently a draft Minimum Energy Performance Standard and Labelling (MEPSL) regulation for heating, ventilation and air conditioning equipment and lighting.

Emissions from the Oil and Gas sector have increased rapidly in the past 4 years due to the LNG production. Private companies operating in this sector have taken the initiative to come up with

their own strategies in reducing these emissions. Oil Search Limited which is one of the longest operating oil companies in the country has a climate change strategy where the target was for a 12% reduction in emissions intensity by 2016 against the 2009 baseline. In 2016 the company achieved a 33% reduction in overall emissions against the baseline.

3.3.2.4. Transport

Transport is a significant emitting subsector under the Energy sector which contributed about 17% of the total sectoral emissions in 2015. However, the focus has been on infrastructure in order for proper access to the rural areas. This is also a major challenge due to the climate and geographical condition of the country.

The NCCDMP identifies three main mitigation actions for the road transport which are also elaborated in the National Transport Strategy but are yet to be implemented. The first action is to promote clean fuel technology and standards by establishing low carbon fuel standards for automobiles, light trucks, heavy trucks, buses, school buses and off-road transportation modes, and encourage research into clean fuel options and system-wide implementation. The second action is the National Government's Action on Vehicle emissions where a regulation will be passed to set standards for greenhouse gas emissions from vehicles at levels consistent with nation-wide and economic-wide greenhouse gas reduction targets (although these targets have not been set yet). And the third is for economic incentives for fuel efficient vehicles which support a system of fees and incentives that encourages the purchase or manufacture of fuel-efficient vehicles and discourages the purchase or manufacture of fuel inefficient vehicles.

As for air and marine transport, PNG is a member of the International Civil Aviation Organization (ICAO) and the International Marine Organization (IMO). Therefore, any resolution in relation to climate change mitigation that is agreed to by members of these organizations will be implemented in the country. One of the actions in which the country will be voluntarily participating in is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) after ICAO member states adopted the Assembly Resolution A39-3 to implement CORSIA.

3.3.2.5. Industrial Process and Product Use (IPPU)

The IPPU sector in PNG is quite small as the country relies heavily on imports. Most emissions in this sector come from product uses. Although, HFCs emissions from refrigeration and air conditions were not estimated in the GHG inventory of this BUR, they are identified as an improvement for the next GHG inventory. The country has signed the Kigali Amendment which aim is to phase out HFCs by 2050. CEPA, the implementing agency of the Montreal Protocol have drafted a regulation on Ozone Depleting Substances and Synthetic Green House Gas which will replace the Environment (Ozone Depleting Substances) Regulation 2007. The HFC phase out schedule of the draft Regulation is in line with the Kigali Amendment.

As for the general IPPU sector, the NCCDMP outlines an Eco-Industrial Development in this sector in which the goal is to create a node of industrial sustainability that minimizes waste, enhances inter-industry cooperation, and more effectively and efficiently utilizes local resources.

3.3.2.6. Waste

The waste sector in PNG is the second highest net emitting sector contributing about 6.5% of the total emissions (excluding LULUCF) in 2015. However, only some actions have been done in the country in terms of domestic solid waste and industrial waste. For the domestic solid waste, a project was implemented by JICA in collaboration with CEPA and NCDC and was focused on rehabilitating the largest open pit dump, improvement of the collection system, and the development the Solid Waste Management master plan. While for the industrial waste, an Oil Palm company, New Britain Palm Oil Limited, is implementing two projects which utilize methane produced from oil palm waste to generate electricity.

The same mitigation action in the NCCDMP, Eco-Industrial Development, anticipated for the IPPU sector will also apply to this sector for the industrial waste. While for the domestic solid waste, there are plans to implement similar projects as that in Port Moresby in other urban centres.

3.4. Quantitative Mitigation Projects

Table 3-1 Showing quantitative mitigation projects

Sector	Name of Mitigation Action	GHG affected	Objectives	Methodologies and Assumptions	Implementing Agencies	Year of Implementation	Performance Indicators
Energy	RE generated from Geothermal Power Project	CO_2, CH_4	Displacement of electricity that would be provided to the user(s) by more- GHG-Intensive means.	ACM0002 Consolidated baseline methodology for grid-connected electricity generation from renewable sources	New Crest Gold Mine (Lihir)	2006 to Current	Amount of GHG Reduced
Energy and Waste	RE Generated from Methane capture *Kumbango POME methane capture project*	CH_4	• Capture, collection and utilization of biogas from an in-ground anaerobic digester to be used as fuel to generate electricity in three biogas engines. • Biogas produced electricity will be used to displace electricity from	• AMS III.H: Methane Recovery in Wastewater Treatment • AMS I.D: Grid Connection renewable electricity generation • AMSI.F: Renewable electricity generation for captive use and mini-grid	New Britain Palm Oil Limited (NBPOL) (West New Britain)	2012 to Current	Amount of GHG Reduced

			the carbon intensive mini-grid at the Refinery and Fractional plant. • Connection of renewable generation source to the PNG Power Kimbe grid.				
Energy and Waste	RE Generated from Methane capture *Mosa POME methane capture project*	CH_4	• Capture, collection and utilization of biogas from an in-ground anaerobic digester to be used as fuel to generate electricity in three biogas engines. • Addition of renewable generation source to the PNG Power Kimbe grid.	• AMS III.H: Methane Recovery in Wastewater Treatment • AMS I.D: Grid Connection renewable electricity generation	New Britain Palm Oil Limited (NBPOL) (West New Britain)	2012 to Current	Amount of GHG reduced
Energy	Facilitating Renewable Energy &	CO_2, CH_4 and N_2O	Enabling of the application of feasible renewable	• Component 1: Energy Policy, Planning, and Institutional Development • Component 2: Renewable	• UNDP • Climate Change and Development	2017-2021	Amount of GHG Reduced

	Energy Efficiency Applications for Greenhouse Gas Emission Reduction		energy and energy efficiency technologies for achieving greenhouse gas emission reduction in PNG	Energy and Energy Efficiency Technologies Applications • Component 3: Financing of Renewable Energy and Energy Efficiency Projects • Component 4: Energy Development and utilization Awareness Enhancement *(Each component has its own set of Methodologies)*	Authority • PNG Power Limited • Partnering Provinces (Milne Bay, Eastern Highlands, and East Sepik) •		
Energy	EU-GIZ Adapting to Climate Change and Sustainable Energy (ACSE) Program "Integrated Water and Sustainable Energy (IWASE) Project" Rigo District, Central Province.	CO_2, CH_4 and N_2O	To support the socio-economic development of three rural communities in the Rigo District: Imaugoro, Keapaera and Kalo villages and to reduce their vulnerability against climate change impacts through the provision of reliable, integrated water and sustainable energy. At national level this objective will contribute towards fulfilling	The project has four outcomes 1. Water supply systems including, protected water sources, treatment and distribution systems, pumps and reservoirs, rainwater harvesting systems are established and used in the target villages. 2. Stand-alone street lighting systems are established in the target communities 3. Refrigeration systems are provided to the target communities 4. Health care centers in the target villages are provided with energy and water supply *Different methodologies will be*	• Department of Petroleum and Energy • Central Province Local Level Government (LLG) • PNG Power • Water PNG • University of PNG	2017	Amount of GHG prevented from being emitted

			PNG's commitment to the Kyoto Protocol.	*used in each outcome.*			
Energy	RE generated from Biomass Project	CO_2, CH_4 and N_2O	Displacement of electricity that would be provided to the user(s) by more- GHG-Intensive means.	Stage 1 (2010-2011): Identification of suitable areas for biomass plantation through soil sampling and studies conducted in more than 2,500 kms across PNG Stage 2 (20110-2014): Planting of over 180,000 trees at over 30 sites across PNG to evaluate growth and survival rates in order to select the best species of trees to support large-scale plantations. Stage 3 (2014-2017): Agreements were negotiated with landowners to lease land covering 16,000 ha to be planted under sustainable forestry practices in order to underwrite the PPA signed with PNG Power Limited for the initial 15MWe. Stage 4 (2018-2019): The 15 MWe power plant modules will be constructed within the plantation area and the power will be tied	Oil Search, PNG Biomass	First delivery of power by 2020	Amount of GHG reduced

				into the 132kV Ramu electricity grid commencing first delivery of power by 2020. Stage 5 (2020+): Ultimately 30 MWe of sustainable power provided into the Ramu grid			

Chapter 4. Information on the description of Domestic Measurement, Reporting and Verification (MRV) System Arrangements

4.1. Introduction and objective of PNG's MRV System

PNG's current MRV arrangement is for REDD+ or LULUCF sector for that matter, and is based on MRV rules prior to 2015 Paris Agreement (MRV in 2015 Agreement). As a signatory to UNFCCC, PNG made it its responsibility to report its MRV of mitigation actions in its BUR1 based on its NDC activities and set priorities. MRV for other mitigation actions as outlined in the PNG's NDC and national goals and policies are yet to be developed. When developed, they should complement the current PNG's MRV system. Hence, this chapter focuses primarily on MRV for REDD+.

After consultation with various key stakeholders, PNG has identified the following requirements to establish a national MRV system:

■ A remote sensing system to measure and monitor the area of forest and land use change, which uses software to interpret and classify data taken by earth observation satellites;

■ Regular forest and land surveys to identify the condition of forest and land and its carbon stocks with verifying and corroborating the result from remote sensing system;

■ The development of a comprehensive greenhouse gas (GHG) inventory from the sectors namely: (1) energy; (2) industrial processes and product use; (3) agriculture, forestry and other land use; and (4) waste based on 2006 IPCC Methodology.

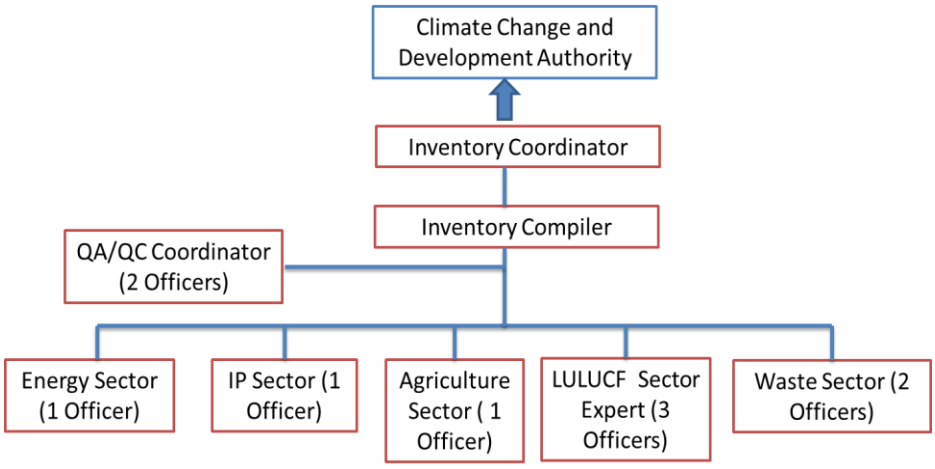


Figure 4-1: PNG GHGi Institutional Arrangement

A preliminary diagnostic on current MRV capabilities across different institutions in PNG indicates that most systems use satellite images and a few ground measurements to monitor land use. These systems have been sponsored by government departments and agencies, academic institutions, and NGOs. Few of these systems have national coverage and none includes all types of greenhouse gas emissions or land-use changes at the moment. Technology, feasibility, and sustainability are the factors in the selection of an MRV system.

4.2. Description of the design and set up of REDD+ MRV System

PNG has been developing its national MRV system based on Decision 4/CP.15 (Methodological Guidance relating to REDD+) and the Decision on the Outcome of the work of the AWG/LCA of COP16. The national MRV system was developed in phases with established framework that supported a fully operational performance-based REDD+ mechanism within a time-frame of three years. PNG National MRV System was established to support the implementation of REDD+ policies and measures as PNG sees REDD+ as the most important climate change mitigation action given the fact that LULUCF is the sector with both highest removals and emissions in PNG compare to the other sectors.

The roadmap developed for the establishment of a MRV system in PNG supported all stages of REDD+ readiness efforts, as outlined in the Climate Change Development Strategy (CCDS) and the Interim Action Plan. The REDD+ process followed 3 broad stages:

Phase 1 - Readiness: Capacity development for the establishment and testing of the national MRV system which involves the assessment of PNG's historical forest area and carbon stock changes;

Phase 2 - Implementation supported by transitional funding: Operational National Forest Monitoring System with functionality of the Satellite Land Monitoring System and National Forest Inventory (pre-sampling data for conservative estimates of EF);

Phase 3 - Payments for verified performance: Fully operational national MRV system. Integration of REDD+ activities with other mitigation mechanisms under UNFCCC.

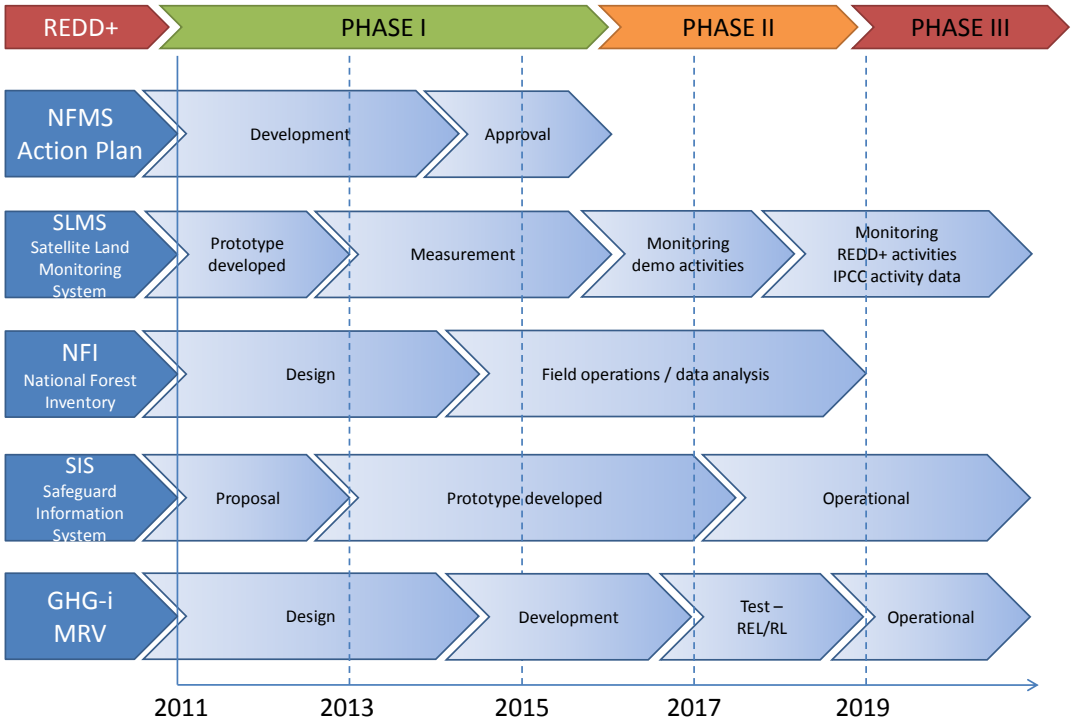


Figure 4-2 PNG MRV Roadmap (developed in 2011, revised in 2018)

4.2.1. Institutions, entities, arrangements and systems involved in domestic REDD+ MRV

The national system was setup through identification and development of an institutional structure with responsibilities undertaken.

The elements of the MRV system outlined above will form part of the National System that a country will establish in accordance with the Cancun Decision on REDD+. In the case of PNG, a number of institutions and government departments were involved in activities related to the functions of a MRV system for LULUCF;

- **Climate Change and Development Authority (CCDA)** was mandated by the NEC to develop and coordinate the national MRV system, Coordinating entity for all Climate Change related policy and actions in PNG and the National Designated Authority (NDA) under the United Nations Framework Convention;

- **Papua New Guinea Forest Authority (PNGFA)** as responsible agency for the management of PNG's forests was overseeing the monitoring and surveillance of forest areas; **Forest Research Institute (FRI)** is the forestry research arm of PNGFA and operates a network of permanent sampling plots.

- **Department of Agriculture and Livestock (DAL)** is the central coordinating body for the agriculture sector including the planning and promotion of agricultural development and

productive employment generation in the sector which may involve conversion of primary and secondary forest.

- **Conservation and Environmental Protection Authority (CEPA)** (formerly the Department of Environment and Conservation) is tasked with the administration and implementation of the Environment Act 2000 to ensure good environmental protection and management and wise management of PNG's natural resources.

- **Department of Lands and Physical Planning (DLPP)** is responsible for managing the alienated and customary land in PNG, including support for land use plans at the GoPNG, province and district levels.

- **National Mapping Bureau (NMB)** is responsible for providing Papua New Guinea, specifically also GoPNG, with mapping products and services.

- **Mineral Resource Authority (MRA)** is responsible for regulating all mining activities in Papua New Guinea according to the Mining Act and Regulation 1992. MRA is also a key data provider of spatial datasets particularly the mining tenement boundaries and other geological information needed in development and implementation of the forest and land-use monitoring system;

- **University of Papua New Guinea (UPNG) the** Remote Sensing Unit is currently operating PNG's most advanced GIS system and supporting GoPNG in many of the tasks outlined above.

- **Papua New Guinea University of Technology (UNITECH)** is mandated to build capacity in lands, surveying and forestry, involving research and training on GIS, remote sensing and biomass.

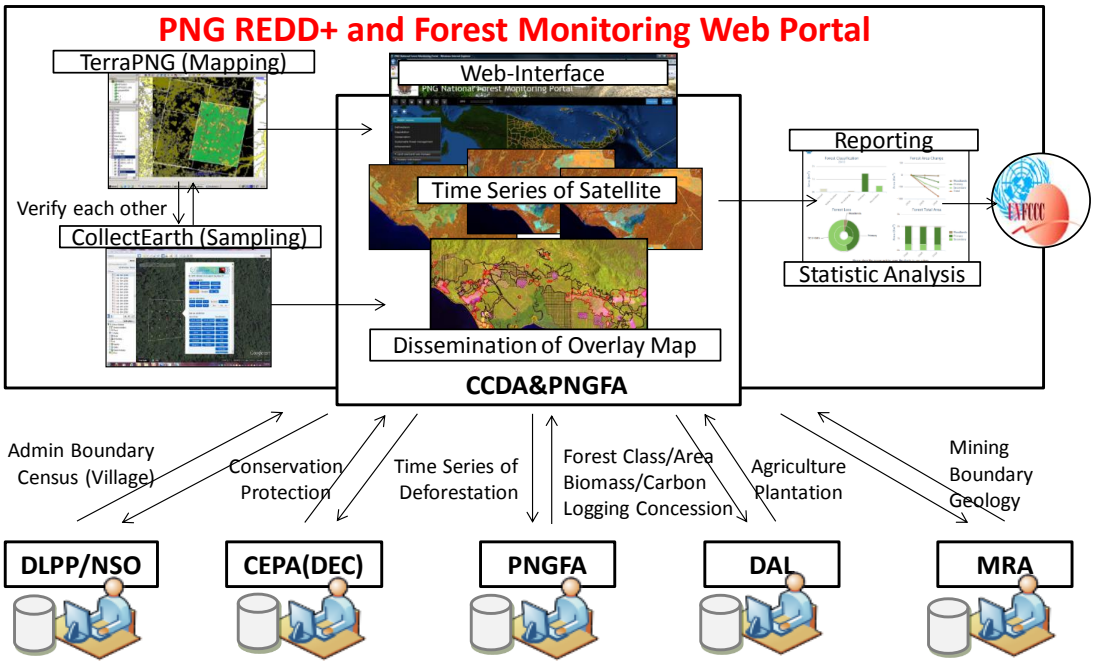


Figure 4-3: PNG Government institutions individual roles in the domestic MRV process

4.2.2. Recognize existing processes, arrangements or systems

The development of an UNFCCC compliant MRV system is key elements to support REDD+ policies and measures and to assess PNG performance in climate change mitigation. Internationally, REDD+ is captured in Article 5 of the Paris Agreement and accounting rules are also defined.

Nonetheless, existing guidelines and reporting requirements about the LULUCF sector for Non Annex I Parties under UNFCCC are sufficient to inform the establishment of a PNG MRV system at this point.

This approach is considered to be conservative as the MRV systems under the Convention are comprehensive and inclusive of all possible land use activities. In this respect the MRV system of PNG is composed of four main pillars:

1) A Satellite Land Monitoring System to assess forest area and forest area changes (i.e. activity data - AD);

2) A Multi-Purpose National Forest Inventory to assess carbon stocks and carbon stock changes (i.e. emission factors - EF);

3) A National GHG Inventory to estimate and report anthropogenic emissions by sources and removals by sinks.

PNG REDD+ and Forest Monitoring Web-Portal to share information (domestically and internationally) on all forest and REDD+ related issues, to allow the participation of all relevant stakeholders and to

ensure that the implementation of national REDD+ policies and measures, including safeguards, are results-based.

These pillars and the portal were operated by CCDA and PNGFA for the coordination of the administrative and technical aspects, for the overall quality of reported estimates to UNFCCC and for the fulfilment of procedural requirements and safeguards of REDD+.

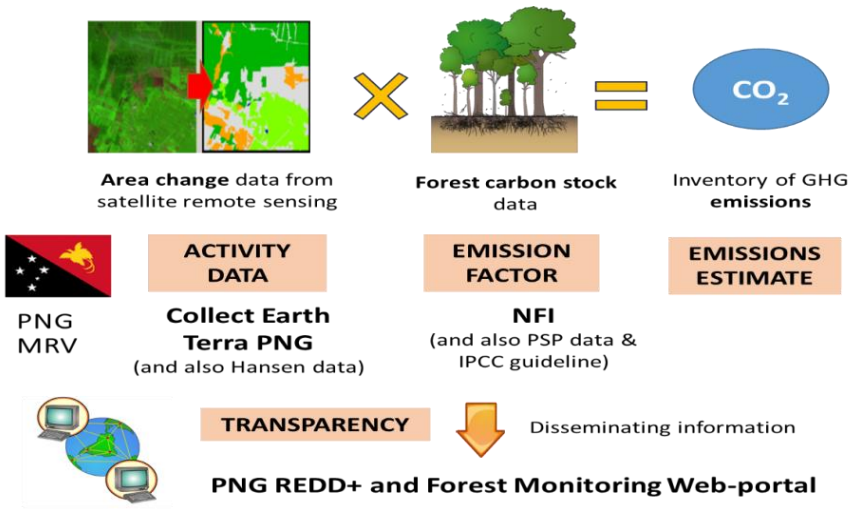


Figure 4-4: PNG existing REDD+ MRV System

4.2.3. Describe new processes, arrangements or systems established

PNG developed a MRV system by learning from other countries' experiences. PNG system combined inputs from already operational and successful monitoring systems that were built on existing capabilities and resources in the country with the objective to develop, shift and align resources to institutions with capacity to deliver, and to meet the quality in compliance with set or accepted methods and standards.

Building on existing resources and technical and financial assistance, the system is envisaged to cover all aspects of a future MRV system, including software, hardware, and capacity building to enable PNG to independently and reliably operate its system in the long-term.

4.3. Description of the methodologies and monitoring protocols

The description of methodologies and monitoring protocols include information on the systems for collection and management of relevant data and how methodologies are being documented.

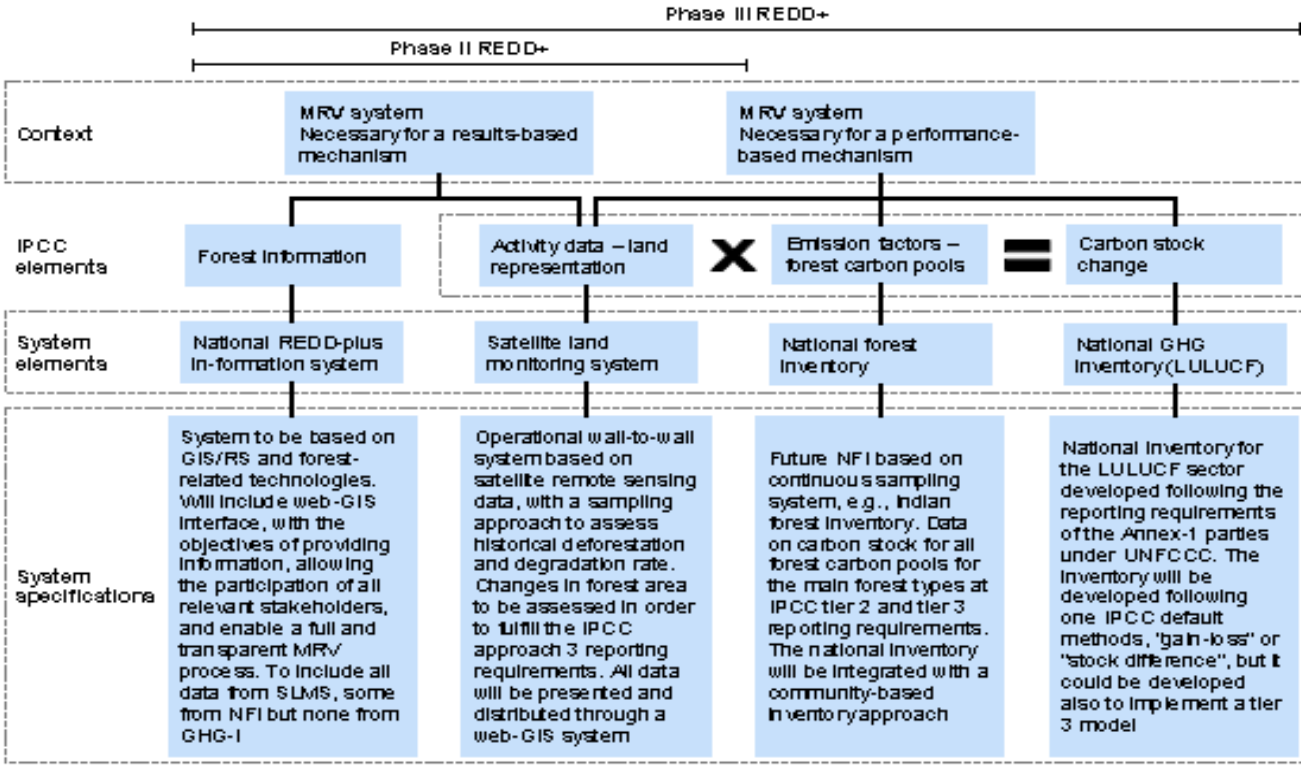


Figure 4-5 The four basic elements related MRV for REDD+

4.4. Approach to domestic REDD+ verification

4.4.1. Approach used to conduct domestic verification of the information

The domestic MRV system currently is set up for REDD+, therefore, both national and international experts from forestry and agriculture related agencies are involved in the design of the MRV system through to the verification process including external technical experts.

There is a MRV technical working group coordinated by CCDA where the experts meet and make technical input to the MRV system and the ongoing progress of work in the country. The experts come from different agencies within the government and also from NGO.

The experts discuss what the country has been doing and report accordingly in relation to PNG's activities on Climate Change Mitigation and Adaptation. The discussion also includes other related work done in the country. GoPNG through CCDA collects information from different agencies, both public and private, for its final documentations for submission to the UNFCCC.

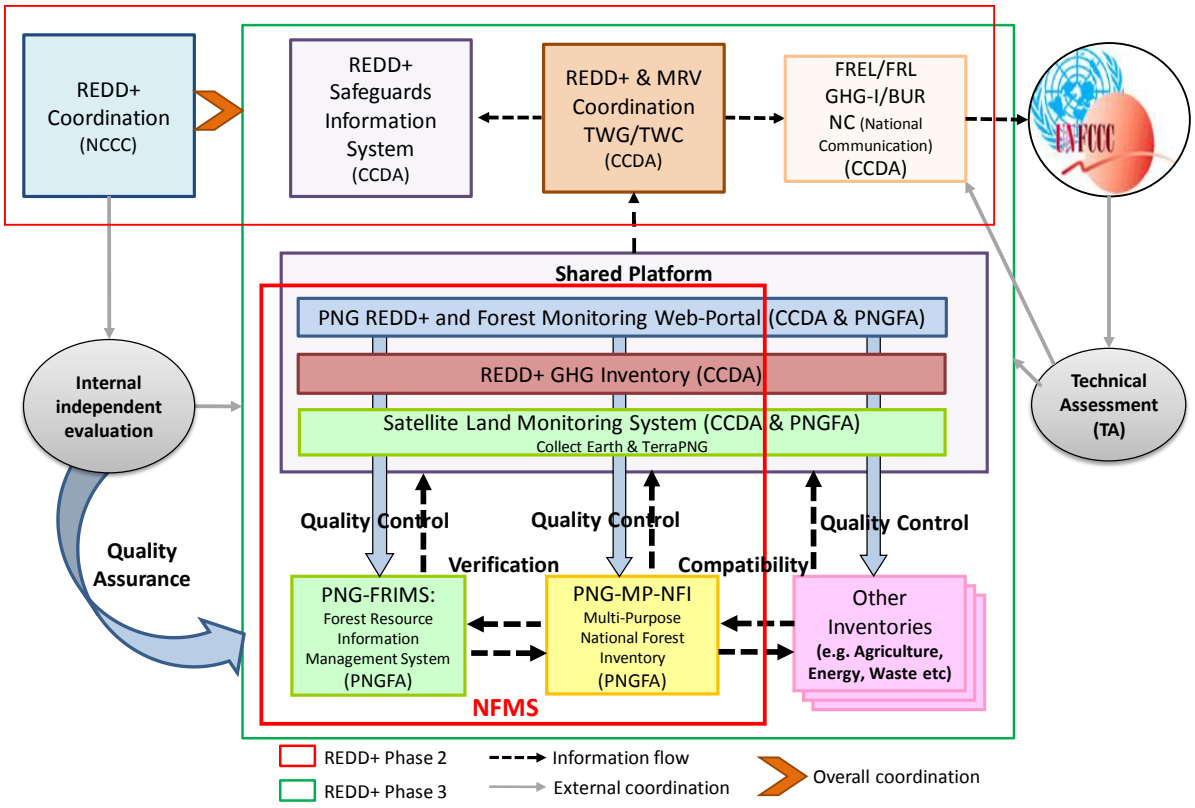


Figure 4-6 PNG's Approach to Domestic Verification (developed in 2011, revised in 2018)

4.4.2. Description of experts engaged in the verification and the mechanisms of verification

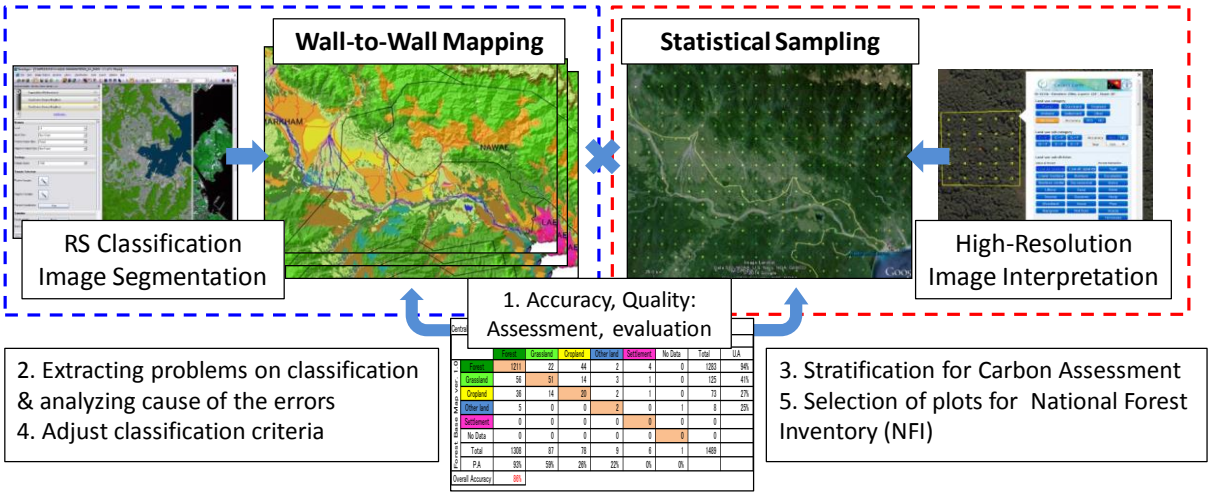
There are number of international experts engaged to assess and guide GoPNG in its effort to progress its MRV work. The international experts that support PNG come from the implementing entities (development partners) that provide technical assistance to GoPNG. These experts are chosen from different fields with deep specializations in the following areas; Geographic Information System (GIS) and Remote Sensing, Land Use and Land Use Change, Agriculture; Forestry, and Environment.

Activity data (AD) from the Collect Earth and Terra-PNG land use assessments are available. This should be able to provide adequate information on the emission of carbon dioxide ($CO_{2)}$ from the LULUCF and Agriculture sectors (AFOLU). The collection of data from other sectors (Waste, Energy and Industrial Process) are all done on parallel through consultation of regional, provincial and district offices. The lead sector officers – responsible for doing the activity data inventories from the different sectors – organize the compilation and provide those activity data to the designated authority for analysis and estimation.

In the LULUCF sector, PNGFA and CCDA house the Collect Earth and Terra-PNG system respectively as part of their National Forest Monitoring system. Both systems are used to collect activity data on Forestry, Land use and Land use Change. Since Collect Earth and TerraPNG uses different mapping approaches (former uses point-sampling while later uses wall-to-wall mapping), their output or results

will be used to verify each other. Both results are then disseminated onto the PNG REDD+ and Forest Monitoring Web Portal where they are accessible to the public and UNFCCC reviewers. The reviewers can then review and verify the results.

GHG inventories and emissions results from other sectors (Energy, Waste, Transport and Industrial Process) in PNG will also be uploaded online onto the PNG's REDD+ and Forest Monitoring Web Portal by means of internet links for transparency and verification purposes.



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

Figure 4-7 Verification by two different methods of Activity Data

4.4.3. Future Plan

The scope of PNG's current MRV system will be expanded to cater for the MRV needs of other mitigation actions that were outlined in PNG's NDC, National Goals and Policies when relevant systems are in place and operational. Current institutional arrangement will be revised when other mitigation actions are developed in the country. A robust internal verification system and an uncertainty mechanism will be developed to address existing and future gaps in PNG's MRV system.

Chapter 5. Constraints, Gaps, and Capacity Needs

Papua New Guinea faces similar situation as other Non-Annex I Parties in terms of constraints, gaps and capacity needs. Table 5-1 below provides a list of constraints, gaps and capacity needs that were faced under the climate change activities carried out in the country. Some of these issues may be addressed through technical and financial support.

Table 5-1 List of constraints, gaps and capacity needs

Activities	Constraints	Gaps	Capacity Needs
GHG Inventory	- Data sensitivity and confidentiality - Limited budget for data collection and survey - Geographical situation of the country preventing data collection (i.e. poor accessibility to communities) - Poor existing institutional arrangement	- Unavailability of data from data sources - Inaccurate and inconsistent data - Poor data management from previous inventory - Country Specific Emission Factor - No database management system - No sector legal regulations for provision of data	- Understanding of 2006 IPCC Guidelines - Data achieving and management skills - Sector specific training needs - Understanding of different software's used - Understanding of initiatives under technology transfer - QA/QC knowledge and skills - Uncertainty analysis knowledge and skills
Mitigation	- Limited budget - Data sensitivity - Geographical situation of the country preventing data collection (i.e. poor accessibility to communities) - Ineffective institutional arrangement	- Other than REDD+ there is no established MRV system for mitigation actions - No legal regulation for sectoral emission mitigation plans	- Mitigation analysis knowledge and skills - Understanding of initiatives under technology transfer - QA/QC knowledge and skills - Uncertainty analysis knowledge and skills
Adaptation	- Limited Budget - Geographical situation of the country preventing data collection - No National Adaption Plan	- No established MRV system for Adaptation Activities - Country Specific historical data for climate induced hazard modelling	- Vulnerability Need Assessment (VNA) knowledge and skills - Climate Induced Hazard modelling knowledge and skills - Monitoring and Evaluation (M&E) knowledge and skills

Chapter 6. Financial and Technical Support Received for Climate Change Activities

Over the years Papua New Guinea has received either financial or technical support for implementing climate change activities in the country. The table provides a list of financial and technical support PNG has received.

Table 6-1 Support received for Climate change activities

Climate Change Activity	Funding Source	Project Title	Duration	Cost	Development Partner (s)	Implementing Agencies
Adaptation	Adaptation Fund	Enhancing adaptive capacity of communities to climate change related floods in the North Coast and Islands Region of Papua New Guinea	2012-2017	US$ 6.5m	UNDP	NSO, NDC, Provincial Administrations
	USAID	Mangrove Rehabilitation for Sustainably-Managed, Healthy Forests	2012-2015 (5 year project but early phase out)	US$ 7m	USAID	IUCN, TNC UPNG & 5 Provincial Administration
	USAID	Coastal Community Adaptation Program	2013-2017	US$1.4m	USAID, Development Alternatives Inc (DAI), University of the South Pacific (USP) & Kramer Ausenco Papua New	PA (Central Province & New Ireland Province)

					Guinea Ltd	
	UN Habitat	Cities and Climate Change Initiative	2012-2014	US$1m	UN Habitat	UPNG, NCDC & Office of Urbanization
	GIZ German Government	Coping with Climate Change in the Pacific Islands Region	2009-2013	EUR 4.2m	GIZ/SPC	CCDA, NARI, DAL
	USAID, AusAID, GEF	Coral Triangle Initiative	2010-2015	US$ 11 million	USAID	CEPA, NFA, CCDA, (Various Departments)
	WB and Japanese Government	Global Fund for Disaster Risk Reduction (GFDRR).	2012-2015	US$ 2.6m	WB	NARI, DAL, OCCD & DoW
	German Government, EU	Solar Farm and Integrated Water Supply for Rural Communities in PNG	2016-2018	EUR 1m	EU-GIZ	DPE, Central Provincial LLG, PNG Power, Water PNG
	Australian Government	Pacific-Australia Climate Change Science and Adaptation Planning Program	Ended June 2013	Regional Program (Total funding unspecified)	AusAID, CSIRO, BoM	NWS, CCDA
	ADB	Strategic Program for Climate Resilience (SPCR) - Building Resilience to Climate Change in PNG	2015-2021	US$ 25m	ADB	PNG Ports, CFDA, NARI, DAL
	EU	Migration, Environment and Climate Change: Evidence	2014-2016	EUR 2.4m	IOM	Foreign Affairs,

		for Policy				NDC,UPNG,
	USAID/PACAM	CBO/CSO Climate Change adaptation projects	On-going	US$ 1,908,478	PGRD	CARE International, ChildFund, Conservation International, MND, PNG CLMA
	EU-GCCA (Global Climate Change Alliance)	Community Climate Change Adaptation Projects	2012-2015		PACE-SD USP & CCCSD UPNG	UPNG
REDD+ & Mitigation	UN-REDD	PNG UN-REDD Programme	2011-2017	US$ 6,388,884	UNDP/UNEP/FAO	CCDA, PNGFA
	World Bank	Forest Carbon Partnership Facility Project	2015-2017	US$ 3.5m	FCPF/UNDP	CCDA, PNGFA, CEPA, DAL, DLPP, DNPM
	World Bank	Forest Carbon Partnership Facility Project 2	2018-2020	US$ 5m	FCPF/UNDP	CCDA, PNGFA, CEPA, DAL, DLPP, DNPM
	Italy Government (Italy-PNG MoU)	REDD+ Programme	2017-2019	Euro 400,000	CfRN	CCDA
	Australian Government	Pacific Appliance Labelling and Standards	2017-2018 (The programme started in 2012 and will end in 2018. PNG joined in	Technical Assistance	SPC	CCDA

			2017)			
	JICA	Biodiversity Conservation through implementation of the PNG Policy on Protected Areas	2015-2020	K15.3 million	JICA	CEPA
	JICA	Capacity Development on Mine Waste Management	2015-2020	K10.2 million	JICA	CEPA, MRA & DMPGM
	JICA	Promotion of Regional Initiative on Solid Waste Management in Pacific Island Countries	2015-2020	K47.2 million	JICA	CEPA and NCDC
	JICA	Port Moresby Wastewater Management Improvement	2017-2020	K8.9 million	JICA	DoH, CEPA and Eda Ranu
	GEF	Facilitating Renewable Energy & Energy Efficiency Applications for Greenhouse Gas Emission Reduction (FREAGER)	2017-2021	US$ 3,140,640	UNDP	CCDA, PPL, Eastern Highlands Provincial Government, East Sepik Provincial Government, Milne Bay Provincial Government
MRV	GEF	Strengthening capacity in the agriculture and land-use sectors for enhanced transparency in implementation of monitoring Nationally Determined Contribution (NDC) under the Paris	2018-2021	US$ 1m	FAO	CCDA, PNGFA and DAL

		Agreement in Papua New Guinea				
	GEF	Preparation of the First Biennial Update Report and Third National Communication under UN Framework Convention on Climate Change (UNFCCC)	2014-2020	US$ 832,000	UNEP	CCDA, NSO,NWS, CEPA, PNGFA, DNPM,DAL,DPE,DoT, DLPP
	JICA	Capacity Development for Operationalization of PNG National Forest Resource Information Management System (FRIMS) for Addressing Climate Change	2014-2019	K 20.3 million	JICA	PNGFA
	JICA	Project for enhancing capacity to develop a sustainable GHG inventory system for PNG	2017-2021	K8.7 million	JICA	CCDA
	GEF	Papua New Guinea: Preparation of Intended Nationally Determined Contribution to the UNFCCC	2017-2021	US$ 210, 000	UNEP	CCDA
	EU	Technical support to the Papua New Guinea Forest Authority to implement a multipurpose National Forest Inventory	2014-2019	EUR5.8 million	FAO	PNGFA

Chapter 7. Other Relevant Information

7.1. Update on REDD+ Safeguards and Safeguards Information Systems

PNG is adopting a country approach to safeguards to meet the United Nations Framework Convention on Climate Change (UNFCCC) requirements, namely, the Cancun Agreements (Decision 1/CP.16)[11], the Durban Outcome (Decision 12/CP.17)[12] and the Warsaw Framework for REDD+ (Decision 9/CP.19)[13]. This country approach is also consistent with the vision stated in its National REDD+ Strategy (2017 – 2027)[14],

> *To catalyse transformational change within the forest and land use sector towards a new responsible economy with lower GHG emissions, stronger long-term economic growth and community livelihoods and the effective conservation of biodiversity and ecosystem services while ensuring the Papua New Guinea's forest resources are used in a sustainable and equitable manner for the benefit of current and future generations.*

PNG has established a multi-stakeholder Technical Working Committee on Social and Environmental Safeguards (SES TWC) to serve as the primary platform for engaging stakeholders in its country approach to safeguards. The SES TWC is co-chaired by Department of National Planning and Monitoring (DNPM) and CCDA. Its members comprise representatives from government agencies, academic institutions, civil society organizations and private sector. At the national legislative and policy level, the Climate Change (Management) Act (2015) also gives consideration towards addressing and respecting the Cancun Safeguards.

As part of addressing safeguards, an assessment of PNG's policies, laws and regulations (PLRs) against the Cancun safeguards has been completed. The findings from this assessment were used to clarify the seven (7) Cancun Safeguards in the PNG context as well as to identify information needs associated with how safeguards are "addressed." Additionally, the country has also identified initial sources of information to inform the design of a safeguard information system (SIS) for PNG using existing and relevant information systems and sources.

Based on the elaboration of specific policies and measures that will be identified through the development of a REDD+ Finance and Investment Plan (RFIP) for PNG, an analysis of the benefits and risks in relation to the Cancun safeguards will be undertaken. This will be followed by assessing the institutional capacity to implement the PLRs and ensure safeguards are "respected". The results are expected to further inform the design and operation of a SIS. Once operational, the SIS will serve as the primary information source for the development and preparation of the Summary of Information (SOI).

In the future, PNG, through its country approach, will also work towards meeting safeguards requirements for all applicable REDD+ financing such as the results-based payments under the Green Climate Fund, as well as other financing for key REDD+ actions.

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[11] The full text of Cancun Agreements is available at http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=2

[12] The full text of Durban Outcome is available at http://unfccc.int/resource/docs/2011/cmp7/eng/10a02.pdf

[13] The full text of Warsaw Framework for REDD+ is available at http://unfccc.int/resource/docs/2013/cop19/eng/10a01.pdf#page=33

[14] The full National REDD+ Strategy is available at https://redd.unfccc.int/documents/index.php?file=4838_1_papua_new_guinea_national_redd_2B_strategy.pdf

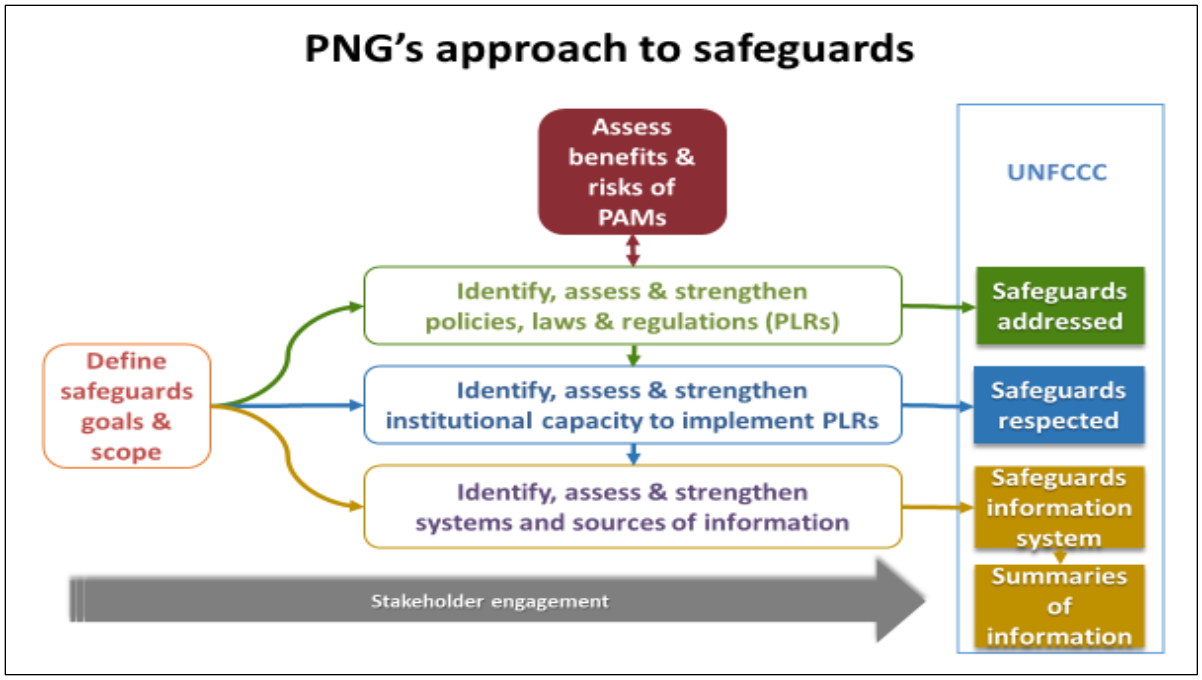

Figure 7-1 PNG's approach to safeguard

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Technical Annex pursuant to Decision 14/CP.19

Results achieved by Papua New Guinea from Reducing Emissions from Deforestation, Forest Degradation and Enhancement of Forest Carbon Stock

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Chapter 1. Introduction

1.1 Background

Papua New Guinea (PNG)'s forests cover 78% of the country's land area with 77%[15] of them undisturbed. Nevertheless, the forest is coming under increasing pressure from logging, agriculture (commercial and small-scale) and mining activities. Due to this reason, PNG has taken various steps in seeking to both initiate and support on-going global efforts to combat climate change, particularly in relation to carbon abatement opportunities offered through the preservation and sustainable management of its tropical forests.

The concept of REDD+ was first recognised and accepted at the 2007 UNFCCC Conference of Parties (COP) in Bali and later adopted under Warsaw REDD+ Framework in 2013, and also under the Paris Agreement in 2015 (mentioned in article 5, paragraph 2). As part of PNG's involvement in its inception and development, the Government of PNG, through the Climate Change and Development Authority (CCDA) and PNG Forest Authority (PNGFA) have made considerable effort in carrying out various REDD+ readiness initiatives, with the support of international multilateral and bilateral development partners. REDD+ is seen as a crucial mechanism for tackling the increasing rates of deforestation and forest degradation in the country and for improving the livelihoods of forest dependent communities.

So far, PNG has completed assessment of the drivers of forest cover change and developing the four key components of REDD+: [16]

- **National REDD+ Strategy** (NRS) – this has been completed and approved by NEC in May 2017. The strategy includes key action areas across sectors including specific action areas for forestry targeting: updating of legislation, strengthening management, monitoring and enforcement capacity, strengthening and diversifying timber production and increasing capacity through training and strengthening of research and training institutions.
- **Forest Reference Level** (FRL) completed and submitted to the UNFCCC in 2017. UNFCCC technical assessment process has been completed and the modified FRL was submitted and published on UNFCCC website. PNG FRL submission shows steady increase of historical (2001-2013) annual emissions of the forest sector from 21.5 million t CO2 eq in 2001 to 41.7 million t CO2 eq in 2013, which strongly fit to linear regression. Such linear regression model;

  Annual emission (t CO2 eq) = 1,679,607 x Year – 3,339,358,085

[15] Source: PNGFA Collect Earth Assessment 2016
[16] COP Decision 1/CP.16-p70
Introduction photo: ©CCDA/Paul Hasagama

was used to predict the annual emissions during the reference period (2014-2018). The difference between the actual annual emission and the predicted annual emission estimated in the FRL is considered as PNG's REDD+ results. PNG FRL is described in details in the next chapter.

- **National Forest Monitoring System** (NFMS) – provides information on the nature of forest and forest management and in PNG has been established and developed by PNGFA in partnership with CCDA and FAO (the web-portal of PNG's NFMS can be found here: http://png-nfms.org).
- **Safeguards and Safeguards Information System (SIS)** – a roadmap has been developed based on a comprehensive assessment of PNG's legal safeguards including environmental regulations. PNG is currently working on the development of a Summary of Information (see BUR chapter 7 for detail information on the status of PNG's SIS).

Central to PNG's approach to REDD+ as laid out in the NRS is the need to allow development to continue but for that development to be done in ways that are economically and environmentally sustainable. An approach that is summed up by PNG's vision for REDD+: "To catalyse transformational change within the forest and land use sector towards a new responsible economy with lower GHG emissions, stronger long term economic growth and community livelihoods and the effective conservation of biodiversity and ecosystem services while ensuring that Papua New Guinea's forest resources are used in a sustainable and equitable manner for the benefit of current and future generations."

In PNGs recent FRL submission in January 2017, it was identified that between 2000 and 2015, 261,528 ha of forest was cleared, resulting in average emissions of over 5m tCO_2e per annum. This deforestation was primarily driven by the conversion of forest land to crop land which accounts for 87% of deforestation, with shifting agriculture responsible for 63% of the land deforested and commercial agricultural developments, primarily in the form of Oil Palm, are responsible for 30% of the deforested land.

Special Agricultural and Business Leases

The trend in clearance for commercial agriculture has increased in the past decade following the rapid expansion of the Special Agricultural Business Leases[17], which were allocated over 5.1million hectares of land, or more than 10 per cent of PNG's total land mass. While only a small number of these have initiated development, there has been an official moratorium and subsequent suspension of Special Agricultural Business Leases, due to abuse of this legal mechanism within the respective legislation. However, some logging and conversion have already occurred.

Population Growth

These trends in clearance of land for shifting agriculture as well as the demand for development through commercial agricultural developments are closely linked to on-going population growth and increases in

[17] Section 10 and 103 of the Lands Act, 1996.

population density. With PNGs population increasing rapidly at 3.1% per annum this trend is likely to continue and worsen over the coming years becoming a significant driver of forest cover change in terms of conversion of forest to both shifting and permanent cropland and oil palm development.

Reforestation and Plantation development

Conversely, efforts to enhance forest cover through reforestation and forest rehabilitation activities have been attempted but are still significantly limited. Despite ambitious goals set out within national policies to establish 800,000 ha of forest planation by 2050[18], PNGFA estimates that it would be more feasible to plant a further 20,000 ha of forests in addition to the 60,000 already reforested prior to 2030. The PNGFA's *Painim Graun Planim Diwai* initiative captures the intent of the PNG Vision 2050. However, this initiative faces significant challenges in securing access to land and investors for this expansion, so it is not likely to be fully realised within the estimated timeframes.

1.2 Objectives for submitting the REDD+ results

PNG submits its REDD+ results assessed against its technically assessed FRL as an annex to the BUR1. PNG also includes an annex in which the REDD+ results are recalculated against a FRL to determine the share of REDD+ results presented to the UNFCCC that could be eligible to the GCF pilot programme for REDD+ results-based payments. Prior to submitting BUR1, PNG has made significant progress towards developing capacities to establish its national REDD+ architecture to be eligible to receive results-based payments through the UNFCCC. So far, PNG has managed to establish three (3) of the four (4) REDD+ elements, notably the National Forest Monitoring System (NFMS), Forest Reference Level (technically assessed FRL) and the National REDD+ Strategy (NRS). PNG's Safeguard Information System (SIS) development is progressing well and should be completed by December 2019. Considering this level of preparedness, PNG is now seeking to claim for the results-based payments under the GCF RBP Pilot Programme to further strengthen its REDD+ System to function effectively for the conservation of the globally last remaining pristine tropical forests, such as those in PNG.

[18] PNG Vision 2050

Chapter 2. Technically Assessed Forest Reference Level

The assessed FRL in terms of CO_2 equivalent, including references to the modified FRL submission and technical assessment report (TAR)

In accordance with decision 13/CP.19 and in the context of results-based payments, PNG proposed that its FRL covers the activities relating to "reducing emissions from deforestation", "reducing emissions from forest degradation" and "enhancement of forest carbon stocks", which are among the elements included in decision 1/CP.16, paragraph 70.

In its submission, PNG had developed a national FRL for the results period 2014 – 2018 with values corresponding to 43,369,737 (2014), 45,049,344 (2015), 46,728,951 (2016), 48,408,557 (2017) and 50,088,164 (2018) tonnes of carbon dioxide equivalent per year. The technical assessment (TA) of PNG's FRL took place (as a centralised activity) from 13 to 17 March 2017 in Bonn, Germany, and was coordinated by the UNFCCC secretariat.[19] It was noted by the assessment team that the data and information used by PNG in constructing its FRL were mostly transparent and complete and in overall accordance with the guidelines contained in the annex to decision 12/CP.17. Some modifications were made to the initial FRL submission as a result of the technical assessment resulting in a modified FRL submission.

The technical assessment (TA) process gave PNG the opportunity to provide clarifications and information that were considered by the Assessment Team (AT) in the preparation of the report.[20] As a result of the facilitative exchange with the AT during the TA session, PNG submitted a modified version of its FRL on 10 July 2017, which took into consideration the technical inputs by the AT. The modifications improved the clarity and transparency of the submitted FRL and altered the approach used to construct the proposed FRL. The TA report (TAR[21]) was prepared based on the modified FRL submission and was published on the UNFCCC website on 02 March 2018. The TAR contains the assessed FRL and a few areas identified by the assessment team for further technical improvement, according to the scope of the technical assessment in the annex to decision 13/CP.19. The modified submission that contains the assessed FRL and the original submission are available on the UNFCCC website as well as the REDD+ Web platform.[22]

[19] Decision 13/CP.19, annex, paragraph 7.
[20] Decision 13/CP.19, annex, paragraphs 1(b), 13 and 14.
[21] https://unfccc.int/documents/65143
[22] See https://redd.unfccc.int/submissions.html?country=png.

Table 2-1: PNG's FRL building blocks

Building blocks	**Description**
Forest definition	○ Tree crown cover ≥ 10%, an area of ≥ 1ha with trees able to attain a minimum height of 3 meters (m)
Data (AD & EF)	Activity Data (AD) ○ Annual time series data for 2000 to 2015 available ○ Accuracy Assessment – Done Emission Factors (EF) ○ Emission factors calculated for each of the identified strata based on 2006 IPCC Guidelines and country specific data ○ Future improvement planned using the data from National Forest Inventory currently under implementation
Scope	○ REDD+ Activities: Deforestation, Forest Degradation and Enhancement of Forest Carbon Stock ○ Pools: Below and above ground biomass ○ Gases (CO_2) first submission– other gases later
Scale	○ Agreement on National scale reached
Methodology	○ Reference period: 13 years (2000 – 2013) ○ Adjustment: Linear projection

The following bullet points provide brief explanations on the key areas covered within the modified FRL submission according to the requirements outlined within decision 13/CP.19, as well as further and specific references within the modified FRL submission where details may be obtained.

- The REDD+ Activities included in the FRL are outlined on page 9 of the modified FRL submission and include deforestation, forest degradation and carbon stock enhancement. It provides specific explanations on the reasons for the selection of these activities as well as those not included.
- The national forest definition for the country is provided on page 6 of the modified FRL submission and provides the basis for determining whether deforestation, degradation, afforestation or reforestation was occurring.
- The Territorial Forest Area covered and Scale of the FRL is restricted to the national level with specific explanations on the reasons for this selection provided on page 11 of the modified FRL submission.

- Pools and Gases included in the FRL are explained in detail on page 10 of the modified FRL submission with details also provided on carbon pools not covered, and the reasons for their exclusion.
- The period (in years) of the assessed FRL are provided on page 11 of the modified FRL submission and outlines the detailed explanations on why these periods were selected.

Chapter 3. Results of REDD+ Activities

3.1 The REDD+ results relative to the FRL in terms of CO_2 equivalent.

Decision 14/ CP.19, paragraph 3, "agrees that the data and information used by Parties in the estimation of anthropogenic forest-related emissions by sources and removals by sinks, forest carbon stocks, and forest-area changes, as appropriate to the activities referred to in decision 1/CP.16, paragraph 70, undertaken by Parties, should be transparent, and consistent over time and with the established forest reference emission levels and/or forest reference levels in accordance with decision 1/CP.16, paragraph 71(b) and (c) and section II of decision 12/CP.17".

CO_2 emissions from deforestation and forest degradation in Papua New Guinea in the period from 2001 to 2013, used in the construction of the FRL, were estimated using the formula:

Annual emission (tCO_2e) = 1,679,607 x Year -3,339,358,085 [23]

For this Technical Annex, the REDD+ results for years 2014 to 2015 were calculated using the same approach, simply by subtracting the Total Emissions and Removals value for that period from the FRL 2014-2018 results. However, PNG realised that the linear extrapolation of post-deforestation removals would result in an over-estimation of emission reduction, i.e. an over-estimation of results, therefore it proposed a small correction as explained in section 3.2. So for year *t*, the reduced emissions from deforestation and forest degradation [24]were as follows:

$$\boldsymbol{REDD + Results\ (t)} = \boldsymbol{FRL\ (2014\ to\ 2018) - Total\ Emissions\ and\ Removals\ at\ year\ t} - \boldsymbol{Post\ deforestation\ c\ correction\ at\ year\ t}; \left(\frac{\boldsymbol{tCO2}}{\boldsymbol{yr}}\right)$$

Hence, the emission reduction in 2014 corresponds to:

43, 369,737 tCO_2 - 38, 677,156 tCO_2 - 735,170 tCO_2 = 3, 957,412t CO_2, etc.

[23] See page 35 of PNG's modified FRL at https://redd.unfccc.int/submissions.html?country=png.
[24] It is important to note that PNG reports zero (0) removals from carbon stock enhancement in the historical reference period (2001 – 2013) and 2014-2015.

The total results achieved by PNG in reducing emissions by REDD+ activities from 2014 to 2015, was the sum of the results achieved for each year of the period shown in Table 3-1.

Table 3-1: REDD+ results in 2004 and 2015

Year	FRL emission	Actual emission	Post deforestation correction[25]	REDD+ results
	($t CO_2$ eq)			
2014	43,369,737	38,677,156	735,170	**3,957,412**
2015	45,049,344	39,024,003	979,439	**5,045,902**

Total REDD+ result achieved by PNG in 2014 and 2015 = 3,957,412 tCO_2 + 5,045,902 tCO_2 = **9,003,314 [26]tCO_2** [(see Figure 3-1) (Refer to Table 3-2 for complete time series information)]

[25] See *Chapter 3.2 Correction of post-deforestation removals* for the description.
[26] The one's place may be differently shown due to the rounding process. This also applies to Table 3-1.

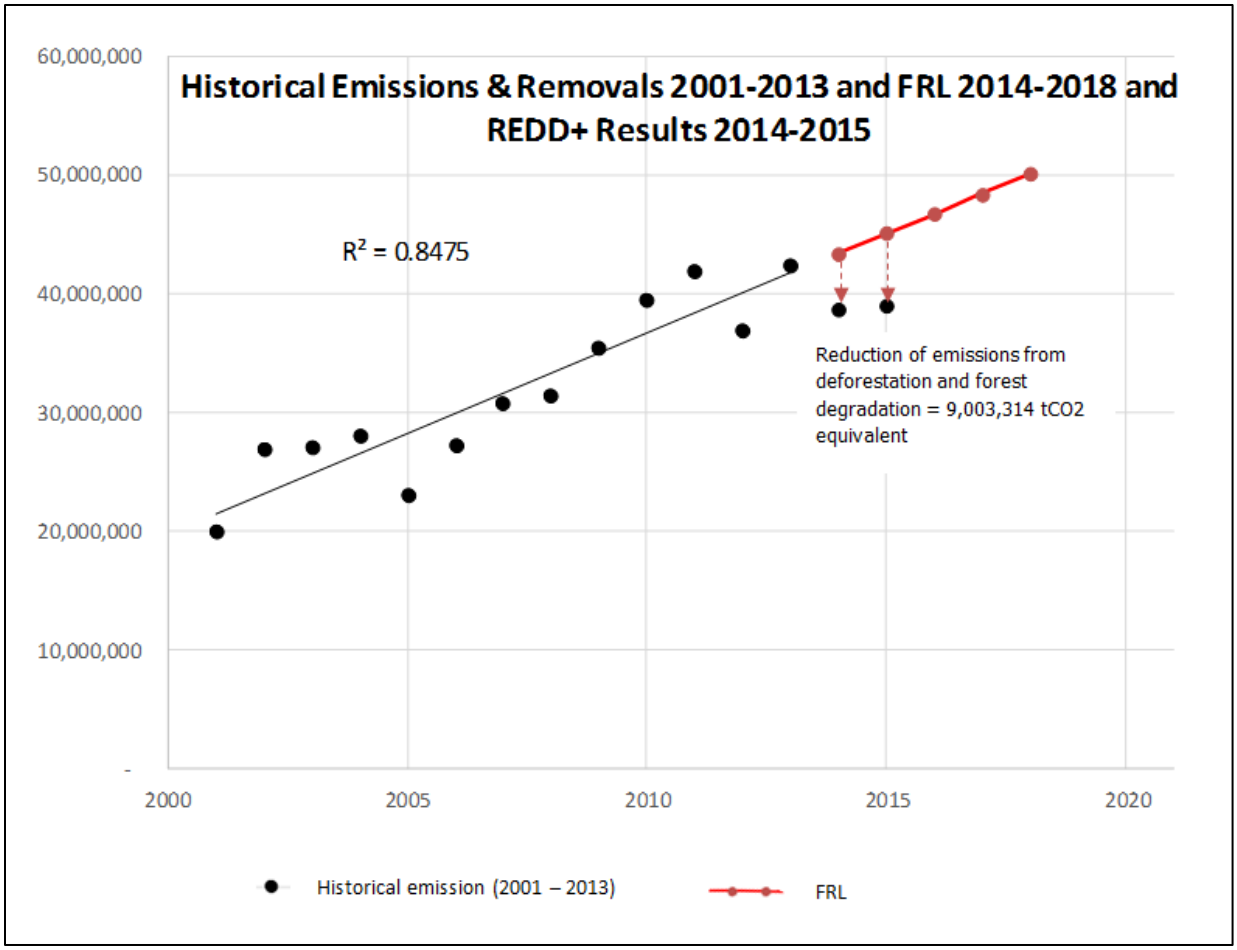


Figure 3-1: REDD+ Results achieved by PNG from 2014 to 2015 assessed against PNG's technically assessed FRL

The GHG emission reductions between 2014 and 2015 can be alluded to the policies and actions listed below. However elucidating what actions and policies contributed how much emission reduction would require separate study.

- Awareness and educational activities on climate change and REDD+ have been extensively conducted throughout the country since OCCD was established;
- PNG moving away from Forest Clearance Authority (FCA) to the Forest Management Agreement (FMA) which has provisions for sustainable forest management. This is in line with the country's overall forestry priority and PNG's international commitment on REDD+;
- Implementation of the Medium Term Development Plan (2011-2015), Papua New Guinea Development Strategic Plan (2010- 2030) and the PNG Vision 2050 which discourage deforestation but promote reforestation/afforestation.
- Forestry and Climate Change Framework for Actions (2009-2015) which identifies afforestation, reduced deforestation and reforestation as means to mitigate climate change;
- Implementation of the Climate Compatible Development Plan for PNG by PNGFA in collaboration with CCDA.

Table 3-2: Annual Emissions from Deforestation and Forest Degradation from 2001 to 2013; Forest Reference Emission Level Used to Estimate; The Emission Reduction Results in the Periods of 2014-2015 and REDD+ Results Achieved on these Periods

Year	Deforestation (tCO_2/yr)	Forest Degradations (tCO_2/yr)	Carbon Stock Enhancement (tCO_2/yr)	Total emissions and removals 2001 – 2013 (tCO_2/yr)	Regression 2001-2013/FREL 2014 - 2018 (tCO_2/yr)	REDD+ Results 2014-2015 (tCO_2/yr)	Post-deforestation correction	Corrected REDD+ Results 2014-2015 (tCO_2/yr)
	Emission	**Emission**	**Removals**	**Emissions & Removals**	**Emissions & Removals**	**Emissions & Removals**	**Removals**	**Emission & Removals**
2001	4,623,017	15,441,146	0	20,064,162	21,534,851			
2002	1,911,491	25,101,056	0	27,012,547	23,214,457			
2003	3,249,282	23,834,478	0	27,083,761	24,894,064			
2004	2,131,153	25,977,828	0	28,108,981	26,573,671			
2005	3,636,414	19,424,818	0	23,061,232	28,253,277			
2006	1,338,504	25,969,659	0	27,308,164	29,932,884			
2007	2,936,725	27,823,956	0	30,760,681	31,612,491			
2008	3,014,378	28,459,714	0	31,474,091	33,292,097			
2009	4,047,172	31,373,792	0	35,420,964	34,971,704			
2010	4,021,547	35,461,013	0	39,482,561	36,651,311			
2011	6,618,171	35,244,691	0	41,862,863	38,330,917			
2012	8,798,126	28,122,531	0	36,920,657	40,010,524			
2013	11,006,534	31,395,182	0	42,401,717	41,690,131			
2014	9,109,166	29,567,990	0	38,677,156	43,369,737	4,692,582	735,170	3,957,412
2015	9,593,969	29,430,034	0	39,024,003	45,049,344	6,025,341	979,439	5,045,902
Total	76,035,651	412,627,889	0	488,663,539	644,607,135	10,717,923	1,714,609	**9,003,314**

The REDD+ results and the calculation used as shown in this Technical Annex applies the same methodology[27], the same data set and the same data source and forest definition[28] used for PNG's FRL and the GHG inventory.

3.2 Correction of post-deforestation removals

Following a suggestion from the TA, PNG has included post-deforestation removals as to not over-estimate emissions from deforestation. PNG's FRL is a linear extrapolation of emissions from degradation, deforestation and post-deforestation removals. The FRL can be disaggregated as the sum of linear projections of the emitting activities and post-deforestation removals as shown in Figure 3-2.

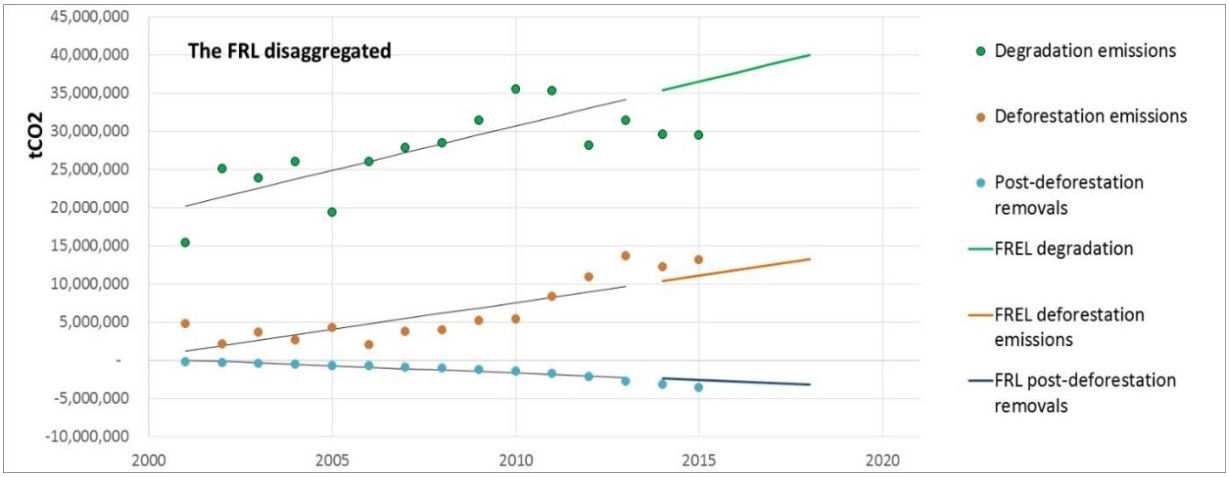


Figure 3-2: The FRL disaggregated by net degradation emissions, gross deforestation emissions and post-deforestation removals (the last two together making net emissions from deforestation)

The disaggregated FRL shows us that the emission reductions (the results assessed against the FRL) come mainly from reduced degradation. Increased deforestation however has a negative impact on the results with its emissions above the linear extrapolation of historical (reference period FRL) deforestation emissions. This negative impact is slightly reduced through the consideration of post-deforestation regrowth, in other words post-deforestation regrowth makes a small contribution to the assessed emission reductions. This is in line with expectations, since post-deforestation removals are expected to have a negative impact on results if emission reductions come from reduced deforestation (emissions and therefore emission reductions would be smaller) but at the same time they temper the negative impact of increased deforestation on the results.

Removals on deforested land are accounted for the year of the deforestation event and 19 subsequent years, applying a linear growth function as suggested by IPCC. This means however, that since accounting for post-deforestation growth starts in the first year of the reference level (2000-2001), post-

[27] See chapter 6 of PNG FRL (http://unfccc.int/8414) for detail information on calculation of emissions and removals.
[28] See chapter 2 of PNG FRL (http://unfccc.int/8414) for information on PNG's National Forest Definition.

deforestation removals increase each year since each year new deforested land is added while growth continues on previously deforested land. As such, in a situation where annual deforestation remains constant over the reference period, the associated removals show a linear increase. In PNG's situation however, deforestation is not constant but instead shows a linear increase. In terms of the associated removals this means that every year, a larger amount of removals are added to the annually increasing cumulative removals on deforested land. As such, the associated removals do not increase linearly, but exponentially which resulted in an exponentially shaped curve (Figure 3-3).

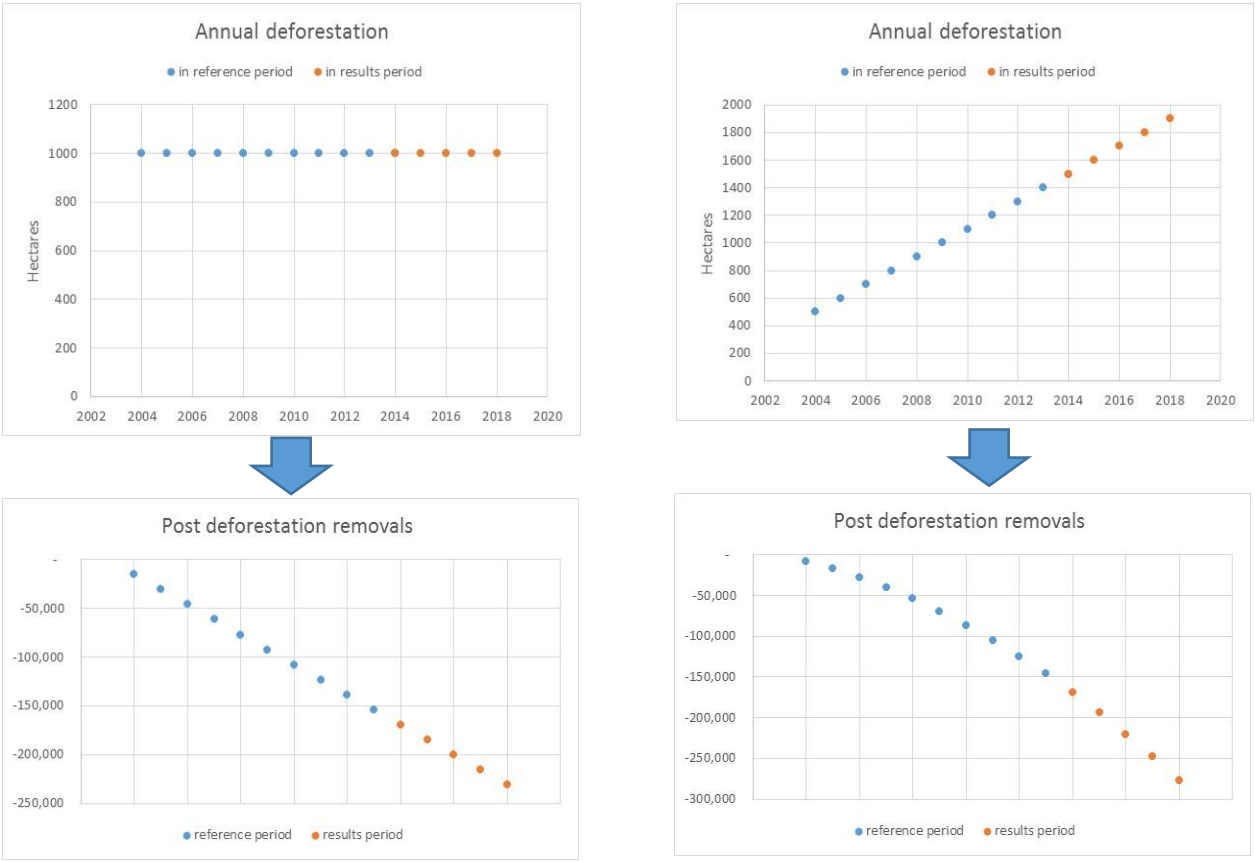


Figure 3-3: Stable and linearly increasing deforestation and the associated post-deforestation removals

The above explanation means that when applying a linear function to removals associated with linearly increasing deforestation, post-deforestation does not increase linearly but exponentially. If we apply a linear extrapolation to the removals during the reference period, the expected removals during the results period would be under-estimated as illustrated in Figure 3-4. Therefore, PNG believes the post-deforestation removals during the results period to be over-estimated with the linear extrapolation FRL. This would result in an over-estimation of emission reductions which would not be accurate and therefore PNG proposes a correction of post-deforestation removals by re-calculating the FRL values in a manner consistent with the linearly increasing deforestation.

The correct calculation of expected deforestation is[29]:

Post-deforestation removals (2001) = (Def area$_{2001}$) x RF

Post-deforestation removals (2002) = (Def area$_{2001}$ + Def area$_{2002}$) x RF

……

Post-deforestation removals (2014) = (Def area$_{2001}$ + Def area$_{2002}$ + Def area$_{2003}$ + Def area$_{2004}$ + Def area$_{2005}$ + Def area$_{2006}$ + Def area$_{2007}$ + Def area$_{2008}$ + Def area$_{2009}$ + Def area$_{2010}$ + Def area$_{2011}$ + Def area$_{2012}$ + Def area$_{2013}$ + Def area$_{2014}$) x RF

This is the same as:

Post-deforestation removals (2014) = Post-deforestation removals (2013) + Def area$_{2014}$ x RF

Which is: -2,706,436 tCO_2 + (28,833 ha x -13.98 tCO_2/ha) = -3,109,566 tCO_2/yr

Post-deforestation removals (2015) = Post-deforestation removals (2014) + Def area$_{2015}$ x RF

Which is: -3,109,566 tCO_2 + (30,824 ha x -13.98 tCO_2/ha) = -3,540,545 tCO_2/yr

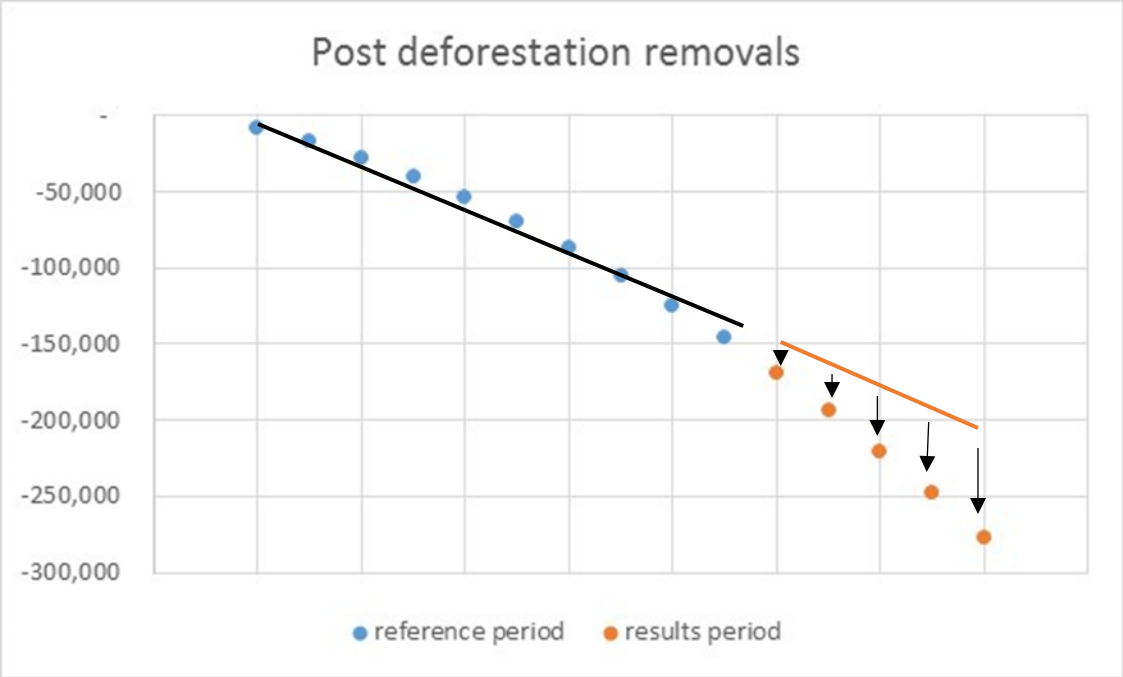


Figure 3-4: Illustration how a linear extrapolation of post-deforestation removals associated with linear increasing deforestation under-estimates future removals expected under "business as usual"

[29] The correct calculation is based on Riemann sum formula

The correction of post-deforestation removals is then as follows (all values are in tCO_2):

Table 3-3: PNG's post-deforestation removals correction

	2014	2015
1. Linear extrapolation post-deforestation removals in FRL	-2,374,396	-2,561,106
2. Correct extrapolation of post-deforestation removals expected with linear deforestation	-3,109,566	-3,540,545
Proposed correction (i.e. row 1 – row 2 in this table)	**-2,374,396 – (-3,109,566)= 735,170**	-2,561,106 – (-3,540,545)= **979,439**

In summary, PNG proposes the above calculated correction to post-deforestation removals in 2014 and 2015 to avoid over-estimating REDD+ results. This correction does not affect the measured values (2001-2013 and 2014-2015) and therefore there is full consistency between the GHG inventory – which reports only the measured/historical data, no projection/FRL involved – and the FRL (based on measured values from 2001-2013). The only thing the correction does is let the FRL approximate better the Business-As-Usual GHG emissions (especially) between 2014 and 2015 which are used in the calculation of REDD+ results against the 2014 -2015 measured values. In other words, the FRL correction seeks to get a better fit with the extrapolation based on the historical data therefore the correction would increase consistency, as shown in Figure 3-5. This approach would be used to improve PNG's future FRLs and REDD+ results.

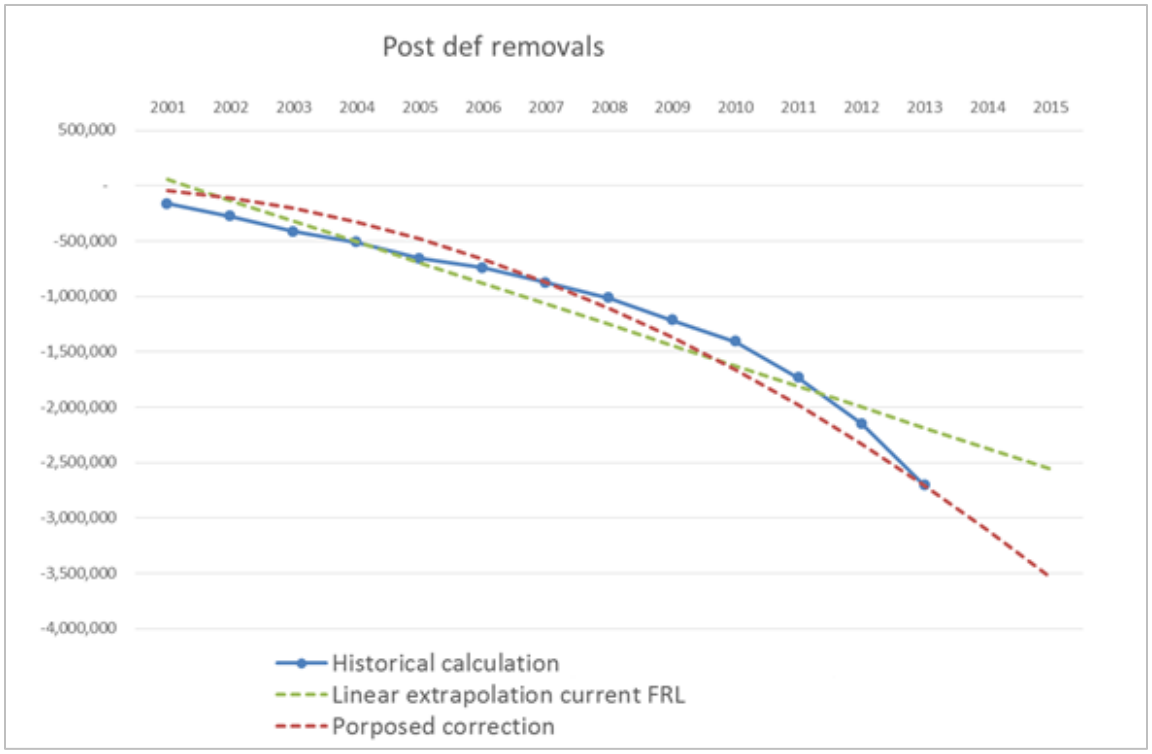


Figure 3-5: Historical calculation (2001-2013), current FRL and proposed corrected FRL

3.3 Consistency with National GHG Inventory and REDD+ Results

Dec 12/CP.17 decides that FRELs and/or FRLs shall be established maintaining consistency with each country's national GHG inventories. Accordingly, PNG GHG inventory, FRL and the REDD+ results uses the same dataset and same methodology but with some differences in included activities, carbon pools and greenhouse gasses.

The most significant differences between the GHG Inventory LULUCF sector (hereafter LULUCF) and FRL/REDD+ results is the choice of inclusion/exclusion of the biomass regrowth of degraded forest that was degraded prior to the reference period. LULUCF and FRL/REDD+ results are prepared using the same data of annual land use change assessment between 2000 and 2015 using Collect Earth tool (see Chapter 4 in this Technical Annex for detailed methodology). PNG included *deforestation*, *forest degradation* and *carbon stock enhancement* as REDD+ activities in the 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 LULUCF by using the growth factors for >20 yr in IPCC Guidelines (2006) (see more details in Section 2.4.4.2). 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 LULUCF in BUR and FRL/REDD+ results. Removal due to regrowth of degraded forest that was degraded prior to 2000 was 41,802 Gg CO2 eq in 2015. This was included for LULUCF in BUR but not in

FRL/REDD+ and it causes the significant differences of the net emissions reported. In addition, FRL/REDD+ results did not include gases other than CO_2 because the reliable data was lacking and also they were likely insignificant for the activities included in the FRL while CH_4 and N_2O on the total land area were also included in LULUCF sector in BUR. Litter and soil organic carbon were not included in FRL and REDD+ results due to lack of reliable data while they were included in LULUCF sector in BUR using 2006 IPCC Guidelines default values for the estimation for reasons of completeness. Fuel wood gathering is not included in forest degradation in FRL/REDD+ results due to lack of reliable data but it was included in LULUCF in BUR. 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 LULUCF sector in BUR and FRL/REDD+ results was 37,308 Gg CO_2 eq in 2015 (BUR LULUCF; 1,716 Gg CO_2 eq, REDD+ results 39, 024 Gg CO_2 eq). The differences on methodology between LLUCF in BUR and FRL/REDD+ results are listed in Table 3-4. 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. Countries can include only emissions and removals of included activities, gasses and pools during the reference period.

Dec 12/CP.17 agrees 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 BUR and FRL/REDD+ results are expected to diminish in the next submission of BUR and FRL/REDD+ results.

Table 3-4: List of the differences on methodology between LULUCF sector in BUR1 and FRL/REDD+ results

	LULUCF in BUR	FRL/REDD+ results
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. A description of how the elements contained in decision 4/CP.15, paragraph 1 (c) and (d), have been taken into account.

4.1 Use of the most recent IPCC guidance and guidelines

The construction of PNG's FRL and its corresponding Technical Annex and GHG inventory of LULUCF sector were based on IPCC methodology. PNG uses 2006 IPCC Guidelines and Good Practice Guidelines LULUCF as a basis for estimating anthropogenic forest-related greenhouse gas emissions 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)[30] . Forest land was stratified by forest type and type of disturbance. Historical annual emissions were estimated using emission factors[31] appropriate to various forest strata, derived from scientific literature and the 2006 IPCC Guidelines, and activity data obtained through the Collect Earth assessment[32]. FRL values for the period 2014–2018 were projected using an equation based on a linear regression model.

4.2 Establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems

PNG established the national forest monitoring system using a combination of remote sensing and ground based forest carbon inventory approaches [33] 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. Phase 1: Remote Sensing data analysis (activity data) based on a systematic sampling method using Open Foris Collect Earth
ii. Phase 2: Ground based forest carbon inventory (emission factors) based on plot clusters on a random restricted sampling design

[30] see BUR section 2.4.4.2 for details on LULUCF
[31] for details on EF refer to PNG modified FRL submission section 6.3
[32] for details on Collect Earth methodology see section 6.3
[33] Decision 4/CP.15cision 4/CP.15

4.2.1 Remote Sensing data analysis (activity data)

PNG uses the established national forest monitoring system to produce activity data for Forest Reference Level as well as REDD+ Results Reporting using the same methodology to be consistent over the time. PNG also has been working to improve the national forest monitoring system to be more transparent. The following sections provide the information of the remote sensing data analysis as a part of the established national forest monitoring system.

Overview of assessment

Activity data used for the construction of PNG national Forest Reference Level (FRL) and REDD+ Results Reporting were obtained from an annual historical time series analysis of land use, land-use change and forestry (LULUCF) carried out by Papua New Guinea Forest Authority (PNGFA) using the same assessment methodology by Collect Earth for both the period of 2000 - 2013 for FRL and 2014 - 2015 for REDD+ Results Reporting.

Collect Earth (CE) 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 CE 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 CE tool to operate functionally, i.e. Google Earth, Google Earth Engine and Bing Maps. The approach used for the CE 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 for National Greenhouse Gas Inventories (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.

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 to estimate 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 a weight coverage of 4%.

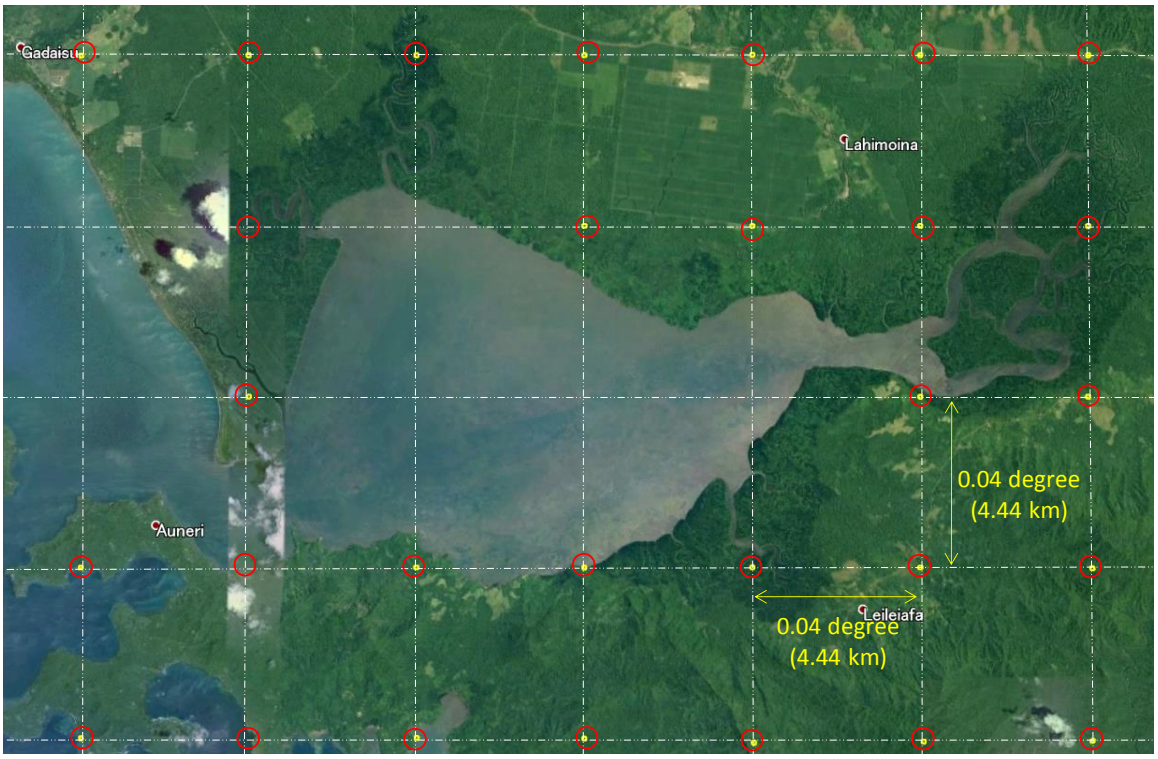


Figure 4-1: Image of the distribution of the assessment plots

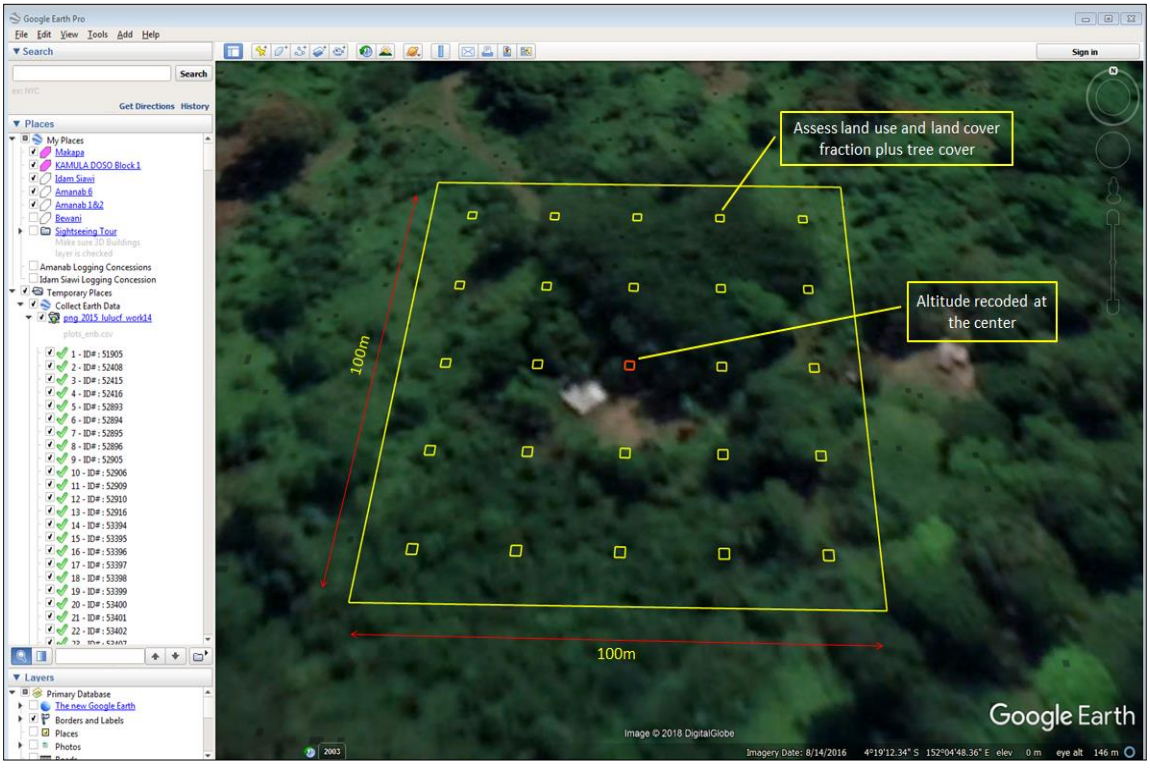


Figure 4-2: Image of the spatial sampling unit of the assessment plots

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. These 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 (Explorer and Code Editor) ensures the completeness of the series through Remote Sensing products from medium resolution imagery repositories between 2000 to 2015 (e.g. Annual TOA Reflectance Composite, Annual NDVI Composite, Annual Greenest-Pixel TOA Reflectance Composite, etc. from Landsat 5, 7 and 8).

Table 4-1: 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)	2000-2015 (to date)	Land use and disturbance
Bing Maps	World-View, QuickBird, Ikonos, SPOT, etc.	High (0.5-2.5m)	2000-2005, 2007-2015 (to date)	Land use and disturbance
Google Earth Engine	Landsat 7 (Annual Greenest Pixel)	Low (30m resolution)	1999-2013	Historical land use change
	Landsat 8 (Annual Greenest Pixel)		2014 -2018	Check Current Situation

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.

Data collection form

Figure 4-3 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.

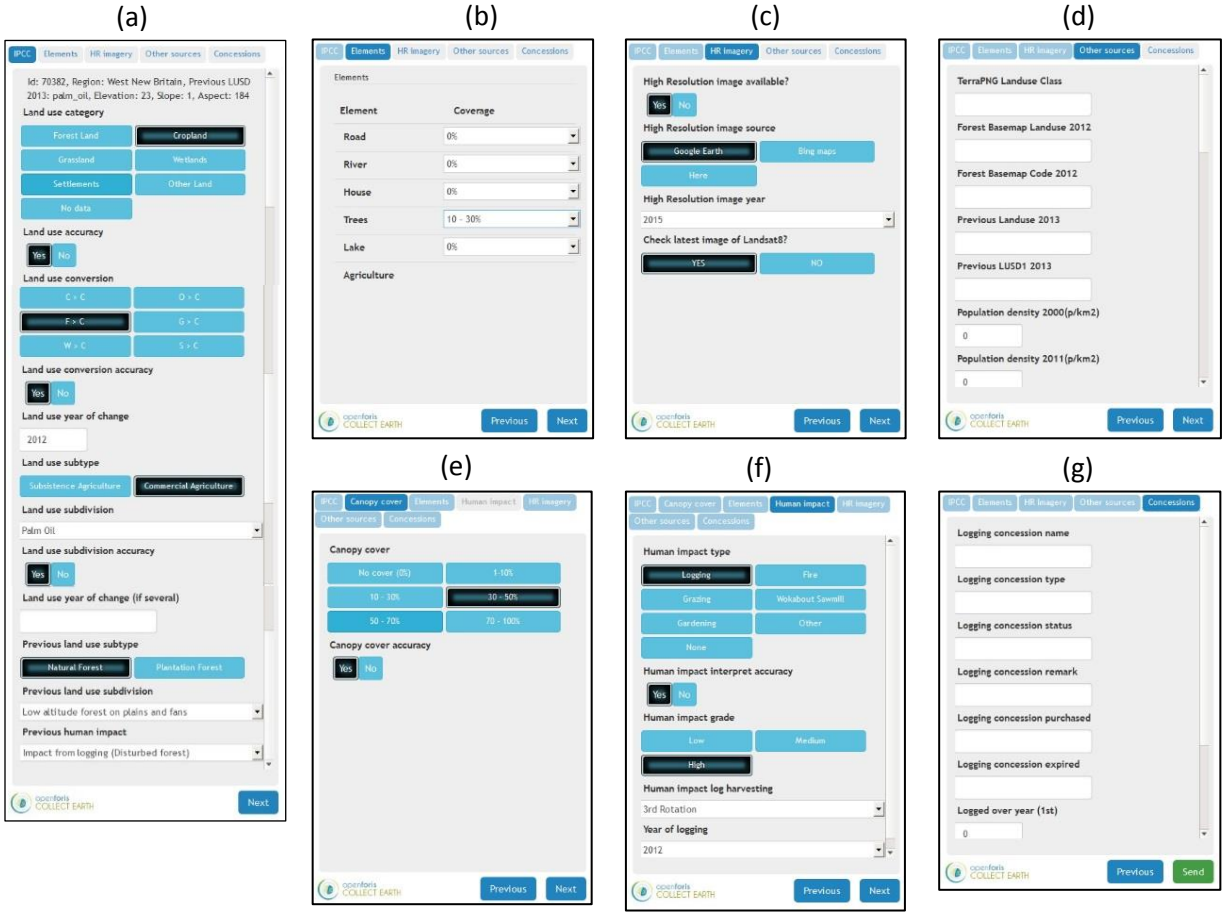


Figure 4-3: Illustration of the seven (7) PNG Collect Earth data collection forms

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 4-2: 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 4-3 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.

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 in the Table 4-3 below.

Table 4-3: Land use Hierarchical Rules

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

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 4-4. 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 4-4: 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[34], 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 Papua New Guinea Resource Information System (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.

[34] 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

Table 4-5: 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
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.

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 4-6: Forest Disturbance and key features used in the Collect Earth assessment

Disturbed forest	Key features	Remarks
Logged forest	Logging roads,	Easy to see
Gardening	Isolated patches of temporary clearings at the edge of cropland areas	Challenging to see in Landsat 8 & 7 images
Fire	Burnt forest	Challenging to detect on Landsat images
Workabout sawmill	Based on local knowledge	As above
Others	Mining clearings & those not identified	As above

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 disturbance 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 include 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).

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 2000-2015 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.

For the purpose of REDD+ Results reporting, Collect Earth assessment data for the accounting period 2014 - 2015 went through the same QA/QC process which was used for developing FRL. The assessment results were compared against the Global Forest Change data (Hansen data) to ensure the reliability of the Collect Earth assessment data.

The version of the Hansen data which PNG used for the FRL and the QA/QC (reference period: 2000-2013, and the FRL period: 2014-2018) was version 1.2, which has data until 2014 but not 2015. By the time of the QA/QC for BUR/REDD+ Results Reporting, Hansen data was updated to version 1.5, which has the data until 2016 and the data of 2014 was revised (increased).

Therefore, the revised Hansen data was re-processed then linked with customized Collect Earth plots and grids. The same QA/QC process was applied for the data 2014 and 2015 then 802 plots in total were reviewed with verification check list. The screenshot of customized Collect Earth with updated Hansen data are shown in Figure 4-4.

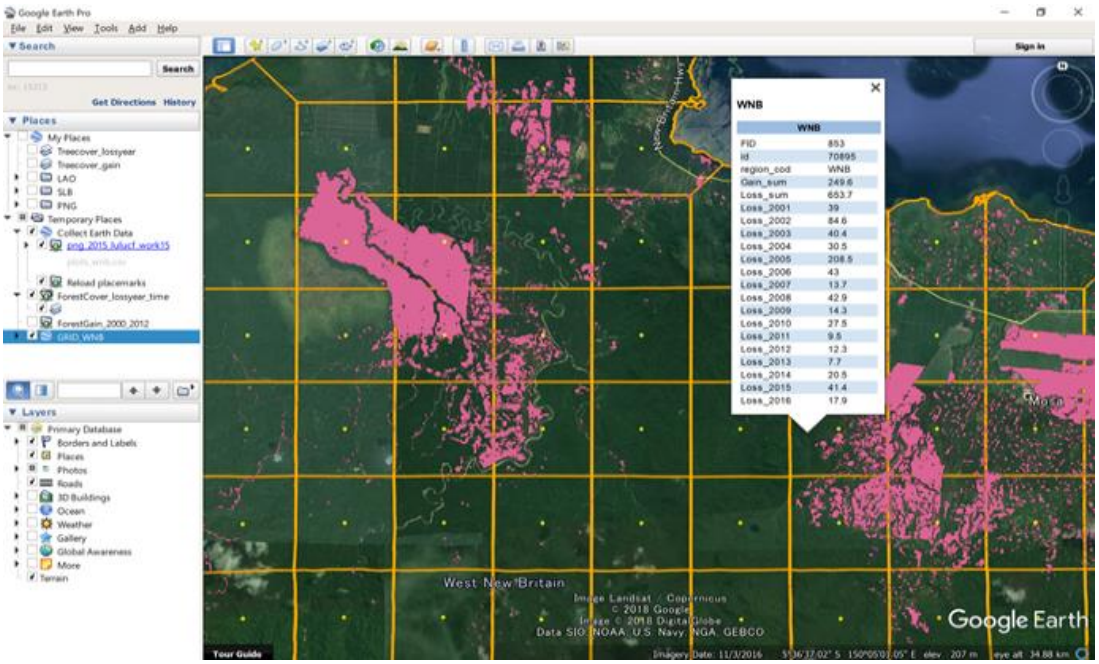


Figure 4-4: Linking revised Hansen Data with Collect Earth plots and grids (pink polygons are the Hansen data)

As a summary of the descriptions in Remote Sensing data analysis (activity data), the illustration of work flow of Collect Earth assessment are shown in Figure 4-5.

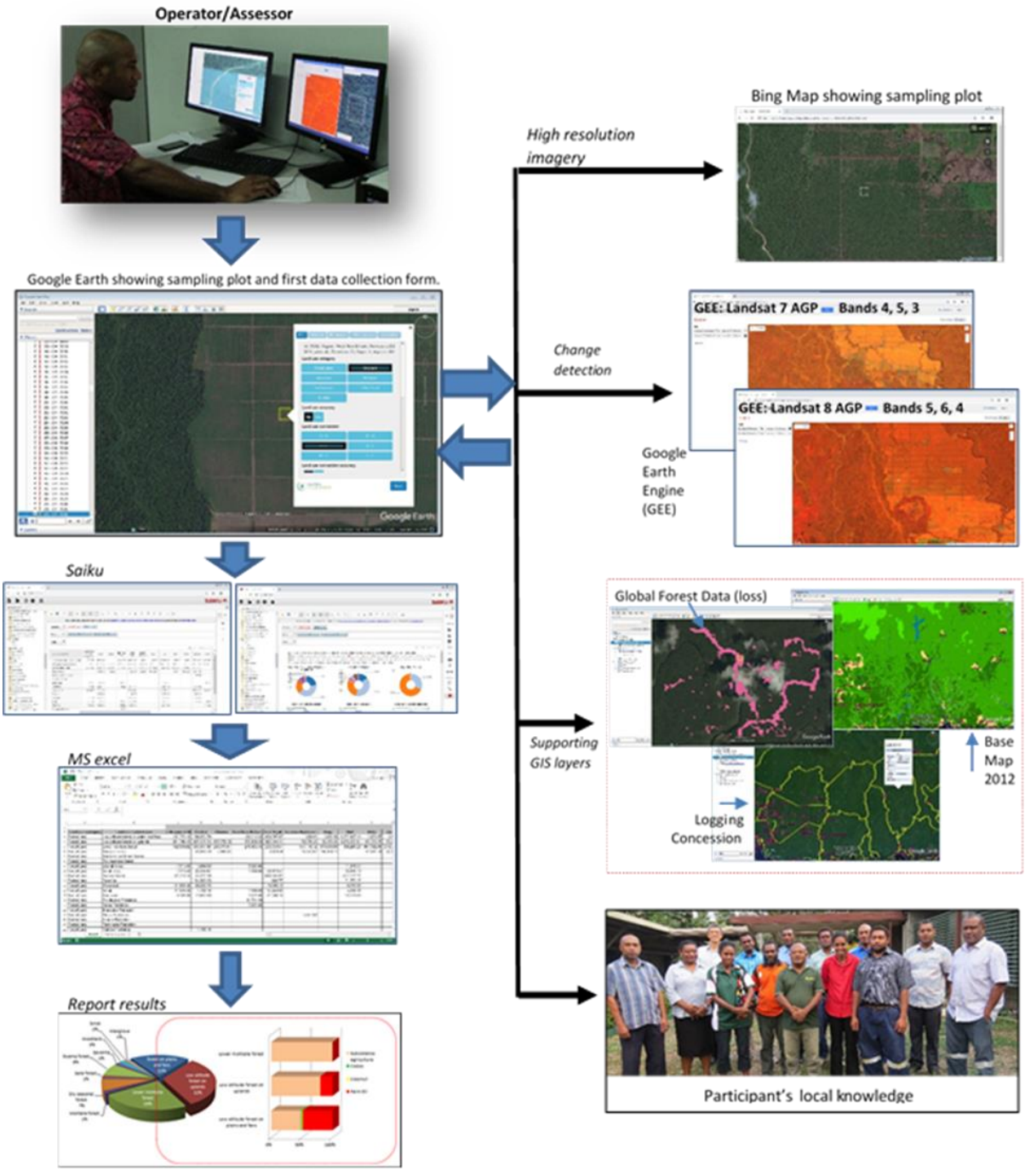


Figure 4-5: Illustration of work flow of Collect Earth assessment

4.2.2 Ground based forest carbon inventory (emission factors)

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 PNG Forest Authority (PNGFA) over a number of years but with a wider scope in addressing forest management and biodiversity conservation in the country. (See section 6.3 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 1st BUR and its Technical Annex. Therefore, the sub-sections below explain the current data used for FRL and REDD+ Results Report, 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).

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, "mountain 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 4-8).

Above ground biomass

Above ground biomass 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 National Forest Inventory, which is currently under implementation. However, it will take another 2-3 years before the full information derived from the National Forest Inventory 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 forest are preferred and selected for ecological studies, and consequently, aboveground biomass of study plots may 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 above ground biomass 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 above ground biomass 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 above ground biomass for logged over lowland tropical rainforest reported in Fox et al. (2010) to logged forests of the five forest 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 aboveground biomass of the forests disturbed by anthropogenic activities other than commercial logging. This information will be available as National Forest Inventory proceeds. In this FRL submission, the same aboveground biomass 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.

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 in lieu. The impact of this simplification is deemed to be small, since small-scale logging accounts for only <1% of all logging by area.

IPCC Guidelines

Other than five forests type discussed in the above section, no sufficient information on above ground biomass 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 4-6 shows similar distribution of montane vegetation and dry vegetation between the PNG Forest Base Map (PNGFA 2014) and Global Ecological zone (FAO 2001). The description of Ecological Zone in tropical climate is summarised in Table 4-7.

Table 4-7: 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^{o}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 > 1000 m, with local variations

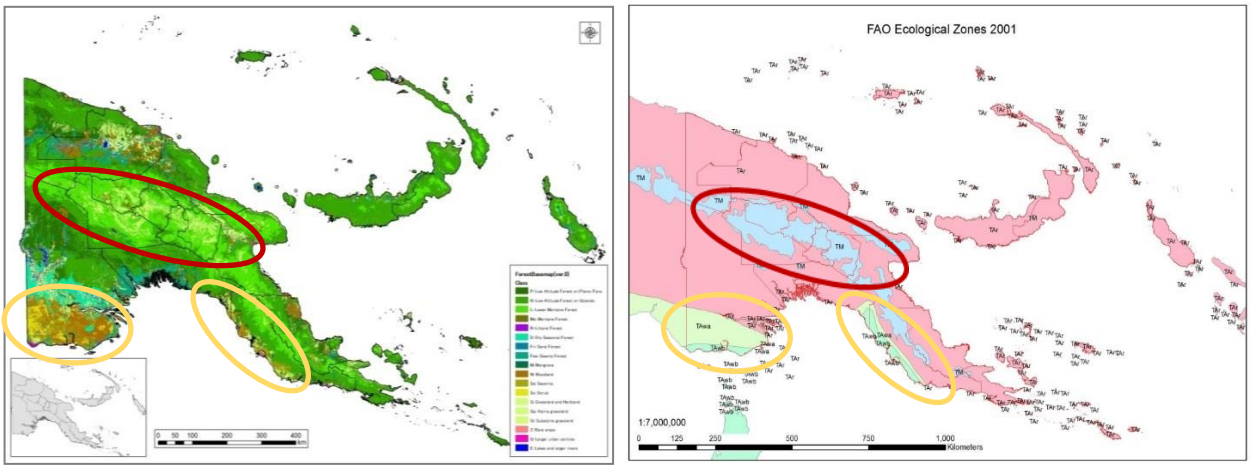


Figure 4-6: Correlation between PNG forest classification in Base Map (Left: PNGFA/JICA 2014) and Global Ecological Zone (Right: FAO 2001). The red ellipse show the distribution of montane vegetation and the yellow ellipse shows the distribution of dry vegetation.

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 4-8. Root to shoot ratio and carbon fraction of IPCC guidelines (2006) were also applied to estimate below ground biomass and carbon contents of above and below ground biomass (Table 4-8). Several carbon pools are not included in the scope of this FRL submission and appropriate values will become available as the National Forest Inventory progresses. In the future, all the Emission Factors used in this FRL submission should be replaced with the country specific values obtained through the National Forest Inventory, which is currently being implemented. After National Forest Inventory is completed then PNG will be able to report near Tier 2-3 level of GHG emission of LULUCF sector.

Table 4-8: Above and belowground biomass Above and below ground biomass in a unit area of PNG forests

Forest type	Human impact	Aboveground biomass			Belowground biomass	
		Source	Ecological zone as per IPCC guidelines	Dry matter (tonnes/ha)	Dry matter (tonnes/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	IPCC Guideline (2006)	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.

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 4-9:Aboveground biomass and mean annual increment of Cropland used for post deforestation GHG removal.

		coconut	oil palm	shifting cultivation	permanent subsistence	other
Relative area	%	1%	31%	63%	3%	2%
AGB	t d.m. /ha	196	136	45	45	45
Source		Table 5.3, IPCC 2006	Table 5.3, IPCC 2006	Table 5.1, IPCC 2006	Table 5.1, IPCC 2006	same as subsistence
Growth duration	Years	20	20	8	8	8
Mean annual increment in AGB	t d.m. /ha /yr	9.80	6.80	5.59	5.59	5.59

The average mean annual increment in living biomass 8.11 t d.m. /year /ha, based on a weighted mean of the mean of the annual increments in AGB and a root-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 long time 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.

Calculation of emission factors

The Emission Factors for emissions in primary deforestation, secondary deforestation and forest degradation are calculated as follows:

Carbon stock = (Aboveground biomass + belowground biomass) x 0.47 (IPCC Guidelines 2006)

Emission factor = (Carbon stock before land use conversion – Carbon stock after land use conversion) x 44/12 (IPCC Guidelines 2006)

Table 4-10: Emission Factor of deforestation of primary forest, deforestation of degraded forest and forest degradation

(tCO2e /ha /yr)

	EF deforestation (primary forest)	EF deforestation (degraded forest)	EF 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

The Removal Factors for removals in carbon stock enhancement and for post-deforestation regrowth are established as follows

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

For carbon stock enhancement, this calculation is carried out for plantations since only there the conversion from non-forests to forests was observed. The removal factor amounts to 24.7 tCO2e /ha /yr, based on a default increment of 9.5 m3 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 is carried out drawing on the mean annual increment calculated above. Applying a mean annual increment is a simplification because of two reasons. First, for some of the vegetation types considered growth levels off after relatively short periods of eight years. Second, once that happens, the relate areas of individual vegetation types should give greater weight for vegetation types with longer growth periods for establishing a weighted mean. Calculations of post-deforestation regrowth 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 PNG’s land use categories “shifting cultivation” and “subsistent agriculture, permanent”. This match of categories was undertaken in a group discussion among sector experts from the CCDA and the PNGFA.

Chapter 5. Uncertainty Analysis

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

5.1. 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 the future based on the progress and result of the currently 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 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 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).

5.2. 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 2000-2015 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).

2001-20013 (FRL Reference Period 1)

The uncertainty 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 2)

The uncertainty 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)

The uncertainty 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!

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 6.3).

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 (IPCC GL 2006)
b. Uncertainty of Root - to - Shoot ratios due to the use of IPCC default values (IPCC GL 2006)
c. Uncertainty of Carbon Fraction value due to the use of IPCC default values (IPCC GL 2006)

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 IPCC GL 2006.

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 = 21.35% in Table 3 of the literature were assigned for degraded and primary forest respectively. All the other values are based on the IPCC GL 2006.

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%	9.2%	11.8%
	Forest(Degraded)	9.2%	0.0%	14.6%
	Non-Forest	11.8%	14.6%	0.0%

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.

2001-20013 (FRL Reference Period 1)

	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 2)

	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)

	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

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

	95% CI (%)
Uncertainty FRL (2001-2013)	24.10%
Uncertainty FRL (2009-2013)	28.78%
Total uncertainty results (2014-2015)	38.53%

Chapter 6. National Forest Monitoring System

6.1 Summary of NFMS and MRV efforts to date

In so far as the design of a monitoring system for REDD+, PNG has managed to finalise a NFMS and submitted its initial 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 FRL and NFMS have been led by PNGFA, with close support and collaboration from CCDA and technical assistance from FAO and the Japan International Cooperation Agency (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 is currently being implemented.

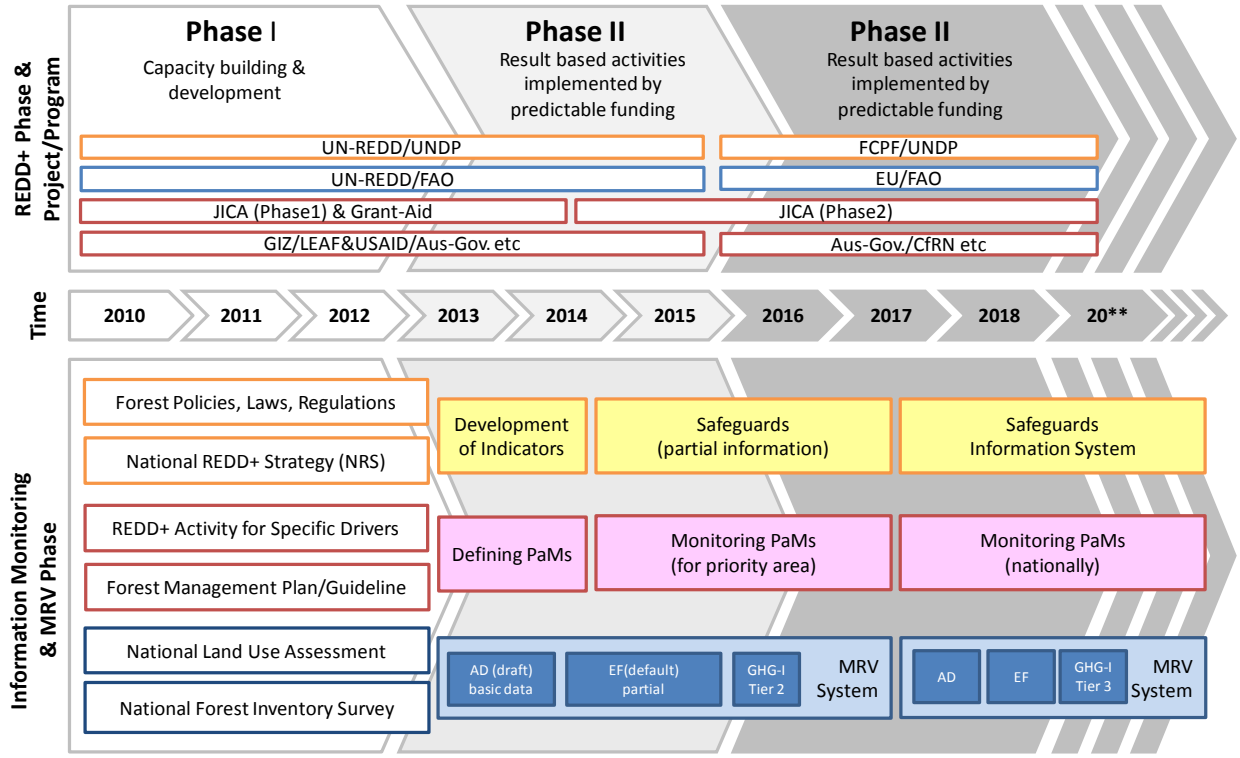


Figure 6-1: NFMS roadmap for Papua New Guinea

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 NI project and JICA. One of the most significant achievement being the development of a forest monitoring GIS web-portal (http://png-nfms.org/portal/) through which numerous land use layers are able to be visualised. The GoPNG launched its forest base map towards

the end of 2013 based on 2012 Rapid Eye data which was developed with the assistance of JICA. The GoPNG through PNGFA also completed two national land use change assessment using the FAO software Open Foris Collect Earth in 2013 and 2016.

Alongside this, PNG has undertaken a national land use analyses, a wall to wall approach through a new system called TerraPNG, housed and managed within the CCDA. Full-time GIS operators are in place in PNGFA and CCDA to ensure the sustainability of this support.

6.2 Operational NFMS in PNG (brief introduction)

The general objective of PNG's NFMS is to provide free access, transparency and timely delivery of all relevant data and information on forest and land use to all relevant stakeholders in a way that is consistent, accurate and verifiable and in line with NFMS Methodological Guidance provided by the COP[35]. PNG's NFMS is made up of the following elements:

1. Collect Earth;
2. TerraPNG[36];
3. PNG REDD+ and Forest Monitoring Web-Portal;
4. National Forest Inventory;
5. Greenhouse Gas Inventory (GHGi).

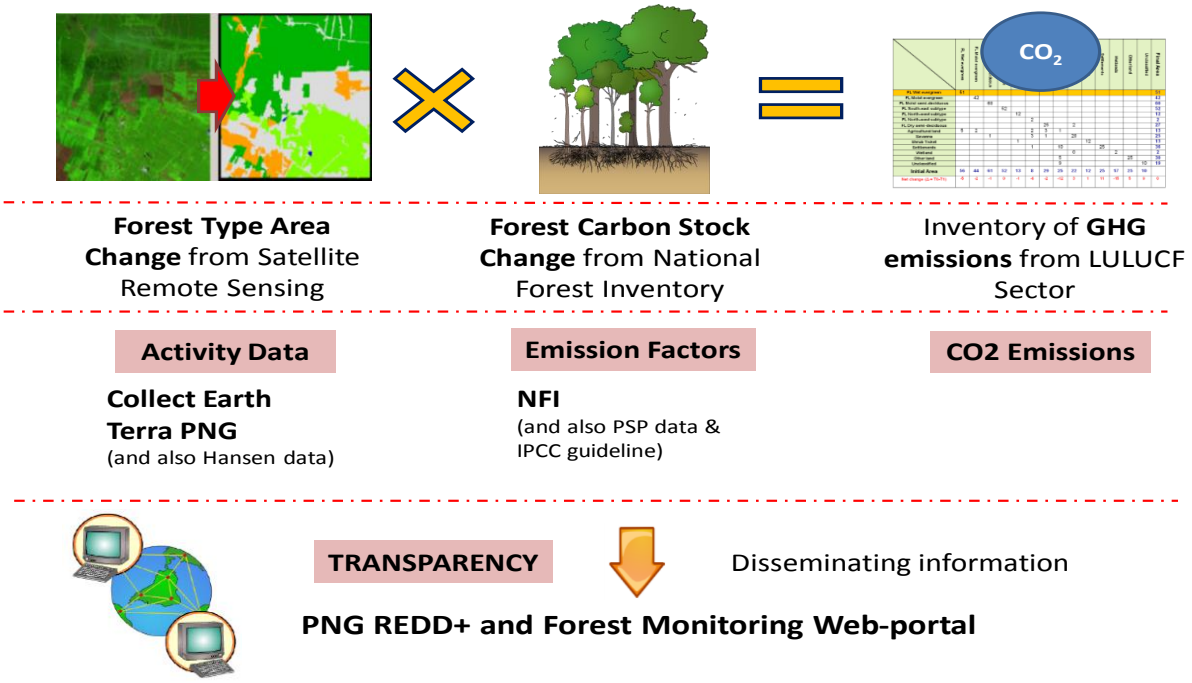


Figure 6-2: Papua New Guinea's NFMS for REDD+ under UNFCCC

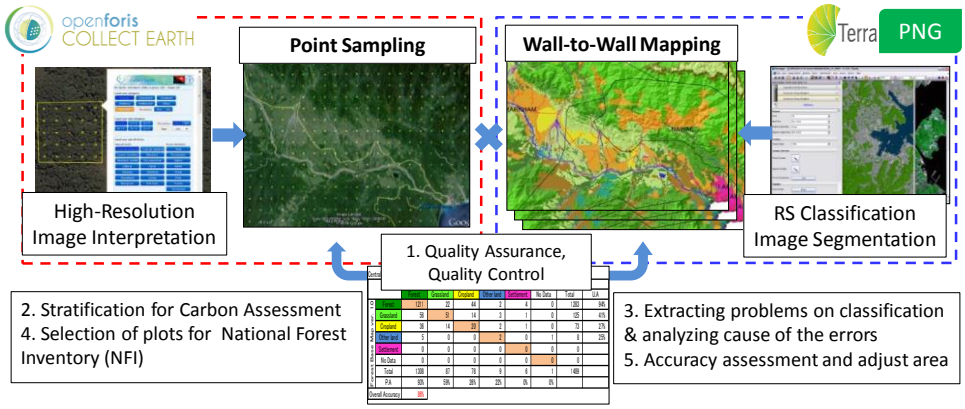
[35] Decision 4/CP.15; Decision 1/CP.16 and; Decision 11/CP.19

[36] TerraPNG is Papua New Guinea's customized version of TerraAmazon which is the Brazil's operational forest monitoring system.

Activity data (AD) is generated by Collect Earth point sampling with verification of TerraPNG wall to wall mapping; emission factor (EF) comes from the NFI; and the web portal was established to disseminate forest and land use information to public in ensuring the transparency of PNG REDD+ process.

Box 1: Brief Introduction of Operational NFMS in PNG

Collect Earth and Terra PNG

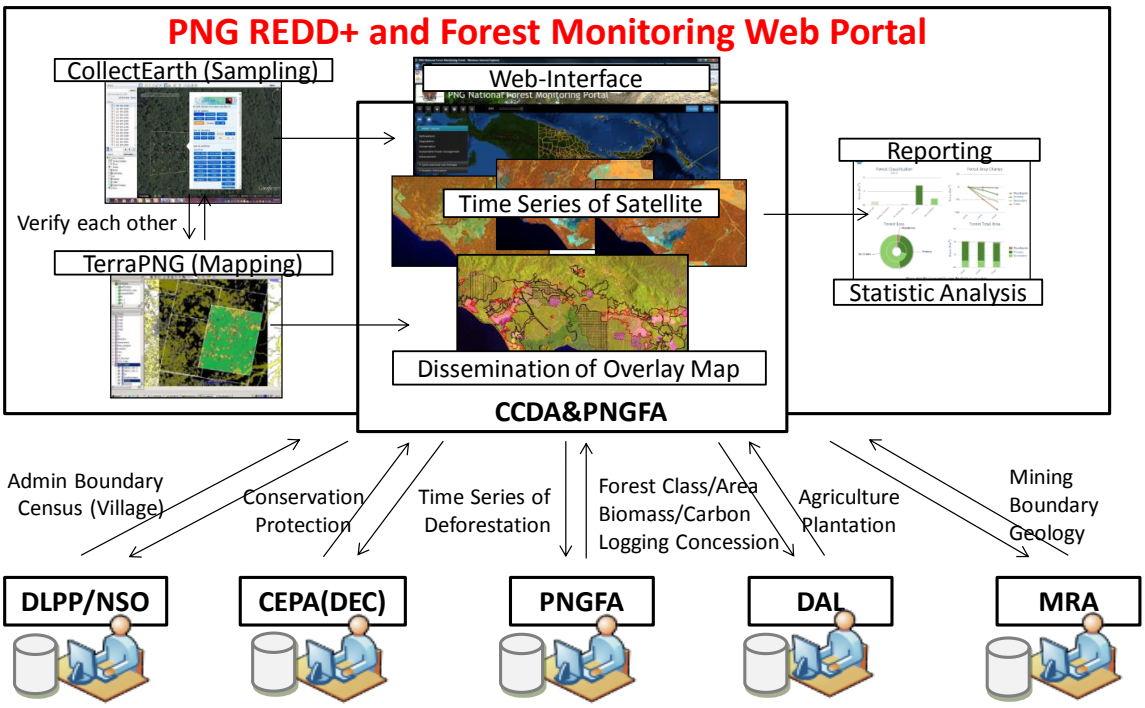


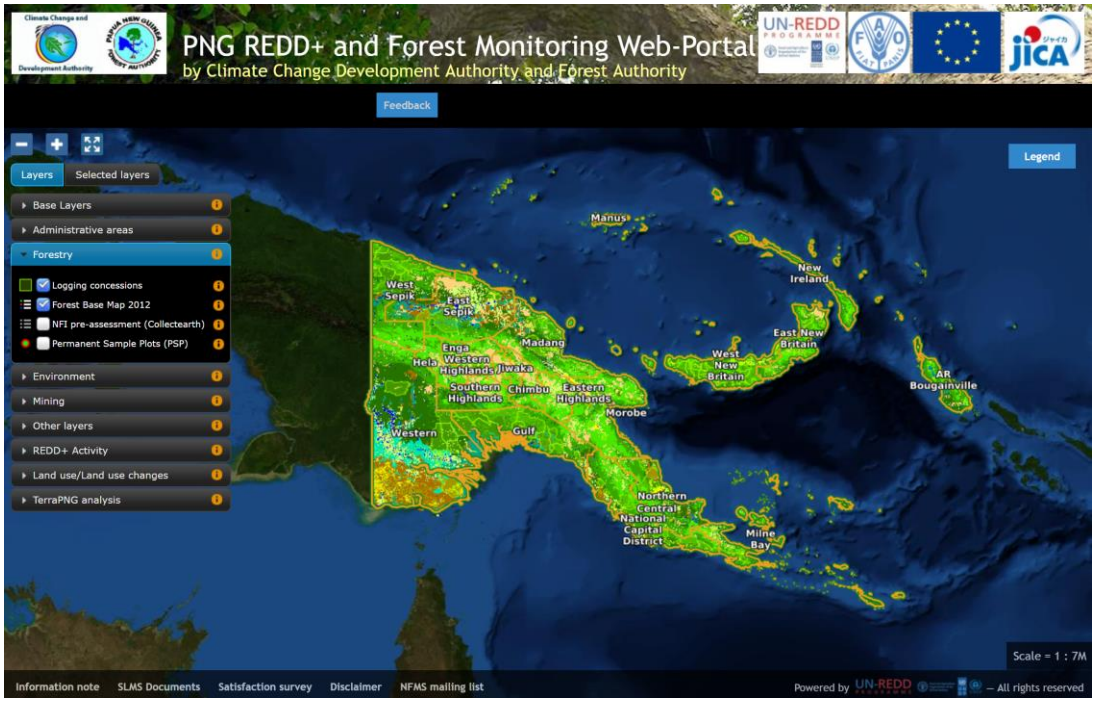
	Point Sampling	Wall-to-Wall Mapping
Spatial Coverage	Sampling Plots	Segmented polygons
Area Calculation	Statistical	Geographical
Boundary	No	Yes
Statistical Analysis	Ample	Limited
Driver Analysis	Ample	Limited

National Forest Inventory（NFI)

Source: PNGFA

PNG REDD+ and Forest Monitoring Web-Portal





Source: CCDA

6.3 Multi-purpose National Forest Inventory

PNG launched a first-ever Multipurpose National Forest Inventory (NFI) in March 2016, along with the PNG Forest Monitoring and REDD+ Web-portal receiving national attention and official endorsement from the Prime Minister of PNG. These initiatives aim to accurately estimate GHG emissions 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 is built on the methods and capacity developed within the PNG Forest Authority (PNGFA) over a number of years. It is anticipated that the data generated by the NFI will significantly improve the accuracy of GHG estimations in the LULUCF sector and provide essential information related to REDD+ (environmental and social) safeguards in PNG. The GoPNG and the EU are currently financing this work with technical support from FAO. This program is expected to end in 2019 and has been successful so far in achieving its objectives 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.

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, important measures such as the National Sustainable Land Use Policy (NSLUP), will be a possible future objective and 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.

6.4 Roles and responsibilities for MRV 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 is provided by the National Statistics Office (see BUR section 4.2.1 for detail information).

Table 6-1: Stakeholders responsibility for REDD+ MRV in PNG

MRV Components	Responsible Institutions/mechanism	Roles	Platforms use
Measuring	PNGFA[37]	Calculating 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.	1. FAO Open Foris Collect tools
	CCDA[38]	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.	TerraPNG system
Reporting	CCDA REDD+ and MRV Technical Working Committees	Providing validation and other technical inputs for 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
Verifying	UNFCCC International Consultation and Analysis (ICA)	Verifying the submissions from Parties, by appointing two LULUCF experts to assess the FRL submissions and the technical annexes.	FRL submission and BUR to UNFCCC

[37] See www.forestry.gov.pg
[38] See www.ccda.gov.pg

Annex to PNG REDD+ Technical Annex

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Chapter 1. Introduction

1.1 Background

PNG submitted its national Forest Reference Level (FRL) to the UNFCCC in January 2017 which underwent Technical Assessment (TA) resulting in a modified FRL and a Technical Assessment Report. The modified FRL contains substantial additional information according to the guidance from the Assessment Team, and was resubmitted later in 2017. The TA of the FRL submitted by Papua New Guinea was undertaken in accordance with the guidelines and procedures for the TA of submissions from Parties on proposed FRELs and/or FRLs as contained in the annex to decision 13/CP.19. Based on the technically assessed FRL, PNG calculated its REDD+ results achieved in 2014 and 2015 and reported the outcome in the technical annex to the country's First Biennial Update Report (BUR1) to UNFCCC in April 2019.

Submission of PNG's FRL occurred before the launching of the GCF Results Based Payment (RBP) pilot programme late October 2017 accompanied by the publication of the GCF Scorecard (GCF/B.18.23). PNG constructed it's FRL in full agreement with the UNFCCC modalities on FREL/FRLs for REDD+ as decided at the UNFCCC Conferences of the Parties, notably the Technical Assessment Report (TAR) assessed it to be in overall accordance with the guidelines contained in the annex to decision 12/CP.17. The GCF Scorecard, however, introduced restrictions on the construction approach for FRELs eligible for RBP beyond the UNFCCC modalities, allowing FRELs to only use historical average of emissions with a limited possible adjustment for high forest cover, low deforestation countries (HFLD).

As HFLD country, PNG has applied a linear regression model based on the emissions in the historical reference period (2001-2013) to estimate business-as-usual emissions during the results reporting period (2014-2018) against which emission reductions will be assessed. Due to the rapidly increasing trend of emissions during the historical reference period, a regression model was considered more appropriate to predict the future emissions than historical average emissions.

PNG still believes the linear projection UNFCCC FRL is the best approximation of business-as-usual, however, to allow participation in the GCF RBP pilot programme, PNG has recalculated it's results conform the restrictions provided through the GCF scorecard.

1.2 Objectives

PNG has submitted its First Biennial Update Report (BUR1) to the UNFCCC in April 2019 with a technical annex containing PNG's REDD+ results for the years 2014 and 2015. In line with UNFCCC decisions, these results are measured against the technically assessed FRL, which is a linear regression of historical emissions from deforestation and forest degradation. PNG would like to participate in the GCF RBP pilot programme for results for the years 2014 and 2015 and later for the years 2016, 2017 and 2018 when the required assessment data for that particular period become available. PNG therefore prepared an annex to the REDD+ Technical Annex that includes REDD+ results assessed against a historical average

FRL with an allowable upwards adjustment for the purpose of participating in the GCF RBP pilot programme.

Chapter 2. PNG FRL and REDD+ results for GCF RBP

2.1 GCF scorecard elements relevant for recalculating PNG's FRL

The GCF RBP Scorecard (GCF/B.18.23) element (ii) under section 2a suggests a fail if *the FREL is not based on average annual historical emissions and the country is not a high Forest Cover, Low Deforestation (HFLD) country.*
For countries that have consistently maintained high forest cover and low deforestation rates an adjustment that:

- *does not exceed 0.1% of the carbon stock over the eligibility period in the relevant national or subnational area, and*
- *does not exceed 10% of the FREL/FRL*

may be applied to the average annual historical emissions to reflect quantified, documented changes in circumstances during the reference period that likely underestimate future rates of deforestation or forest degradation during the eligibility period.

PNG has REDD+ Results in 2014 and 2015 (9,003,314 tCO_2) against the Technically Assessed FRL. In this annex, PNG recalculates which part of these results would be eligible for the GCF RBP pilot programme by assessing them against historical average emissions and an upwards adjustment of 0.1% of the carbon stock over the eligibility period in the national area. For this recalculation, PNG uses the same data as the UNFCCC technically assessed FRL only replacing the linear regression with a 5 year historical average and above mentioned adjustment.

The following sections address the relevant scorecard elements and provide a recalculation of the share of REDD+ results that could be eligible for RBPs following the scorecard restrictions.

2.2 PNG is a high forest cover, low deforestation (HFLD) country

Forest area of PNG declined from 36.25 million ha (78.6% of the country's land area) in 2000 to 35.99 million ha (78.0% of the country's land area) in 2015. Annual deforestation rate during the reference period (2001-2013) ranges between 0.2% to 0.11%. Annual deforestation rate in 2014 and 2015 are 0.08% and 0.09% respectively (PNG Forest Authority, Collect Earth land use assessment 2001-2015 Results). Fonseca et al. 2007 define HFLD as >50% forest cover and <0.22% annual forest loss. With its high forest cover and low deforestation rate, PNG can therefore be considered an HFLD country.

2.3 PNG's recalculated Forest Reference Level for GCF RBP pilot programme

PNG did the recalculation of its FRL and REDD+ results in accordance with the GCF scorecard for the GCF RBP pilot programme. The recalculation only concerns the construction approach (i.e. only how the data is "projected" using a historical average instead of linear projection) but uses the exact same historical data points, the exact same underlying methods as the technically assessed FRL, the same scale, the same scope and the same forest thresholds.

For the purpose of recalculating the FRL for the GCF RBP pilot programme, PNG calculated average historical emissions for the period 2009-2013. In view of the rapidly changing national circumstances and rapidly increasing emissions (see Figure 1), a recent period is believed to be a better approximation of expected emissions under business-as-usual.

Considering PNG's HFLD status and increasing emissions over the reference period, PNG proposes an upwards adjustment to its recalculated FRL for RBPs. The scorecard provides two restrictions for upwards adjustments, namely; the FRL should not exceed 10% of historical average emissions OR 0.1% of the total carbon stock over the accounting period (i.e. 0.02% of the total carbon stock).

The average historical emissions for 2009-2013 were 39,217,752tCO_2/year, therefore 10% of the FRL suggests an allowable upwards adjustment of 3,921,775tCO_2/year.

The total forest carbon stock in PNG corresponding to the year 2013 was 14,772,860,913 tCO_2, therefore 0.1% of the total forest carbon stock divided by the eligibility period (5 years) suggests an allowable upwards adjustment of 2,954,572 tCO_2/year.

After examining the results produced by the two different methods, PNG decided to use the most restrictive limit or adjustment method which is 0.1% of the total carbon stock over the accounting period (i.e. 0.02%)

As such, the recalculated FRL (CO_2 emissions from deforestation and forest degradation in Papua New Guinea in the period from 2009 to 2013) for GCF RBP pilot programme applied the following formula:

Annual emission (tCO_2e) = average emissions from deforestation and forest degradation 2009-2013 + (0.001 x total forest carbon stock)/5

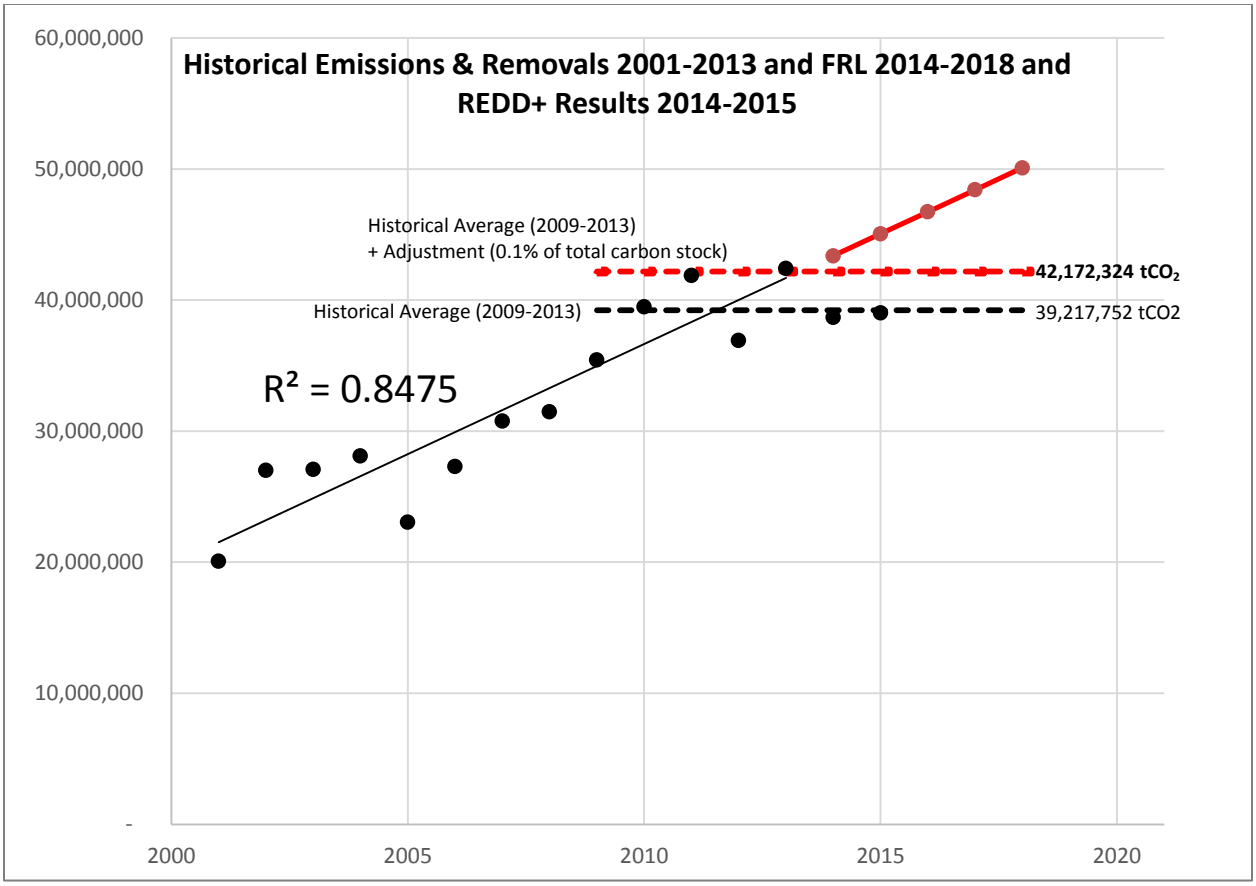

Figure 1 PNG's Recalculated Forest Reference Level for GCF RBP

The recalculated FRL [(Historical Average (2009-2013) + Adjustment (0.02% of total carbon stock)] in Figure 1 for the period 2009-3013 has a value of **42,172,324 tCO_2** compared to the Historical Average (2009-2013) which is **39,217,752 tCO_2**.

Table 1 Recalculated Historical Average 2009-3013 FRL values for PNG

Year	Deforestation (tCO_2/yr)	Forest Degradations (tCO_2/yr)	Carbon Stock Enhancement (tCO_2/yr)	Total emissions and removals 2009 – 2013 (tCO_2/yr)	Historical Average 2009-2013 (tCO_2/yr)	Historical Average + 0.1% of total Carbon Stock/5 (tCO_2/yr)
	Emission	**Emission**	**Removals**	**Emissions & Removals**	**Emissions & Removals**	**Emissions & Removals**
2009	4,047,172	31,373,792	0	35,420,964	39,217,752	42,172,324
2010	4,021,547	35,461,013	0	39,482,561	39,217,752	42,172,324
2011	6,618,171	35,244,691	0	41,862,863	39,217,752	42,172,324
2012	8,798,126	28,122,531	0	36,920,657	39,217,752	42,172,324
2013	11,006,534	31,395,182	0	42,401,717	39,217,752	42,172,324

Chapter 3. PNG REDD+ results 2014-2015 against the adjusted historical average FRL 2009-2013

3.1 REDD+ Results Calculation

The REDD+ results for the years 2014 to 2015 were assessed against the recalculated historical average FRL of 5-year (2009-2013) Historical Average plus 0.02% of total carbon stock in 2013. The following formula was applied to calculate the REDD+ results:

REDD+ results (*t*) = FRL (Historical Average + 0.02% of total C Stock) 2014 to 2018 – Total Emissions and Removals at year *t;* (tCO_2/yr.)

Thus, REDD+ results achieved by Papua New Guinea in 2014 and 2015 against the historical average FRL is calculated as follows:

(i) 2014: 42,172,324 tCO_2 – 38,677,156 tCO_2= **3,495,169 tCO_2**

(ii) 2015: 42,172,324 tCO_2 – 39,024,003 tCO_2 = **3,148,321 tCO_2**

Total REDD+ results achieved by PNG in 2014 and 2015 against the Historical Average FRL= 3,495,168 tCO_2 + 3,148,321tCO_2 = **6,643,490 tCO_2**[39]

Table 2 PNG REDD+ results 2014-2015

Year	Total emissions and removals 2009 – 2015 (tCO_2/yr)	FRL /(Historical Average + 0.02% of total C Stock) (tCO_2/yr)	REDD+ Results 2014-2015 (tCO_2/yr)
2009	35,420,964	42,172,324	
2010	39,482,561	42,172,324	
2011	41,862,863	42,172,324	
2012	36,920,657	42,172,324	
2013	42,401,717	42,172,324	
2014	38,677,156	42,172,324	3,495,169
2015	39,024,003	42,172,324	3,148,321
Total			**6,643,490**

3.2 Existing system for monitoring REDD+ results

PNG has an operational and robust national REDD+ MRV System[40] for monitoring and evaluating the REDD+ results achieved through the implementation of REDD+ activities (Deforestation and Forest

[39] The one's place may be differently shown due to the rounding process. This also applies to the total value shown on Table 2.

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 also in the process of developing a REDD+ Registry and Nesting system which will further enhance monitoring and evaluation of the REDD+ results reported.

The cause of the emission reduction observed between 2014 and 2015 was due to the implementation of REDD+ related policies and measures[41] 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.

[40] Detail information on PNG's REDD+ MRV is available at Chapter 6 of the PBG BUR1 Technical Annex.
[41] These policies and measures are listed on Page 8 of the Technical Annex.

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