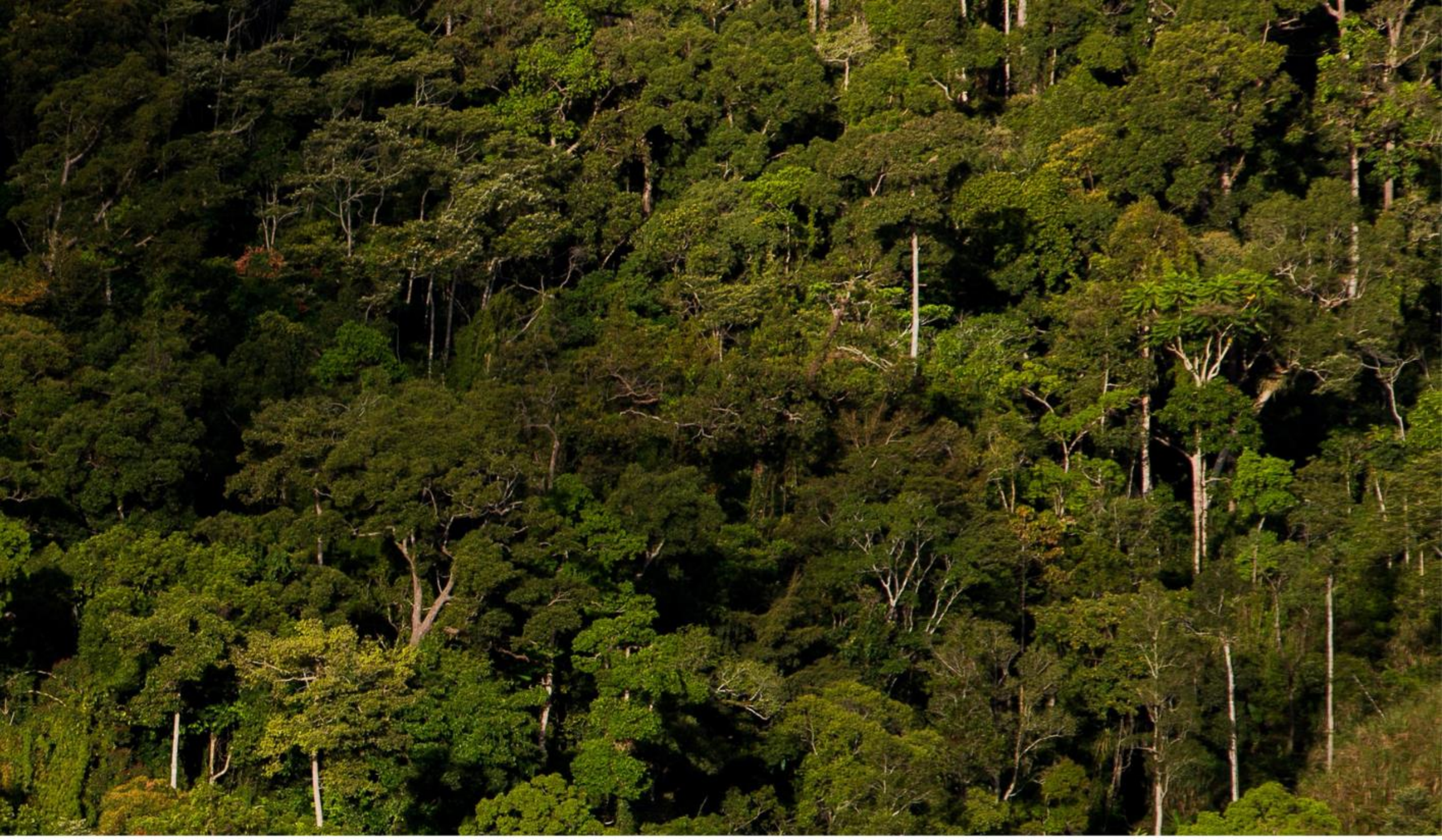


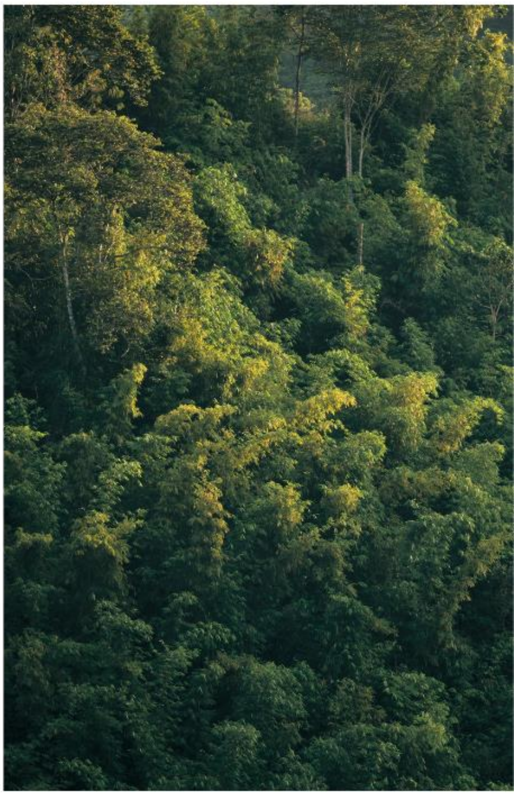

# Philippines Forest Reference Level under the UNFCCC REDD+ Framework

Republic of the Philippines

December 2022

**UNFCCC Focal Point of the Philippines**

Climate Change Commission

**Executive in Charge**

TIRSO P. PARIAN JR., CESO IV
Director
Forest Management Bureau

**Authors**

FMB Technical Working Group

**Contributors**

USFS, SIG, Mullion Group, Silva Carbon

Cover photo:

Different forest photos are from the National Greening Program
Main photo: Tarlac (2021), (L) Pampanga (2021), (M) Negros Island (2021), (R) Davao (2021)

# FOREWORD

The United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) encourages developing nations who want to participate in Reducing Emissions from Deforestation and Forest Degradation (REDD+) to voluntarily submit a Forest Reference Emission Level in the framework of result-based payments. Through this submission the Philippines expresses its keen interest and commitment to REDD+.

The Forest Management Bureau (FMB) of the Department of Environment and Natural Resources (DENR) is responsible for developing the Forest Reference Level (FRL). The Philippines constructed FRL will be able to improve over time by incorporating better data, improved methodologies, and, when necessary, additional pools, while taking into account the importance of adequate and dependable support as mentioned in decision 1/CP.16, paragraph 71, in the adoption of a stepwise approach to FRL calculation.

To lower the costs associated with updating the FRL and improve forest management and consistency in forest monitoring, a national FRL scale level has been developed. Construction includes activities that increased the carbon stock in the forests and the reduced emissions due to deforestation. Two types of biomass classes were chosen to be included in the document: above-ground biomass and below-ground biomass and C02 for the gasses included.

The Philippine FRL area coverage has a total size of 30 million hectares and is divided into two categories: land that is in the public domain (which includes national parks, mineral lands, and forests), and land that is either alienable and disposable or used for agriculture. The whole country's territory, including all of the major islands, is included in the baseline assessment's coverage area.

# EXECUTIVE SUMMARY

The Philippines' first National Forest Reference Level (FRL) is presented in this document to the United Nations Framework Convention on Climate Change (UNFCCC). The Philippine FRL, which is measured in tons of carbon dioxide equivalent annually, is used to evaluate how well the nation is doing at carrying out the REDD+ initiatives mentioned in decision 1/CP.16, paragraph 70. It offers historical baseline data on the nation's emissions stated in annual terms for a reference period, which will be contrasted with the emissions and removals from a result period.

The FRL's main goal is to support the Philippines in its efforts to combat climate change, specifically by analyzing and assessing the role that REDD+ initiatives, policies, and strategies play in achieving sustainable forest management objectives.

The development process of the FRL underwent several technical workshops and sessions, starting from capacity-building activities of the Technical Working Group (TWG) towards the finalization of the national FRL's development. This was led by the Department of Environment and Natural Resources – Forest Management Bureau (DENR-FMB), in close coordination with its partners.

The national scale level is where the FRL for the Philippines is proposed in this submission, which should reduce associated costs and increase consistency between forest monitoring and forest management. It started out with the best national data that were available for the deforestation and reforestation activities that took place during the reference period from 2000 to 2018, and it will be improved over time by the addition of new and better data, improved methodologies, and new carbon pools and activities support, as mentioned in decision 1/CP.16, paragraph 71.

The calculation of the Philippines' reference emissions, which account for yearly variations in forest cover, is based on past emissions resulting from the deforestation of the country's forests. The FLINTpro software is used to calculate all emissions. All national environmental data sets were built using the software, and Tier 2 and Tier 1 IPCC methods were applied. Each pixel's past history of the forest cover is explicitly identified and examined by FLINTpro, which then applies the appropriate emissions or removals computation method for the events that have been detected as changing the forest cover.

In the years 2000 to 2018, 1,197,127 ha of forest were lost as a result of the construction of the FRL, while 671,713 ha were estimated to have been planted with new trees during that time. The unbiased area estimation is used to calculate the total area of both reforestation and deforestation, and the TerraPulse forest cover time series was used to calculate the relative distribution of the area to each year in the study period of 2000–2018.

Over the years 2000 to 2018, there were 18,140,907 t$CO_2$-e in average gross emissions from deforestation, while there were 2,836,485 t$CO_2$-e in average gross removals. Net emissions on average were 15,304,422 t$CO_2$-e. While the Removals (carbon stock gains) due to reforestation over the period 2000-2018 is 1,797,720 t$CO_2$-e over time, the trend in net deforestation emissions is consistent with the pattern in the area of deforestation over the historical era. From 2000 to 2018, the historical average yearly emissions from deforestation and the improvement of forest carbon stocks (reforestation) were 13.507 Mt$CO_2$-yr$^{-1}$. Deforestation-related emissions account for the majority of emissions (15.304 Mt$CO_2$-yr$^{-1}$), while reforestation removes 1.797 Mt$CO_2$-yr$^{-1}$.

Before the emission figures were determined, the Philippines had already implemented a number of laws and policies to cut emissions and strengthen the nation's initiatives to support adaptation

and mitigation of climate change. These policies help to strategize and provide a road map for day-to-day operations. It ensures compliance with laws and regulations and streamlines the internal process. One of them is the development of the National REDD+ Action Plan (2022-2031). This strategy will benefit its target clientele and the public in general. The release will accelerate REDD+ implementation and operationalization in the country, with concrete outputs in achieving poverty alleviation, biodiversity conservation, and sustainable forest management.

# TABLE OF CONTENTS

## ACRONYMS

| | |
|---|---|
| AD | Activity Data |
| ADSDPP | Ancestral Domains Sustainable Development and Protection Plan |
| AFOLU | Agriculture, Forestry, and Other Land Use |
| AGB | Above ground biomass |
| ARR | Afforestation, Reforestation, and Restoration |
| AT | Assessment Team |
| BGB | Below Ground Biomass |
| BUR | Biennial Update Report |
| C | Carbon |
| CAVCS | Carbon Accounting, Verification, and Certification System |
| CBFMA | Community Based Forest Management Agreement |
| CCC | Climate Change Commission |
| CCS | Climate Change Service |
| CLUP | Comprehensive Land Use Plan |
| COP | Conference of Party |
| CPL | Cropland Probability Layer |
| CRMF | Community Resource Management Framework |
| DAO | DENR Administrative Order |
| DENR | Department of Environment and Natural Resources |
| DHSUD | Department of Human Settlements and Urban Development |
| DMC | DENR Administrative Order |
| DOM | Dead Organic Matter |
| EF | Emission Factor |
| ERDB | Ecosystems Research and Development Bureau |
| FAO | Food and Agriculture Organization of the United Nations |
| FGDIS | Forest Geospatial Data Information Section |
| FIS | Forest Information System |
| FLUP | Forest Land Use Plan |
| FMB | Forest Management Bureau |
| FRA | Forest Resources Assessment |
| FRL | Forest Reference Level |
| FSD | Forest Spatial Datasets |
| GDEM | Global Digital Elevation Model |
| GEE | Google Earth Engine |
| GEZ | Global Ecological Zones |
| GIS | Geographic Information System |
| GHG | Greenhouse Gas |
| ha | hectares |
| ICCA | International Congress and Convention Association |
| IEF | Implied Emission Factor |
| IFMA | Industrial Forest Management Agreement |
| IP | Indigenous People |
| IPCC | Intergovernmental Panel on Climate Change |
| ITPLA | Industrial Tree Plantation Lease Agreement |
| JBIC | Japan Bank for International Cooperation |
| KBA | Key Biodiversity Area |
| LCA | Long-term Cooperative Action |
| LGC | Local Government Code |

| | |
|---|---|
| LULUCF | Land Use Land Use Change and Forestry |
| MRV | Measurement, Reporting, and Verification |
| NAMRIA | National Mapping and Resource Information Authority |
| NCCAP | National Climate Change Action Plan |
| NCIP | National Commission on Indigenous Peoples |
| NDC | Nationally Determined Contribution |
| NDFI | Normalized Degradation Fraction Index |
| NDMI | Normalized Difference Moisture Index |
| NDVI | Normalized Difference Vegetation Index |
| NFI | National Forest Inventory |
| NFMS | National Forest Monitoring System |
| NFSCC | National Framework Strategy on Climate Change |
| NGP | National Greening Program |
| NIPAS | National Integrated Protected Areas System |
| NMRC | National Multi-Stakeholder REDD+ Council |
| PA | Protected Area |
| PAGASA | Philippine Atmospheric, Geophysical and Astronomical Serrvices Administration |
| PNRPS | Philippine National REDD+ Strategy |
| QA | Quality Assurance |
| QC | Quality Control |
| REDD+ | Reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forest and enhancement of forest and enhancement of forest carbon stocks in developing countries |
| SIFMA | Socialized Industrial Forest Management Agreement |
| SIG | Spatial Informatics Group |
| SIS | Safeguards Information System |
| SLMS | Satellite Land Monitoring System |
| SWG | Small Working Group |
| $tCO_2$-e | Tonnes of $tCO_2$ equivalent |
| TA | Technical Assessment (of the FREL/FRL) |
| TCC | Tree Canopy Cover |
| TCM | Tree Canopy Model |
| tdm | Tonnes of dry matter |
| TWG | Technical Working Group |
| U | Uncertainty |
| UDP | Upland Development Program |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UN-REDD | United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation |
| USFS | United States Forest Service |

# LIST OF TABLES

## LIST OF FIGURES

# 1. INTRODUCTION

## 1.1. Relevance

Decision 1/CP.16 Paragraph 70 of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC), encourages developing country Parties to contribute to mitigation actions in the forest sector by undertaking the following activities, as deemed appropriate by each Party and in accordance with their respective capabilities and national circumstances: (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Conservation of forest carbon stocks; (d) Sustainable management of forests; (e) Enhancement of forest carbon stocks.

In accordance with the provision of adequate and predictable support, including financial resources and technical and technological support, paragraph 71 of decision 1/CP.16 requested developing countries seeking to engage in REDD+ activities under the convention to develop a number of elements, including: (a) National Action Plan or Strategy for REDD+, (b) Forest Reference Level (FRL), (c) National Forest Monitoring System (NFMS) that is reliable and transparent, and (4) Safeguard Information System.

According to Dec. 12/CP.17, developing country Parties planning to engage in REDD+ activities should include in their FREL/FRL submission accurate, complete, consistent with the COP's guidance, and transparent information to enable a technical evaluation of the information used to create the FREL/FRL. The most recent recommendations and policies of the Intergovernmental Panel on Climate Change (IPCC) should be used as a guide for the information supplied, as approved or promoted by the COP (UNFCCC, 2012).

In accordance with Dec. 12/CP.17, the Philippines accepts the invitation by notifying the UNFCCC to voluntarily submit a proposed national FRL for deforestation and reforestation in the context of results-based payments for activities related to "reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries (REDD+)" under the UN Framework Convention on Climate Change (UNFCCC).

A comprehensive set of instructions for participating nations to advance with REDD+ preparation was indicated in Dec. 13/CP.17. These include decision-making guidelines and processes for evaluating technical submissions from parties regarding proposed forest reference emission levels and/or FRLs (UNFCCC, 2012).

The Philippines opted to report a national scale level FRL based on the data availability on a "*stepwise*" approach which will aid the country to improve its FRL by adding new, high-quality information, enhanced and appropriate procedures, new carbon pools, and activities over time while adhering to Dec. 12/CP.17 criteria.

The Philippines has a strong institutional and legal framework that offers the necessary frameworks for REDD+ implementation under its national objectives and commitments on climate change, reporting on national communications, intended nationally determined contributions (NDCs), and Biennial Update Report (BUR). The Climate Change Act (Republic Act No. 9729), a law that mainstreams climate change into government policy formulations, established the framework strategy and program on climate change, and established the Climate Change Commission (CCC) for this purpose, was officially promulgated in the nation in 2009. The nation subsequently created the Climate Change Action Plan and the National Framework Strategy on Climate Change, both of which were signed by the President of the Philippines.

The CCC, under RA 9729, was given the responsibility of coordinating and directing all climate change-related initiatives, and serving as the country's UNFCCC national focal point.

## 1.2. General Approach

Decision 1/CP.16 Paragraph 70, encouraged the COP-16 in Cancun to contribute to mitigation actions in the forest sector, based on their respective capabilities and national circumstances, by undertaking the following activities: (a) Reducing emissions from deforestation; (b) Reducing emissions from forest degradation; (c) Conservation of forest carbon stocks; (d) Sustainable management of forests; and (e) Enhancement of forest carbon stocks (UNFCCC, 2011).

## 1.3. Country Context

The Philippines is an archipelagic country comprising over 7000 islands, with mountain ranges, active volcanoes, and coastal plains. The country has a total land area of 30,000,000 ha legally classified into two: alienable and disposable lands, and forestlands. Alienable and disposable (A&D) lands cover 14,194,675 ha, about 47.3% of the total land area of the country, which is certified from the data of 2006 Land Classification Statistics. These lands that may be alienated for private ownership are limited to agricultural lands, which may further be classified by law according to the uses they may be devoted. A&D lands can only be disposed of for homestead settlement, by sale, by lease, and by confirmation of imperfect or incomplete titles. On the other hand, forestlands cover 15,805,325 ha, approximately 52.7% of the Philippines' total land area. Forestlands include the public forest, permanent forest or forest reserves, and forest reservations, which the government seeks to protect, develop, and rehabilitate to ensure sustainable production and utilization of the forests and forest resources therein. Further, Section 3 of Article XII (National Economy and Patrimony) of the 1987 Philippine Constitution classified lands of the public domain into four categories: (i) agricultural, (ii) forest or timber, (iii) mineral lands, and (iv) national parks. Mineral lands and National Parks are part of the forest lands declared to be through the aid of legislation.

The 2020 land cover data released by NAMRIA estimates that the national forest cover is around 7,226,394 ha or 24.09% of the total land area of the country. This shows a slight increase of about 3.03% from the 2015 land cover data. Enhancing forest cover is a key priority of the Philippine Government in its commitment to accelerate climate action.

The Philippines has a solid institutional and legal framework that provides the needed structures to be able to implement REDD+ consistent with its national objectives and commitments on climate change, nationally determined contributions, national communication reporting, and BUR. The country has promulgated the Climate Change Act of 2009 (Republic Act No. 9729), an Act mainstreaming climate change into government policy formulations, establishing the framework strategy and program on climate change, and creating for this purpose, the CCC to coordinate and guide all policies related to climate change. Subsequently, the country developed the National Framework Strategy on Climate Change (NFSCC) signed by the President of the Philippines, which also led to the development of the National Climate Change Action Plan (NCCAP). The NCCAP strategically established the Philippines' long-term climate agenda from 2011–2028. The NCCAP also serves as the country's road map for climate action and is the lead policy document guiding the climate agenda at all levels of government.

Institutionally, the Philippines has adopted the Philippine National REDD+ Strategy (PNRPS), providing the National REDD+ Action Plan with a 10-year timeframe (2022-2031) as the country's framework, guide, and roadmap for the implementation of the REDD+ Strategy and in accessing Results-Based Payment and Financing mechanisms in the country. The strategy calls for a decentralized approach that allows for the establishment of sub-national projects, which must eventually form a part of the National REDD+ program.

## Drivers of forest change

The Philippines have seen a significant reduction of its forest cover over the last few decades. From 1990 to 2013, forests in the Philippines decreased by over 14 million hectares (Forest Management Bureau [FMB], 2018). The rate of deforestation in the country hastened during the abundance of log exports in the early twentieth century (Stenberg, & Siriwardana, 2008).

The known drivers of forest loss in the Philippines are legal/illegal logging/poaching, kaingin making, conversion of forests (to plantations, agroforestry, or fishponds), grazing, mining, road construction, hydropower dam construction, settlement, typhoons, floods, landslides, and forest/brush fires (these were the options provided to interpreters for reference data collection, see Annexes 2 and 3). The most frequently observed driver of forest loss (according to the reference data from this FRL) is conversion of forests to either plantations, agroforestry, or fishponds. Kaingin making and legal/illegal logging are also commonly observed drivers, with fires being observed slightly less frequently.

The drivers of forest change in the Philippines are described below:

### Timber harvesting

While the removal, relocation, and cutting of timber are authorized under registered plantations and within valid tenure agreements issued by the Government, the incredible global demand for wood and wood products still accounts for around 70% of forest degradation nationwide due to massive clearing of trees for the construction of access roads and improvement of government projects in general. On the other hand, illegal timber harvesting continues to contribute to the rapid rate of forest degradation and deforestation.

### Land Conversion and Expansion

Forest land conversion is the largest cause of global deforestation today as it clears the forests to use the land for another purpose, i.e., agriculture, grazing, commodity production, and settlement, where the process is usually irreversible. Attributing to the growing demand for available lands to expand urbanization, the introduction of cheap labor requirements, poor implementation of environmental regulations, and global trade barriers and arrangements, the communities and other stakeholders concerned highly dependent on the occupation and development of forest lands causes a range of ecological and social impacts.

### Mining

As worldwide demand for minerals and metals rises due to the vital role it plays in society, it puts pressure on forest degradation as well. Not only does this activity clear vegetation for mineral extraction, but they also often introduce massive new infrastructures, which unknowingly facilitates new access to land for further clearing. When managed irresponsibly, the mining sector can lead to several serious unwanted effects that will potentially harm the planet in the long run.

**Fires and Other Natural Hazards**

The country is vulnerable to a number of natural hazards such as typhoons, landslides, floods, drought, earthquakes, forest fires, and climate change are influencing factors leading to deforestation and forest degradation. Heavy rains that accompany typhoons cause flash floods and landslides that destroy forest areas in the process.

The occurrence of forest fires in the country is often a result of the regular burning of kaingins and accidental fires that spread through the forests. The risks of forest fires are heightened during drought years. The tropical climate is conducive to forest regrowth and recovery. However, the threat of extensive forest fire is still present since most of the forests are open to public access.

**Slowing down forest loss and degradation**

As of 2020, the Philippine Forest cover is estimated at 7.2 million hectares in which 30.7% is closed forest, 65% is open forests and 4.3% is mangrove forests. As illegal logging continues, the country's remaining forest is still in danger. According to the Food and Agriculture Organization (FAO) (2010), the cause of deforestation is either natural or man-made.

Policies have been passed to help address deforestation and degradation. Some of the key relevant policies that impact forest land and resource use from 2000 to 2018 are the following:

- National Integrated Protected Areas System Act of 1992 (NIPAS) (RA 7586)
- Community-based Forestry Management Agreement (DAO 29, 2004 Revised IRR)
- Sustainable Forest Management (EO 318, s. 2004)
  - Suspension of Utilization and Transport of Trees and Issuance of Harvesting Permits in Private Lands; Suspension of Approval of Multi-Year Operational Plans of Timber License Agreements (Memo 574, s. 2004) National Greening Program (NGP) (EO 26, s. 2011)
- Moratorium on Cutting and Harvesting of Timber in Natural and Residual Forests (EO 23, s. 2011)
- Expanded National Greening Program (EO 193, s. 2015)

While policies are important instruments in the fight against further loss of forests, a FAO and International Tropical Timber Organization (ITTO) policy brief released in 2009, attribute deforestation and forest degradation to the lack of forest law compliance and good governance. This is further supported in study by Carandang et al. (2013) that analyzed the drivers of deforestation and forest degradation in the country. In their analysis of drivers in different case study sites in the country, the Philippines' weak policies and governance have shown to have exacerbated the impact of poverty, population pressure, and market demands in creating conditions in further loss of forests. Carandang et al. stressed that the governance issues stemmed from unstable, confusing, and conflicting forest policies and mandates, and a lack of will and coordination among and between sectors. Also, they identified inadequate monitoring and law enforcement, which aggravates the situation. This trend puts the Philippines' Forest in continuous decline if issues and gaps are not sufficiently addressed.

## 1.4. Objective of the Submission

The main objective of the FRL submission is to support the climate change mitigation efforts of the Philippines. The national REDD+ strategy supports the sustainable development goals of the country and offers another facet in forest management particularly in the reduction of greenhouse gas (GHG) emissions, as well as social and environmental benefits. Further objectives include the following:

- Assess and evaluate the importance of REDD+ policies, strategies, and measures in the attainment of sustainable forest management goals;
- Provide baseline information on the country's FRL emissions to relevant stakeholders including other government agencies, the private sector, and the general public on a clear, transparent, and consistent basis;
- Facilitate access to potential funding sources for results-based payments and support efforts to reduce greenhouse gas emissions from the land use and forestry sector; and
- Establish the historical deforestation rate for the Philippines as input to policy analysis, monitoring, and evaluation of forestry plans and programs.

## 1.5. FRL

The Forest Management Bureau (FMB) of the DENR is pushing for the nationwide implementation of the Reducing Emissions from Deforestation and Forest Degradation (REDD+) strategy to help reduce the impact of climate change by protecting and sustainably managing the country's forests. One element of this is the establishment of a country Forest Reference Emission Level to be developed by country parties implementing REDD+ activities (according to paragraph 71 of decision 1/CP.16).

To become a REDD+-ready country, the Philippines is completing the four elements of REDD+. The Country's Forest Reference Level reporting period starts from the year 2000 to 2018. Reference levels are expressed as tonnes of $CO_2$ equivalent per year for a reference period and will be compared against the emissions and removals from a result period. The emission from the forestry sector was calculated as a simple historical average of the country's FRL emissions. To assess the performance, emissions occurring after implementing REDD+ activities (post-2018) will be compared to the FRL established by the country, and success will be measured by emission reductions or increased removals relative to the FRL. It serves as a benchmark for assessing a country's performance in implementing REDD+ activities and needs to maintain consistency with the greenhouse gas inventory estimates.

The submission of the proposed FRL is subject to a technical assessment. Parties may recall that the COP, in its decision 13/CP.19, adopted the guidelines and procedures for the TA of submission from parties on proposed forest reference emission level in a context of result-based payments. The technical assessment process identifies areas for technical improvement and the capacity building needs in the construction of the FRL.

An overall national scale FRL was adopted to reduce the costs related to calculating and updating the FRL and increase efforts in forest monitoring and forest management. Using the best nationwide available data, a stepwise approach is used to improve the FRL over time by incorporating new and better information, improved methodologies, and new carbon pools and activities.

## 1.6. Process of FRL establishment

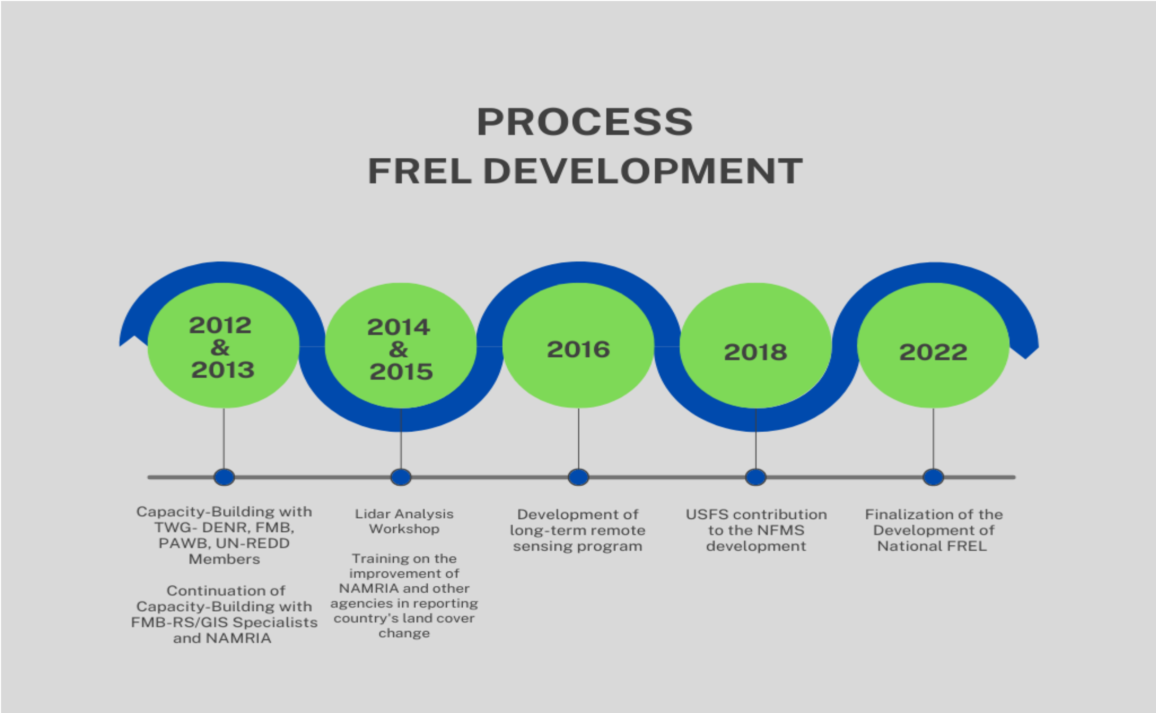


*Figure 1. Development Process of the Forest Reference Emissions Level*

In 2012, United States Forest Service (USFS) remote-sensing experts conducted capacity-building activities in the Philippines in which the technical working group (TWG) from the DENR, FMB, PAWB, and UN-REDD TWG members for Measurement, Reporting, and Verification (MRV) participated. Possible collaboration with NAMRIA and USFS was discussed during the visit. The USFS staff worked closely with FMB'S RS/GIS specialist and separately with NAMRIA personnel. There were further discussions in 2013 on how USFS can assist in the continuation of capacity-building in remote sensing for forest land and land cover mapping and monitoring as they apply to both agencies' information and product needs.

USFS conducted a Lidar Analysis Workshop in July 2014 in which various organizations, including government agencies, academes, and Non-Government Agencies (NGOs) participated. The objective of the training was to share the complexities, necessary tools, and workflows of large lidar datasets to create a seamless canopy structure product, forest inventory models, and hydrological models. The USFS held a training with the FMB and NAMRIA in 2015 and discussed how to improve the accuracy of current project results for both NAMRIA and other agencies in reporting the country's land cover changes over time.

In 2016, USFS developed a long-term remote sensing roadmap in response to the request of the FMB to meet MRV and REDD+ requirements. The roadmap included building the capacity of the Forest Geospatial Data Information Section (FGDIS) from FMB to create the necessary data independently.

The capacity building continued in 2018, when FMB staff were brought to the Global Landover Change Facility (GLCF) in University of Maryland. The staff received training on validating the Phil-Lidar Calibrated Forest Cover Datasets. Possible technical support for the Measurement, Reporting, and Validation (MRV) Components of the Philippine National Forest Monitoring System (NFMS) was also discussed during this trip.

In line with the capacity-building activities and the years of assistance in developing capacity within FMB in relation to its REDD+ readiness, FMB, USFS, and other partners agreed to pursue the partnership further. In 2020, despite the constraints brought on by the pandemic, FMB and USFS were able to set up regular online sessions to guide the FMB TWG in processing forest cover and national forest inventory data, implement unbiased area estimates, and draft the FRL document. The final FRL document is now ready for submission to the UNFCCC in January 2023 to undergo the technical review process.

# 2. DEFINITION

This section includes a definition of the forest and all REDD+ activities based on the formal definition in the Philippine documents and the operational definition used in constructing this FRL. Although all REDD+ activities are defined, only deforestation and reforestation are included in this FRL submission. Other REDD+ activities are defined here only to show how these other activities may be considered in future updates.

## 2.1. Forest

The official definition of forest in the Philippines is based on FAO's (2001) forest definition and formalized through the DENR Memorandum Circular (DMC) 2005-005 and NSCB Resolution No. 12 Series of 2004. This is also echoed in the Philippine National REDD+ Strategy (2017) document. Forest is described as:

> *"Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use".*

The definition mentions key parameters such as tree height and canopy cover percentage that are identifiable using remote sensing technologies. Beyond these key parameters, the same policy further qualifies what is considered forests in the Philippines.

> *"It consists either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 percent. Young natural stands and all plantations established for forestry purposes, which have yet to reach a crown density of more than 10 percent or tree height of 5 meters are included under forest. These are normally forming parts of the forest area, which are temporarily*

*unstocked as a result of human intervention or natural causes but which are expected to revert to forest. It includes forest nurseries and seed orchards that constitute an integral part of the forest; forest roads, cleared tracts, firebreaks, and other small open areas; forest within protected areas; windbreaks and shelterbelts of trees with an area of more than 0.5 hectare and width of more than 20 meters; plantations primarily used for forestry purposes, including rubberwood plantations. It also includes bamboo, palm, and fern formations (except coconut and oil palm).*"

This definition of forest is adopted by the National Mapping and Resource Information Authority (NAMRIA), but it is not entirely clear how the percent canopy cover parameter is implemented in its forest cover mapping protocol in the 2010 and 2015 maps. For the Philippine FRL construction, the forest cover data was created using the time series of tree canopy cover (TCC) developed by TerraPulse[1] through USFS's support. The TCC is measured as the vertically projected area of woody plant matter, which is commonly used as an attribute for defining forest in carbon monitoring and accounting work (Feng et al., 2018). A user-defined minimum threshold TCC to define forest (Sexton et al., 2015, 2013) and a forest cover probability value was used to determine forest cover extent for the entire time series. Data produced for the Philippines included an annual TCC with a 10% and 30% threshold. After a qualitative study of the forest cover extent of both TCC thresholds and the NAMRIA forest cover, it was decided that the forest cover using the 30% post-processed TCC TerraPulse product is a better approximation of known forest areas. Thus it was used as a starting point for sample distribution and annual forest maps. However, the official 10% TCC definition was used in reference data collection and bias correction. Although the 30% TCC was used in the process, the final results are still representative of the 10% TCC Philippine forest definition.

## Forest data used in the GHGI and FRL

The forest data used in the Philippine Greenhouse Gas Inventory (GHGI) (2018) and the FRL differ. In the GHGI the forest data was based on the NAMRIA 2010 forest data, categorized into closed, open, mangrove, and forest plantations (based on FMB data). The GHGI also stratified the forest based on the mentioned categories. However, in the FRL establishment, this was not used because it is expected that forests can switch from closed to open canopy forests through the years.

This FRL used the TerraPulse forest data, as discussed earlier. Further, this forest data were stratified using the Philippine Atmospheric, Geophysical and Astronomical Services Administration's (PAGASA) four Philippine Climatic Types instead of the Global Ecological Zones (GEZ). The IPCC Guidelines (2006) consider it good practice to stratify forest lands into more homogeneous strata to reduce variance within strata and improve accuracy and uncertainty. It is discussed in the FRA results (Section 4) that there is a significant difference in the calculated mean of above-ground biomass (AGB) of the inventory tracts based on Philippine climate types than based on the GEZ. The four Philippines Climate types are described as:

**Type 1**- Two pronounced seasons, dry from November to April and wet during the rest of the year. Maximum rain period is from June to September;

[1] A company who develops, distributes, and analyzes geospatial data to optimize land-use planning and investment.

**Type 2**- No dry season with a very pronounced maximum rain period from December to February. There is not a single dry month. Minimum monthly rainfall occurs during the period from Dec. to Feb. or from Mar to May;

**Type 3**- No very pronounced maximum rain period, with a dry season lasting only from one to three months, either during the period from December to February or from March to May. This type resembles Type 1 since it has a short dry season;

**Type 4**- Rainfall is more or less evenly distributed throughout the year. This type resembles Type 2 since it has no dry season (PAGASA, 2015)

This forest stratification used is then identified as Forest types 1, 2, 3, and 4 in discussions in Sections 4 and 5.

## 2.2. Deforestation

In this submission, deforestation is defined as the human-induced "conversion of forest to another land-use or the long-term reduction of the tree canopy cover below the minimum 10% threshold'. A conservative approach to classifying deforestation has been taken for this initial submission. Through the unbiased area estimation method, deforestation was classified based on observing only a single change of forest to non-forest throughout the time-series. This provides a conservative estimate of the area of deforestation because areas with multiple forest loss and gain events have not been included at this stage.

## 2.3. Forest Degradation

Forest degradation activity is not currently covered in this submission but is defined as changes within the forest, whether natural or human-induced, negatively affect the structure and function of the stand or site, and thereby lower the capacity to supply products and/or services resulting in a degraded forest (FMB, 2005).

Although this activity is not included in the submission, the accuracy assessment team (AT) was instructed to note if forest degradation could be identified during the reference data collection. Based on the team members' comments, a pixel marked as forest degradation because of its diminished canopy recovers quickly in one year. This experience shows the difficulty of identifying forest degradation and is one of the critical tasks to improve on in future updates of the FRL.

## 2.4. Conservation of Forest Carbon Stock

Protection of existing forest areas can have a significant impact on preserving existing carbon pools and reservoirs. The Philippines has promulgated laws and policies on establishing and managing areas for protection and conservation and invested in improving systems for onsite enforcement of forest protection and other environmental resource-related laws.

The protection and conservation areas of the country can be broadly categorized into two types. First are the national parks established through proclamations, and the second type are the protection forests which are lands of public domain (commonly referred to as forest lands) that are designated as areas for protection based on certain biophysical conditions these lands possess.

Republic Act (RA) No. 7586 or the National Integrated Protected Areas System (NIPAS) Act of 1992, as amended by RA 11038, the Expanded National Integrated Protected Areas System (ENIPAS) Act of 2018, defines protected areas and the categories or types of PAs and prescribes the activities that are allowed, regulated, and prohibited within the PA and imposes fees for allowed and regulated uses.

Areas of the PA are made up of management zones, namely the Strict Protection Zone (SPZ) and the Multiple Use Zone (MUZ). The SPZ is closed to human activities because of its significant biodiversity value, high susceptibility to geo-hazard, and identification as permanently dangerous. These areas may also include habitats of threatened species or degraded areas designated for restoration and subsequent protection, regardless of their regeneration stage.

On the other hand, the areas of the PA's MUZ are where varied land uses may be allowed. This is where settlement, traditional, and sustainable land use, including agriculture, agroforestry, extraction activities, income-generating, or livelihood activities, may be allowed to the extent prescribed in the protected area management plan. Most PA management plans prohibit the expansion of said land uses within the MUZ.

DENR Administrative Order (DAO) No. 1995-15 or the Revised General Guidelines in the Implementation of the Sub-classification of Forest Lands and Other Inalienable Lands of the Public Domain, identifies Protection Forest as one of the subclassifications of Forest Lands. Forest Lands are part of the public domain lands owned by the State and cannot be disposed of or alienated. Protection forests are land outside of the PA and differentiated essentially for their beneficial influence on soil and water in particular and the environment in general. These are areas above 50% slope and more than 1,000 meters in elevation. This category includes critical watersheds, mossy forest, strips of specified width bordering rivers, streams, shorelines, reservoirs, steep, rocky areas, and other naturally unproductive lands. In 2011, natural and residual forests were added as part of the Protection Forest through Executive Order No. 23, which declared a moratorium on the cutting and harvesting of timber in these areas.

Forests within the PAs and Protection Forests are to be conserved and will not be subjected to removal. The onsite enforcement level is higher in PAs than in the Protection Forest. This is because PAs have a protected area office with staff members in charge of the overall management and on-the-ground enforcement activities of the PA. In 2016, the implementation of the Forest Biodiversity Protection System by DENR (often referred to as Lawin) helped in improving protection activities in PAs and in forest lands in general. Through the conducted apprehensions in the patrolling, the rangers can intervene and prevent illegal activities such as logging in forest areas.

## 2.5. Sustainable management of forest

Sustainable forest management is envisioned to foster collaborative management mechanisms in implementing programs that enable communities to produce goods and services. It is defined as managing a forest to achieve one or more specified management objectives concerning the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undesirable effects on the physical and social environment.

In the Philippines, the main mechanism for this forest management approach is through the issuance of land tenure agreements over portions of the forest lands (legal land classification). It is viewed as a vehicle to co-manage these areas with communities, individuals, or corporations interested in developing forest plantations, tree farm and agroforestry areas, and wood-based processing facilities to meet domestic demand for round wood, fuelwood, and other services. The DENR is the main overseer of the program as the primary agency responsible for the management, protection, development, and proper use of the country's natural resources.

The two main modes of tenure issuances that would directly qualify under this REDD+ activity are a) industrial plantations and b) community agreements. The tenure agreement requires the tenure holder to submit a management plan to state the strategies and activities to be implemented and provide a spatial plan of resource utilization and development in their respective areas.

### 2.5.1. Industrial plantations

Several types of tenure instruments are under this mode and include the following: Industrial Forest Management Agreement (IFMA), Socialized Industrial Forest Management Agreement (SIFMA), and Industrial Tree Plantation Lease Agreement (ITPLA). These tenure agreements are production-sharing contracts with the government and were implemented starting in 1999. This instrument was viewed as a way to encourage the infusion of private investments in forestlands. These tenure agreements permit the growing and harvesting of timber and non-timber species for commercial production purposes. SIFMA and IFMA holders may also export logs, lumber, and other forest products found within their permitted areas.

### 2.5.2. Community-based management agreements

Executive Order No. 263, s. 1995 instituted the Community-Based Forest Management Agreement (CBFMA). This is a land tenure program that caters to communities living within or adjacent to the forestlands and entitles the tenure holder rights to occupy, possess, utilize and develop the forest lands and resources in designated zones within the CBFMA area and claim ownership of introduced improvements. One of the key distinctions the program had over previous community-oriented programs of the DENR was that CBFMA allowed selective logging by the community in secondary natural forests within their tenured area. However, the issuance of harvesting permits was suspended nationwide in 2004. The moratorium continues up to this time, especially with the promulgation of Executive Order No. 23, s. 2011 that placed a temporary ban on timber harvesting in natural forests, which included CBFMA holders. Nevertheless, other entitlements of the agreement continue to be enjoyed. They can harvest non-timber species, and they plant agroforestry crops while conducting reforestation, assisting natural regeneration, and conducting timber stand improvement activities where it is needed within their tenure area. The establishment of forest plantations and harvesting from them continues to be permitted.

Maps of the forestlands with land tenure agreements are available, but the data on spatial extent and location of where forest plantations were established is not uniformly available for all the tenure holders. This implies that currently, there are limited means to claim that any forest loss happening within the tenured area is part of sustainable forest management activities.

## 2.6. Enhancement of forest carbon stocks

Reforestation is one of the major actions that REDD+ program participating countries can include under the enhancement of forest carbon stocks activity. For this FRL submission, only reforestation will be included, primarily because of the availability of maps showing where reforestation was done together with information about the specific actions accomplished.

Several terms are being used that refer to the regrowing of trees on previously forested lands and different authors have defined the terms based on objectives, approaches used and the type of land targeted. As for reforestation, some literature has defined it as the establishment of forests on recently deforested lands, and those that qualified as "recent" are those <10 years and others as <50 years.

In the Philippines, reforestation is defined as the re-establishment of forests through planting and/or deliberate seeding of previously forested lands. Species used in reforestation may or may not be the same species that used to thrive in the area (DAO, 2021). In this FRL submission, the identification of reforestation areas is based on the observation of a single change of a non-forest to a forest area and does not include the requirement of planting or seeding in previously forested lands. It is typically not possible to distinguish with certainty using remote sensing whether a reforestation event was caused by planting/seeding, which is why this was not required in the definition for our reference data collection. The areas that meet the Philippines official definition would not be excluded from those selected by our methodology, and only includes reforestation where the change from non-forest to forest is persistent over time

Several reforestation programs have been implemented in the past and among the notable examples done at a national scale were the Watershed Subproject under the Forest Sector Program implemented from 1993 to 2000 (through the Japan Bank for International Cooperation (JBIC), the Luntiang Pilipinas' 10 Million Trees Program in 2008, and the Upland Development Program (UDP) in 2009-2010.

The most recent and ongoing reforestation program known as National Greening Program (NGP) is the government's banner program for reforestation and forest rehabilitation of degraded and denuded forestland in the country. Using the watershed as the planning unit, this program aims to implement strategies that address the ecological, environmental, economic, and social aspects of area development.

Reforestation activities include forest rehabilitation which can be done through assisted natural regeneration and the establishment of forest and agroforestry plantations. Forest rehabilitation activities are intensified within critical watersheds and PAs. Deforested and degraded areas of watersheds, particularly in the headwaters, are prioritized for rehabilitation. Forest rehabilitation efforts are also viewed to benefit the faunal habitat and the diversity of flora species in the area.

One of the main objectives of the NGP is to contribute to reducing poverty among upland and lowland poor households, indigenous peoples (IPs), and in coastal and urban areas; another facet is the establishment of forest and agroforestry plantations. Planting of fast-growing forest tree species on degraded and denuded forestlands is coupled with the intercropping of fruit trees and other agricultural crops through the agroforestry approach.

While the NGP is focused on the forestlands, the DAO No. 2021-43 establishes a Carbon Accounting, Verification, and Certification System (CAVCS) for forest carbon projects that cover not only the forestlands but also the alienable and disposable lands. The CAVCS aims to encourage and support investments in activities that sequester carbon dioxide and avoid emissions from deforestation and forest degradation. Forest Carbon Projects that are eligible under CAVCS should not be older than five (5) years and shall be implemented for a minimum of 20 years to ensure the permanence of project benefits. Thus, qualified participants may engage in any single or combination of the following activities: 1. Forest Protection - Patrolling, Establishment of look-out towers and firelines, risk assessment, and management of forest occupants, etc., 2. Afforestation, Reforestation, and Restoration (ARR) where activities increase carbon stocks but are not limited to tree/mangrove plantations, agroforestry, and assisted natural regeneration.

### 2.7. Forest Reference Level

In UNFCCC COP decisions the term forest reference emission levels and/or forest reference levels (FREL/FRLs) are often used. In this document, we refer to the country's benchmark as FRL to adopt the common understanding that FRL includes both emissions by sources and removals by sinks, which then also includes the conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks. Whereas FREL is more commonly understood to be emissions from deforestation and forest degradation only. The Philippines includes in its benchmark the net emissions from deforestation and gross removals from reforestation.

In this submission, FRL is defined as a benchmark for assessing the Philippines' performance in implementing REDD+, expressed in tons of carbon dioxide equivalent per year. The technical definition of FRL adopted in this submission covers the years from 2000-2018 taking the average of $CO_2$ gross emissions that is used as a reference to compare against actual emissions at a certain time in the future. This is aligned with Decision 12/CP.17 wherein the FRL will be updated periodically as appropriate, and takes into consideration new knowledge, new trends, and changes of scope and methodologies.

This FRL was constructed by looking at the country's annual historical forest changes to provide a benchmark for future performance evaluation of REDD+ activities. The FRL construction took into consideration the availability, and reliability of historical data and the length of the reference period that encapsulates significant policy changes and their impacts on the land cover. Further, this submission was guided by the lessons learned and recommendations of technical experts from their review of various countries' FREL/FRL submissions (FAO, 2019).

## 3. AREA, ACTIVITIES, AND POOLS COVERED

### 3.1. Area Covered

The Philippines' total area of about 30 million hectares is classified as Land of the Public Domain (it includes forestlands, mineral lands, and national parks) and Alienable and Disposable land or Agricultural land. The former covers about 15.8 million hectares or 52.7% of the area, while alienable and disposable lands encompass 14.2 million hectares or

47.3%. The area covered in the baseline assessment covers 100% of the country's territory, including all of the major islands.

## 3.2. Activities Covered

The activities that fall within the scope of REDD+ include the following: a) reducing emissions from deforestation; b) reducing emissions from forest degradation; c) conservation of forest carbon stocks; d) sustainable management of forests; and e) enhancement of forest carbon stocks. However, in this FRL construction, only the emission from deforestation activities and the removals from reforestation activities are included in this submission. As far as the emission is concerned, emission from deforestation is the biggest source and most significant category.

## 3.3. Pools and Gases

Two carbon pools were considered in the emission calculation: (1) Above Ground Biomass (AGB) and (2) Below Ground Biomass (BGB). The Dead Organic Matter (DOM) will be included in the NFI in the future improvement plan, but is not currently available, so only AGB and BGB values were included.

*Table 1. Carbon Pools considered in FRL submission.*

| Carbon Pools | Included in FRL | Justification/ Explanation |
|---|---|---|
| Above Ground Biomass (AGB) | Yes (Tier 2) | AGB makes up the majority of the forest biomass in the Philippines and is thus considered a significant carbon pool.<br>The computation of the AGB is based on the results of the latest FRA data. |
| Below Ground Biomass (BGB) | Yes (Tier 1) | On average, the BGB is 37% of the AGB per ha.<br>Hence, BGB is considered a significant carbon pool |
| Dead Wood (DW) | No | The Philippines currently does not have country-specific data to account for the DW in this FREL. Given that DW accounts for only 1% of total carbon stocks it is considered conservative to exclude it on the basis that including it would tend to increase deforestation emissions in the baseline period. |
| Litter | No | The past NFIs have not involved the measurement of litter.<br>As with dead wood, exclusion of litter is considered to be conservative. |
| Soil organic carbon | No | There is no reliable country-specific data for soil organic carbon.<br>The exclusion of soil organic carbon is considered to be conservative. |

The greenhouse gas that will be accounted for in the FRL is carbon dioxide ($CO_2$) since this gas is the primary and most dominant GHG emission in the forestry sector. Based on the submitted sectoral GHG Inventory of the Forestry and Other Land Use (FOLU), GHGs from the forestry sector arise from anthropogenic activities that influence the absorption and release of carbon in the atmosphere. Currently, the fire data available is only from the report "2010-2019 Compendium of Philippines Environment Statistics" which is insufficient to make necessary calculations for $CH_4$ and $N_2O$ from fire. Also, fire incidences were not explicitly mapped for this FRL, but this addition is included in the continuous improvement plan.

# 4. METHODOLOGY AND PROCEDURES

The data, methods, and procedures used in the current construction of the Philippines' National FRL form part of the National Forest Monitoring System (NFMS) of the country. Overall, the Philippines' NFMS establishes the methods, activities, and institutional arrangements for the collection, production, storage, and access of reliable information on Philippine forests. It aims to provide country-specific data on activities affecting forests (activity data, AD) including forest carbon estimates (emissions factors) that are necessary for measuring the impacts of REDD+ activities. Moreover, the NFMS is the main tool to assess if the implementation of REDD+ activities, policies, and strategies has resulted in measurable climate change mitigation. The DAO 2021-32 was approved to set Guidelines on the Operationalization of the NFMS for the implementation of the Philippine REDD+ Strategy.

The section below describes the data production, methods, and procedures used that follow the IPCC standards to a) utilize remote sensing and ground-based inventory approaches, b) perform estimation procedures that are transparent, consistent, accurate, and reduce uncertainties, and c) are transparent and accessible for review.

## 4.1. Methodology for Calculating Emission Factors for Deforestation

### Emission factor for Deforestation

In developing the emission factor for deforestation, country-specific data was utilized to calculate the above-ground biomass available from the Forest Resource Assessment (FRA) conducted from 2013 to 2019 by the Forest Management Bureau of the DENR. This most recent inventory was intended to be a remeasurement of the initial FRA plots established from 2002 to 2004; however, no remeasurement was done because of problems locating the plots again.

The Philippine FRA was based on a low-intensity, systematic, and without-stratification sampling design. The sample site population was selected based on the latitude/longitude grid and established at each 15' latitude and 15' longitude. The distance between tracts was approximately 25km. A total of 395 tracts were established from the national grid. In the 2013-2019 assessment, 370 plots were inventoried (Consolacion, 2019).

A tract is a square of 1km x 1km. At each corner of the tract, a rectangular plot measuring 20 m wide and 250 m long was established. Plot 1 is at the southwest corner of the tract and is oriented in a South-North direction. Succeeding plots are numbered 2-4, clockwise. Within each of these four plots, 3 pairs of subplots or nested plots were established. Nested Plots 1 are made up of three (3) rectangular subplots measuring 20m x 10m, and Nested Plots 2 are made up of circular plots with a radius of 3.99 m and located within nested plot 1. (See Figure 2)

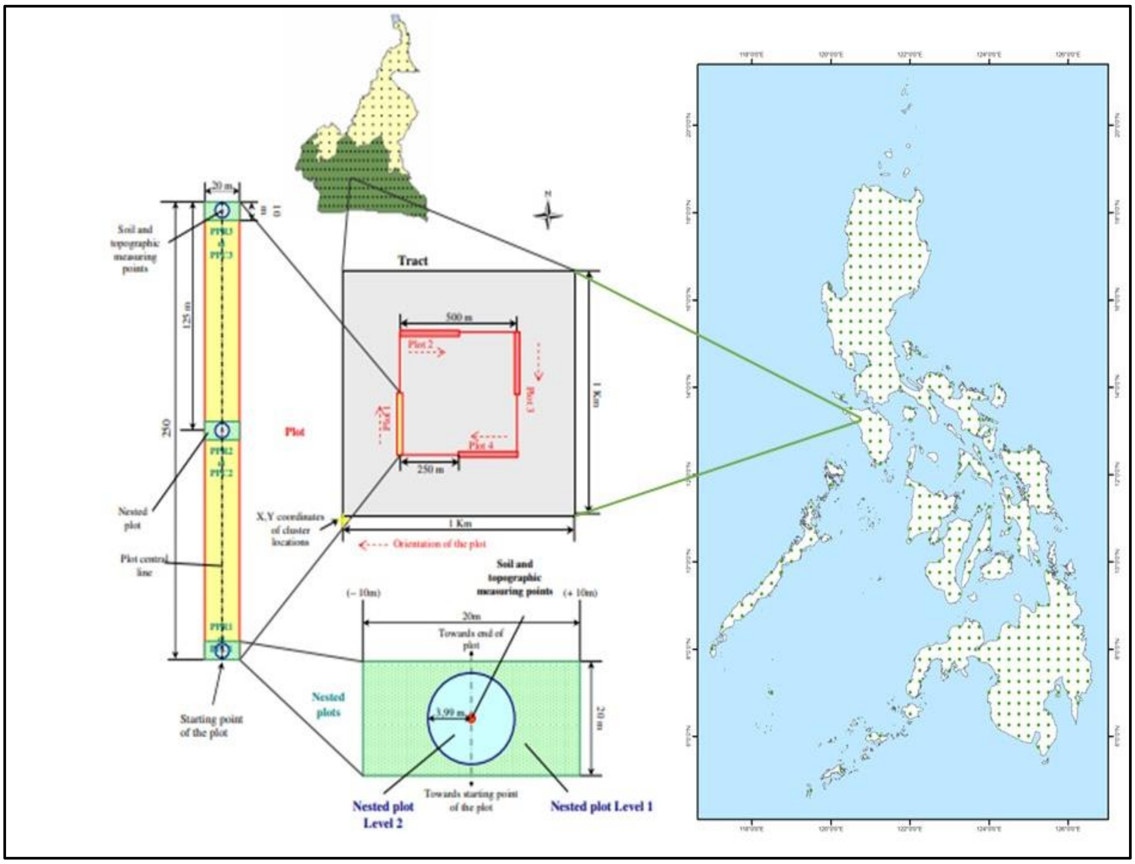


*Figure 2. Philippine FRA sampling plot design*

Forest and tree inventory data were gathered at different levels: at the plot level and the two smaller sub-plots. All trees ≥ 20 cm in diameter at breast height (DBH) growing within the plot were measured. For the other diameter categories, tree measurements were carried out at nested plot 1 for trees with ≥ 10 cm DBH and < 20 cm. At nested plot 2, smaller trees (tree height ≥ 1.30 m and DBH < 10 cm) were measured. Tree data collected within the nested plots are counted by species. Only trees reaching 5 m in situ are measured. In the case of other forest categories, the data collected included the species, height, diameter, and health and tree quality measurements.

The FRA data were initially encoded in Microsoft Excel. Some data found to have been incomplete or had typographical errors were double-checked with the source field data sheets and then subsequently corrected. After the final data cleaning, the tables were imported into Microsoft Access to calculate the biomass.

Since no local allometric models are available, the AGB of individual trees in the plots was calculated using the allometric model developed for pantropical forests (Chave et al., 2014). The pantropical allometric models of Brown (1997) were also tested but not used as they were found to provide unrealistic estimates of AGB, with almost twice the estimated biomass of Chave et al., 2014 and with greater Standard Error (SE). The Chave model uses DBH and wood density (WD) as key parameters in its computation. The WD values were taken from a compilation of local wood density studies by the Forest Products Resources Development Institute (FPRDI) that featured a mix of commercial, lesser-known, and plantation species (Alipon et.al., 2005). It included data such as the official common name and scientific name. This local dataset builds on an earlier compilation of wood density data published in 1985.

For WD data not found in the local dataset, the "Wood Densities of Tropical Tree Species" (Reyes et. al., 1992) was used.

To compute the per tree AGB, the Chave (2014) equation below was used.

$$\mathbf{V_B = 0.0673 \times (\varrho \times DBH^2 \times Height)^{0.976}}$$

where: $V_B$: Biomass of a tree in kg
$\varrho$: Wood density of tree in $g/cm^3$
DBH: Diameter at breast height in cm
Height: Total tree height in meter

To compute the total AGB of trees with DBH ≥ 20 cm the equation below was used:

$$\mathbf{T_B = sum(V_B) \times blow\text{-}up\ factor \times plot\ expansion\ factor}$$

where: $T_B$: Total biomass DBH ≥ 20 cm
$V_B$: Biomass of a tree in kg

$$T_B = sum(V_B) \times (30{,}000{,}000\ ha / 2\ ha) / 292$$

$$T_B = sum(V_B)\ (1 / 2\ ha) \times (30{,}000{,}000\ ha / 292)$$

(1 / 2 ha) also called *trees per hectare (tph)* or *blow-up factor* (GIZ, 2017)
(30,000,000 ha / 292) also called the *plot expansion factor*

The same equation was used to compute the AGB of trees with DBH between 10 and 20 cm in nested plot 1 and trees with DBH <10 cm in nested plot 2. The blow-up factors for these DBH levels are indicated below:

1/0.24 for DBH between 10 cm and 20 cm
1/0.06 for DBH <10 cm

The total AGB of a forested tract for all of the Philippines is a summation of the AGB of the plot, nested plot 1, and nested plot 2. To calculate the ratio of tonnes of biomass per hectare the equation below was used:

$$R_B = T_B / A_T$$

Where: $T_B$ is the total biomass
$A_T$ is the total forested area of all tracts (divided by 2 as the area of each tract is 2 hectares)

Results of the calculation of AGB are shown in Table 2 and are stratified into forest strata or forest types based on the four Philippine Climate types. Following IPCC Guidelines (2006), a country is encouraged to stratify forest lands into more homogeneous strata to reduce variance within strata and improve accuracy and uncertainty. The calculated mean AGB of the inventory tracts, which were grouped based on their location in the Philippine climate map, showed a significant difference in their mean AGB compared to the computed mean using the GEZ as forest strata. An overlay of the coverage of the GEZ and the Philippine 4 Climate Types (See Figure 3) shows that 70% of the country is under the tropical rainforest type (in green). In contrast, the local climatic zonation segregates the same area into three types. The local climate classification distinguishes the effect of the different mountain systems that primarily run with a north-south orientation through the major islands. This geomorphological configuration shapes the impact of monsoon winds responsible for rains in the archipelago and creates the country's north-south bands of climatic differentiation.

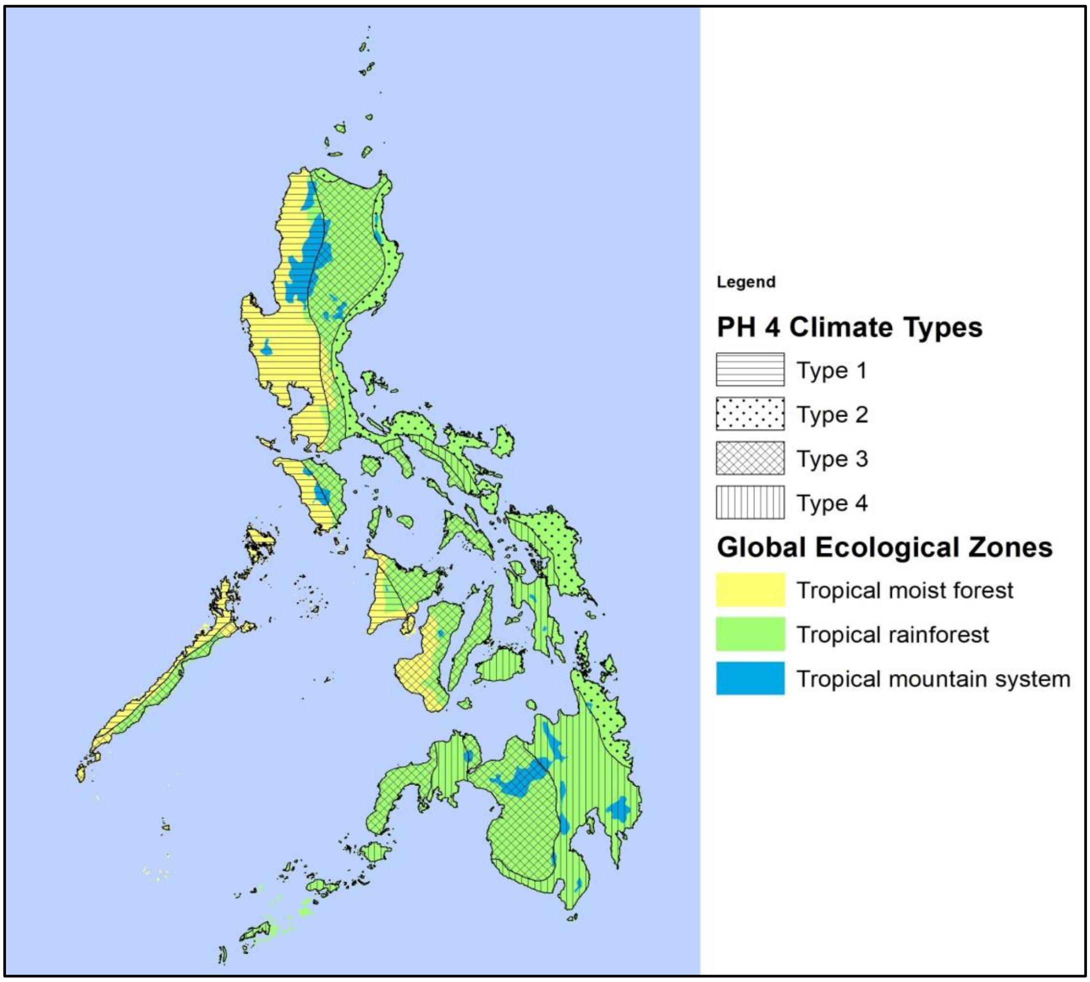


*Figure 3. Overlay of the coverage of the Philippines 4 Climate Types and the GEZ*

Transforming the AGB to an emission factor requires other parameters such as the root-to-shoot ratio to compute the BGB and the carbon fraction to derive the tons of carbon per hectare of forest. These parameters are available in IPCC Tables however, these are organized using the GEZ. To apply the appropriate parameters, it was necessary to compare the GEZ and the forest strata map and decide how the Philippine climate zones align with the GEZ. A visual comparison of the map of GEZ and Philippine Climatic types was made, and it was decided that Forest Type 1 will take the values of the Tropical moist forest zone since both cover almost the same area. Forest Types 2-4 use the values from the Tropical rainforest zone. The tropical mountain system area was no longer considered because the absence of a mountain climate type in the local climate zones suggests that areas with higher elevation do not have significant differentiation from areas with lower elevation. Table 2 summarizes the parameters used to compute the emission factor.

*Table 2. Summary of the parameters used in the calculation of the emission factor per hectare of forest*

| Forest strata | Mean Above-ground Biomass (tdm per ha) | SE | Tracts | Root-shoot ratio | Below-ground Biomass (tdm per ha) | Carbon fraction | Emission Factor (tC per ha) |
|---|---|---|---|---|---|---|---|
| Forest Type 1 | 102.5 | 12.6 | 41 | 0.323 | 33.11 | 0.47 | 63.74 |
| Forest Type 2 | 201.5 | 57.7 | 20 | 0.212 | 42.72 | 0.47 | 114.78 |
| Forest Type 3 | 107.7 | 27.9 | 30 | 0.207 | 22.29 | 0.47 | 61.10 |
| Forest Type 4 | 148.1 | 26.1 | 28 | 0.212 | 31.40 | 0.47 | 84.37 |
| All types | 129.6 | 14.8 | 119 | | | | |
| Source | Derived from the results of the FRA conducted in 2013-2019 | | | IPCC 2019 Refinement - Table 4.4 | AGB x RS | IPCC 2006 - Table 4.7 | (AGB + BGB) x Carbon fraction |

After deforestation, forest lands do not remain as deforested and transition to other land uses. An estimation of the volume of biomass of the new land uses needs to be provided. In the absence of disaggregated non-forest data, the relative proportion of major non-forest land cover categories in the 2020 NAMRIA map was used to indicate the extent of the area of new land cover after deforestation. The relative frequency of conversion to each land cover type was calculated on the relative proportion of each land use for each of the four Forest Types (Table 3).

*Table 3. Relative proportion of each land use for each Forest Type*

| Forest strata | Brush/ Shrubs | Grassland | Annual Crop | Perennial Crop | Open/ Barren | Built-up |
|---|---|---|---|---|---|---|
| Forest Type 1 | 0.344 | 0.128 | 0.308 | 0.070 | 0.015 | 0.085 |
| Forest Type 2 | 0.215 | 0.048 | 0.119 | 0.547 | 0.010 | 0.030 |
| Forest Type 3 | 0.238 | 0.082 | 0.343 | 0.253 | 0.005 | 0.037 |
| Forest Type 4 | 0.248 | 0.082 | 0.164 | 0.439 | 0.003 | 0.037 |

Table 4 summarizes the potential biomass, growth, and uncertainty parameters used to calculate the emissions related to conversions to and from land uses other than forests.

*Table 4. Potential biomass, growth rate, and uncertainty value of major non-forest land use categories.*

| NAMRIA Classification | Max Biomass | Uncertainty Max Biomass | Carbon Fraction | $G_w$ Growth Rate | Uncertainty Growth | *R* R:S | Source |
|---|---|---|---|---|---|---|---|
| | (tdm.ha-1) | See Source notes | | (tdm.ha-1.yr-1) | See Source notes | | |
| Brush/ Shrubs | 47.0 | 52% | 0.47 | 9.40 | 15% | 0.34 | IPCC 2019 Refinement - Max biomass from Table 5.1 Tropical Fallow, Growth rate and R:S calculated from Table 5.2. Uncertainty = 95% CI. |
| Grassland | 6.2 | 75% | 0.47 | 6.20 | 75% | 1.6 | IPCC 2006V4 Ch6 - Table 6.4 Tropical - Moist & Wet. Uncertainty represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. |
| Annual Crop | 10.0 | 75% | 0.47 | 10.00 | 75% | 0 | IPCC 2019 Refinement - Table 5.9 Annual cropland - Note table only reports total biomass therefore no R:S ratio is necessary. Uncertainty represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. |
| Perennial Crop | 102.1 | 55% | 0.47 | 5.11 | 24% | 0.23 | IPCC 2019 Refinement - Max biomass from Table 5.1 Tropical Shaded Perennial, Growth rate and R:S calculated from Table 5.2. Uncertainty = 95% CI. |
| Open/ Barren | 0 | NA | NA | NA | NA | NA | Open barren land from NAMRIA 2020 - no biomass in this system |
| Built-up | 0 | NA | NA | NA | NA | NA | IPCC 2019 Refinement - Tier 1 assumption of zero biomass applied |

Some of the parameters compiled in Table 4 directly reflect what is indicated in the IPCC Guidelines. However, the values for Perennial crops and Brushland required a review of local carbon stock literature and a discussion among the TWG members to decide what values are best suited for these land cover types. Table 5.1 in the 2019 IPCC Guidelines describes some of the perennial crop systems to guide users in identifying which would best represent the perennial crop systems of their country. Initially, the TWG identified the perennial crop area of the Philippines to be a mix of agroforestry (fallows, alley cropping, multi-strata systems, shaded perennial-crop systems) and monoculture (plantations of mostly coconut). The team eventually agreed to select the shaded perennial-crop systems category primarily because the listed biomass is below the forest biomass of the different forest types indicated in Table 4; furthermore, the value is close to the average biomass of agroforestry systems in the Philippines (Lasco and Pulhin, 2003).

For the brushlands, the value of the fallows category was used because the description highlights a mix of woody vegetation and crop rotation area, which best approximates the condition of brushland areas in the country.

## 4.2. Activity Data Methodology

In developing the FRL, the UNFCCC requires historical data to properly represent the emissions and activities within the country. The reference period chosen for the initial submission covers the years 2000 to 2018. The following processes were conducted using the 30% tree cover maps to produce area estimates of forest cover and forest changes.

1. Production of Tree Canopy Cover by TerraPulse
2. Creation of post-processed forest cover maps
3. Change Strata Development
4. Reference Data Collection
5. Sample-based Area Estimation

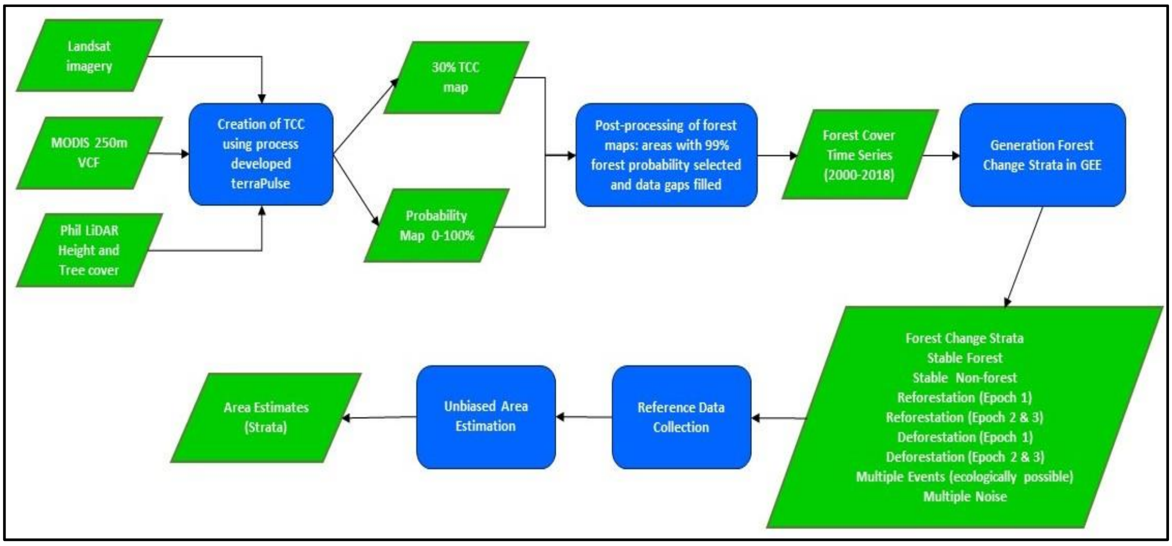


*Figure 4. Process flow of the development of area estimates of forest cover changes from time series tree cover maps.*

### 4.2.1. Production of Tree Canopy Cover

The forest cover data used in the construction of FRL is annual binary forest and non-forest cover data from 2000 to 2018, which are based on the percentage TCC generated by TerraPulse[2] for the years 2000 to 2018.

The TCC estimates were developed by using a machine learning algorithm that was trained against estimates of tree-canopy cover derived from MODIS VCF after it was calibrated

[2] TerraPulse was engaged by USAID-USFS to generate annual forest/non-forest data from 1990 to 2018

with Phil-LIDAR measurements from the field and masked using the MODIS Cropland Probability Layer (CPL). The machine learning algorithm is further dependent on empirically derived parameters and covariates. Covariates included TOA-surface-reflectance Landsat imagery and spectral indices derived from that imagery, which were topographically stratified using ancillary topographic data from the ASTER Global Digital Elevation Model (GDEM). These data were produced by TerraPulse with their proprietary software.

The TCC maps are expressed as a percentage of pixel area at a 30-meter annual resolution. Forest cover was defined using two scenarios, first with a TCC of at least 10%, which is the official Philippines forest definition threshold, and second at a threshold of at least 30% TCC which is a threshold that is easier to detect and visually observe. These threshold interpretations were based on time-series maps of the estimated percentage of tree cover and its uncertainty in each pixel. The estimate of TCC and its uncertainty in each pixel were used together to determine areas with a very high probability of being forest.

A comparison was done between the 10% and 30% TCC and the existing 2015 NAMRIA land cover map and disagreements were checked against high-resolution reference imagery. After this, it was decided to proceed using the 30% TCC product rather than the 10% TCC product for the rest of the analysis. Comparison done between the 30% TCC and NAMRIA land cover show a closer association of area extent compared to the coverage of the 10% TCC (the 10% TCC covered about 15,823,120 ha or about 53% of the PH land area while the 30% TCC covers 12,137,294 hectares or about 41.0%of PH land area). The NAMRIA 2015 Forest map covers 7,012,776 hectares. A detailed discussion of the results of the comparison of the 3 datasets is included in Annex 6, Qualitative Assessment of the TerraPulse Tree Cover Maps and NAMRIA Forest Cover Maps.

To create a forest cover time series for the Philippines, TerraPulse had to refer to multiple satellite imagery sources and process it using their proprietary technology. Different sensor images from multiple Landsat missions, training data from Moderate Resolution Imaging Spectroradiometer (MODIS), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and calibration data from Light Detection and Ranging (LiDAR) measurement from the Phil-LiDAR program were used by TerraPulse to create an average image per pixel for each year. Each pixel was then determined to be forest or non-forest based on the calculated TCC and was given a forest probability value. Refer to Annex 1 for TerraPulse's complete documentation for the development of the TCC data.

NAMRIA land cover data is available with more thematic classes, however, it is produced for three time periods (2003, 2010, 2015) only and with different methods and land cover classes in each time period. In addition, updates to the NAMRIA data are periodic, occurring every 5-7 years and as such it does not support regular consistent updating of forest cover change estimates for FRL update reporting and BUR. Therefore, while it would be possible to use the NAMRIA data for the FRL, it was not considered to be ideally suited for REDD+ reporting purposes.

*Table 5. Attribution of the Forest - Non Forest maps with the Land cover classes used by the FRA, NAMRIA Land Cover Map, and IPCC Land Use Maps*

| FRA 21 Land Cover Classes (2003 Land Cover Map) | Aggregated to 14 Classes (2010 Land Cover Map) | Aggregated to 12 Classes (2015 Land Cover Map) | 6 IPCC Land Use | 2 classes (FRL Construction Land cover Map) |
|---|---|---|---|---|
| Closed forest, broadleaved | Closed forest | Closed forest | Forest | Forest |
| Closed forest, mixed | | | | |
| Closed forest, coniferous | | | | |
| Other wooded land, fallow | Fallow | Open forest | | |
| Open forest, broadleaved | Open forest | | | |
| Open forest, mixed | | | | |
| Open forest, coniferous | | | | |
| Forest plantation, broadleaved | Closed or Open Forest | Closed or Open Forest | | |
| Forest plantation, coniferous | | | | |
| Mangrove forest | Mangrove forest | Mangrove forest | | |
| Other wooded land, shrubs | Shrubs | Brush/Shrubs | Grassland | Non-forest |
| Other wooded land, wooded grassland | Wooded grassland | | | |
| Other land, natural, grassland | Grassland | Grassland | | |
| Other land, cultivated, pastures | | | | |
| Other land, cultivated, annual crop | Annual crop | Annual crop | Cropland | |
| Other land, cultivated, perennial crop | Perennial crop | Perennial crop | | |
| Other land, natural, barren land | Open/Barren | Open/Barren | Other land | |
| Other land, built-up area | Built-up | Built-up | Settlements | |
| Other land, natural marshland | Marshland/Swamp | Marshland | Wetland | |
| Other land, fishpond | Fishpond | Fishpond | | |
| Inland water | Inland water | Inland water | | |

### 4.2.2. Creation of forest cover maps and change maps

The initial TCC was then subjected to a post-processing methodology in Google Earth Engine. This post-processing includes two steps: (1) multiplying the tree cover map by the tree probability mask in which only pixels with at least 99% probability of being forest were included and (2) filling in the no-data pixels using data from surrounding years. The no-data values, which were typically due to clouds, were filled in by getting the mean probability from the surrounding four-year window and counting only the mean values of at least 99% probability as forest. The change maps were created in GEE as well using a time series of the annual post-processed forest maps. The forest cover change is then prepared by analyzing the high-confidence and gap-filled annual forest maps as a time series, comparing the current year's pixel label to the previous year's label to give 'forest change' labels to each pixel. For each two-year increment, the pixel was marked as stable non-forest, stable forest, deforestation, or forest gain. Each pixel was labeled with whether it switched from forest to non-forest, non-forest to forest, or experienced multiple land cover changes from 2000-2018. In the completed change map, each pixel contained information to show the full sequence of forest changes from the entire series.

### 4.2.3. Change Strata Development and Sample Distribution

The change map captured forest gains and losses across the time period but to properly classify the changes and note deforestation and reforestation events, strata development was conducted. Observed forest gain and deforestation events throughout the time period were grouped into simpler categories that represented the overall changes in the landscape. A stratification map is required to distribute samples for reference data collection that sufficiently represent the total area. This is in preparation for the data to be subjected to sample-based unbiased area estimation.

The final stratification map was completed in two stages, an initial stratification and a modification to compensate for errors in the initial map design and better target areas of forest change for sampling. Details on the original stratification map design and the reasoning and procedures for the modification are documented in Annex 4. The final change map's strata definitions and relative sizes are listed below and detailed in Table 6.

The final strata summarizing the changes from 2000-2018 were:

1. Stable Forest
2. Stable Non-forest
3. Deforested Epoch 1 (2000-2005)
4. Multiple Changes (formerly Def E1)
5. Deforested Epoch 2/3 (2006-2012, 2013 - 2018)
6. Multiple Changes (formerly Def E2/3)
7. Reforested Epoch 1 (2000-2005)
8. Multiple Changes (formerly Ref E1)
9. Reforested Epoch 2/3 (2006-2012, 2013 - 2018)
10. Multiple Changes (formerly Ref E2/3)
11. Multiple Events 2/3
12. Multiple Events 3+

*Table 6. Final Strata of Final Sample Design Map*

| Stratum Value | Stratum name | Description of the stratum | Pixel Count | Percent of Area | Area in stratification map (hectares, not bias corrected) |
|---|---|---|---|---|---|
| *55* | stable forest | stable forest land cover 2001-2018 | 82,877,320 | 25.08% | 7,458,959 |
| *66* | stable non-forest | stable non-forest land cover 2001-2018 | 148,198,299 | 44.85% | 13,337,847 |
| *11* | Deforested E1 | Single event of deforestation 2001-2005 | 2,942,702 | 0.89% | 264,843 |
| *17* | Multiple changes (formerly Def E1) | Multiple forest changes 2001-2018 (relabeled from original Deforested Epoch 1) | 13,657,598 | 4.13% | 1,229,184 |
| *22* | Deforested E2/3 | Single event of deforestation 2006-2018 | 2,093,867 | 0.63% | 188,448 |
| *27* | Multiple changes (formerly Def E2/3) | Multiple forest changes 2001-2018 (relabeled from original Deforested Epoch 2/3) | 15,759,556 | 4.77% | 1,418,360 |
| *31* | Reforested E1 | Single event of reforestation 2001-2005 | 2,477,060 | 0.75% | 222,935 |
| *37* | Multiple changes (formerly Ref E1) | Multiple forest changes 2001-2018 (relabeled from original Reforested Epoch 1) | 2,345,602 | 0.71% | 211,104 |
| *41* | Reforested E2/3 | Single event of reforestation 2006-2018 | 10,934,597 | 3.31% | 984,114 |
| *47* | Multiple changes (formerly Ref E2/3) | Multiple forest changes 2001-2018 (relabeled from original Reforested Epoch 2/3) | 10,886,981 | 3.30% | 979,828 |
| *88* | 2/3 changes | Two or three forest change events 2001-2018 as marked by original and modified stratification map; this many events are ecologically possible within 18 years | 24,146,582 | 7.31% | 2,173,192 |
| *77* | 3+ changes | More than 3 forest change events 2001-2018 as marked by original and modified stratification map; this many forest change events within 18 years are unlikely to be ecologically possible | 14,083,476 | 4.26% | 1,267,513 |

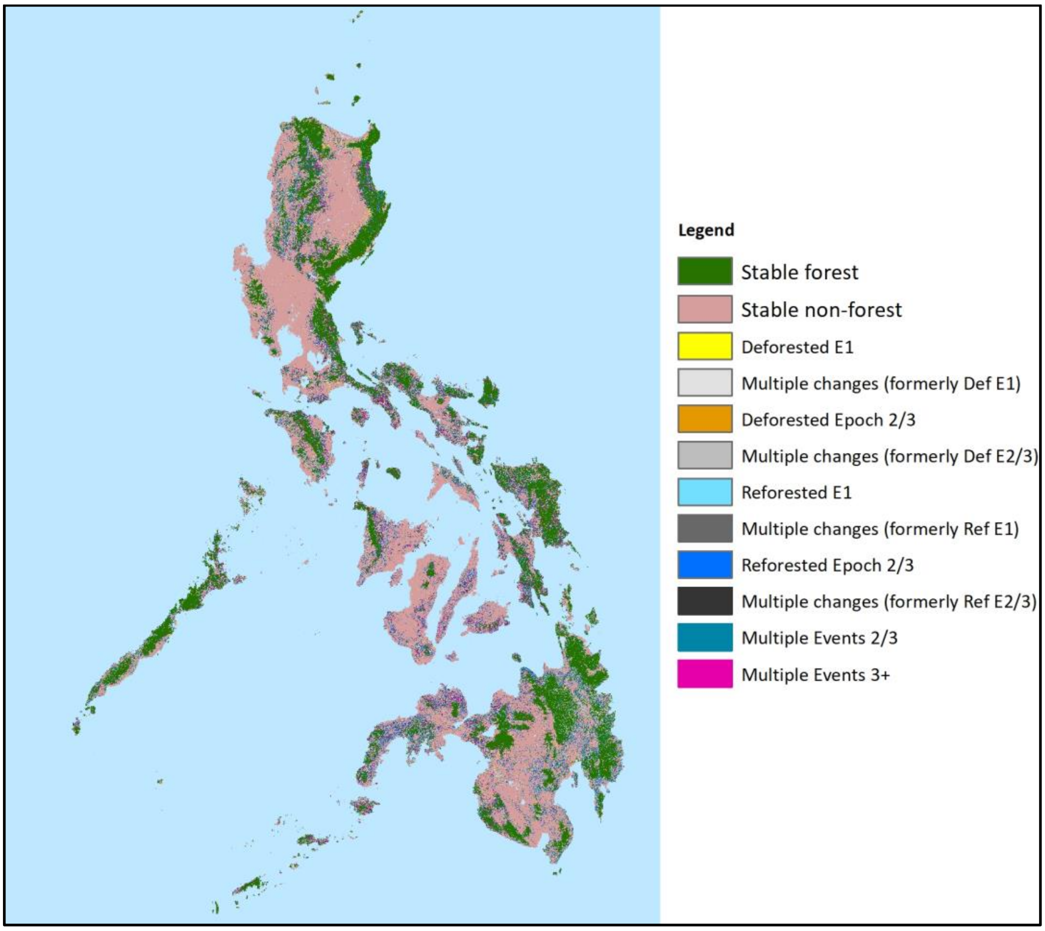


*Figure 5. The final stratification map/Modified Sample Design Map.*

Note, those strata named as multiple changes that were formerly another classification are due to the modification procedure described in Annex 4. Additionally, because of the large quantity of areas of forest change and the fact that the time period of interest was quite long, including diversity in conditions and the implementation of multiple forest policies at different times, we divided up the areas of change temporally into epochs. The total time period was divided into three approximately equal epochs (2000-2005, 2006-2012, and 2013-2018) to examine whether this subdivision was necessary to observe temporal variation or whether the frequency of forest loss and reforestation was consistent over time. We determined that epoch 1 was sufficiently different, with higher deforestation and lower reforestation, to warrant the 2000-2005 period as a separate strata for sampling. Epochs 2 and 3 were similar enough that they could be grouped, as is seen in the names of the final strata. Pixels with multiple forest changes between 2000 and 2018 were split into those with two or three events and those that had more than three changes. Two or three changes were separated out because this was a reasonable number of changes to occur and still allow enough time for forest recovery over 19 years. Pixels with three or more change events were grouped into a separate sampling strata to separately sample areas more likely to be experiencing noise from mapping errors and/or frequent changes from repeated harvesting.

The total number of reference data sample points to collect was determined according to the availability of the interpretation team and a required minimum sample size of 35 for all forest change strata. The distribution of the 929 total reference data points is given in Table 7. We used a stratified random sampling design, with points distributed using GEE.

*Table 7. Distribution of additional CEO points in Final Sample Design Map*

| *Final* **Sample Design Map Value** | **Stratum Name** | **Number of Points Collected Within Strata** |
|---|---|---|
| 55 | Stable forest | 193 |
| 66 | Stable non-forest | 346 |
| 11 | Deforested E1 | 35 |
| 17 | Multiple changes (formerly Def E1) | 41 |
| 22 | Deforested E2/3 | 35 |
| 27 | Multiple changes (formerly Def E2/3) | 50 |
| 33 | Reforested E1 | 35 |
| 37 | Multiple changes (formerly Ref E1) | 25 |
| 44 | Reforested E2/3 | 35 |
| 47 | Multiple changes (formerly Ref E2/3) | 27 |
| 88 | 2/3 changes | 56 |
| 77 | 3+ changes | 51 |
| Grand Total | | 929 |

### 4.2.4. Reference Data Collection

According to Arevalo, et. al. (2017), unbiased estimation of the areas of conversion between land categories ("activity data") and their uncertainty is critical for producing more accurate estimates of carbon emissions and removals from the atmosphere. The FMB TWG, along with SIG and the local consultants conducted several meetings to decide on the details of the analysis as well as to develop an interpretation key to be used in the assessment of the changes in Collect Earth Online (CEO).

Interpretation keys help identify land cover types with the use of remote sensing data and time-series information for the creation of training data, verifying algorithm outputs, and creating reference data for sample-based estimates of the identified strata. The interpretation key document also helps create consensus in the interpretation of a group conducting the assessment and helps in the documentation of the interpretation process. Lastly, this document creates institutional knowledge for future reference. Please refer to Annex 3 for the complete documentation of the interpretation key.

The unbiased area estimation was conducted within the CEO. CEO is an open-source web platform able to use satellite images and derivatives to show its users land cover information. It pools imagery and data from open data repositories across multiple periods and data sources. Our CEO interpreters[3] interpreted and validated 850 sample plots for observation of the above-mentioned strata. These samples were randomly distributed across the change map strata using an area-proportional design with a minimum required sample size for the smaller strata. In CEO, the interpreters have options to view Landsat images that show false color images highlighting vegetation as well as multiple periods of true color composite images, The interpreters also can access the time series graphs of indices including Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI), Normalized Degradation Fraction Index (NDFI) and other indices that dictate the

[3] Technical staff from the offices of National Greening Program Coordinating Office (NGPCO), Forest Resources Conservation Division (FRCD), and Forest Policy, Planning and Knowledge Management Division (FPPKMD) served as interpreters for this activity

presence of vegetation at a certain time period. High-resolution imagery from Planet data and Google Earth were also available to the interpreters. Please refer to Annex 5 for the complete survey questionnaire used in CEO.

### 4.2.5. Quality Control of Reference Data

Steps undertaken for reference data quality control during interpretation and iterative point review during the analysis included:

1. Duplicate interpretations were completed by a small team of interpreters on 150 points of the 850. Since these points were already within the original 850, by the end they had been interpreted in triplicate.
2. Subject Matter Expert (SME) reviews were completed in stages on points as needed, when:
    - The SMEs reviewed the 150 duplicate points, assessing rates of disagreement and then updating the final survey question answers once an agreement was reached, and then the duplicates were removed.
    - An initial SME review of all 850 points collected by the interpretation team, focusing on any points marked with low confidence.
    - Initial analysis detected larger-than-expected disagreements between map and interpreter labels in a cross-tabulation matrix. Review of anything marked as a perennial crop was also a focus at this stage. (100, then 41 points reviewed)
3. Sample points labeled as "Degradation" change events were relabeled to either "Deforestation", "multiple events", "stable forest", or "stable non-forest" after re-examination in CEO. Degradation will not be reported as an activity class in this FRL submission. (43 points were relabeled)
4. The additional 79 CEO points were collected by subject matter experts.
5. Of the total 929 points, 17 points with illogical combinations of survey answers were found via queries in Rstudio and relabeled by SMEs. This included points where a reforestation event was followed by a perennial crop land cover or other non-forest land cover type, and when the land cover was marked as forest at the beginning of the time period and non-forest at the end, but no forest change event was indicated.

### 4.2.6. Sample-Based Area Estimation

Collected samples by the interpreters using Collect Earth Online were then analyzed using an error matrix to quantify agreements between the reference data from interpreters' surveys and the map strata labels. Through this comparison, via sample-based area estimation, we will be able to calculate unbiased area estimates and uncertainties of the activity data.

The sample CEO survey responses were summarized in R final labels of deforestation, multiple change events, reforestation, stable forest, stable non-forest, or stable perennial crop. Because the samples were not distributed proportionally, but instead had a minimum required sample size, Table 8 is presented as a weighted proportion of the total area in hectares rather than sample counts (Oloffson et al., 2020). The sample-based area estimation was conducted using the strata weights from the Final Sample Design Map. The total area in hectares for the Philippines was assumed to be 30,000,000 hectares, for consistency with other official Philippines reporting documents (FMB-FGDIS). Table 8 is the proportionally weighted cross tabulation of the reference data results, quantifying their agreement and disagreement with the map strata labels. Each cell in Table 8 composes a proportion of the total 30,000,000 ha area with the corresponding reference data (columns) and map strata labels (rows). The highlighted cells are areas where both the map and the interpreters agree on the changes that were observed throughout the reference period.

*Table 8. Summary of estimated areas that were correctly classified by the maps and the interpreters and the distribution of estimates based on the interpretation done by the technical working group.*

| Map Strata | Deforestation (ha) | Multiple events (ha) | Reforestation (ha) | Stable forest (ha) | Stable non-forest (ha) | Stable perennial (ha) |
|---|---|---|---|---|---|---|
| Stable forest | 194,951 | 77,980 | 77,980 | 6,199,433 | 311,921 | 662,832 |
| Stable non-forest | 77,781 | 38,891 | 77,781 | 466,686 | 11,161,574 | 1,633,401 |
| Deforested E1 | 53,438 | 0 | 0 | 22,902 | 83,974 | 106,877 |
| Multiple events (relabeled from Def E1) | 241,967 | 60,492 | 30,246 | 241,967 | 211,721 | 453,689 |
| Deforested E2/3 | 86,912 | 5,432 | 0 | 32,592 | 21,728 | 43,456 |
| Multiple events (relabeled from Def E2/3) | 343,425 | 85,856 | 57,237 | 228,950 | 314,806 | 400,662 |
| Reforested E1 | 0 | 6,426 | 32,130 | 89,965 | 38,556 | 57,835 |
| Multiple events (relabeled from Ref E1) | 8,519 | 8,519 | 25,557 | 34,076 | 42,595 | 93,709 |
| Reforested E2/3 | 0 | 28,367 | 56,734 | 85,101 | 595,704 | 226,935 |
| Multiple events (relabeled from Ref E2/3) | 36,612 | 0 | 146,447 | 146,447 | 329,505 | 329,505 |
| 2/3 multiple events | 78,302 | 430,662 | 117,453 | 665,569 | 352,360 | 548,116 |
| 3+ multiple events | 75,221 | 100,294 | 50,147 | 250,736 | 501,471 | 300,883 |

Table 9 shows how the area and uncertainties were calculated. The unbiased area estimates were calculated by summing each column from Table 9, and the +/- 95% confidence intervals and margin of error for each reference data category were calculated using standard equations for stratified random sampling designs (Oloffson et al., 2020).

*Table 9. Unbiased area estimates of forest cover changes throughout the reference period and their margins of error.*

| Forest Change Strata | Area (ha) | % of Country | ±95% CI (ha) | Margin of Error |
|---|---|---|---|---|
| Stable Forest | 8,464,423 | 28.21% | 630,874 | 7.45% |
| Stable Non-forest | 13,965,918 | 46.55% | 718,907 | 5.15% |
| Stable Perennial | 4,857,900 | 16.19% | 717,974 | 14.78% |
| Deforestation | 1,197,127 | 3.99% | 344,827 | 28.80% |
| Reforestation | 671,713 | 2.24% | 283,425 | 42.19% |
| Multiple Events | 842,919 | 2.81% | 314,731 | 37.34% |

The final unbiased area and uncertainty estimations of the activity data were later used for bias correction of the results modeled using FLINTpro.

### 4.2.7. Reference Level Emissions Calculation

The Reference Level emissions of the Philippines are calculated based on the historical emissions due to forest loss through deforestation from the year 2000 to 2018 that captures the changes of forest cover annually. The GHGs emitted were calculated on an annual basis and the reported emission is the average over the reference period.

All the calculations of emissions are done using the FLINTpro software, which was used to integrate the TerraPulse forest cover data and emissions/removals estimation methods described below. A series of filters or strata were used for this FRL including Forest type, Land cover, and alternative land use. These filters helped to determine the appropriate emissions and removals factors that were applied. Worked examples of these calculations are provided in the supplementary material.

Using FLINTpro, we compiled the national environmental data sets and made simulations that used the full Approach 3 time-series forest cover data, together with IPCC Tier 2 and Tier 1 methods. This provided uncorrected estimates of the emissions and removals for deforestation and reforestation. A bias correction determined from the unbiased area estimation approach in section 4.2 was then applied to adjust the area and emissions and removals estimates to provide an unbiased estimate of the area and emissions and removals from deforestation and reforestation.

FLINTpro specifically identifies and analyzes the forest cover history for each pixel and then applies the relevant emissions or removals calculation method for the identified forest cover change events. Detailed time-series emissions and removals data is recorded for the simulations, and aggregated results are used for the purposes of reporting the summarized results.

The emissions calculation for deforestation and reforestation follows standard IPCC methods. Changes in carbon stocks in biomass from land converted to a new land-use category were calculated separately for above and below ground biomass, following equation 2.15 of Volume 4 Chapter 2 of the 2006 IPCC Guidelines:

$$\Delta C_b = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$

Where:

$\Delta C_b$ = annual change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr-1

$\Delta C_G$ = annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tonnes C yr-1

$\Delta C_{CONVERSION}$ = initial change in carbon stocks in biomass on land converted to other land-use category, in tonnes C yr-1

$\Delta C_L$ = annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use category, in tonnes C yr-1

The calculation of $\Delta C_{CONVERSION}$ follows equation 2.16 of Volume 4 Chapter 2 of the 2006 IPCC Guidelines:

$$\Delta C_{CONVERSION} = \sum_{i} \{(B_{After_i} - B_{Before_i}) * \Delta A_{TO-OTHERS_i}\} * CF$$

Where:

$\Delta C_{CONVERSION}$ = initial change in biomass carbon stocks on land converted to another land category, tonnes C yr-1

$B_{After_i}$ = biomass stocks on land type *i* immediately after the conversion, tonnes d.m.ha-1

$B_{Before_i}$ = biomass stocks on land type *i* before the conversion, tonnes d.m.ha-1

$\Delta A_{TO-OTHERS_i}$ = area of land use *i* converted to another land-use category in a certain year, ha yr-1

$CF$ = carbon fraction of dry matter, tonnes C (tonnes d.m)-1

*i* = type of land use converted to another land-use category

The calculation of $\Delta C_G$ follows equation 2.9 of Volume 4 Chapter 2 of the 2006 IPCC Guidelines:

$$\Delta C_G = \sum_{i,j} \left(A_{i,j} * G_{TOTAL_{i,j}} * CF_{i,j}\right)$$

Where:

$\Delta C_G$ = annual increase in biomass carbon stocks due to biomass growth in land remaining in the same land-use category by vegetation type and climatic zone, tonnes C yr-1

$A$ = area of land remaining in the same land-use category, ha

$G_{TOTAL}$ = mean annual biomass growth, tonnes d. m. ha-1 yr-1

*i* = ecological zone (i = 1 to n)

*j* = climate domain (j = 1 to m)

$CF$ = carbon fraction of dry matter, tonne C (tonne d.m.)-1

The calculation of $G_{TOTAL}$ follows equation 2.10 of Volume 4 Chapter 2 of the 2006 IPCC Guidelines:

$$G_{Total} = \sum \{G_w * (1 + R)\}$$

Where:

$G_{TOTAL}$ = average annual biomass growth above and below-ground, tonnes d. m. ha-1 yr-1

$G_W$ = average annual above-ground biomass growth for a specific woody vegetation type, tonnes d. m. ha-1 yr-1

R = ratio of below-ground biomass to above-ground biomass for a specific vegetation type, in tonne d.m. below-ground biomass (tonne d.m. above-ground biomass)-1.

#### 4.2.8. Emissions and subsequent removals calculation from deforestation

For the purposes of the FRL, only lands that had a single forest cover loss event were treated as deforestation. The area of these pixels in each year, together with carbon stock changes was tracked and recorded explicitly over the baseline period (2000-2018). This provided a relative trend of the area and carbon stock changes of deforestation over the time-series. These simulated area and carbon stock changes were then adjusted using the ratio of simulated area to unbiased area estimate for deforestation (Table 10). The results were then aggregated to higher levels (by forest type and then national total) for reporting purposes.

As noted in the deforestation definition (section 2.2), land areas that had multiple events over the historical period (an estimated 842,919 ha) were not accounted for as deforestation in this initial FRL. This means that a potentially significant source of deforestation emissions has not been included for this initial FRL. Land that has had multiple cover changes has a complex history and can be a varying source of emissions and removals over time as forest loss and forest regrowth occurs over time. This complex history means that it is important to have a high level of confidence as to when the changes are occurring and the causes of these changes. For example, multiple changes could be occurring due to shifting cultivation (kaingin), forest logging (legal and illegal), and natural disturbances such as hurricanes causing temporary loss and then recovery of canopy cover. While it was not possible for this initial FRL to account for these complex challenges, excluding the emissions source from these land areas is conservative, and the continuous improvement plan aims to improve the capacity to account for these land areas in the future.

*Table 10. Simulated area of deforestation pixels, unbiased area estimate and correction ratio applied to adjust the simulated area and carbon stock changes to calculate the unbiased area and carbon stock change estimates for deforestation.*

| CEO Strata | Simulated Area (ha) | Unbiased Area (ha) | Correction Ratio |
|---|---|---|---|
| Deforestation | 396,670 | 1,197,127 | 3.0179 |

For the estimation of deforestation emissions and removals equation 2.15 was applied. Emissions due to $\Delta C_{CONVERSION}$ were calculated using equation 2.16. The biomass before conversion was determined using the aboveground and belowground biomass for the four unique Philippines forest types (Table 2). The biomass after conversion ($B_{After_i}$) was assumed to be zero, following the IPCC default assumption.

Removals due the subsequent land use ($\Delta C_G$) were calculated following equation 2.10, where the average annual biomass growth ($G_W$) and the ratio of below-ground to above-ground biomass were estimated using Tier 1 biomass factors for each of the specific subsequent land use types *(i)* (Table 4). Consistent with IPCC default assumptions, removals were assumed to begin the year after deforestation. As can be seen in Table 3, the Philippines has a relatively high proportion of land other than forest that contains woody or otherwise high biomass values. This reflects a high proportion of perennial crops and brush/shrublands following conversion and fallow. The relative frequencies also vary significantly between the four major forest types, with the higher biomass forest types (Types 2 and 4) having relatively higher proportions of high biomass subsequent land uses. A major outcome of this is that deforestation results in immediate emissions (loss of carbon stocks) due to the loss of the forest biomass, with subsequent increases in carbon stocks (removals) due to growth in biomass of the subsequent land use (Figure 6). This means that the net-emissions from deforestation are relatively lower as the emissions due to carbon stock change from deforestation are offset by the removals from the growth in biomass of the subsequent land-use of deforestation that had occurred earlier in the baseline period (2000-2018).

Emission due to carbon losses $\Delta C_L$ in the subsequent land use were assumed to be zero. This follows the default methods for the IPCC land-uses that represent the subsequent land uses, that is, there are no default loss factors for the subsequent land-uses. This assumption applied to the FRL is also considered conservative as the emission source is not included in the baseline FRL estimate.

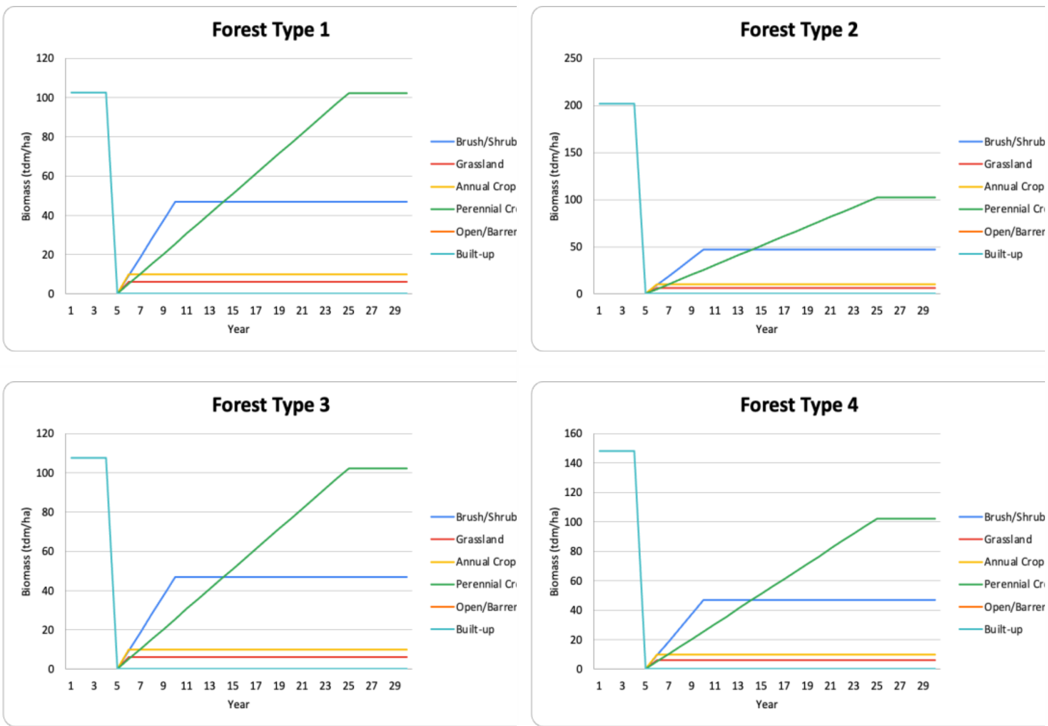


*Figure 6. Example trend in aboveground biomass for deforestation under each combination of forest type and subsequent land use. In all examples deforestation occurs in year 5, and removals due to the subsequent land-use begin in year 6.*

### 4.2.9. Removals calculation from reforestation (Enhancement of forest carbon stocks)

For the purposes of the FRL, only pixels that had a single forest cover gain event over the baseline period were treated as reforestation pixels. The area of these pixels in each year, together with carbon stock changes was tracked and recorded explicitly over the baseline period (2000-2018). This provided a relative trend of the area and carbon stock changes of reforestation over the time-series. These simulated area and carbon stock changes were then adjusted using the ratio of simulated area to unbiased area estimate for reforestation (Table 11). The results were then aggregated to higher levels (by forest type and then national total) for reporting purposes.

As noted in the discussion on deforestation in section 4.1.10, land with multiple land cover changes (an estimated 842,919 ha) have not been included in this initial FRL. For reforestation this means a potential removals source has been excluded, however, overall we consider excluding this land from the initial FRL is conservative. It is likely that with appropriate attribution of the cause of change the land with multiple changes will eventually be accounted for in the activity definitions of degradation and sustainable management of forests. While some of the land may be subject to natural disturbance emissions from hurricanes. The remaining land that may be going through multiple clearing and regrowth cycles due to activities such as shifting cultivation (kaingin) is expected to be a net source of emissions during the reference period. This is because of asymmetry of forest loss emissions compared to forest gain removals. That is, forest loss emissions occur as a large emissions source in the year of loss, while removals due to forest regrowth occur gradually over time as the forest regrows. Over a short period of time such as the period of the FRL baseline, the land would therefore be expected to be a net source of emissions, and only over a relatively long period of time would the removals balance emissions. As such excluding land with multiple changes at this point in time is considered conservative.

*Table 11. Simulated area of reforestation pixels, unbiased area estimate and correction ratio applied to adjust the simulated area and carbon stock changes to calculate the unbiased area and carbon stock change estimates for reforestation.*

| CEO Strata | Simulated Area (ha) | Unbiased Area (ha) | Correction Ratio |
|---|---|---|---|
| Reforestation | 1,223,076 | 671,713 | 0.5492 |

For the estimation of reforestation removals equation 2.15 was applied. Emissions due to land-use conversion $\Delta C_{CONVERSION}$ were assumed to be zero. This assumption is considered to be conservative on the basis that treating this initial loss as zero will result in a more conservative estimate of carbon stock change due to reforestation (estimated emissions will be lower and therefore the net-removals in the baseline will be higher). While this will tend to be conservative for the baseline, this is an area of continuous improvement to improve accuracy in the estimates in future submissions.

Removals due to growth $G_{TOTAL}$ were calculated separately for aboveground and belowground biomass for each of the four Forest Types. While two FRA sampling campaigns have been conducted (2002-2004 and 2016-2019) as noted in section 4.1.1 there were difficulties in relocating trees and tracts for re-sampling, and as a result the FRA data were not suitable for estimating growth of the trees/forests between the two FRA assessments. The annual growth increments were therefore derived from the IPCC Tier 1 above-ground biomass growth rates for equivalent forest types from Table 4.4 of the IPCC 2019 Refinement Vol 4 Ch 4.

In FLINTpro, the growth of forests is tracked explicitly based on age since establishment. This allows the forest growth to be constrained by the measured aboveground biomass for each of the forest types. This ensures that the total biomass growth of the reforestation is calculated on the basis of mass balance and the total increase in biomass carbon stock cannot exceed the biomass measured based upon the FRA results (Table 12 and Figure 7).

*Table 12. Maximum biomass potential, growth rates and root to shoot ratios for the four Philippine forest types. Forest Type 1 uses values for Tropical Rainforest - Asia, Forest Types 2-4 use Tropical Moist Forest - Asia.*

| Forest/Climate Type | Maximum AGB (FRA) | Growth rate <=20 years | Growth rate >20years | R:S <125 tdm AGB | R:S >125 tdm AGB |
|---|---|---|---|---|---|
| | tdm/ha | tdm/ha/yr | tdm/ha/yr | Ratio | Ratio |
| **Forest Type 1** | 102.5 | 2.40 | 0.90 | 0.323 | 0.246 |
| **Forest Type 2** | 201.5 | 3.40 | 2.70 | 0.207 | 0.212 |
| **Forest Type 3** | 107.7 | 3.40 | 2.70 | 0.207 | 0.212 |
| **Forest Type 4** | 148.1 | 3.40 | 2.70 | 0.207 | 0.212 |

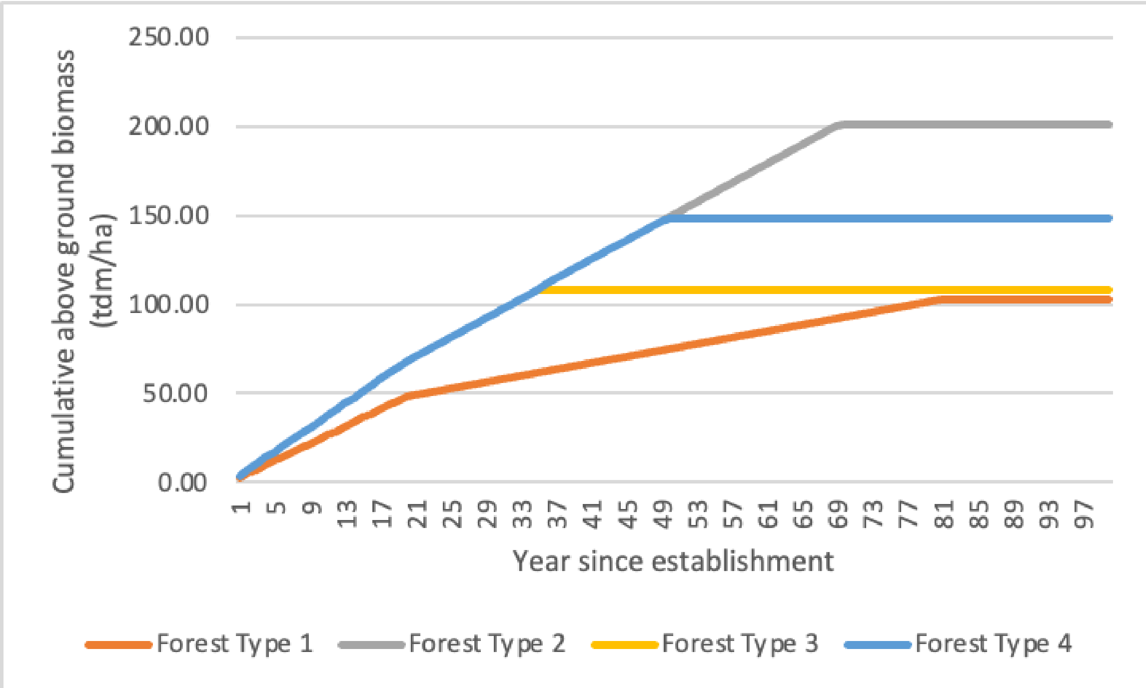


*Figure 7. Cumulative aboveground biomass for reforestation for each of the four Philippine Forest Types. The total aboveground biomass is constrained by the measured biomass for each of the Forest Types from the FRA.*

# 5. RESULTS OF THE CONSTRUCTION OF FOREST REFERENCE LEVEL (FREL)

## 5.1. Estimates of Deforestation and Reforestation Area

The estimated area of deforestation over the period 2000-2018 is 1,197,127ha (Table 13), while the estimated area of reforestation over the same period is 671,713ha (Table 13). The total area of both deforestation and reforestation is determined from the unbiased area estimation, while the relative distribution of the area to each year in the time-period 2000-2018 was determined from the TerraPulse forest cover time-series. This provides an unbiased estimate of the area of each activity with the annual area informed by the forest cover time-series. The trend in deforestation shows relatively higher areas of deforestation in the period 2000-2003 followed by relatively low deforestation over the period 2004-2010, followed by an increasing rate of deforestation from 2011-2018 (Figure 8). The area of reforestation shows a similar trend (Figure 8). The certainty of the time-series distribution of the deforestation and reforestation area was not directly addressed as part of the unbiased areas estimation process. An estimate of the statistical uncertainty of the temporal trend is therefore not available. It is noted that there are potential national-level policy drivers that may partially explain this temporal trend. For example, a moratorium on the harvesting of forests on private lands was put in place in 2004, which may explain some of the reduction in the estimated area of deforestation in 2004. In a similar manner, the NGP began in 2011, which may explain some of the trend in reforestation for the later part of the time-series. There is however a relative concurrence of the trend in deforestation and reforestation which may suggest that the time-series is being influenced by underlying data issues, such as issues of cloud or the Landsat 7 line scanning issue in the satellite time-series. While the uncertainty of the total area of reforestation and deforestation is unbiased and well-quantified, there is lower confidence in the time-series distribution of the change. This is discussed further with respect to the calculation of the FRL in section 5.1.6. This is an important area for continuous improvement for the Philippines.

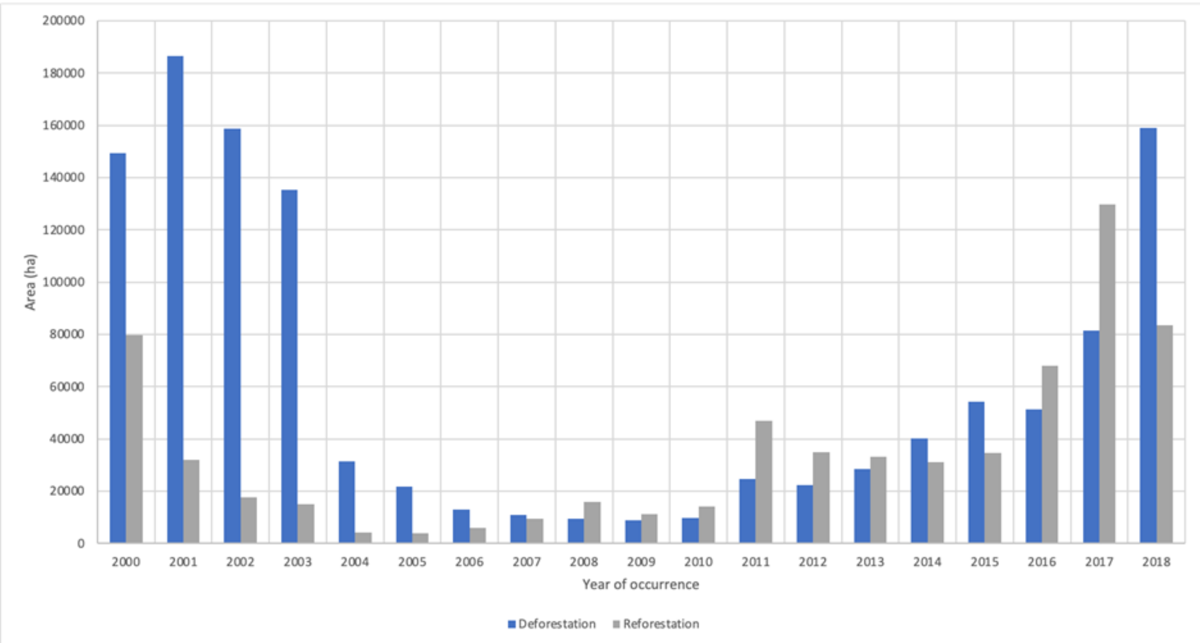


*Figure 8. Annual area of deforestation and reforestation in the Philippines over the baseline period 2000-2018.*

A more detailed disaggregation of the deforestation area according to the subsequent land use following deforestation is provided in the supplementary spreadsheets.

*Table 13. Annual area of deforestation and reforestation for the Philippines disaggregated by Philippine Forest Types.*

| FRL Activity | Forest Type | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Deforestation | Type 1 | 29,931 | 46,212 | 35,864 | 17,968 | 7,935 | 5,382 | 2,414 | 2,382 | 2,314 | 2,198 | 2,238 | 1,397 | 2,001 | 3,114 | 5,153 | 7,535 | 6,975 | 8,848 | 16,659 | 206,517 |
| | Type 2 | 9,653 | 9,656 | 10,848 | 13,155 | 4,078 | 3,134 | 2,181 | 1,749 | 1,414 | 1,430 | 1,775 | 4,433 | 3,390 | 3,361 | 6,576 | 7,078 | 6,659 | 15,290 | 32,417 | 138,277 |
| | Type 3 | 76,797 | 96,361 | 83,967 | 74,819 | 16,499 | 11,204 | 7,283 | 6,088 | 4,927 | 4,371 | 4,793 | 4,882 | 6,159 | 10,631 | 12,599 | 18,463 | 19,863 | 27,153 | 49,495 | 536,354 |
| | Type 4 | 33,074 | 34,260 | 28,098 | 29,368 | 2,925 | 2,194 | 1,267 | 785 | 746 | 855 | 956 | 13,985 | 10,782 | 11,404 | 15,934 | 21,140 | 17,739 | 30,050 | 60,418 | 315,979 |
| | **Total** | **149,455** | **186,488** | **158,778** | **135,310** | **31,436** | **21,913** | **13,144** | **11,003** | **9,401** | **8,854** | **9,762** | **24,697** | **22,333** | **28,510** | **40,262** | **54,216** | **51,236** | **81,341** | **158,989** | **1,197,127** |
| Reforestation | Type 1 | 9,089 | 4,445 | 2,223 | 1,825 | 1,412 | 1,602 | 2,625 | 3,493 | 4,756 | 2,942 | 4,866 | 10,486 | 8,343 | 6,311 | 5,480 | 6,312 | 7,858 | 17,565 | 12,121 | 113,753 |
| | Type 2 | 22,302 | 9,220 | 3,800 | 2,476 | 395 | 435 | 536 | 812 | 1,226 | 1,182 | 1,293 | 3,274 | 2,587 | 2,744 | 1,876 | 2,435 | 4,718 | 8,029 | 5,128 | 74,468 |
| | Type 3 | 18,970 | 6,764 | 3,378 | 2,127 | 1,537 | 1,401 | 2,005 | 3,490 | 6,645 | 5,027 | 5,525 | 15,800 | 13,958 | 14,155 | 14,674 | 14,472 | 30,211 | 59,590 | 39,551 | 259,280 |
| | Type 4 | 29,424 | 11,547 | 8,381 | 8,655 | 919 | 629 | 900 | 1,577 | 3,199 | 2,070 | 2,576 | 17,384 | 10,119 | 9,880 | 9,093 | 11,438 | 25,109 | 44,727 | 26,589 | 224,212 |
| | **Total** | **79,785** | **31,975** | **17,782** | **15,083** | **4,263** | **4,066** | **6,066** | **9,371** | **15,826** | **11,221** | **14,260** | **46,944** | **35,006** | **33,090** | **31,122** | **34,658** | **67,896** | **129,911** | **83,388** | **671,713** |

## 5.2. Emissions from Deforestation and Removals from Reforestation

### 5.2.1. Emissions and subsequent removals from deforestation

The emissions and subsequent removals from deforestation are reported separately for carbon stock changes (gains and losses) in aboveground biomass and belowground biomass (Table 14). Losses occur due to the loss of carbon in forest biomass from conversion $\Delta C_{CONVERSION}$, while the removals occur due to the growth $G_{TOTAL}$ in biomass for relevant subsequent land uses. The gross Implied Emission Factor (IEF) for emissions per area averages 171.6 tdm/ha (Table 14) over the 2000-2018 period, which is consistent with the biomass of the Philippines Forest Types (Table 2). The IEF tends to increase over the historical period which is a result of earlier deforestation occurring in the lower biomass Forest Type 3, while later deforestation is more prevalent in the higher biomass forest Types 2 and 4 (Figure 10). Figure 10 also highlights the impact of including removals due to subsequent land use in the deforestation emissions estimates. Where the net emissions are low through the period 2004-2010. This is a result of the relatively smaller area of deforestation over the 2004-2010 period producing lower emissions while the removals due to the subsequent land uses result in the net emissions being even lower. Indeed, for forest type 3 the emissions from deforestation are low during this period and the removals due to the subsequent land use of land previously deforested result in this forest type being a net sink (net removals) in some years.

The average gross emissions from deforestation over the 2000-2018 period is 18,140,907,928 $tCO_2$-e, while the average gross removals due to the subsequent land use is 2,836,485 $tCO_2$-e. The average net emissions being 15,304,422 $tCO_2$-e. The trend in deforestation net emissions is consistent with the trend in the area of deforestation over the historical period. It is worth noting that the IEF for net emissions varies considerably over the historical period which reflects the combination of the variable area of annual deforestation, together with increasing gross removals as the quantity of removals from subsequent land uses accumulates through the time-series as the area of deforestation accumulates. The annual combined uncertainty from net emissions ranges between 22% and 27% over the 2000-2018 period.

*Table 14. Annual emissions from deforestation for the Philippines disaggregated by above and belowground biomass gains and losses.*

| Deforestation | Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Carbon Stock Change | AGB | | | | | | | | | | | | | | | | | | | | |
| | Gains (ktC) | - | 425.9 | 633.0 | 700.2 | 767.5 | 559.3 | 551.3 | 537.1 | 535.0 | 534.3 | 538.8 | 547.3 | 604.4 | 607.8 | 637.3 | 691.4 | 756.3 | 779.9 | 908.4 | 595.5 |
| | Losses (ktC) | (8,545.5) | (10,403.1) | (8,961.3) | (7,943.0) | (1,807.3) | (1,275.9) | (779.7) | (643.2) | (546.7) | (522.1) | (585.1) | (1,707.5) | (1,479.6) | (1,800.1) | (2,617.8) | (3,439.2) | (3,206.7) | (5,340.2) | (10,583.1) | (3,799.3) |
| | BGB | | | | | | | | | | | | | | | | | | | | |
| | Gains (ktC) | - | 213.4 | 297.6 | 289.3 | 274.6 | 156.3 | 146.1 | 134.6 | 132.2 | 130.6 | 131.1 | 133.7 | 153.1 | 153.9 | 165.5 | 185.4 | 210.5 | 214.3 | 260.9 | 178.1 |
| | Losses (ktC) | (2,460.4) | (2,949.4) | (2,541.6) | (2,280.8) | (514.6) | (367.5) | (222.9) | (182.3) | (156.4) | (152.1) | (171.9) | (588.3) | (492.1) | (571.3) | (852.9) | (1,103.1) | (1,006.8) | (1,731.8) | (3,469.6) | (1,148.2) |
| Deforestation Emissions | ktCO₂-e | 40,355.0 | 48,958.9 | 42,177.4 | 37,487.2 | 8,513.4 | 6,025.8 | 3,676.1 | 3,027.0 | 2,578.2 | 2,472.3 | 2,775.4 | 8,418.1 | 7,229.8 | 8,695.2 | 12,725.9 | 16,655.0 | 15,449.5 | 25,930.6 | 51,526.4 | 18,140.9 |
| Removals due to subsequent land use | ktCO₂-e | - | 2,343.9 | 3,412.0 | 3,628.3 | 3,820.9 | 2,623.9 | 2,557.0 | 2,462.8 | 2,446.3 | 2,438.2 | 2,456.3 | 2,496.7 | 2,777.6 | 2,792.7 | 2,943.6 | 3,215.0 | 3,544.8 | 3,645.6 | 4,287.5 | 2,836.5 |
| Net Emissions | ktCO₂-e | 40,355.0 | 46,615.0 | 38,765.4 | 33,858.9 | 4,692.5 | 3,401.9 | 1,119.1 | 564.1 | 131.9 | 34.1 | 319.1 | 5,921.3 | 4,452.2 | 5,902.5 | 9,782.3 | 13,440.0 | 11,904.7 | 22,285.0 | 47,238.9 | 15,304.4 |
| Deforestation Area | kha | 149.5 | 186.5 | 158.8 | 135.3 | 31.4 | 21.9 | 13.1 | 11.0 | 9.4 | 8.9 | 9.8 | 24.7 | 22.3 | 28.5 | 40.3 | 54.2 | 51.2 | 81.3 | 159.0 | 63.0 |
| EF/Area | ktCO₂-e /ha | 270.0 | 262.5 | 265.6 | 277.0 | 270.8 | 275.0 | 279.7 | 275.1 | 274.3 | 279.2 | 284.3 | 340.9 | 323.7 | 305.0 | 316.1 | 307.2 | 301.5 | 318.8 | 324.1 | 292.15 |
| EF/Area | tdm/ha | 156.7 | 152.3 | 154.1 | 160.8 | 157.1 | 159.6 | 162.3 | 159.6 | 159.1 | 162.0 | 165.0 | 197.8 | 187.9 | 177.0 | 183.4 | 178.3 | 175.0 | 185.0 | 188.1 | 169.5 |
| Net EF/Area | ktCO₂-e /ha | 270.0 | 250.0 | 244.1 | 250.2 | 149.3 | 155.2 | 85.1 | 51.3 | 14.0 | 3.9 | 32.7 | 239.8 | 199.4 | 207.0 | 243.0 | 247.9 | 232.4 | 274.0 | 297.1 | 181.38 |
| Uncertainties | Emissions U | 27% | 27% | 27% | 28% | 28% | 27% | 29% | 29% | 28% | 27% | 28% | 29% | 27% | 26% | 26% | 26% | 26% | 26% | 27% | 0.27 |
| | Removals U | - | 46% | 41% | 35% | 32% | 32% | 33% | 34% | 35% | 36% | 36% | 36% | 33% | 34% | 33% | 32% | 32% | 32% | 31% | 0.35 |
| | Combined E/R U | 27% | 26% | 26% | 27% | 23% | 23% | 23% | 23% | 22% | 22% | 22% | 25% | 23% | 23% | 23% | 23% | 23% | 24% | 25% | 24% |

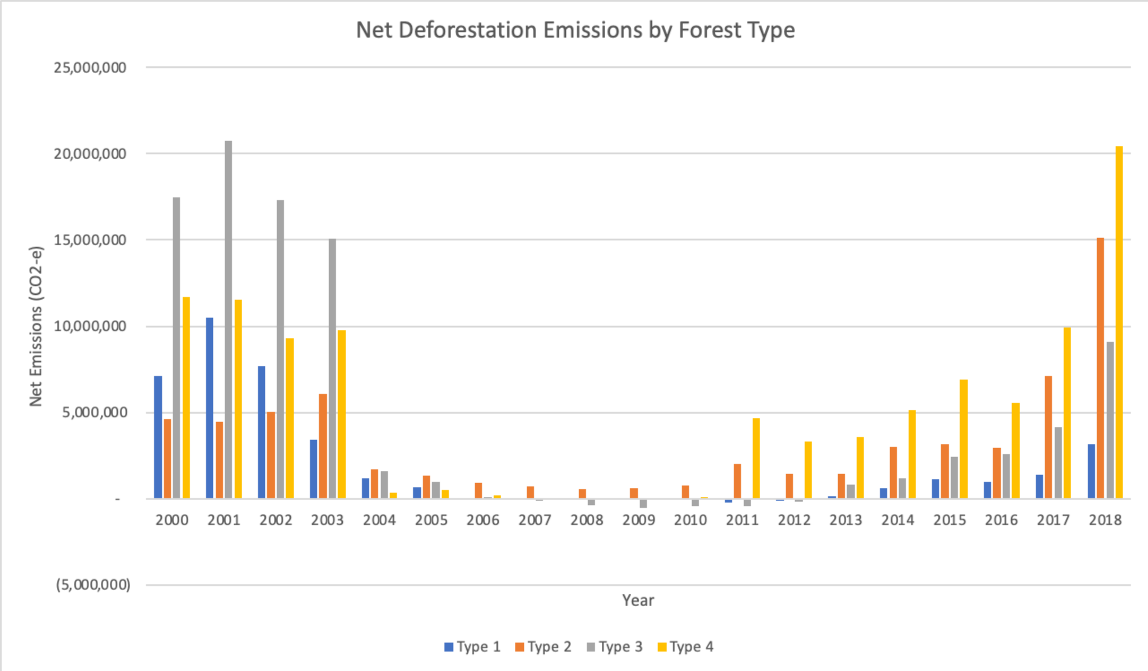


*Figure 9. Annual net deforestation emissions by Forest Type in the Philippines over the baseline period 2000-2018.*

### 5.2.2. Removals from reforestation (Enhancement of forest carbon stock)

Removals (carbon stock gains) due to reforestation over the period 2000-2018 are reported separately for above and below ground biomass are reported in Table 15. The combined removals across all four forest types averages 1,797,720 $tCO_2$-e over the period (Table 15), with a clear trend of increasing removals over time as a result of the increasing area of reforestation contributing removals with each additional year in the time series. That is, the removals in 2018 are the combined removals for all reforestation since the year 2000, while the removals in the year 2000 are only from reforestation in that year. The relative contribution to removals for each of the four Philippine Forest Types are reported in Table 16 and also presented in Figure 10. Reforestation of Forest Types 3 and 4 are the largest contributors to removals (Table 16, Figure 10). The implied removal factors (average removals per area of reforestation) averages 3.5 tdm/ha/year (Table 16) which is consistent with the combined aboveground and belowground biomass increment taken across the four Forest Types.

As can be seen in Figure 10, the removals from reforestation grew rapidly in the later part of the time-series due to both the accumulation of reforested area as well as the forests being young in age and at their maximum growth rate. Following standard forest growth theory, the rate of growth peaks at a young age and then slows as forests age. As a result, the removals from reforestation are likely to reach a peak in near future. This will mean that future updates to the FRL will need to take into account the declining sink from reforestation.

*Table 15. Annual removals from reforestation for the Philippines disaggregated by pool (AGB and BGB) including implied removal factors (removals per hectare).*

| Reforestation | Quantity | Year | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | Annual area | kha/yr | 79.79 | 31.98 | 17.78 | 15.08 | 4.26 | 4.07 | 6.07 | 9.37 | 15.83 | 11.22 | 14.26 | 46.94 | 35.01 | 33.09 | 31.12 | 34.66 | 67.90 | 129.91 | 83.39 | 35.35 |
| | Cumulative area | kha | 79.79 | 111.76 | 129.54 | 144.63 | 148.89 | 152.95 | 159.02 | 168.39 | 184.22 | 195.44 | 209.70 | 256.64 | 291.65 | 324.74 | 355.86 | 390.52 | 458.41 | 588.33 | 671.71 | NA |
| Carbon Stock Change | ABG (Gains) | ktC | 121.61 | 171.59 | 199.24 | 222.54 | 228.92 | 234.67 | 243.09 | 256.36 | 279.29 | 295.92 | 316.37 | 385.80 | 438.06 | 488.00 | 535.19 | 587.54 | 691.66 | 889.76 | 1,018.26 | 400.20 |
| | BGB (Gains) | ktC | 26.75 | 37.86 | 43.98 | 49.13 | 50.64 | 52.05 | 54.15 | 57.37 | 62.77 | 66.63 | 71.53 | 87.43 | 99.44 | 110.71 | 121.28 | 133.05 | 155.87 | 199.58 | 228.03 | 89.91 |
| | ABG + BGB (Gains) | ktC | 148.36 | 209.45 | 243.22 | 271.67 | 279.56 | 286.72 | 297.24 | 313.73 | 342.06 | 362.55 | 387.89 | 473.23 | 537.50 | 598.71 | 656.48 | 720.60 | 847.53 | 1,089.33 | 1,246.28 | 490.11 |
| Removals | Removals due to growth (AGB, BGB) | $ktCO_2$-e | 544.00 | 767.97 | 891.81 | 996.12 | 1,025.05 | 1,051.30 | 1,089.87 | 1,150.33 | 1,254.21 | 1,329.34 | 1,422.28 | 1,735.18 | 1,970.85 | 2,195.26 | 2,407.09 | 2,642.18 | 3,107.61 | 3,994.21 | 4,569.70 | 1,797.07 |
| Implied Emission Factors | IEF CO2 | $ktCO_2$-e /ha/yr | 6.82 | 6.87 | 6.88 | 6.89 | 6.88 | 6.87 | 6.85 | 6.83 | 6.81 | 6.80 | 6.78 | 6.76 | 6.76 | 6.76 | 6.76 | 6.77 | 6.78 | 6.79 | 6.80 | 6.81 |
| | IEF Biomass | tdm/ha/yr | 3.96 | 3.99 | 3.99 | 4.00 | 3.99 | 3.99 | 3.98 | 3.96 | 3.95 | 3.95 | 3.94 | 3.92 | 3.92 | 3.92 | 3.93 | 3.93 | 3.93 | 3.94 | 3.95 | 3.95 |
| Removals Uncertainty | | % | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.30 | 0.30 | 0.30 | 0.30 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.30 | 0.30 | 0.31 | 0.31 | 0.32 | 0.30 |

*Table 16. Annual removals from reforestation for the Philippines disaggregated by Forest Type.*

| **Forest Type** | | **Year** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forest Type 1 | Area | kha | 9.09 | 4.44 | 2.22 | 1.82 | 1.41 | 1.60 | 2.62 | 3.49 | 4.76 | 2.94 | 4.87 | 10.49 | 8.34 | 6.31 | 5.48 | 6.31 | 7.86 | 17.57 | 12.12 | 5.99 |
| | Removals due to growth (AGB+BGB) | $ktCO_2$-e | 49.08 | 73.74 | 86.06 | 96.08 | 103.83 | 112.59 | 126.87 | 145.92 | 171.86 | 188.08 | 214.57 | 271.55 | 317.36 | 352.03 | 382.08 | 416.55 | 459.44 | 554.86 | 621.57 | 249.69 |
| Forest Type 2 | Area | kha | 22.30 | 9.22 | 3.80 | 2.48 | 0.39 | 0.43 | 0.54 | 0.81 | 1.23 | 1.18 | 1.29 | 3.27 | 2.59 | 2.74 | 1.88 | 2.44 | 4.72 | 8.03 | 5.13 | 3.92 |
| | Removals due to growth (AGB+BGB) | $ktCO_2$-e | 156.30 | 222.99 | 250.48 | 268.19 | 271.19 | 274.27 | 278.07 | 283.80 | 292.47 | 300.87 | 310.05 | 333.11 | 351.55 | 371.02 | 384.43 | 401.67 | 434.97 | 491.67 | 528.36 | 326.60 |
| Forest Type 3 | Area | kha | 18.97 | 6.76 | 3.38 | 2.13 | 1.54 | 1.40 | 2.01 | 3.49 | 6.65 | 5.03 | 5.53 | 15.80 | 13.96 | 14.16 | 14.67 | 14.47 | 30.21 | 59.59 | 39.55 | 13.65 |
| | Removals due to growth (AGB+BGB) | $ktCO_2$-e | 132.40 | 181.37 | 205.57 | 220.73 | 231.66 | 241.58 | 255.70 | 280.24 | 326.95 | 362.65 | 401.68 | 512.47 | 611.36 | 711.44 | 815.17 | 917.54 | 1,129.74 | 1,548.43 | 1,830.01 | 574.56 |
| Forest Type 4 | Area | kha | 29.42 | 11.55 | 8.38 | 8.65 | 0.92 | 0.63 | 0.90 | 1.58 | 3.20 | 2.07 | 2.58 | 17.38 | 10.12 | 9.88 | 9.09 | 11.44 | 25.11 | 44.73 | 26.59 | 11.80 |
| | Removals due to growth (AGB+BGB) | $ktCO_2$-e | 206.22 | 289.88 | 349.69 | 411.13 | 418.37 | 422.86 | 429.23 | 440.36 | 462.93 | 477.73 | 495.98 | 618.05 | 690.58 | 760.76 | 825.41 | 906.42 | 1,083.46 | 1,399.25 | 1,589.76 | 646.21 |

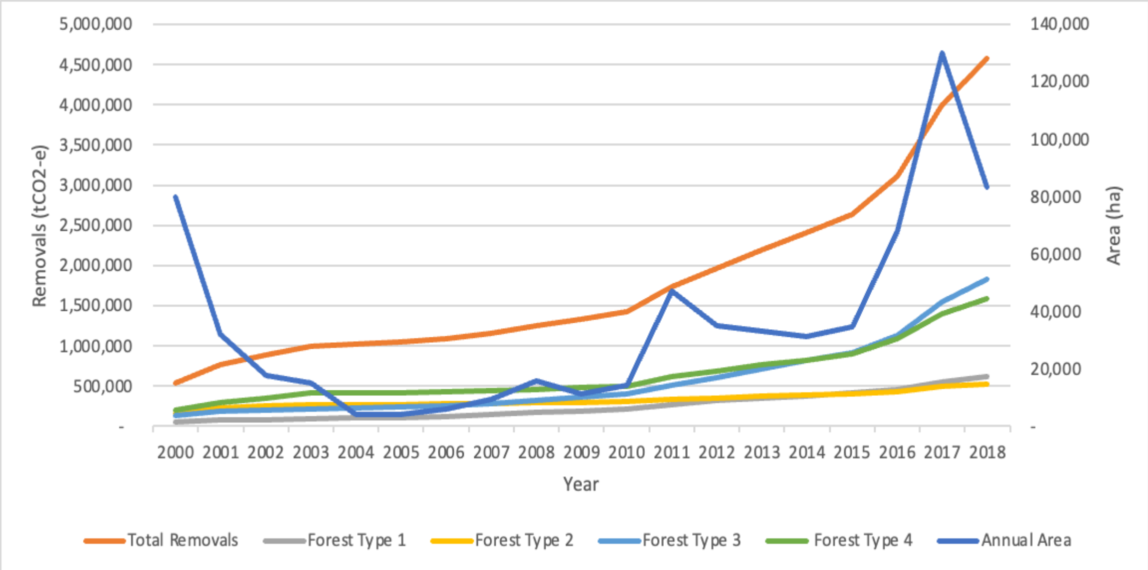


*Figure 10. Annual reforestation removals by Forest Type in the Philippines over the baseline period 2000-2018.*

## 5.3. Uncertainty Sources and Analysis

Combined Uncertainty estimates were calculated using the IPCC Approach 1, simple propagation of error (IPCC, 2019 Vol1 Ch3).

Where quantities were combined by multiplication, U was calculated using IPCC equation 3.1 for combining uncertainties -

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

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)

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

Where quantities were combined by addition, U was calculated using IPCC equation 3.2 for combining uncertainties -

$$U_{total} = \frac{\sqrt{(U_1 * x_1)^2 + \ldots + (U_i * x_i)^2 + \ldots + (U_n * x_n)^2}}{|x_1 + \ldots + x_i + \ldots x_n|}$$

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)

$x_i$ = quantities to be combined; $x_i$ may be a positive or a negative number

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

### 5.3.1. Forest Cover/Change

The calculation of uncertainty for the activity data is described in detail in section 4.2. The Margin of Error (Percent Uncertainty for the 95% Confidence Interval) presented in Table 10 was used in the calculation of the combined uncertainty for both deforestation and reforestation activities respectively.

### 5.3.2. Emission Factors

Following Box 3.0A of the IPCC 2019 Refinement (Vol 1 Ch 3), where available the 95 percent confidence interval for emission factors (including carbon stock factors) were calculated using standard error *(SE)* -

$$Uncertainty = \pm \left( \frac{1.96 * SE}{\mu} \right) * 100\%$$

where:

μ is the estimated parameter

SE is the standard error

In some instances, where IPCC Tier 1 factors were used, the *SE* was not available, and instead the standard deviation *(SD)* was used.

$$Uncertainty = \pm \left( \frac{1.96 * \sigma}{\mu} \right) * 100\%$$

Where this was the case the percent uncertainty is relatively higher compared to using the *SE.*

### 5.3.3. Combined Uncertainty

**Deforestation**

The uncertainty for emissions ($\Delta C_{CONVERSION}$) from deforestation was calculated by first calculating the uncertainty related to the total biomass lost for each Forest Type and then combining this with the activity data uncertainty for deforestation (Table 17). Finally, the overall emission uncertainty was calculated annually by combining the uncertainty for the emissions from each forest type using IPCC equation 3.2 (for addition) (Table 14). The total biomass emissions uncertainty was calculated by combining the uncertainty of the aboveground biomass estimated from the FRA with the uncertainty of the belowground biomass based upon the uncertainty of the respective R:S ratio using IPCC equation 3.2 (for addition). While the SE of the aboveground biomass was available from the FRA analysis, only the SD of the belowground biomass was available for the IPCC factors, resulting in a relatively higher uncertainty estimate for belowground biomass. The combined uncertainty for total biomass and activity data was then calculated for each forest type using IPCC equation 3.1 (for multiplication).

*Table 17. Uncertainty parameters in relation to emissions (carbon losses) from deforestation due to the $\Delta C_{CONVERSION}$ for each of the four Philippine Forest Types.*

| | **AGB** | | | **AGB U for 95% CI** | **SD of R:S** | **BGB U for 95% CI** | **Combined AGB and BGB U** | **AD U for 95% CI** | **Combined U (EF and AD)** |
|---|---|---|---|---|---|---|---|---|---|
| **Forest Type** | tdm/ ha | SE | Num | % | SD | % | % | % | % |
| **Type 1[1]** | 102.5 | 12.6 | 41 | 24% | 0.073 | 44% | 21% | 28.8% | 36% |
| **Type 2[2]** | 201.5 | 57.7 | 20 | 56% | 0.077 | 71% | 48% | 28.8% | 56% |
| **Type 3[2]** | 107.7 | 27.9 | 30 | 51% | 0.072 | 68% | 44% | 28.8% | 52% |
| **Type 4[2]** | 148.1 | 26.1 | 28 | 35% | 0.077 | 71% | 31% | 28.8% | 42% |
| 1. Forest biomass estimated from Philippines FRA. R:S ratio from IPCC 2019 Refinement Table 4.4 - Tropical Moist Forest - Asia. Growth rate (and SD) from IPCC 2019 Refinement Table 4.9 - Tropical Moist Forest - Asia). 2. Forest biomass estimated from Philippines FRA. R:S ratio from IPCC 2019 Refinement Table 4.4 - Tropical Rainforest - Asia. Growth rate SD from IPCC 2019 Refinement Table 4.9 - Tropical Rainforest - Asia) | | | | | | | | | |

The uncertainty for removals ($G_{TOTAL}$ ) due to subsequent land use after deforestation was calculated for each of the subsequent land uses using IPCC equation 3.1 (for multiplication) to combine the assumed growth uncertainties for each subsequent land use with the activity data uncertainty (Table 18). The overall uncertainty due to removals from the subsequent land uses were calculated based upon the annual removals for each land use.

Finally, the overall uncertainty for the combined emissions and subsequent removals were calculated annually using IPCC equation 3.2 (for addition) (Table 14).

*Table 18. Uncertainty parameters in relation to removals due the subsequent land use (carbon gains) from deforestation due to the $G_{TOTAL}$ for each of the subsequent land use types.*

| **Land Use** | **Uncertainty $G_{TOTAL}$** | **AD U** | **Combined U (EF and AD)** | **Notes** |
|---|---|---|---|---|
| Units | See notes | % | % | |
| Brush/ Shrubs | 15% | 28.8% | 32% | IPCC 2019 Refinement - Max biomass from Table 5.1 Tropical Fallow, Growth rate and R:S calculated from Table 5.2. Uncertainty = 95% CI. |
| Grassland | 75% | 28.8% | 80% | IPCC 2006V4 Ch6 - Table 6.4 Tropical - Moist & Wet. Uncertainty represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. |
| Annual Crop | 75% | 28.8% | 80% | IPCC 2019 Refinement - Table 5.9 Annual cropland - Note table only reports total biomass therefore no R:S ratio is necessary. |

| | | | | |
|---|---|---|---|---|
| | | | | Uncertainty represents a nominal estimate of error, equivalent to two times standard deviation, as a percentage of the mean. |
| Perennial Crop | 24% | 28.8% | 37% | IPCC 2019 Refinement - Max biomass from Table 5.1 Tropical Shaded Perennial, Growth rate and R:S calculated from Table 5.2. Uncertainty = 95% CI. |
| Open/ Barren | NA | 28.8% | NA | Open barren land from NAMRIA 2020 - no biomass in this system |
| Built-up | NA | 28.8% | NA | IPCC 2019 Refinement - Tier 1 assumption of zero biomass applied |

**Reforestation**

The uncertainty for reforestation removals was calculated by combining the uncertainty for total growth in biomass $G_{TOTAL}$ with the uncertainty for the total biomass uncertainty achievable for each forest type. This was then combined with the uncertainty in the reforestation activity data (Table 19). The uncertainty due to the assumed growth rates $G_{TOTAL}$ for each forest type were calculated by combining the uncertainty due to growth in aboveground biomass with the uncertainty due to growth in belowground biomass using IPCC equation 3.2 (for addition). This was combined with the uncertainty for total biomass using IPCC equation 3.2 (for addition) on the basis that the FLINTpro system keeps track of the total biomass growth and caps the forest growth at the measured value for each forest type, the overall uncertainty of the removals is therefore a function of the total biomass uncertainty. This was then combined with the reforestation activity data uncertainty to provide uncertainty estimates for each Forest Type using IPCC equation 3.1 (for multiplication) (Table 19).

The overall uncertainty for removals was then calculated annually by combining the uncertainties in the removals for each forest type using IPCC equation 3.2 (for addition) (Table 15).

*Table 19. Uncertainty parameters in relation to removals due the removals (carbon gains) from reforestation due to the $G_{TOTAL}$ for each of the Forest Types.*

| Forest Type | SD of Growth rate | Growth rate U for 95% CI | AGB U for 95% CI | BGB U for 95% CI | Total[3] Biomass Uncertainty | Refor Combined Growth and Mass U | Refor AD U for 95% CI | Reforestation Combined U (EF and AD) |
|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | % | % |
| **Type 1[1]** | 0.3 | 0.2 | 24% | 44% | 21% | 21% | 42.2% | 47% |
| **Type 2[2]** | 3.9 | 2.2 | 56% | 71% | 48% | 47% | 42.2% | 63% |
| **Type 3[2]** | 3.9 | 2.2 | 51% | 68% | 44% | 43% | 42.2% | 60% |
| **Type 4[2]** | 3.9 | 2.2 | 35% | 71% | 31% | 31% | 42.2% | 52% |
| 1. Forest biomass estimated from Philippines FRA. R:S ratio from IPCC 2019 Refinement Table 4.4 - Tropical Moist Forest - Asia. Growth rate SD from IPCC 2019 Refinement Table 4.9 - Tropical Moist Forest - Asia). 2. Forest biomass estimated from Philippines FRA. R:S ratio from IPCC 2019 Refinement Table 4.4 - Tropical Rainforest - Asia. Growth rate SD from IPCC 2019 Refinement Table 4.9 - Tropical Rainforest - Asia). 3. Total Biomass Uncertainty is equivalent to the Combined AGB and BGB Uncertainty from Table 17. | | | | | | | | |

### 5.3.4. Constructed National Forest Reference Level

The constructed national FRL has been calculated as the average net emissions from deforestation and reforestation of the 2000-2018 baseline period. Because of the lower-confidence in the estimated timing of the deforestation and reforestation events over the baseline period, this is considered a conservative approach as it does not reflect the possible trend for increasing deforestation emissions towards the end of the time-series. For example, a shorter time-period of 2008-2018 could have been used with the application of a linear trend line to calculate a projected FRL. This would have resulted in a significantly higher FRL than the average used here, but would not have been conservative

The average annual historical emissions from deforestation and enhancement of forest carbon stocks (reforestation) from 2000-2018 were 13.507 $MtCO_2$-$yr^{-1}$ (Table 20). Emissions from deforestation are the largest contributor at 15.304 $MtCO_2$-$yr^{-1}$, with reforestation contributing removals of 1.797 $MtCO_2$-$yr^{-1}$. The combined uncertainty using IPCC equation 3.2 (for addition) is 27% for the 95% confidence interval.

*Table 20. Constructed National Forest Reference Emission Level for deforestation and enhancement of forest carbon stocks (reforestation) for the 2000-2018 baseline period.*

| **Activity** | **Average emissions 2000-2018** | **Uncertainty** |
|---|---|---|
| | $tCO_2$-e $yr^{-1}$ | % for 95% CI |
| Deforestation | 15,304,422 | 24% |
| Reforestation | (1,797,072) | 30% |
| **Total emissions from deforestation and reforestation (Enhancement of forest carbon stocks)** | **13,507,350** | **27%** |

# 6. POLICIES AND PLANS AND THEIR IMPLICATIONS TO THE CONSTRUCTED FOREST REFERENCE EMISSION LEVEL

## 6.1. Forest Governance in the Philippines

Forest lands are governed both in the context of political-administrative units as well as landscape ecosystems. Despite this complex and multi-stakeholder administrative landscape, Philippine forestlands are governed under the policy regimes of the 1987 Philippine Constitution which classified lands as agricultural, forest, protected areas, and mineral lands. Presidential Decree 705 also known as, the "Revised Forestry Code of the Philippines" which provides the basic and enabling legal framework and a system of land classification, it also spells out a basis for utilization and management, including reforestation and protection, as well as a system of penalties for illegal logging and other acts leading towards forest degradation; and Executive Order (EO) No. 192, entitled, "Providing for the Reorganization of the Department of Environment, Energy and Natural Resources, Renaming it as DENR and For Other Purposes" which created the FMB as a staff bureau whose main function is to recommend policies pertaining to the protection, development, occupation, management, and conservation of forest lands and watersheds. While forest management within the DENR cascades from the Central Office through the FMB, as a staff bureau, to the regional, provincial, and community levels, in their respective forest management division, sections, and units, the dynamics of forest land management and governance go beyond the manageable interest of FMB and the forest management-related subdivisions.

In addition, various policies on forest tenure instruments and management arrangements were issued by the DENR to allocate public forests and forest lands to interested individuals, organizations, or entities for the sustainable management of these areas. Moreover, several laws and policies were issued which have direct impacts on forest land management in the country such as Republic Act (RA) No. 7160 or the "Local Government Code of the Philippines of 1991" which prescribes the administrative functions of the Local Government Units relative to devolved functions in managing forest lands within their jurisdictions; DENR-DILG Joint Administrative Order No. 1998-01 which provides for the shared responsibility of LGUs and DENR in the sustainable management and development of the forest resources within their territorial jurisdiction and in conducting forest land use planning as an integral activity of comprehensive land use planning to determine the optimum and balanced use of natural resources to support local, regional and national growth and development; RA 7586 or the "National Integrated Protected Areas System Act of 1992" as amended by RA 11038 or the "Expanded National Integrated Protected Areas System Act of 2018" which supported the government's mandate to delineate and sustainably manage all protected areas in the country, as part of the thrust to delimit the final forest line by delineating the protection from the production forests; and RA 8371 or the "Indigenous Peoples' Rights Act of 1997" which added a new governance dynamic when forest lands within Ancestral Domain areas were placed under the manageable control of holders of Certificate of Ancestral Domain Title.

Several Executive Orders were also issued relative to forest governance and management in the country. These include Executive Order No. 23 series of 2011 which declared a moratorium on the cutting and harvesting of timber in natural and residual forests and created an Anti-Illegal Logging Task Force, Executive Order No. 26 series of 2011 which created an interdepartmental convergence initiative for an NGP, and Executive Order No. 193 series of 2015 which expanded the coverage of the NGP.

**Policy Intervention to Reduce Emissions**

The Philippine Government has issued various legislations and policies to enhance the country's efforts in promoting adaptation and mitigation of climate change.

In 2009, the Philippine Congress enacted Republic Act No. 9729, or the Climate Change Act of 2009 to ensure that national and subnational government policies, plans, programs, and projects are founded upon sound environmental considerations and the principle of sustainable development. It integrated the concept of climate change in various phases of policy formulation, development plans, poverty reduction strategies, and other development tools and techniques by all agencies and instrumentalities of the government.

In 2010, the Philippine National REDD+ Strategy (PNRPS) was developed and updated in June 2017 to facilitate the country's participation in reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries (REDD+). REDD+ is an incentive system for reducing greenhouse gas emissions. The PNRPS was updated into an action plan in 2021 based on the Warsaw Framework. The National REDD+ Action Plan (2022-2031) is currently being finalized by the FMB.

In 2013, the Master Plan was updated to take into consideration the potential impacts of climate change on the forestry sector to develop the Philippine Master Plan for Climate Resilient Forestry Development (Forestry Master Plan) covering the period of 2016-2028.

The Forestry Master Plan is the national framework plan for the forestry sector with a vision towards climate-resilient and sustainably managed watersheds and forest ecosystems. It was developed in response to the present forestry landscape in the Philippines characterized by changing climate conditions, the expanded role of forests as the provider of ecosystem services, and the institutional challenges in managing forest resources. The Forestry Masterplan is the outcome of the project entitled *"Climate-Proofing of the Philippines Revised Master Plan for Forestry Development"* which was developed by the MB, DENR, Republic of the Philippines with financial support from the Korea Forest Service (KFS), Republic of Korea.

In 2019, the Philippine Master Plan for Climate Resilient Forestry Development was adopted, and popularized versions of the Master Plan in various vernacular languages were published. With the adoption of the Forestry Master Plan by virtue of DAO No. 2019-06 on 06 June 2019, it is ensured that all programs and projects of DENR, as well as local government units, and other government agencies in the development and sustainable management of forests and forestlands are strategically anchored to the targets of the Forestry Master Plan.

In 2021, DAO No. 2021-32, entitled, *"Guidelines on the Operationalization of the National Forest Monitoring System for the Implementation of the Philippine REDD+ Strategy"* was issued to establish and operationalize an NFMS. Specifically, this DAO provides for the establishment and operationalization of the Satellite Land Monitoring System (SLMS), the generation of activity data on forest land use and land-use change every two (2) years, adoption of the Forest Resource Assessment (FRA) as the National Forest Inventory (NFI) of the Philippines, and the development of Forest Information System (FIS) or a web portal where all verified data on Philippine forests lands are published, stored, and accessed, to enable the Department to produce data relevant to the generation and submission of the BURs, National Communications, and reporting requirements from other international commitments. As part of the operationalization of the NFMS, the FMB issued FMB Technical Bulletin No. 34 to increase efficiency and incorporate carbon stock assessment parameters in the Forest Resources Assessment (FRA) Methodology.

In the same year, DAO No. 2021-43 entitled "Guidelines on the Establishment of the CAVCS for Forest Carbon Projects" was also issued to establish a system that encourages investments in forest carbon projects that sequester and/or maintain carbon stocks. Specifically, the CAVCS aims to incentivize and recognize the efforts of the private sector, upland organizations, and other entities in forest protection and afforestation, reforestation, and other restoration activities through the provision of verified carbon certificates; contribute to climate change mitigation efforts by reducing carbon emissions and increasing sequestration of carbon dioxide from the atmosphere; provide standardized guidance for the monitoring, measurement, carbon accounting, and verification of forest carbon projects; and establish a registry for all forest carbon projects undertaken within the Philippines. The FMB is currently developing the CAVCS operations manual for the guidance of the DENR Field Offices and other stakeholders. Said operations manual shall include the procedures on carbon accounting, monitoring, and reporting, validation and verification manual for third-party validators and verifiers, and carbon stock assessment.

## 6.2. Land tenure, carbon rights, forests rights

There are already numerous existing laws and regulations that already govern the preservation, utilization, and development of the country's natural resources. These provide a basis for administrative and technical issuances as well as the process for establishing clarity and certainty on required approvals. It is important to note that the REDD+ and its activities must be implemented at multiple scales to allow the participation of the state and non-state actors while honoring existing land tenure and rights regimes of the country. If not, this may result in the marginalization and disenfranchisement of REDD+ project. Thus, project managers or project developers who want to engage in and implement REDD+ from their own forests or enter into partnerships with communities must have guidance to do so.

Carbon ownership was identified as an area of concern for REDD+ implementation in the Philippines. The FMB created a Small Working Group (SWG) under FMB Special Order No. 2015-61, hereby tasked to discuss and draft a Carbon Rights Policy which is considered as pivotal requirements of REDD+ Readiness implementation. It is necessary to clarify "who owns the carbon?" and "who can sell carbon?" before any significant national-level REDD+ developments. Pertaining hereof, indigenous cultural communities are entitled to engage and participate in natural resource extraction by themselves or participate in benefit-sharing from the use of these resources by non-members of the community pursuant to the Indigenous Peoples Rights Act 1997 (Republic Act No. 8371 of 1997). This is because the only clear and categorical declaration by a government agency on carbon rights was made by the National Commission on Indigenous Peoples (NCIP).

REDD+ is not only a strategy for climate adaptation and mitigation, but it is also a strategy that aims to overcome the gaps between forests, biodiversity, and communities. It is where the relevant institutions such as the DHSUD, DENR - FMB, BMB, CCS, ERDB, NCIP, and CCC shall act collaboratively to ensure the harmonization of the overlapping governance schemes in forestlands. The country shall uphold the policy of multiple land use considering that the country's natural resources may be rationally explored, developed, utilized, and conserved.

### 6.2.1. Financing & Benefit-sharing

A financing and benefit-sharing system are essential pieces of the National REDD+ Systems and are closely linked to the REDD+ Strategy, Monitoring, Reporting, and Verification (MRV) system, and Safeguards Framework and Guidelines (SFG). The schemes on financing and benefit-sharing should consider all potential funding sources and ensure effectiveness, efficiency, equity, transparency, and accountability at all stages.

There are existing guidelines on benefit-sharing under the Local Government Code (LGC), NIPAS Law, Indigenous Peoples Right Act (IPRA) Law, and Community Based Forest Management (CBFM) rules, among others. For example, for the distribution among LGUs and their constituents, it is provisioned that the LGU shares in carbon revenues are to its share in the distribution of income from national wealth. On pursuing equitable and reasonable benefit sharing among stakeholders and exploring fund management arrangements, there is a concept for operationalizing a REDD+ financing and benefit sharing schemes developed under the project "Preparation of a National REDD+ Mechanisms for GHG Reduction and Conservation of Biodiversity in the Philippines". This concept illustrates benefit-sharing agreements within the FMUs, and how funds can be managed and governed at the local level as well as at the national level.

It is recommended to scale up the thinking on REDD+ from the project level to national and subnational levels to institutionalize and operationalize the benefit-sharing scheme. In line with this, this concept provided the following approaches and options for decision:

1. If REDD+ is implemented through a national approach, performance-based payments will likely be based on national-level REDD+ performance and inflow into a national-level financing structure with consultations and decision-making on the allocation criteria for the vertical distribution of the benefits given to different jurisdictions, FMUs, and stakeholders on the ground.
2. There are three (3) broad options for receiving and channeling REDD+ results-based financing:
   - Funds flowing into the overall government budget and then fragmented down to different forest-related agencies and forest management units;
   - Through direct payment for REDD+ projects at the site level; and
   - Through the national fund.
3. Elements of horizontal distribution of REDD+ benefits (monetary and non-monetary incentives) within FMU's fund management and governance, monitoring, and conflict resolution among others are suggested in the concept.

### 6.2.2. REDD+ Models and Forest Carbon Programs

The REDD+ and its activities must be implemented at multiple scales to allow the participation of the state and non-state actors while honoring the existing land tenure and rights regimes of the country. There are four (4) broad approaches to REDD+ to be able to organize REDD+ activities at multiple scales: 1. Centralized, 2. Centralized-nested, 3.

Decentralized, and 4. Decentralized-nested (World Bank, 2021). Among these approaches, the country is adopting the decentralized approach as a policy where the project managers and project developers are incentivized through financing and regulated by the government.

### 6.2.3. How do REDD+ credits relate to the NDC?

Article 6 of the Paris Agreement reaffirms that countries can cooperate to meet their mitigation goals as efficiently as possible, including through transferring emissions reductions between countries (known as "internationally transferred mitigation outcomes" or ITMOs). The process for how countries will transfer emissions reductions under the Paris Agreement and the rules for what activities will be eligible are under development in the UNFCCC climate negotiations and should be finalized in November 2021.

Before any emissions reductions (from REDD+ or another sector) can be transferred, the host country will need to consider whether the emissions reductions proposed for trading are needed to meet their National Determined Contributions (NDCs) or if they have achieved (or are projected to achieve) an excess of emissions reductions and can transfer "extra" reductions. In practice, this will mean that all emission transfers will need to be approved or authorized by the host country before they can be transferred to another country. This accounting step is known as a "corresponding adjustment." These requirements are not specific to REDD+.

As requirements for inclusion of forestry and land use section in NDC, forests must be included as part of the overall NDC target, but specific NDC targets for forest are not required. Further, 15 April 2021, the Philippines submitted the first NDC which states that "The Philippines shall undertake adaptation measures across but not limited to the sectors of agriculture, forestry, coastal and marine ecosystems and biodiversity, health, and human security, to preempt, reduce and address residual loss and damage. The Philippines shall pursue forest protection, forest restoration and reforestation, and access the RBF in forest conservation.

## 6.3. Summary of National Policies

The table below (Table 10) summarizes the various national policies that influence the Laws and Policies Influencing REDD+ Related Elements.

*Table 21. Summary of Philippines national policies relating to REDD+ Related Elements*

| Laws and Policies | Forests, Land, And Natural Resource Use | Forest Management, Environmental Conservation, and Enforcement | Safeguards | Benefit Sharing | Governance |
|---|---|---|---|---|---|
| **National Laws** | | | | | |
| Article II of the Constitution | | ✓ | ✓ | | |
| Article III of the Constitution | | | ✓ | | |
| Article XII of the Constitution | ✓ | | ✓ | | |
| Article XIII of the Constitution | | | ✓ | | |
| The Public Land Act (CA 141 of 1936) | ✓ | | | | |
| Revised Forestry Code of the Philippines (PD 705, s. 1975) | ✓ | ✓ | | ✓ | |
| Environmental Impact Statement System (EIS) (PD 1586, 1978) | | | ✓ | | |
| Local Government Code of 1991 (LGC) (RA 7160) | ✓ | ✓ | ✓ | ✓ | ✓ |
| National Integrated Protected Areas System Act of 1992 (NIPAS) (RA 7586) | ✓ | ✓ | ✓ | ✓ | |
| Strategic Environmental Plan for Palawan (SEP) (RA 7611, 1992) | ✓ | ✓ | ✓ | | |
| Indigenous Peoples' Rights Act of 1997 (RA 8371) | | | ✓ | ✓ | |
| Wildlife Resources Conservation and Protection Act (RA 9147, 2001) | | ✓ | | | |
| National Environmental Awareness and Education Act of 2008 (RA 9512) | | ✓ | | | |
| Climate Change Act of 2009 (RA 9729) | | ✓ | | | |
| Philippine Disaster Risk Reduction and Management Act of 2010 (RA 10121) | | ✓ | | | |
| People's Survival Fund (RA 10174) | | | | ✓ | |
| Integrated Social Forestry under LOI 1260 (1982) | | | | ✓ | |
| Providing for the reorganization of the Department of Environment, Energy and Natural Resources renaming it as the Department of Environment and Natural Resources, and for other purposes (Executive Order No. 192,s. 1987) | | | | | ✓ |
| Moratorium on Cutting and Harvesting of Timber in Natural and Residual Forests (EO 23, s. 2011) | | ✓ | | | |
| National Greening Program (NGP) (EO 26, s. 2011) | | ✓ | | | |
| Institutionalizing Philippine Greenhouse Gas Inventory Management and Reporting System (EO 174, s. 2014) | | | | | ✓ |

| Laws and Policies | Forests, Land, And Natural Resource Use | Forest Management, Environmental Conservation, and Enforcement | Safeguards | Benefit Sharing | Governance |
|---|---|---|---|---|---|
| Expanded National Greening Program (EO 193, s. 2015) | | ✓ | | | |
| Climate Change Commission as coordinator of existing climate change initiatives, and REDD+ mechanisms (EO 881, s. 2010) | | | | | ✓ |
| Sustainable Forest Management (EO 318, s. 2004) | | ✓ | | | |
| Community-based Forestry Management Agreement (DAO 29, 2004 Revised IRR) | | | ✓ | ✓ | |
| **Administrative Issuances to Implement National Laws** | | | | | |
| Revised Omnibus Rules on Delineation and Recognition of Ancestral Domains and Lands of 2012 (NCIP Administrative Order No.4, s. 2012) | | | ✓ | | |
| Community-based Forest Management Strategy (EO 263, 1995) | | | ✓ | | |
| Socialized Industrial Forest Management Agreement (SIFMA) (DENR DAO 1996-24) | | | ✓ | | |
| Certificate of Stewardship Contract (CSC) (DENR DAO 1996-29) | | | ✓ | | |
| Industrial Forest Management Agreement (IFMA) (DENR DAO 1997-04) | | | ✓ | | |
| Guidelines on the Operationalization of the NFMS for the Implementation of PH REDD+ Strategy (DENR DAO 2021-32) | | ✓ | ✓ | | |
| Guidelines on the Establishment of the Carbon Accounting, Verification and Certification System (CAVCS) for Forest Carbon Projects (DENR DAO 2021-43) | | ✓ | ✓ | | |

Adapted from Updated PH REDD+ Strategy (2017) and updated with new relevant policies

# 7. OPPORTUNITIES FOR IMPROVEMENT

Sessions on the continuous improvement plan activity were held by the FMB with a focus on the difficulties and lessons discovered while completing the FRL. Members of the TWG, which was made up of technical staff from the Bureau, participated.

## 7.1. Improvement of Activity Data

One of the critical improvements currently being pursued is to develop FMB's own tree cover model (TCM) that will produce forest cover for subsequent reports after FRL document submission. Since the forest cover data utilized for establishing the reference emission level uses a proprietary algorithm, it is deemed vital that FMB produce its own forest cover data for the REDD+ future reporting. The tree model under testing is similar to TerraPulse's TCM. It uses LiDAR and multispectral data and is a semi-automated system capable of estimating tree canopy cover. It also allows custom setting of percentage thresholds for the purpose of forest/non-forest delineation. This new TCM needs to address issues in terraPulse TCM, including its difficulty in capturing mangrove forests and in separating coconut plantations from forests, as plantations are considered to be perennial agricultural crops. This may involve adjusting the algorithm and developing additional workflows to supplement the TCM and tackle the key issues mentioned.

FMB's Forest Protection Section is currently compiling and building a database of the reported and known forest fire incidents. This will help map the location and extent of fire incidents that occurred in the Philippines and can form part of the computation of other greenhouse gasses such as $CH_4$ and $N_2O$.

Alongside this initiative of enhancing methods of producing annual forest cover maps are initiatives to improve spatial data management that will contribute in part to improving the activity data. FMB's FGDIS, in collaboration with the bureau's IT administrators, have set up a geospatial data server for the FMB's use. This local data server will house all quality-controlled data (spatial and non-spatial) that will be of service in the upcoming reporting phase. The aim is to have the various FMB units that contribute and update geospatial datasets to the server follow set reporting standards, standard attributes, and naming conventions. Data administrators, contributors, and users will have varying levels of data access rights. To ensure FMB-wide compliance, the FGDIS is developing a Forest Spatial Datasets (FSD) guidebook to ensure quality controlled geospatial data in the forestry sector. It is envisioned that with standardized geospatial datasets, it would be easier to integrate into geodatabases and use in new software and applications. An improved data architecture of geospatial information intends to overcome challenges with data availability and quality, allowing efficient and responsive forest inventory and analysis. This FSD Guidebook is still a draft and a continuing initiative of FMB.

**Improvement of Emission Factors (Carbon Stock)**

The emission factors currently used in the document are a mix of Tier 1 and Tier 2. Country-specific data of AGB is derived from the national FRA, but other estimation parameters are derived from IPCC default values. In the upcoming update of the FRA, Technical Bulletin No. 34 on Revised procedures in the conduct of FRA in the Philippines incorporates new concepts, best practices, and other lessons learned from the different initiatives by the DENR.

One of the key changes is the densification of the tracts by tripling the number of tracts throughout the country. Additional tracts will be spaced every 5 minutes (longitude and latitude) instead of the 15 -minute interval in the previous FRA, in effect increasing also the number of forest tracts. Further, the design of tracts was changed from 4- 20 m x 250 m rectangular plots to 4 circular plots both for main plots and subplots. This was an adjustment made to accommodate feedback from the inventory teams who reported difficulty in locating the rectangular plots for remeasurement following the current design.

Another important addition in the FRA is the inclusion of carbon measurement of DOM (standing and lying dead wood) and litter in the subplots. Other improvements focus on the quality control of field inventory, inventory data encoding, and inventory data management based on the lessons learned from the previous inventory. Specific improvements include the following: photo documentation of field forms, standardizing field data entry in field sheets, standardizing data encoding, and use of Microsoft Access to store and manage data more efficiently and relate and analyze sizable amounts of inventory and other auxiliary data.

### 7.2. Inclusion of Other REDD+ Activities

Inclusion of the remaining activities: reducing emissions from forest degradation, conserving forest carbon stocks, and sustainable management of forests in the BUR has substantial implications on the data that needs to be built up and maintained and the methods that need to be developed.

Degradation is one of the significant issues of the country's forests and developing methods to account for its impact on the Philippines' carbon emissions will be important. Forest degradation in the Philippines is generally fine scale occurring in small areas, such as with selective logging, and methods to detect these events are a challenge. It will be favorable for the country to look at the experience of other countries in the region (e.g., Indonesia) and other tropical countries with similar forest change trends.

## 8. SAFEGUARDS

According to Paragraph 71 of Decision 1/CP.16, Safeguards Information System (SIS) is a system for providing information on how the safeguards are being addressed and respected throughout the implementation of REDD+ activities. The systems should build upon existing systems, be implemented at the national level and also be transparent and flexible to allow for improvements over time.

Parties implementing REDD+ should, implement, in a manner that ensures safeguards are promoted and supported, support the following:

1. Those actions complement or are consistent with the objectives of national forest programs and relevant international conventions and agreements;
2. Transparent and effective national forest governance structures, taking into account national legislation and sovereignty;
3. Respect for the knowledge and rights of IPs and members of local communities, by taking into account relevant international obligations, national circumstances and laws, and noting that the United Nations General Assembly has adopted the United Nations Declaration on the Rights of IPs;
4. The full and effective participation of relevant stakeholders, in particular IPs and local communities;
5. That actions are consistent with the conservation of natural forests and biological diversity while ensuring that the REDD+ actions are not used for the conversion of natural forests, but are instead used to incentivize the protection and conservation of natural forests and their ecosystem services, and to enhance other social and environmental benefits, taking into account the need for sustainable livelihoods of IPs and local communities and their interdependence on forests in most countries, as reflected in the United Nations Declaration on the Rights of Indigenous Peoples, as well as the IP International Mother Earth Day;
6. Actions to address the risks of reversals; and
7. Actions to reduce displacement of emissions.

To date, the current Framework and Guidelines is composed of the following components: (1) Identified and assessed risks; and (2) Principles, criteria, indicators, and appropriate actions, specific to the Philippines. Hence, these (1) will address identified governance, socio-economic, and environmental risks associated with implementation of REDD+ in the Philippines; and (2) develop the standards to ensure that the safeguards are consistent. To properly evaluate the implementation of REDD+ both at the national and sub-national levels, the means of verification have been identified for each set of principles, criteria, and indicators, and which serves as the bases for evaluating REDD+ implementation. Further, in evaluating implementation, different methods of data collection shall be used. These methods involve the engagement of various stakeholders that are expected to have roles and responsibilities in ensuring that existing policies are implemented or supported by complementary or consistent actions.

The current version of the SFG has 8 principles, 26 criteria and 51 indicators (see Annex 7). The eight principles translate the Cancun safeguards to reflect the Philippine context. Criteria and indicators provide responses and key measures to address the principles, while appropriate actions and suggested implementers recommend next steps. The means of verification were also developed; consisting of documents, reports, practices, and other concrete outputs to substantiate and evaluate compliance with the Principles and Criteria. Moreover, the country envisions to operationalize the SFG and be adopted through the development of the SIS.

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# ANNEX

## Annex 1. Mapping Tree Canopy Cover, Forest Cover, and Forest-Cover Change in the Philippines (1990 –2020)

### Executive Summary

TerraPulse is a cloud-based platform for monitoring forest cover and change. The core of its technology is a network of machine-learning algorithms that extract time-serial data on the past, present, and potential state of forests and other land cover from satellite imagery.

TerraPulse produced forest activity data for the US Forest Service (USFS) covering the Philippines at annual, 30-meter resolution from 1990 to 2020. Based on time-serial maps of the estimated percentage of tree cover and its uncertainty in each pixel, forest cover was defined as pixels exceeding 10% tree cover for the 2000 – 2015 dataset and as pixels exceeding 30% cover for the 1990 – 2020 dataset. The estimate of tree canopy cover and its uncertainty in each pixel were translated into the per-pixel probability of forest, and losses and gains of forest cover over time were detected as significant negative and positive changes in the probability of forest in each pixel.

The resulting geospatial data products were delivered to USFS as raster GIS files via Secure File Transfer Protocol (SFTP) and through the terraPulse web mapping interface, terraView (https://www.terrapulse.com/terraView/phil/; username: guest, password: training1).

https://www.terrapulse.com/terraView/phil/

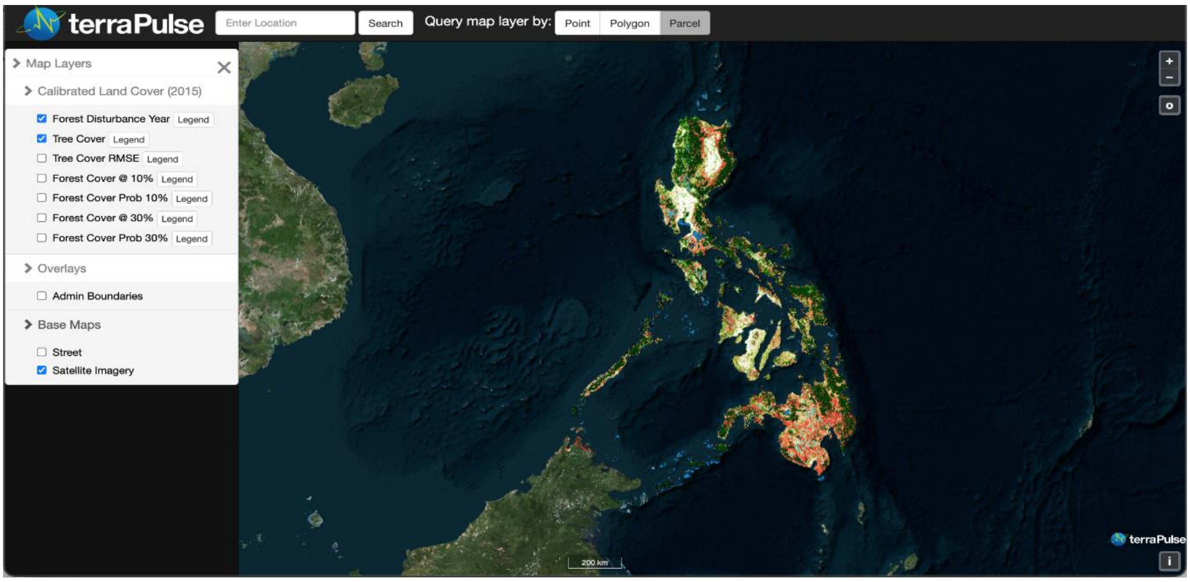


**Figure 1. TerraPulse™ *terraView* dashboard showing Tree Canopy Cover (TCC) in shades of green and year of most recent detected Forest Loss in shades of red over the Philippines.**

**Company Overview**

Established in 2014, terraPulse, Inc. (http://www.terrapulse.com) creates timely, accurate data about the changing world and delivers actionable geospatial information to forestry, wildlife conservation, urban planning, and watershed management, as well as natural resource investment, development, and insurance. TerraPulse's roots in ecology, remote sensing, computer science, machine learning, and GIS enable sustainable land use in concert with the health of ecosystems and prosperity of local economies.

TerraPulse mines large volumes of satellite imagery with machine learning to detect, map, and monitor land-cover and land-use over time. Our forestry datasets are based on the measurable attribute of tree cover, and our algorithms have been vetted through rigorous peer review and published in high- ranking scientific journals (relevant citations in References section below, copies available upon request). The terraPulse process delivers long-term, globally consistent mapping and monitoring of current forest cover and activity, and it enables retrieval of historical baselines from the satellite record.

The accuracy, consistency, and scalability of terraPulse forest activity data have led a growing number of countries to adopt terraPulse's unique technology to assess forest reference emission levels (FREL). These include the Philippines, Costa Rica, Belize, and the Dominican Republic, which are using terraPulse to measure, report, and verify their emissions reduction targets and to qualify for results-based payments.

**Introduction**

TerraPulse mines petabytes of global, long-term satellite imagery to map and monitor forest cover and change. Machine learning algorithms convert satellite images to an estimate of tree-cover and its uncertainty in each pixel in each year, which are calibrated nationally and converted to maps of forest cover, gain, and loss over time. The estimation and change-detection process uses a statistically rigorous algorithm that can accommodate alternative definitions of forest and makes maximum use of available information. The product is a geospatial dataset that can be used to establish national Forest Reference Emissions Levels (FREL).

This document describes the terraPulse process, from estimation and calibration of tree cover to classification of forests and detection of change, as well as the resulting geospatial data products delivered to the USFS and Philippines Forest Management Bureau.

**Products & Processes**

Tree canopy cover is mapped as a percentage of pixel area at 30-meter, annual resolution based on multiple sources of satellite imagery. Tree-canopy cover is then converted mathematically to maps of forest-cover probability, which are then subject to time-series analysis to detect change over time (Figure 1). Forest is defined as a land cover class where tree cover meets nationally defined criteria of tree cover; in the Philippines, this criterion is set to 10%.

Both tree cover and forest cover are modeled as probabilities in every pixel. Tree cover is represented as a continuous percentage and modeled as a Normal probability defined by the estimate and its uncertainty in each pixel. Based on the estimates of tree cover and uncertainty in each pixel, forest cover is represented as a binary category and modeled as a binomial probability. Forest-cover change is defined as either gain or loss of forest cover in a pixel over time, which is tested for statistical significance by time-series analysis.

Uncertainty is addressed explicitly throughout the estimation and change-detection process. Atmospheric, phenological, and other noise in the estimates of tree cover are propagated into the probabilities of forest cover, and these probabilities are used to discriminate significant from nonsignificant (i.e., erroneous or noise-induced) changes over time. This is done through an iterative process that outputs a complete time series of maps of forest cover, gain, and loss, as well as their respective probabilities.

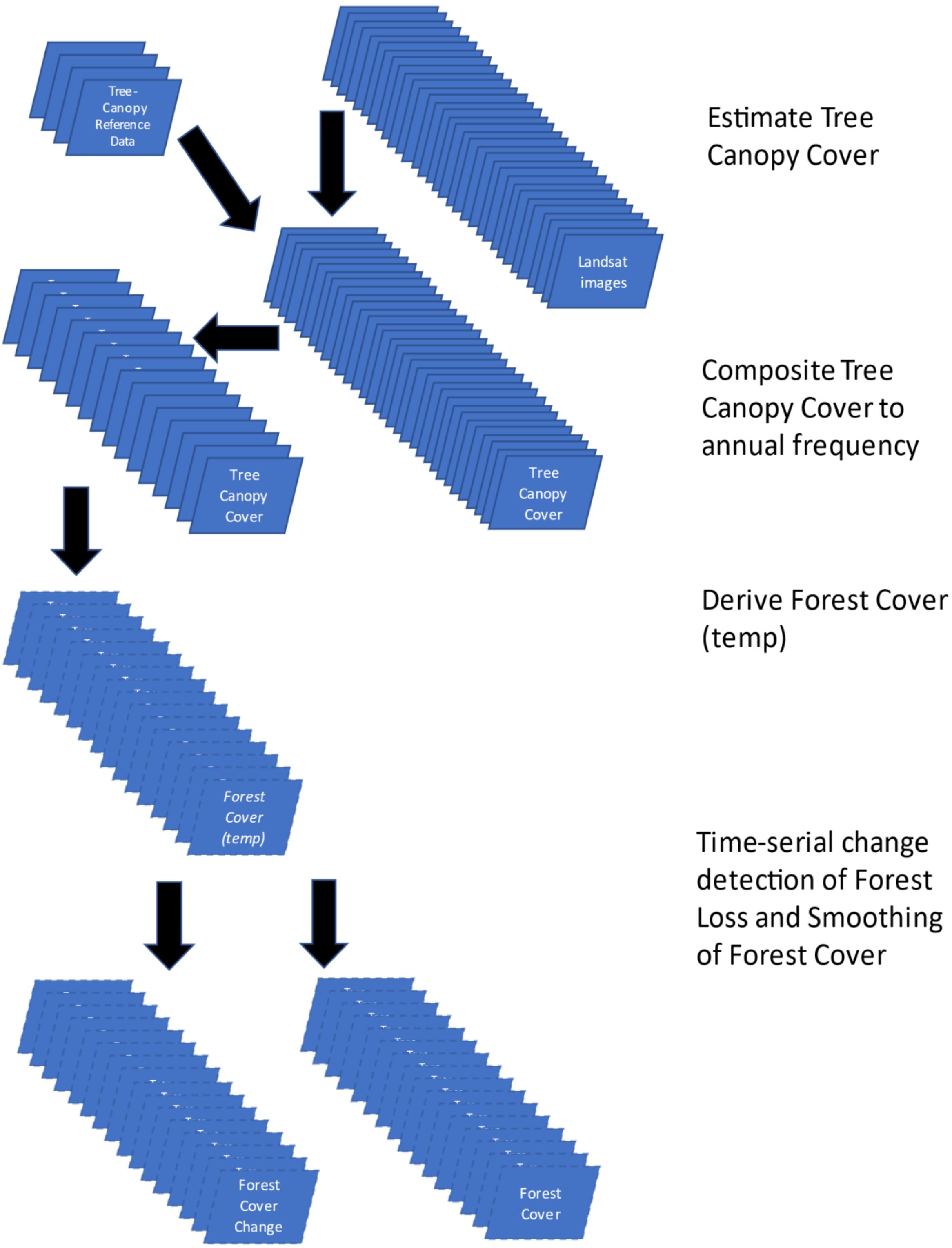


**Figure 1. Flowchart of general process of estimation of tree-canopy cover, derivation of forest cover, and time-serial detection and smoothing of forest-cover and forest-cover change.**

**Tree Canopy Cover**

The terraPulse Tree Canopy Cover (TCC, Table 1) layer contains an estimate of the percentage of each 30-m pixel covered by trees, which are defined as woody vegetation greater than 5 meters in height. In addition to the percent TCC layer, a layer of the uncertainty or residual error (as Root-Mean Squared Error, RMSE)) of each TCC estimate is also produced. This uncertainty (ERR, Table 1) is also expressed as a percentage and can be interpreted as the standard deviation of the TCC estimate.

Both TCC and ERR are expressed as percentages. For example, a TCC estimate of 78% and ERR of 14% would have more uncertainty in the model estimate (two-thirds of the model predictions would fall in the range of 64-92%), while the same TCC estimate of 78% with 8% ERR would have less uncertainty in the same estimate (two-thirds of the model predictions would fall in the range of 70-86%). Additionally, a second layer of TCC is stored in floating-point precision (DAT, Table 1) and can be interpreted as identical to ERR. These TCC, ERR, and DAT layers have been produced as uncalibrated products for the years 2000, 2005, 2010, 2015 and as calibrated products for the years 2013-2020, all of which are described in the "Process" section below.

## Products

**Table 1. Tree Canopy Cover data products produced and delivered to the Philippines Forest Management Bureau (FMB).**

| SFTP Directory | Data | Product | Temporal Extent |
|---|---|---|---|
| maps/refer/ | tiles.shp | shapefile of tiles used in original processing | N/A |
| maps/tree_cover/calibrated/2013-2018/rmse/<tile> | <tile>_dat_err.tif | Calibrated uncertainty (RMSE) of Tree Canopy Cover (%) in floating point precision | 2015 |
| maps/tree_cover/calibrated/2013-2018/tcc/<tile>/<year> | <tile>_<year>_dat_dat.tif | Calibrated Tree Canopy Cover (%) in floating point precision | 2013-2018 |
| maps/tree_cover/calibrated/2013-2018/tcc/<tile>/<year> | <tile>_<year>_dat_err.tif | Calibrated uncertainty (RMSE) of TCC (%) in floating-point precision | 2013-2018 |
| maps/tree_cover/calibrated/2013-2018/tcc/<tile>/<year> | <tile>_<year>_dat_tcc.tif | Calibrated Tree Canopy Cover (%) in floating-point precision | 2013-2018 |
| maps/tree_cover/uncalibrated/2000/err/data/<tile> | <tile>_y2000_err.tif | Uncertainty (RMSE) of uncalibrated Tree Canopy Cover (%) in 8-bit integer precision | 2000 |
| maps/tree_cover/uncalibrated/2000/tcc/data/<tile> | <tile>_y2000_tcc.tif | Uncalibrated Tree Canopy Cover (%) in 8-bit integer precision for the year 2000 | 2000 |
| maps/tree_cover/uncalibrated/2005/err/data/<tile> | <tile>_y2005_err.tif | Uncertainty (RMSE) of uncalibrated Tree Canopy Cover (%) in 8-bit integer precision for 2005 | 2005 |
| maps/tree_cover/uncalibrated/2005/tcc/data/<tile> | <tile>_y2005_tcc.tif | Uncalibrated Tree Canopy Cover (%) in 8-bit integer precision for 2005 | 2005 |
| maps/tree_cover/uncalibrated/2010/err/data/<tile> | <tile>_y2010_err.tif | Uncertainty (RMSE) of uncalibrated Tree Canopy Cover (%) in 8-bit integer precision for 2010 | 2010 |
| maps/tree_cover/uncalibrated/2010/tcc/data/<tile> | <tile>_y2010_tcc.tif | Uncalibrated Tree Canopy Cover (%) in 8-bit integer precision for 2010 | 2010 |
| maps/tree_cover/uncalibrated/2013-2018/err/<tile> | <tile>_y2015_err.tif | Uncertainty (RMSE) of uncalibrated Tree Canopy Cover (%) in 2015 | 2015 |
| maps/tree_cover/uncalibrated/2013-2018/rmse/<tile>/ | <tile>_<year>_dat.tif | Uncalibrated Tree Canopy Cover (%) in floating-point precision | 2013-2018 |
| maps/tree_cover/uncalibrated/2013-2018/rmse/<tile>/ | <tile>_<year>_err.tif | Uncertainty of uncalibrated Tree Canopy Cover (%) in 8-bit integer precision | 2013-2018 |
| maps/tree_cover/uncalibrated/2013-2018/rmse/<tile>/ | <tile>_<year>_tcc.tif | Uncalibrated Tree Canopy Cover (%) in 8-bit integer precision | 2013-2018 |

*These intermediate data products are the building blocks of the Forest Cover and Forest Cover Change products. Since they are continuous estimates (0-100%) of tree canopy cover, they could have great utility for many sub-national applications. However, they are currently un-mosaiced and would require significant post-processing to be converted into a usable format. Unfortunately, they are also not available for the entire time-series.*

## Process

### Estimation

Tree-canopy cover is estimated through a gradient-boosted regression tree (Dorogush et al., 2018), *f()*, of remotely sensed variables (***X)*** in any location *l* (Sexton et al. 2013a):

$$\hat{c}_i = f(X; \hat{\beta}) + \varepsilon, \quad (1)$$

where *c* is the percentage of a pixel (*l*)'s area covered by trees (TCC); β is a set of empirically estimated model parameters; ε is residual error or uncertainty (ERR); and ***X*** is a set of covariates of surface reflectance, derived indices (NDVI, NDWI, and MNDWI), topography, and metadata describing acquisition and sensor characteristics.

The combination of *c* and ε in each pixel provides a model of tree canopy cover as a Normal probability density function (Figure 2) in each pixel, incorporating both the estimate (TCC) and its uncertainty (ERR). This allows the rigorous, probabilistic approach to mapping forest cover and forest cover change described in the sections below.

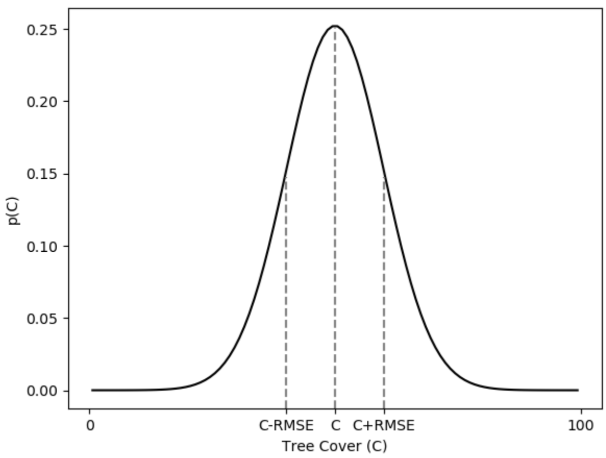


**Figure 2. Tree cover in each pixel is modeled as a Normal probability density function, with the estimate (TCC) as the mean (C) and the uncertainty (ERR) as the standard deviation (RMSE) of the Normal distribution.**

**This model is replicated in each pixel and every year using the TCC and ERR (or DAT) products. While the TCC percentage assigned to each pixel is the mean value in the Normal distribution, the confidence in that TCC value is expressed in the ERR value. High ERR values would indicate less confidence in the TCC estimate. This is most important when the TCC estimate is close to the "forest" threshold (e.g., 10% or 30%).**

## Sampling

Model parameters were fit in 3x3-tile windows (Figure 3), and the fitted model equation was applied to the image in the window's center tile to map tree-cover and its uncertainty in the center tile. The training sample for each 3x3-tile's model was pooled from 2000 to 2018 to minimize spurious inter-annual variability, and each tile's fitted equation was applied to up to six Landsat images in that tile. The median tree canopy cover estimate of each year was taken as that year's estimate of TCC, and the standard deviation of medians within the year were recorded as the pixel's uncertainty (RMSE) in that year; in addition to minimizing inter-annual noise, this compositing minimized filled gaps due to clouds and their shadows.

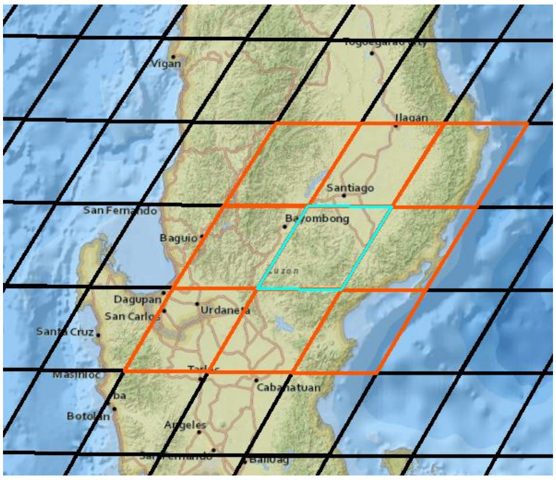


**Figure 3. 3x3 window of Landsat World Reference System (WRS-2) tiles (red) used to fit the model to estimate TCC in the center tile (aqua).**

## Input training data

Training data were acquired from the 250-meter resolution Moderate Resolution Imaging Spectroradiometer (MODIS) Vegetation Continuous Fields (VCF) (MOD44B) Collection-6 Tree Canopy Layer (https://lpdaac.usgs.gov/tools/data-pool/), which was calibrated to lidar measurements from the Phil-LiDAR program and masked for agricultural land use prior to use as reference data (Figure 4). Small-footprint, discrete return measurements of canopy height from the Phil-LiDAR program were binned into "tree" and "non-tree" categories using a 5-meter criterion and gridded at 1-meter spatial resolution for years in which the data was available (2013-2018). The resulting high-resolution, binary maps of tree cover were then coarsened as percentages of tree cover at 250-meter resolution, and their values were extracted at locations and times coincident with tree-cover values from the MODIS VCF training dataset. A regression tree was then used to fit Equation 1 to the training dataset of lidar-derived measurements and coincident MODIS estimates, and the fitted model was subsequently applied back to the uncalibrated MODIS data. The MODIS Cropland Probability Layer (https://glad.umd.edu/dataset/gce/modis-global-crop-extent-discrete-croplandnot-cropland-data) was then used to mitigate remaining over-estimation of tree cover in agricultural fields; MODIS VCF tree-cover values less than 30% were reset to 0 where cropland probability >50%.

*The MODIS Cropland Probability Layer will need to be downloaded and made part of the FREL project record. As part of FMB's continuous improvement process, a validation of this layer for the Philippines will need to be completed and adjustments made if it is to be used for FREL updates in the future.*

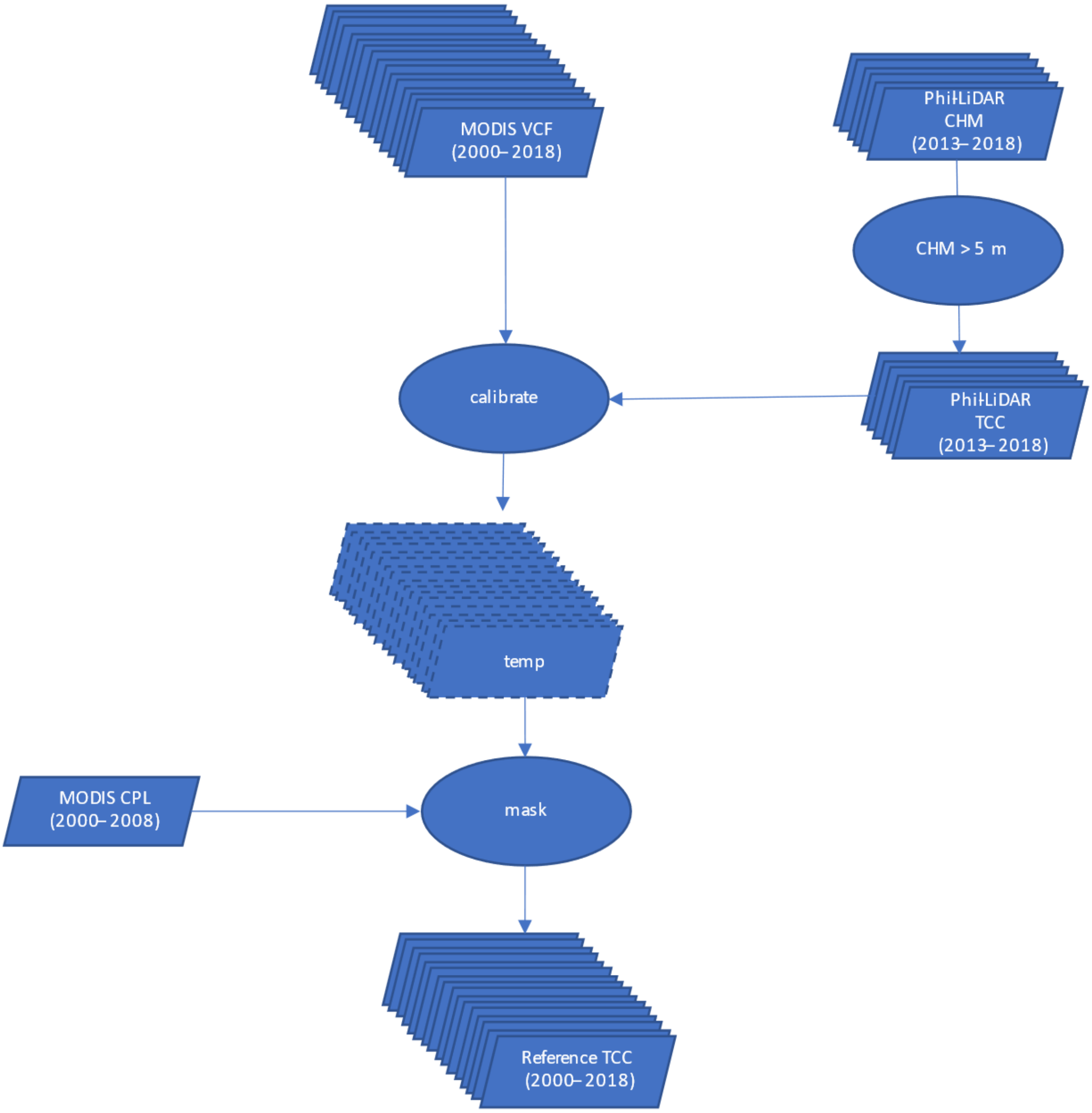


**Figure 4. Calibration of MODIS Vegetation Continuous Fields (VCF) Tree Canopy Layer to Phil-LiDAR Canopy Height Model (CHM) and subsequent masking based on MODIS Cropland Probability Layer (CPL) to produce reference estimates of tree-canopy cover. The calibration model is fit to a training sample from the years 2013 to 2018 and applied to the 2000 to 2018 population from which the sample was drawn.**

Covariates (X in Equation 1) were drawn from the Landsat series of satellite sensors, as well as ancillary topographic data from the ASTER Global Digital Elevation Model (GDEM) to stratify fit across topographic slope, aspect, and elevation. Landsat Collection-1 images from 1990 to 2020 were downloaded from USGS/EROS Data Center (http://landsat.usgs.gov), including level-1 Terrain Corrected (L1T) Landsat-4 and -5 Thematic Mapper (TM) images, Landsat-7 Enhanced Thematic Mapper Plus (ETM+) images, and Landsat-8 Operational Land Imager (OLI) images. Each image was converted to units of surface reflectance; the Landsat Ecosystem Disturbance Adaptive Processing System was used for TM/ETM+ images, and the Landsat Surface Reflectance (LaSRC) was used for OLI images (Vermote et al. 2018). A maximum of six images from each year were selected in each World Reference System 2 (WRS-2) tile. All Landsat images were scored by cloud coverage, seasonality, and image quality (e.g., SLC-off, Landsat processing levels), and the images with the highest scores in each year were selected for analysis. Each covariate was aggregated to mean values at the 250-meter spatial resolution of the MODIS VCF-based response data (Feng et al., 2012); clouds and their shadows were removed using the FMASK algorithm (Zhu and Woodcock, 2012).

## Forest Cover & Forest Cover Change

Whereas tree canopy cover (TCC) is estimated statistically, the corresponding maps of forest cover and forest cover change are derived from the TCC estimates using probability theory. The estimate of tree canopy cover (TCC) and its uncertainty (ERR) in each pixel, both expressed as percentages, are mathematically translated into the probability of the discrete class "forest" in that pixel, and forest-cover change is then detected as statistically significant changes (e.g., gains and losses) of those forest cover probabilities over successive years with a parametric z-test.

### Products

**Table 2. Forest Cover and Change data products delivered to the Philippines Forest Management Bureau (FMB).**

| SFTP Directory | Data | Product | Temporal Extent |
|---|---|---|---|
| 20201001/maps/change/ forest_<threshold>_tcc/<year> | forest_<year>_gain.tif | Binary value (1) indicating a GAIN in forest cover for that year | 2000-2015 for 10p TCC<br><br>1990-2018 for 30p TCC |
| 20201001/maps/change/ forest_<threshold>_tcc/<year> | forest_<year>_gain_prob.tif | The probability of forest cover GAIN for that year expressed as a floating point value with a range of 0.0-100.0 | 2000-2015 for 10p TCC<br><br>1990-2018 for 30p TCC |
| 20201001/maps/change/ forest_<threshold>_tcc/<year> | forest_<year>_loss.tif | Binary value (1) indicating a LOSS in forest cover for that year | 2000-2015 for 10p TCC |

| | | | |
|---|---|---|---|
| | | | 1990-2018 for 30p TCC |
| 20201001/maps/change/ forest_<threshold>_tcc/<year> | forest_<year>_loss_prob.tif | The probability of forest cover LOSS for that year expressed as a floating point value with a range of 0.0-100.0 | 2000-2015 for 10p TCC<br><br>1990-2018 for 30p TCC |
| 20211101/maps/forest/ forest_<threshold>_tcc/<year> | forest_<year>_data.tif | Binary value (1) indicating whether forest cover at that threshold for that year | 2000-2015 for 10p TCC<br><br>1990-2020 for 30p TCC |
| 20211101/maps/forest/ forest_<threshold>_tcc/<year> | forest_<year>_prob.tif | The probability of forest cover at that threshold for that year expressed as a floating point value with a range of 0.0-100.0 | 2000-2015 for 10p TCC<br><br>1990-2020 for 30p TCC |

## Definitions

**Cover**: presence in space and/or time; can be expressed as a binary value (i.e., presence, absence), a percentage of an area (e.g., pixel or polygon), or as an area (e.g., ha) within a defined spatial unit. Temporal coverage is usually not stated explicitly, but is inherited from the temporal scale of the data.

**Change**: gain or loss (i.e., increase or decrease) of **cover** in a spatial location over a period of time; expressed as either a rate over time (%/year, ha/year) or as a binary value (i.e., "gain", "loss")

**Tree**: vegetation greater than 5 meters in height above the ground surface; assumed to be woody

**Tree Cover**: **cover** of the class **tree**

**Tree Cover Change: change** in **cover** of the class **tree** in a spatial location over time

**Forest**: land where **tree cover** exceeds a predefined threshold value over a period of time, typically one year

**Forest Cover**: **cover** of the class **forest** within a location in space and time

**Forest Cover Change**: **gain** or **loss** of the class **forest** in a spatial unit over an interval of time

**Kernel**: subset of data over an interval in time

**Residual Error**: difference between reference and modeled values

**Uncertainty**: imprecision, i.e., noise or information not explained by a model

**Model Parameter**: estimate of the numerical relationship between variables

**Training Data**: sample of data used to estimate **model parameters**.

**Probability**: number describing the chance or likelihood of an event.

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## Frequently Asked Questions

### What reference data were used to estimate tree-canopy cover?

*The machine learning algorithm that estimated tree-canopy cover at 30-meter resolution was trained on estimates of tree-canopy cover derived mainly from the MODIS Vegetation Continuous Fields (VCF) Tree Canopy Cover Layer after calibration to airborne lidar measurements and masking of agricultural fields. The covariates were mainly Landsat-based estimates of top-of-atmosphere reflectance, stratified by topography.*

### How does the resolution of the training data impact the resolution of the final forest maps?

*Because tree-canopy cover is a continuous fraction of pixel area, which can be applied at any resolution, the resolution of the training data has minimal impact on the resolution of the final maps.*

### Which years of tree-canopy cover reference data were calibrated with lidar?

*Every year's reference data from 2000 to 2018 were calibrated with lidar. The calibration equation was trained on a sample of airborne lidar and coincident (uncalibrated) reference data collected from 2013 to 2018, and that equation was applied to each year's uncalibrated MODIS VCF estimates in the production of the reference data for estimating tree-canopy cover at 30-meter resolution.*

### Probabilities are used in many places throughout the process. How are they related to one another?

*Each estimated response variable is represented as a probability density function to communicate its own uncertainty. For example, percentage tree-canopy cover is represented as a Normal probability distribution, and binary Forest Cover is represented as a Binomial distribution. The probabilities are related to each other in the way that those variables are related to each other (e.g., the relationship between trees and forests is a threshold of tree-canopy cover), as dictated by probability theory. In some cases this is an integral (tree-canopy cover to forest cover), and in others it is a significance test (forest-cover to forest-cover change). Although the probabilities are represented in the same or similar units (i.e., percent or unit-scale), each variable and its uncertainty should be interpreted independently from one another.*

### If more than three forest-loss events are detected in the time series, which ones are recorded?

*In the unlikely event that more than three significant forest-losses are detected in the 28-year time series, the three most recent events will be recorded.*

### Was the output of the time-series analysis used to refine the forest-cover dataset and its respective uncertainty?

*The time-series analysis was used to remove noise in the forest-cover layer in addition to its use for detecting forest-cover change. The forest/nonforest output of the change-detection process was used as the final forest/nonforest estimate in each pixel over time, and the original probability was used as its uncertainty.*

## Annex 2: Forest Change Interpretation Key

# Philippines: Interpretation Key

I. Table of Contents

## Why Create an Interpretation Key?

Being able to identify land cover types using remote sensing data and time-series information is an important skill for creating training data, verifying algorithm outputs, and creating sample-based estimates of area. Creating an interpretation key is important to support all of these tasks and serves multiple purposes, including:

1. Creating consensus. The interpretation key helps your team build a shared understanding of what each land cover type is and how to identify it. This means that if you have multiple interpreters, they should be able to classify land cover categories in the same way.
2. Creating documentation. The key records what your team considers the land cover types in your region and what each type looks like. This is important for funding and publishing.
3. Creating institutional knowledge. An interpretation key allows new team members to understand what existing team members consider to be defining characteristics of each land cover type. This helps your new team members start collecting data and contributing to your project quickly and accurately.

## Intended Purpose of this Interpretation Key

This interpretation key is prepared as a guide for interpreters in maintaining the consistency in their interpretation of the land cover and land cover changes happening in each plot within the observation period from 2000 to 2018. The results of this mapathon is part of the accuracy assessment done on the activity data used by the Philippines for the construction of the Forest Reference Level.

## Development of this Interpretation Key

This interpretation was developed by Spatial Informatics Group and iteratively improved by the FMB and USFS team in the course of the practice sessions prior to the actual accuracy assessment mapathon.

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## Term Definitions - Specific to this Assessment

| Term | Definition (specific to assessment in the Philippines) |
|---|---|
| Forest | Land with an area of more than 0.5 hectare and tree crown (or equivalent stocking level) of more than 30 percent. The trees should be able to reach a minimum height of 5 meters at maturity in situ. This includes closed forest, open forest, and mangrove forests. |
| Deforestation | The conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10% threshold |
| Reforestation | The establishment of forest plantations on temporarily unstocked lands that are considered as forest. Also called Artificial Regeneration. However, for this assessment any tree growth causing a non-forested area to change so it meets the Philippine definition of forest, regardless of cause, is referred to broadly as "reforestation." |

| | |
|---|---|
| Normalized Difference Vegetation Index (NDVI) | NDVI is calculated given the following equation:<br><br>$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$<br><br>Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).<br><br>NDVI always ranges from -1 to +1. But there isn't a distinct boundary for each type of land cover.<br><br>It has values between -1 and +1. If you have low reflectance (or low values) in the red channel and high reflectance in the NIR channel, this will yield a high NDVI value. And vice versa.<br><br>Overall, NDVI is a standardized way to measure healthy vegetation. When you have high NDVI values, you have healthier vegetation. When you have low NDVI, you have less or no vegetation. |
| Normalized Degradation Fraction Index (NDFI) | NDFI is calculated given the following equation:<br><br>$\mathrm{NDFI} = \frac{\mathrm{GV_{Shade}} - (\mathrm{NPV} + \mathrm{Soil})}{\mathrm{GV_{Shade}} + \mathrm{NPV} + \mathrm{Soil}}$<br><br>Where $GV_{Shade}$ is the shade-normalized GV fraction:<br><br>$\mathrm{GV_{Shade}} = \frac{\mathrm{GV}}{100 - \mathrm{Shade}}$<br><br>Non-photosynthetic vegetation (NPV) and soil are end members calculated by decomposing the spectral mixture using spectral mixture analysis (SMA).<br><br>NDFI detects forest degradation caused by multiple drivers and is more sensitive to forest disturbances than transforms based on spectral reflectance alone, such as NDFI. |

### Satellite Images Available for Assessment

| Imagery Options | Time Period | Description |
|---|---|---|
| Mapbox Satellite | | |
| Planet NICFI Public | 2015 to present | Basemaps for Tropical Forest Monitoring |
| Sentinel 1<br><br>Polarisations:<br>• VH, VV, VH/VV<br>• VH, VV, VV/VH<br>• VV, VH, VV/VH<br>• VV,VH, VH/VV | 2015 to present | Sentinel-1 can play an important role in sustainable forest management with clear-cut and partial-cut detection, forest type classification, biomass estimation and disturbance detection. For climate change, mapping of forest fire scars can be an important part of mapping the carbon history of a forest and plays a critical role in the estimation of carbon emissions. |
| Sentinel 2<br><br>Band Combinations:<br>• **True Color**<br><br>• **False Color Infrared**<br><br>• **False Color Urban** | 2015 to present | Sentinel-2 carries the Multispectral Imager (MSI). This sensor delivers 13 spectral bands ranging from 10 to 60-meter pixel size.<br><br>The True color band combination uses the red (B4), green (B3), and blue (B2) channels. **Its purpose is to display imagery the same way our eyes see the world.** Just like how we see, healthy vegetation is green, urban features often appear white and grey and water is a shade of dark blue depending on how clean it is.<br><br>The False-color infrared band combination is meant to emphasize healthy and unhealthy vegetation. By using the near-infrared (B8) band, it's especially good at reflecting chlorophyll. **It is most commonly used to assess plant density and health,** as plants reflect near-infrared and green light while absorbing red. Since they reflect more near-infrared than green, plant-covered land appears deep red. Denser plant growth is darker red. Cities and exposed ground are gray or tan, and water appears blue or black.<br><br>The false-color urban band combination uses SWIR (B12), near-infrared (B8), and blue (B2). **This composite is used to** |

| | | |
|---|---|---|
| | | **visualize urbanized areas more clearly.** Vegetation is visible in shades of green, while urbanized areas are represented by white, grey, or purple. Soils, sand, and minerals are shown in a variety of colors. |
| ● **Agriculture** | | The agriculture band combination uses SWIR-1 (B11), near-infrared (B8), and blue (B2). **It's mostly used to monitor the health of crops because of how it uses short-wave and near-infrared.** Both these bands are particularly good at highlighting dense vegetation that appears as dark green. |
| ● **Healthy Vegetation** | | Because near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs), **the vegetation index is good for quantifying the amount of vegetation.** The formula for the normalized difference vegetation index is (B8-B4)/(B8+B4). While high values suggest dense canopy, low or negative values indicate urban and water features. |
| ● **Short Wave Infrared** | | The short-wave infrared band combination uses SWIR (B12), NIR (B8A), and red (B4). This can **help to estimate how much water is present in plants and soil, as water reflects SWIR wavelengths.** Shortwave-infrared bands are also useful for distinguishing between cloud types (water clouds versus ice clouds), snow and ice, all of which appear white in visible light. |

### Land Cover Definitions - Specific to the Philippines

| Land Cover Class | Definition | Sub Classes |
|---|---|---|
| Forest | Land with an area of more than 0.5 hectare and tree crown (or equivalent stocking level) of more than 10 percent. The trees should be able to reach a minimum height of 5 meters at maturity in situ. | **Closed forest** - formations where trees in the various storeys and the undergrowth cover a high proportion (>40 percent) of the ground and do not have a continuous dense grass layer. They are either managed or unmanaged forests, in advanced state of succession and may have been logged -over <one or more times, having kept their characteristics of forest stands, possibly with modified structure and composition<br><br>**Open forest** - formations with discontinuous tree layers with a coverage of at least 10 percent and less than 40 percent. They are either managed or unmanaged forests, in the initial state of succession.<br><br>**Mangrove forest** - forested wetland growing along tidal mudflats and along shallow water coastal. Areas extending inland along rivers, streams and their tributaries where the water is generally brackish and composed mainly of *Rhizopora, Bruguiera, Ceriops, Avicenia, Aegiceras*, and Nipa species. |
| Other Wooded Land | lands either with a crown cover (or equivalent stocking level) of 5-10 percent of trees able to reach a height of 5 meters at maturity; or a crown cover (or.equivalent stocking level) of more than 10 percent not able to reach a height of 5 meters at maturity (e.g. dwarfed or stunted trees); or with shrubs or bush cover of more than 10 percent. | **Shrubland** - where the dominant woody vegetation are shrubs, generally of more than 0.5 meter and less than 5 meters in height in maturity and without a definite crown. The growth habit can be erect, spreading or prostrate. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minim:um tree and maximum shrub height,which may vary between 5 and 7 meters approximately. |
| Other Land | Land with tree cover less than 5%. It includes agricultural land, pastures, | **Bare areas** - land not covered,by (semi-) natural or artificial cover. These include, |

| | | |
|---|---|---|
| | built-up areas, bare areas, grassland, etc. | among others, sand dunes, riverwash,lahar laden areas and rocky or stony areas.<br><br>**Grassland** - areas predominantly vegetated with grasses such as Imperata, Themeda, Saccharum spp., among others.<br><br>**Annual cropland** - land cultivated with crops with a growing cycle under one year, which must be newly sown or planted for further production after harvesting.<br><br>**Perennial cropland** - land cultivated with long term crops that do not have to be replanted for several years after each harvest; harvested components are not timber but fruits, latex and other products that do not significantly harm the growth of the planted trees or shrubs; orchards, vineyards and palm plantations, coffee, tea, sisal, banana, abaca, etc.<br><br>**Built up area** - composed of areas of intensive use with much of the land covered by structures. It includes cities, towns,villages, strip developments along highways, transportation, power, and communication facilities, and areas occupied by malls, shopping centers, industrial and commercial complexes, and institutions that may, in some instances, be isolated from urban areas.<br><br>**Inland waters** - bodies of water surrounded by land (e,g. Rivers, lakes, streams, mudflats; ponds/fishponds, dams and reservoirs) |

### Drivers of Deforestation in the Philippines

| Driver | Description |
|---|---|
| Forest products extraction | Selective and clear-cutting |

| | |
|---|---|
| Agricultural expansion | **Kaingin making -** A farming system based on shifting, or slash and burn clearing of forest for the planting of agricultural and agro-forestry crops.<br>Reference: DENR. 1999. Guidelines for Watershed Management and Development in the Philippines. Manila.<br>**Conversion of forests (plantations, agroforestry, fishpond)**<br>**Grazing Land -**Portion of the public domain which has been set aside, in view of its topography and vegetation, for the raising of livestock.<br>Reference: PD 1559. Further Amending PD 705, Otherwise Known as The Revised Forestry Code of the Philippines. 1978. |
| Infrastructure expansion | Mining<br>Road construction<br>Hydropower dam construction<br>Settlement |
| Natural Disturbance | Typhoons<br>Floods<br>landslides<br>Forest/brush fire |

## Land Cover Types Identification Guidance/Examples

**Forest**

Definition: *"Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ.*

*It does not include land that is predominantly under agricultural or urban land use."*

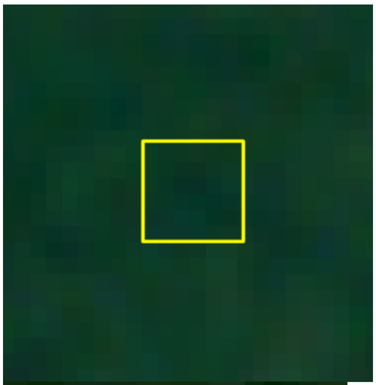
Additional indicators in context:

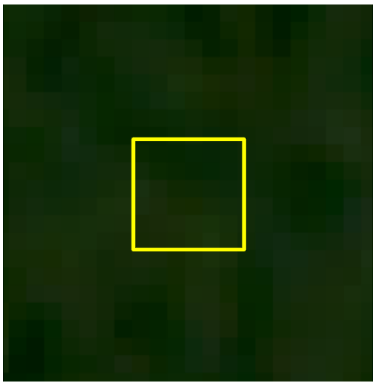
How land cover presents in imagery and time-series:

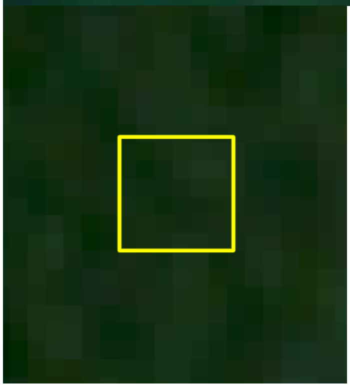
Local Example (Imagery/time-series):

MapBox imagery

Planet 2015-12_2016-05 Planet 2017-06_2017-11 Planet 2019-06_2019-11

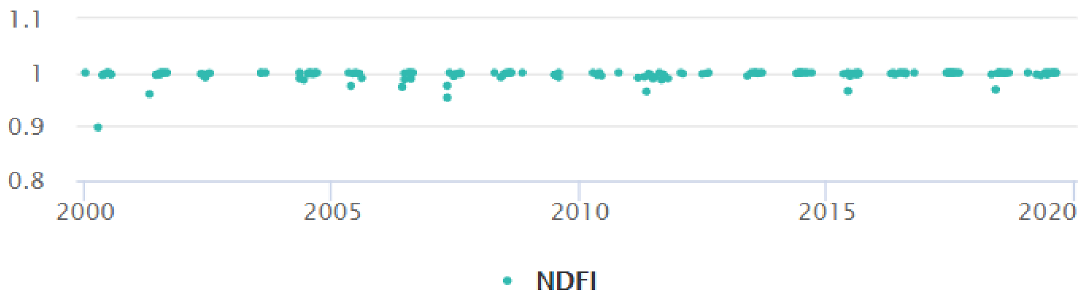






Green patch, indicative of forest, same characteristics observed for all years in between

NDFI time series: stable throughout the years, between 0.9 and 1




*End of example*

**Inland Forest**

Definition: Land with an area of more than 0.5 hectare and tree crown (or equivalent stocking level) of more than 10 percent. The trees should be able to reach a minimum height of 5 meters at maturity in situ. These include both the NAMRIA classification of close and open forest.

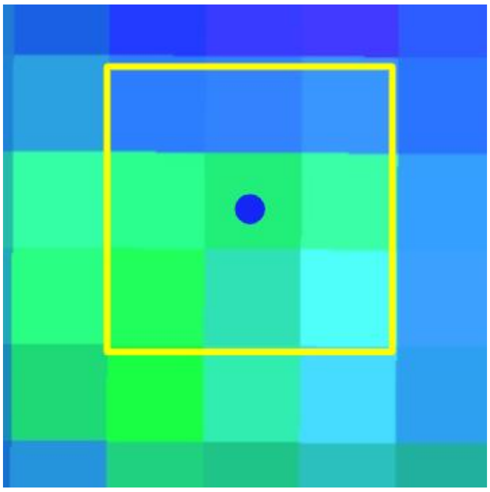
Additional indicators in context:

How land cover presents in imagery and time-series:

Potential causes of confusion:

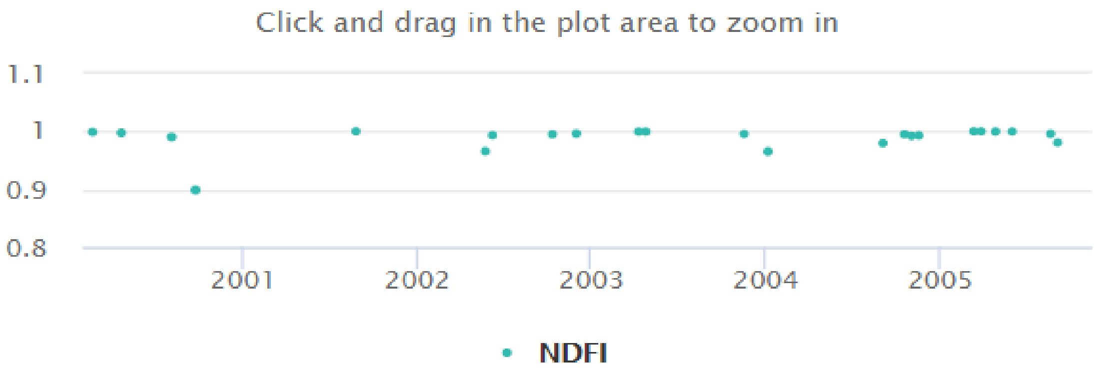
Local Example (Imagery/time-series):

**Mapbox Imagery** **Planet NICFI**



**Sentinel 1 (VH, VV, VH/VV)**

NDFI Time Series:

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Mangrove Forest

Definition: Forested wetland growing along tidal mudflats and along shallow water coastal areas extending inland along rivers, streams and their tributaries where the water is generally brackish and composed mainly of Rhizopora, Bruguiera, Ceriops, Avicenia, and Aegicera spp.

Reference: (1) Center for International Forestry Research. (2) PD 705 Revising PD 389, Otherwise Known as The Revised Forestry Code of the Philippines. Section 2. 1975.

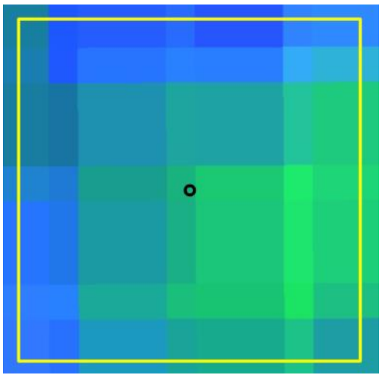
Additional indicators in context: Looks very similar to inland forests when zoomed in but normally when zoomed out there would be a coast nearby. There are those that are found further inland and often would be connected by a river to the sea.

How land cover presents in imagery and time-series:

Potential causes of confusion:

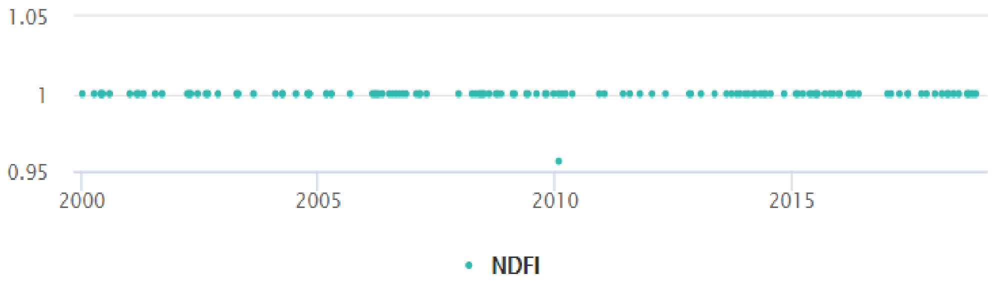
Local Example (Imagery/time-series):

**Google Earth** **Mapbox Imagery**

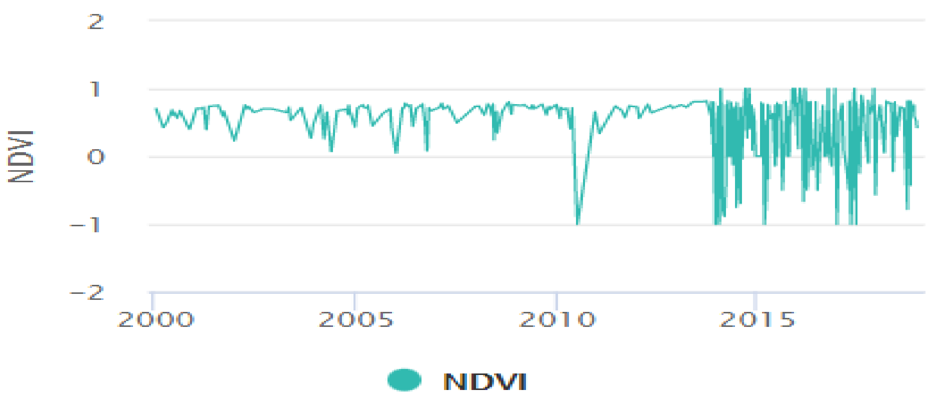


**Sentinel 1 (VH, VV, VH/VV)**

NDFI Time Series: Almost a flat one thru the entire time series.




NDVI Time Series:




**Negative NDVI values may indicate a water body or barren land.*

**Shrubs**

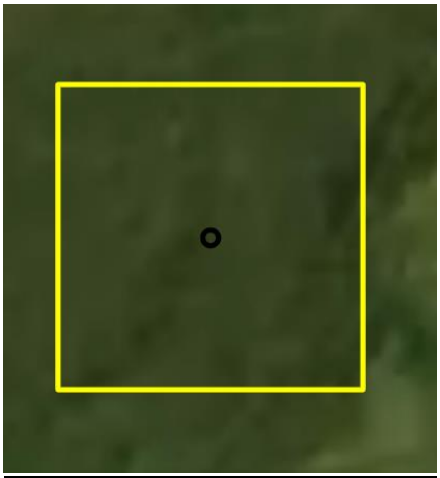
Definition: Land where the dominant woody vegetation are shrubs, generally of more than 0.5 meter and less than 5 meters in height in maturity and without a definite crown. The growth habit can be erect, spreading or prostate. The height limits for trees and shrubs should be interpreted with flexibility, particularly the minimum tree and maximum shrub height, which may vary between 5 to 7 meters approximately.

Reference: FAO. 2001. Global Forest Resources Assessment 2000. Main Report. FAO Forestry Paper No. 140. Rome.

Additional indicators in context:

How land cover presents in imagery and time-series:

- Shrubland is relatively smoother in texture compared to forest area.

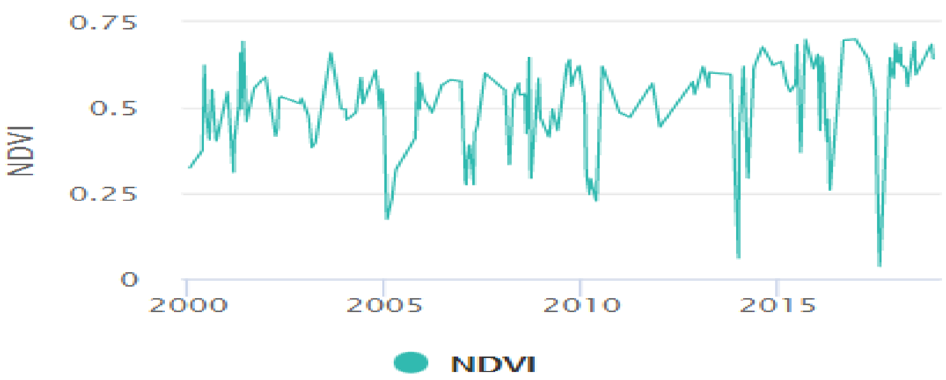


Potential causes of confusion:

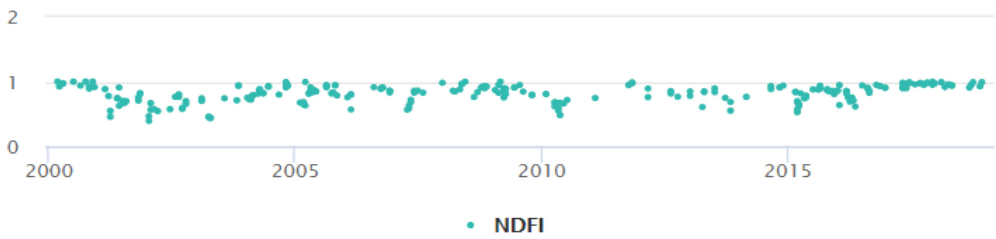
Local Example (Imagery/time-series):

**Mapbox**

NDVI Time Series:




**NDFI Time Series:**




**Grassland**

Definition: Areas predominantly vegetated with grasses such as Imperata, Themada, Saccharum spp., among others.

Reference: Interagency Task Force on Geographic Information Resolution No. 1 Series of 1995.

Additional indicators in context:

How land cover presents in imagery and time-series:

Potential causes of confusion:

Local Example (Imagery/time-series):

**Perennial crops**

Definition: Land cultivated with long term crops that do not have to be replanted for several years after each harvest. Includes coconut and other palms, fruit trees and banana plantations.

Additional indicators in context:

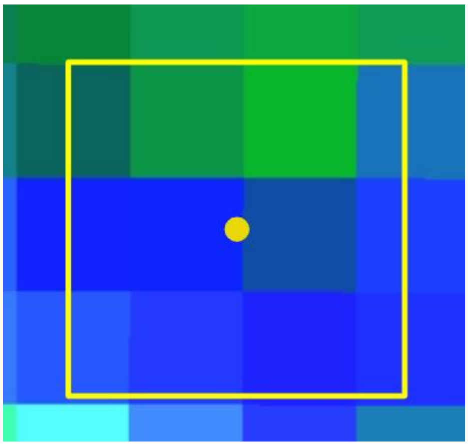
1. **Coconut plantations :** Observe the pattern of the image, palms look rough with a star-like shapes.

How land cover presents in imagery and time-series:

Potential causes of confusion:

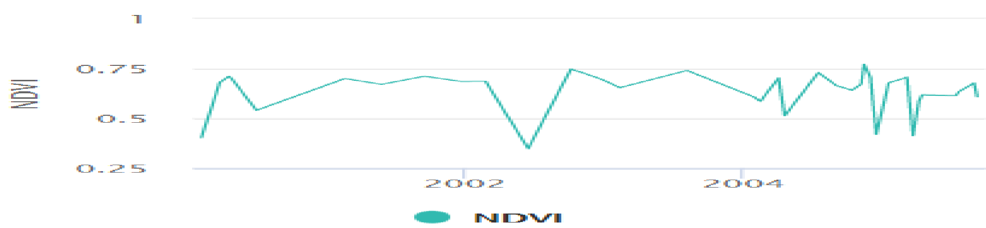
Local Example (Imagery/time-series):

**Mapbox Imagery** **Planet NICFI**

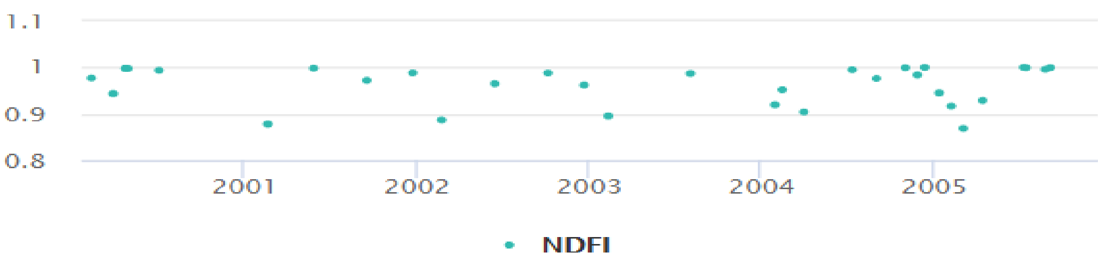


**Sentinel 1 (VH, VV, VH/VV)**

<u>NDVI Time Series: </u> Values in between 0.3 to 0.75




<u>NDFI Time Series: </u> Values in between 0.8 to 1



**Drivers of Forest Disturbance Interpretation Guidance/Examples**

By coupling time-series plots with visual inspection of the remote sensing imagery and local knowledge, we can identify forest disturbances due to specific drivers.

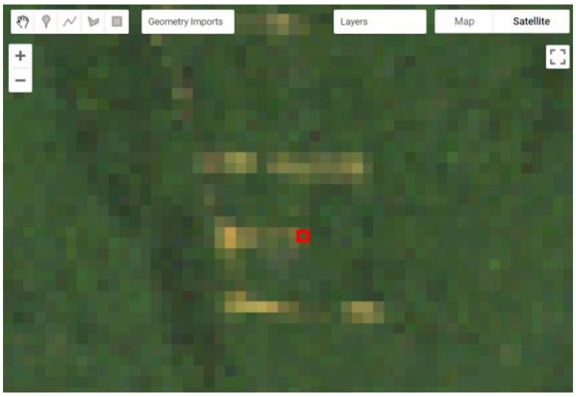
Illegal logging/ timber poaching

Definition: Removal of small forested patches indiscriminately. Caused by humans.

Additional indicators in context: Can be preceded by selective logging and followed by establishment of a pasture land.

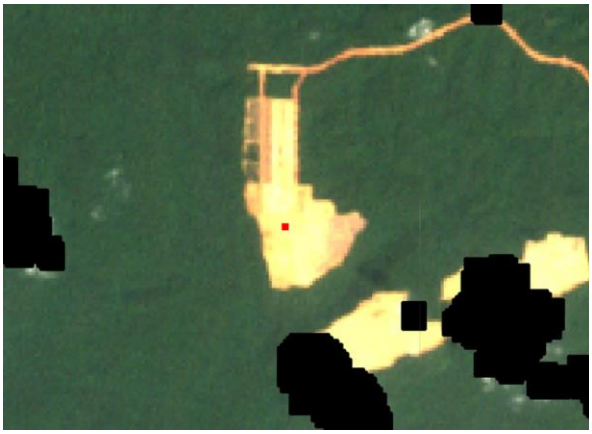
How driver presents in imagery and time-series: Typically seen as a sharp change in color from green to earth tones. The boundaries of the disturbance are often geometric, since it is human caused. The NDVI and NDFI drops severely and typically either recovers slowly or switches to a different seasonal variation in NDFI at a different magnitude, which is indicative of a forest being clear cut and replaced with agriculture.

Local example:



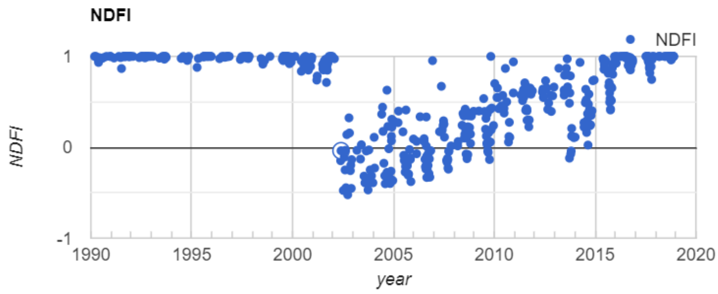

Google Earth Imagery - September 11, 2000

Planet - August 2002



Planet - November, 2002

NDFI series:




**Kaingin making**

Definition:

Additional indicators in context:

How driver presents in imagery and time-series:

Local example:


March 2018


June 2017


June 2019

Mining

June 2018

Landslides


May 19 20


Feb - 29, 2021

Natural Disturbances

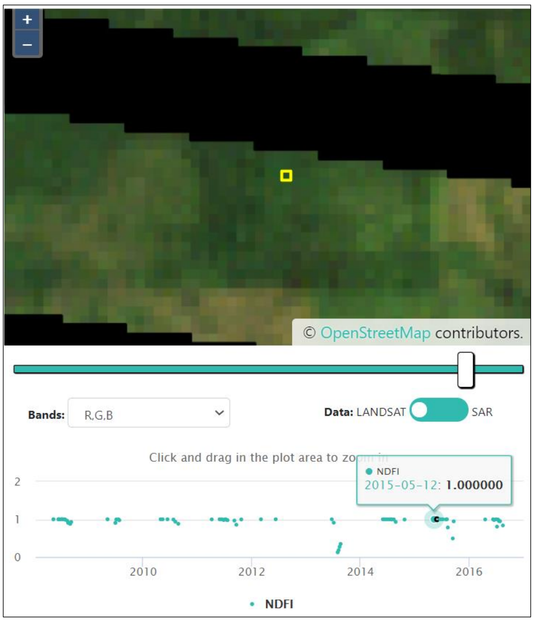
Landslides

April 4 2017

**Best Interpretation Practices**

*Example from another project - delete*

1. While you wait for the Geo-Dash to load the widgets, go back to the main window and zoom out and in and look at the plot in context using Mapbox imagery
    a. Use the Planet NICFI mosaic 2015-12_2016-05 to help you interpret the land cover at the beginning of 2016.
2. Go to the Geo-Dash and see if NDFI values in 2015 are high (above around 0.85), that indicates forest cover. Also click at the NDFI points in 2015 to see the Landsat Image referent to that time.
   **NOTE: If the Geo-Dash takes a while to load, refresh the whole page. Sometimes the plots will load faster this way.**



3. Go to the GEE Script, if needed, and slide the Landsat time series to 2015 year mosaic for both Landsat 7 and 8 (darker green will mean forested areas)


These will help with the interpretation of the Land Cover in 2015.

4. Download the plot KML to look for high resolution imagery from 2015 in Google Earth Pro. 

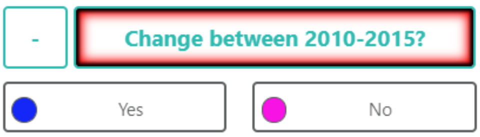

5. Based on these analyses, answer if the Land Cover in 2015 was forest or non-forest.

6. Now, go back to Google Earth Pro and check for any change in the landscape between 2010-2015, if you find available images.
   Remember to zoom in and out -- different images might be available at different zoom scales.

7. Go to the GeoDash again and look at the NDFI, and SWIR charts. Check for any decreases or increases in the NDFI and SWIR values between 2010 and 2015.
   Click at specific NDFI points to see the Landsat Image referent to that time

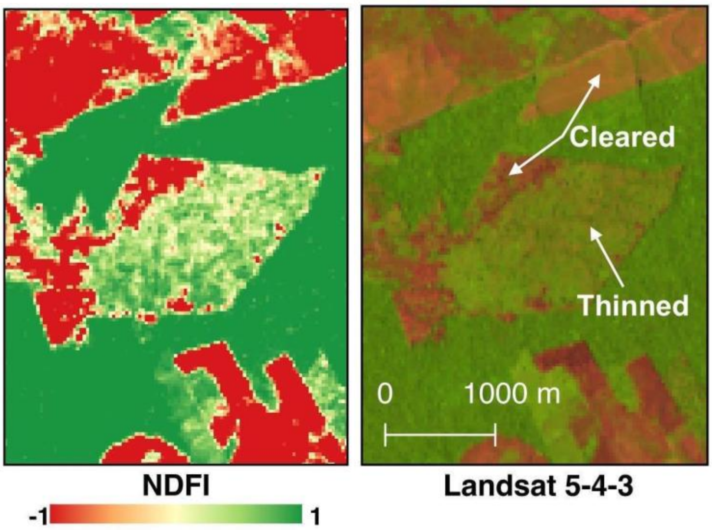

   Also see the MapBiomas classifications between those years (Change in green color - forest - to another color). Note that MapBiomas **might NOT capture** events that NDFI is able to capture, especially subtle degradation events.

8. If you believe a change has occurred, respond Yes, if not, respond No




9. If you responded Yes, answer the "Type of Change" question accordingly: Increase in canopy (regeneration -- we are focusing on farms/non-forested areas that showed a regeneration process) or decrease in canopy

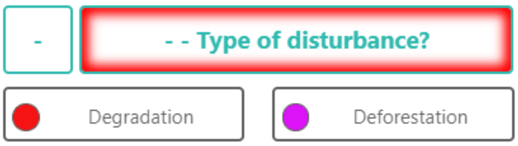

10. If you answered Decrease in canopy, specify if it was a Degradation or Deforestation event. For this, use imagery available (Google Earth Pro if you are lucky) and the NDFI time series. Usually, in the Amazon, subtle changes indicate degradation events (NDFI values above around 0) whereas stronger decay indicates deforestation (NDFI values below around 0) although you may encounter variations. Look for the change in the NDFI time series and check if change in the land cover occurred or not.



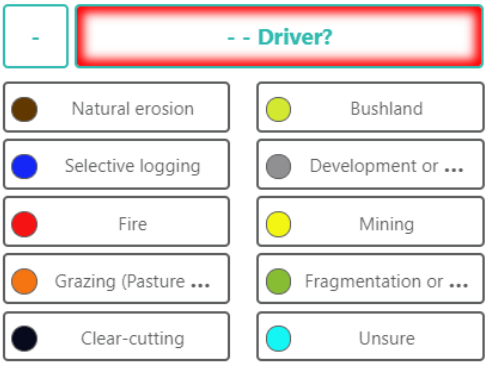

Use the MapBox imagery to check the surroundings for context.

Check the examples of disturbances events below to help your interpretation.

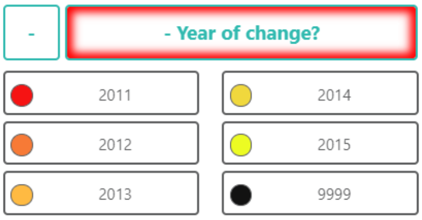
Keep in mind that deforestation results in a change in the land cover whereas degradation does not.




11. If possible, indicate which driver caused the disturbance. If you are unsure, respond "Unsure"

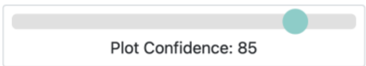



12. If possible, also indicate the year of change. If you are unsure or it's impossible to indicate, mark "9999".




13. If you believe a second event occurred in this time period (2010-2015), respond yes to the next question and go through the process again.
    Note that if a short isolated degradation event occurred and regrowth took place immediately after, we don't need to mark it as a regeneration event.

14. Select plot confidence




90-100% = Very Confident --- confident that change occurred or not, and if change occurred, the type of change is clear

80-89% =Confident --- confident that change occurred or not, but type of change is arguable

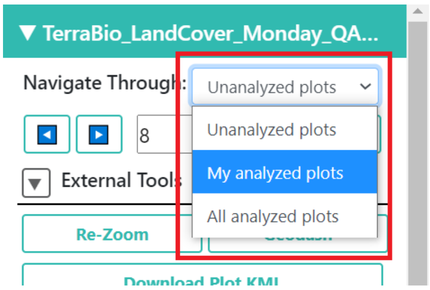
60-79% = Moderately Confident --- Not so sure if change occurred and/or type of change is not clear (reasoning in notes)

0-59% = Low Confidence --- very unsure if change occurred and/or the type of change is not clear, needs a double check (reasoning/confusing points in notes) ***flag plot**

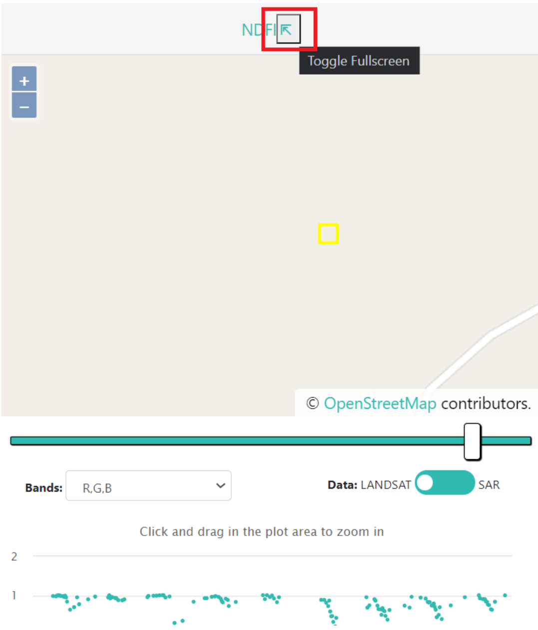

15. Leave notes of reasoning or confusion in short answer question and click 'Save'

16. Click 'Save' and proceed to next point 

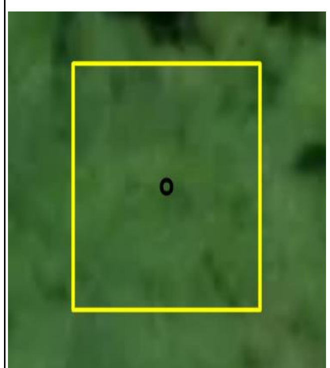
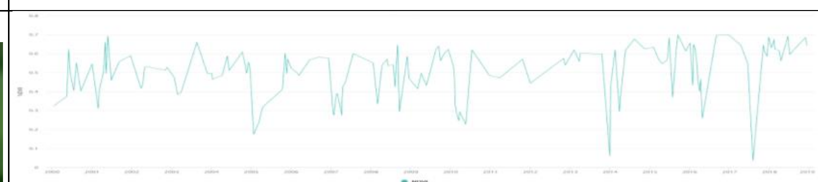

- If you are very unsure of the land cover in 2015 and/or if change occurred, and/or the type of change, and find it impossible to provide an interpretation, flag the plot for later examination by an expert interpreter for the region
- If you want to go back to a previously analyzed plot, change the "Navigate through" option at the top right of the screen from "Unanalyzed plots" to "My analyzed plots" and go to the desired plot you want to check:

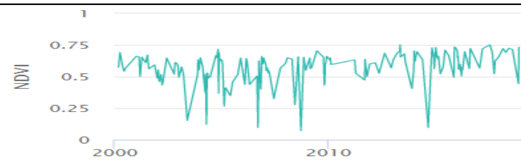
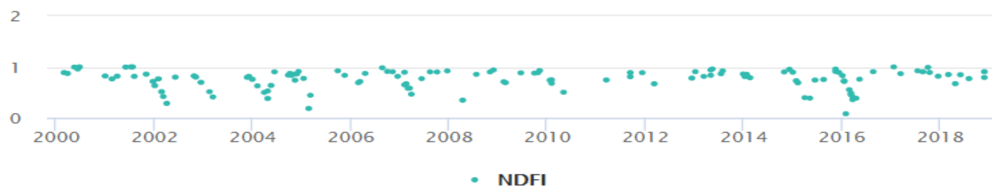


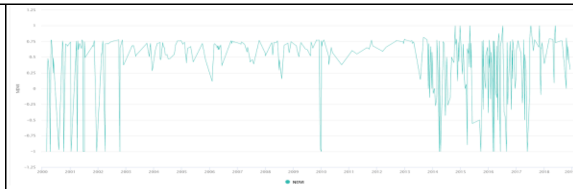

- Remember that you can toggle the NDFI and other widgets in the Geodash full screen in case they show too small in your monitor



II. Cheat sheet values for  Land cover interpretation and indexes

| Land cover | Photo | NDVI/NDFI/NDWI | Remarks |
|---|---|---|---|
| Inland Forest |  | | Forest are usually rough in texture. |
| Mangrove Forest | | | |
| Shrubs |  |  NDVI Values : 0.03 to 0.7   NDFI Values : -0.12 to 0.83 | |

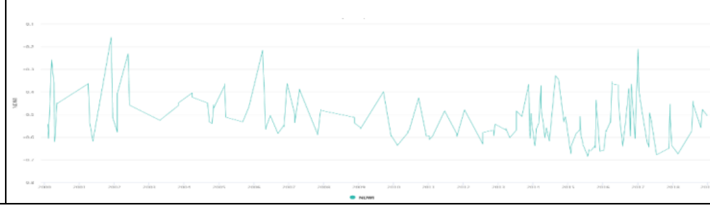
| | | | |
|---|---|---|---|
| Grassland |  | <br><br>NDVI Values : 0.07 to 0.75<br><br><br>NDFI Values : 0.08 to 1.0 | |
| Annual crop |  | | Annual croplands are relatively smooth in texture and has rectangular patterns/ shapes. |

<table>
<tr>
<td>Perennial crop</td>
<td></td>
<td>
NDVI Values : -1.0 to 1.0


NDFI Values : 0.72 to 1.0

NDWI Values: -1.0 to 1.0</td>
<td>Plantations have distinct crown shape that are well spaced. You can observe the regular patterns in the image if it's a plantation area.</td>
</tr>
<tr>
<td>Open/Barren</td>
<td></td>
<td>
NDVI Values : -0.18 to 1.0

</td>
<td>Easy to identify as it has a different spectral signature. Looking at the satellite image, it can be all brown in inland and if its near shoreline, it can either be black or white in color when viewing it with true color composite.</td>
</tr>
</table>

| | | | |
|---|---|---|---|
| | | NDFI Values: -0.18 to 1.0  NDWI Values: -0.15 to -0.6 | |

**REMINDER :**

- Observe the pattern/texture of the satellite images.
- Sometimes you need to zoom-out and check on the outside of plot to get some hints of the land cover.
- Fluctuating NDFI Values may indicate disturbance or changes.
- Low NDWI Value and Low NDVI value may indicate an open/barren area.
- NDFI is a good index to determine disturbances. Observe if the values are fluctuating, it means that there are changes/disturbances.

## Annex 3: Questions for Philippines FRL Reference Data Collection

**Sample Strata:**

- Stable forest
- Stable non-forest
- Deforested (2000-2005)
- Deforested (2006-2018)
- Reforested (2000-2005)
- Reforested (2006-2018)
- Multiple events ecologically possible (2 or 3 events)
- Multiple events noise (4 or more events)

**CEO Questions (would repeat for each time period of interest):**

**PH Forest Change 2000-2005** (Name of project should have the period so its easier for the reviewer to be reminded of the period they reviewing

- Land cover in 2015?
    - Forest
        - If forest
            - Mangrove forest
            - Inland forest
        - If non-forest
            - Shrubs
            - Grassland
            - Annual crop
            - Perennial crop
                - If perennial
                    - Coconut and other palm
                    - Banana
                    - Fruit trees (mango, cashew, avocado, rambutan durian)
                    - Unsure
            - Open/Barren
            - Built-up
            - Marshland/Swamp

- Was there a change within 2000-2005?
    - No
        - If no, no more follow-up questions
    - Yes

- Type?
  - Reforestation
  - Deforestation
    - Driver?
      - Legal / illegal logging / poaching
      - Kaingin making
      - Conversion of forests (plantations, agroforestry, fishpond)
      - Grazing
      - Mining
      - Road construction
      - Hydropower dam construction
      - Settlement
      - Typhoons
      - Floods
      - Landslides
      - Forest / brush fire

- Year of change?
  - 2011
  - 2012
  - 2013
  - 2014
  - 2015
  - 9999 (Unsure)

- Was there second change?
  - No
    - If no, no more follow-up questions
  - Yes

  - Type?
    - Reforestation
    - Deforestation
      - Driver?
        - Legal / illegal logging / poaching
        - Kaingin making
        - Conversion of forests (plantations, agroforestry, fishpond)
        - Grazing
        - Mining
        - Road construction
        - Hydropower dam construction
        - Settlement
        - Typhoons

            - Floods
            - Landslides
            - Forest / brush fire
    - Year of change?
        - 2011
        - 2012
        - 2013
        - 2014
        - 2015
        - 9999 (Unsure)

## Annex 4: Detailed Methodology of Sample Design Modification

The forest change stratification map required modification to compensate for errors in the initial map design and better target areas of forest change for sampling.

The initial strata summarizing the changes from 2000-2018 were:

1. Stable Forest
2. Stable Non-forest
3. Deforested Epoch 1 ( 2000-2005)
4. Deforested Epoch 2/3 (2006-2012, 2013 - 2018)
5. Reforested Epoch 1 ( 2000-2005)
6. Reforested Epoch 2/3 (2006-2012, 2013 - 2018)
7. Multiple events 2/3 - Multiple events that are ecologically possible (2-3 changes)
8. Multiple events 3+ - Multiple events noise (more than 3 changes)

Because of the large quantity of areas of forest change and the fact that the time period of interest was quite long, including diversity in conditions and the implementation of multiple forest policies at different times, we divided up the areas of change temporally into epochs. We examined various ways to divide up the observed changes over time, to make sure that time periods of high deforestation (hypothesized to be more prevalent before the implementation of any forest protection policies) and time periods that likely contained more reforestation (time periods after forest action policies) were both well sampled. The total time period was divided into thirds (2000-2005, 2006-2012, and 2013-2018), referred to as epochs 1-3, to examine whether this subdivision was necessary to observe temporal variation or whether the frequency of forest loss and reforestation was consistent over time. We determined after comparing the areas of deforestation and reforestation split across these epochs that epoch 1 was sufficiently different to warrant the 2000-2005 period was a separate strata for sampling, but that epochs 2 and 3 were similar enough that they could be grouped (see Figure A4.1). However, these pixel count comparisons may not be correctly representative of the changes since errors in the original stratification map were later discovered.

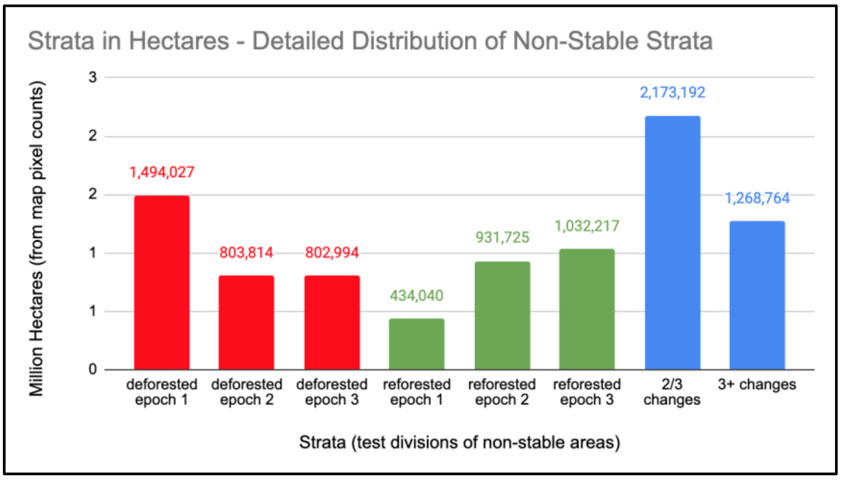



*Figure A4.1: Examination of the non-stable classifications in the original sample design map split by epochs to determine whether the changes should be temporally divided for representative sampling*

It was determined that the interpretation team had the capacity to collect 850 samples, with all of those samples being reviewed at least two times and those with low interpretation confidence being discussed as a group. The 850 samples were distributed across the eight strata using area proportional random sample design with a minimum required sample size of 51. This was chosen over a basic area proportional sample design because the smaller 'reforested epoch 1' and '3+events' strata were not well sampled using the proportional approach. See the final sample allocation of the 850 points Table A4.1.

*Table A41. Sample allocation of the original 850 plots to be interpreted in Collect Earth Online.*

| Map Strata | % of map | Basic Area proportional | Area Proportional with Minimum Required Sample Size |
|---|---|---|---|
| | | Point Distribution | |
| Stable forest | 25.08% | 213 | 193 |
| Stable non-forest | 44.85% | 381 | 346 |
| Deforested epoch 1 | 5.02% | 43 | 51 |
| Deforested epoch 2 & 3 | 5.40% | 46 | 51 |
| Reforested epoch 1 | 1.46% | 12 | 51 |
| Reforested epoch 2 & 3 | 6.60% | 56 | 51 |
| Multiple events 2/3 | 7.31% | 62 | 56 |
| Multiple events 3+ | 4.26% | 36 | 51 |
| TOTAL | 100% | 850 | 850 |

However, after the first 850 points were collected an error was discovered in the original sample stratification map, where the deforestation epoch 1, deforestation epoch 2/3, reforestation epoch 1, and reforestation epoch 2/3 strata were over-inclusive. Some pixels that had multiple changes within the time period of interest had been grouped into these single-change strata. Consequently, too few sample points had been collected within the intended (as labeled without the error) pixels of these single-change strata. A modified sample design was then created to add more points to these strata while still using the original 850 points already collected.

In summary, the original stratification map (sample design map v1) was created based on a change map generated from a series of annual forest cover maps, but was later determined to have inaccuracies and overgeneralizations in how the strata were defined. Known issues were that some multiple-event pixels had been labeled as single-event changes and that changes in the year 2000 were excluded. The pixels labeled as multiple events that should have been single events make up 12.91% of the total map, while missed year 2000 changes make up only ~0.67% of the total map. A new map was created fixing issues found in the original map (intended sample design map v1A). For the intended sample design map to be directly comparable to the original, it was accepted to exclude the year 2000 events in a second version (intended sample design map v1B). This choice was made in order to still utilize the samples distributed using the original map v1 and also add more samples to strata of interest mapped as intended in v1B the areas of the original strata could be subdivided but not expanded, as would have occurred with including the year 2000 changes. The original Sample Design map was directly overlayed with the Intended V1B Map, and this comparison became the final stratification map.

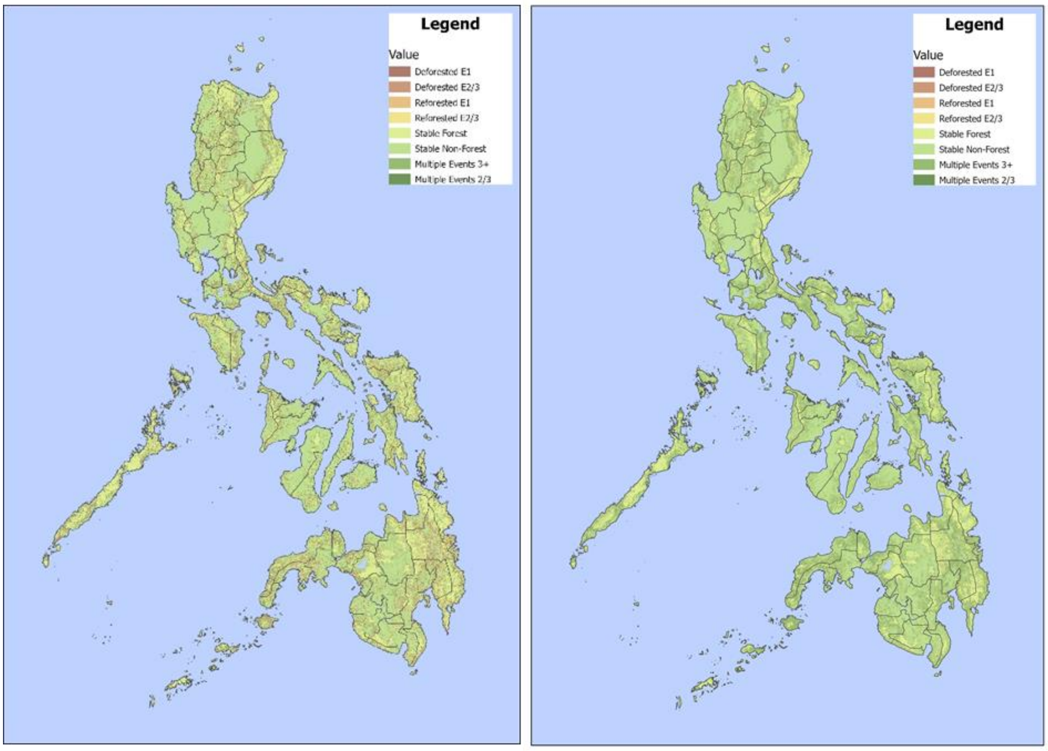



*Figure A4.2: (Left) The original stratification map - sample design map v1 ; (Right) The intended sample design map v1A - right.*

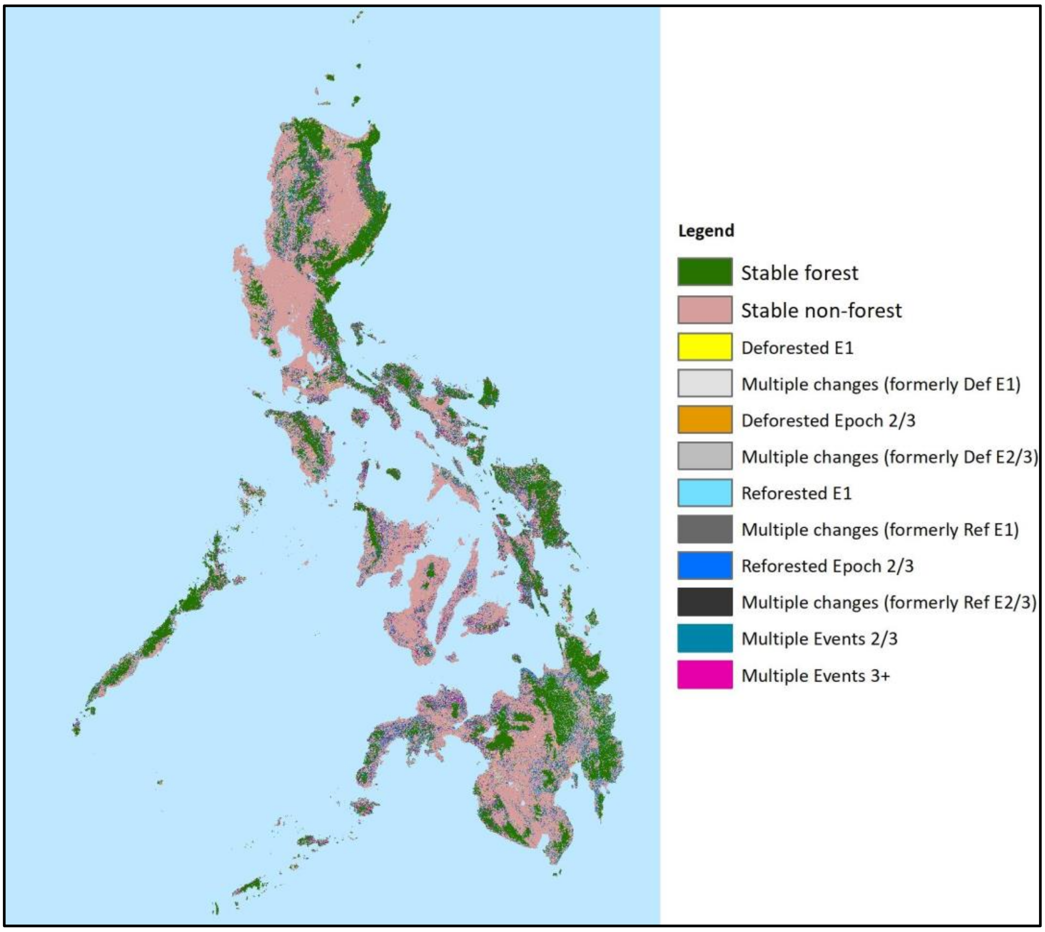



*Figure A4.3: The Final Sample Design Map*

After the corrections the modified final strata reflecting the changes were established as (detailed in Table A4.2):

1. Stable Forest
2. Stable Non-forest
3. Deforested Epoch 1 ( 2000-2005)
4. Multiple Changes (formerly Def E1)
5. Deforested Epoch 2/3 (2006-2012, 2013 - 2018)
6. Multiple Changes (formerly Def E2/3)
7. Reforested Epoch 1 ( 2000-2005)
8. Multiple Changes (formerly Ref E1)
9. Reforested Epoch 2/3 (2006-2012, 2013 - 2018)
10. Multiple Changes (formerly Ref E2/3)
11. Multiple Events 2/3
12. Multiple Events 3+

Simple simulations were completed to see what minimum sample size for the single-change strata from the Final Sample Design Map would help reach a desired likely level of uncertainty. We simulated the margins of error if a minimum sample size of 35 (just above a statistically valid minimum number of samples) were required for the four single-interpretation strata in the Final Sample Design Map, or if 51 were required (the original minimum sample size requirement). The simulation was accomplished by adding the additional number of points to the confusion matrix with 850 points in a similar pattern to show how they were already being interpreted and calculating the simulated margins of errors. Based on the results of the simple simulation (Figure 7) we determined that 35 points minimum would be sufficient and that requiring 51 points would not substantially improve the results. Enough points were added to these four strata to reach the 35 points minimum, which added 79 more points to the total dataset for interpretation. The additional allocated points were randomly distributed using the Final Sample Design Map in a Google Earth Engine script.

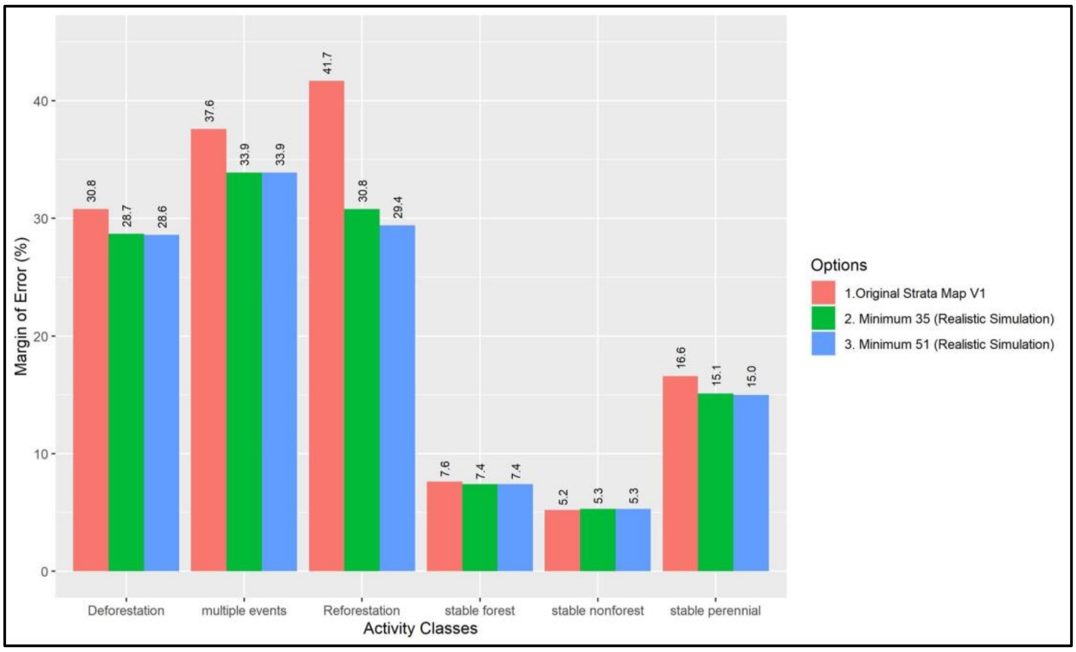



*Figure A4.4: Simulation of the margin of error results if requiring 35 or 51 as a minimum sample size.*

The following table (Table A4.2) shows the distribution of the original 850 CEO points within the Final Sample Design Map. To achieve a good sampling of the single-change classes, 79 more CEO points were added to reach a minimum of at least 35 points within these four strata.

*Table A4.2. Distribution of additional CEO points in Final Sample Design Map*

| Final Sample Design Map Value | Final Sample Design Map stratum name | Count of original CEO points within Final Map Strata | Number of new CEO points needed to reach 35 minimum |
|---|---|---|---|
| 55 | Stable forest | 193 | |
| 66 | Stable non-forest | 346 | |
| 11 | Deforested E1 | 10 | 25 |
| 17 | Multiple changes (formerly Def E1) | 41 | |
| 22 | Deforested E2/3 | 1 | 34 |
| 27 | Multiple changes (formerly Def E2/3) | 50 | |
| 33 | Reforested E1 | 26 | 9 |
| 37 | Multiple changes (formerly Ref E1) | 25 | |
| 44 | Reforested E2/3 | 24 | 11 |
| 47 | Multiple changes (formerly Ref E2/3) | 27 | |
| 88 | 2/3 changes | 56 | |
| 77 | 3+ changes | 51 | |
| Grand Total | | 850 | 79 |

## Annex 5: Qualitative Assessment of the TerraPulse Tree Cover Maps and NAMRIA Forest Cover Datasets

### Summary

This assessment was conducted to help FMB determine how best to use the different forest cover datasets available to them for the development of the Philippine FREL. Three different datasets were evaluated including the 2015 NAMRIA land cover data set and two 2015 forest cover datasets produced by terraPulse at different tree canopy cover thresholds; 10% and 30% (TCC10 & TCC30 respectively).

Initial observations comparing the NAMRIA dataset and the TCC10 showed a significant difference in the amount of mapped forest cover in the Philippines. This prompted a need to produce a terraPulse data set at a higher tree canopy threshold (i.e., TCC30) which tends to be more accurate in identifying true forest cover from other land cover types. These products were produced on a pixel-level basis without any post-processing to create minimum patch size polygons or apply stricter probability estimates. The two 'raw' terraPulse products were filtered by a very high probability (99%) threshold and had a 0.5ha minimum patch size algorithm applied to them prior to comparison with the NAMRIA data set.

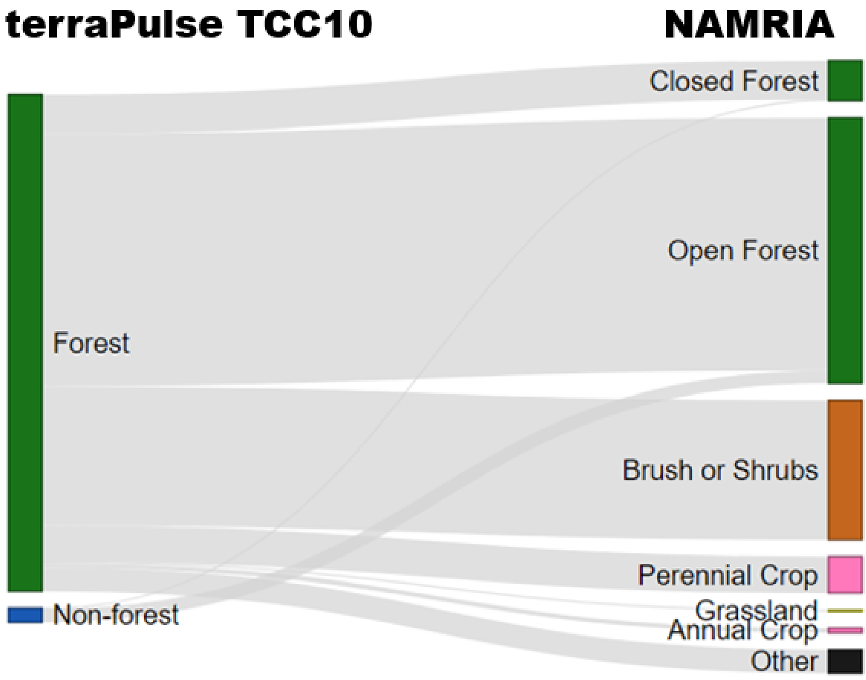
The NAMRIA and terraPulse data were produced by different methodologies for different purposes. Therefore, it is important to note that this comparison is not intended to be an accuracy assessment of any of these products or attempt to determine which is 'right or wrong'. Rather, the intent is to help shed light on why there are differences in the extent of forest being mapped and whether these differences occur in any geographic, biophysical, or land use setting.

Simple forest cover statistics were calculated for the national extent and ten study sites were selected for more in-depth comparison. These sites were chosen to capture the diversity of forest types across the Philippines. Specific polygons of disagreement between the three datasets were selected within each sample area to be evaluated using high resolution imagery and image derivatives (e.g., NDVI).

Results show significant differences in the extent of mapped forest cover across all three datasets within the national extent of the Philippines (PH) for 2015:

| Dataset | Hectares | % of PH Landbase |
|---|---:|---:|
| TCC10 | 15,823,120 | 53.5 |
| TCC30 | 12,137,294 | 41.0 |
| NAMRIA | 7,012,776 | 23.7 |

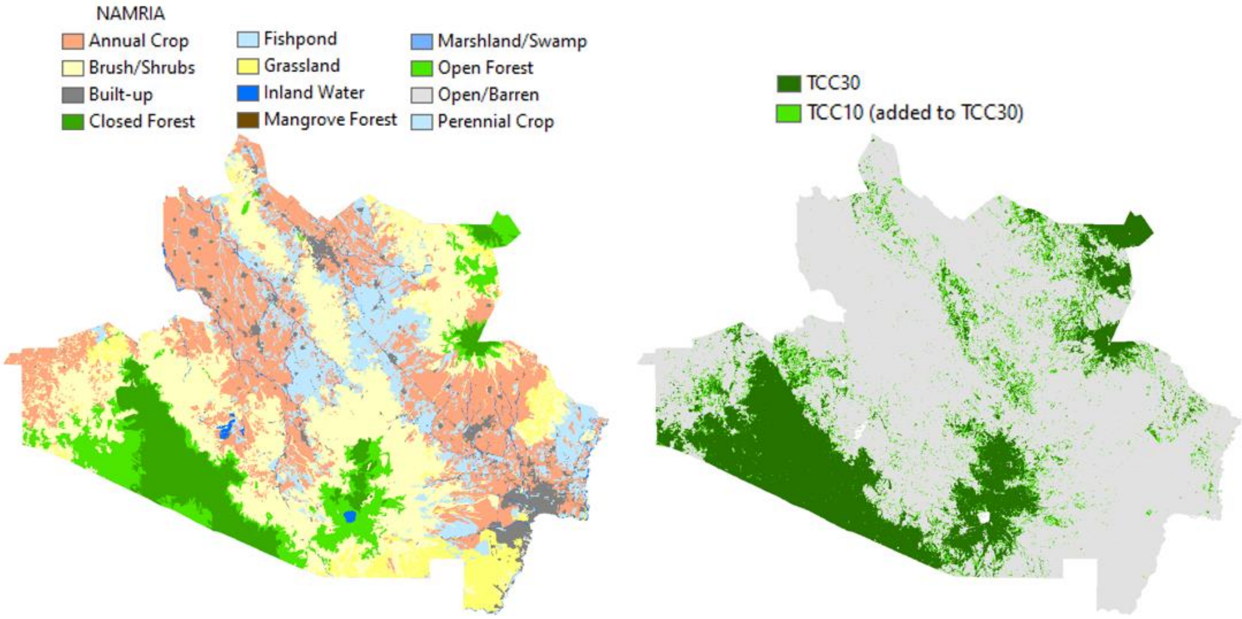
Across all 10 study areas that were examined, much of the lack of disagreement between the terraPulse products and the NAMRIA maps was in areas where tP mapped Forest and NAMRIA mapped those areas as Brush/Shrubs as shown in the sankey diagram below..



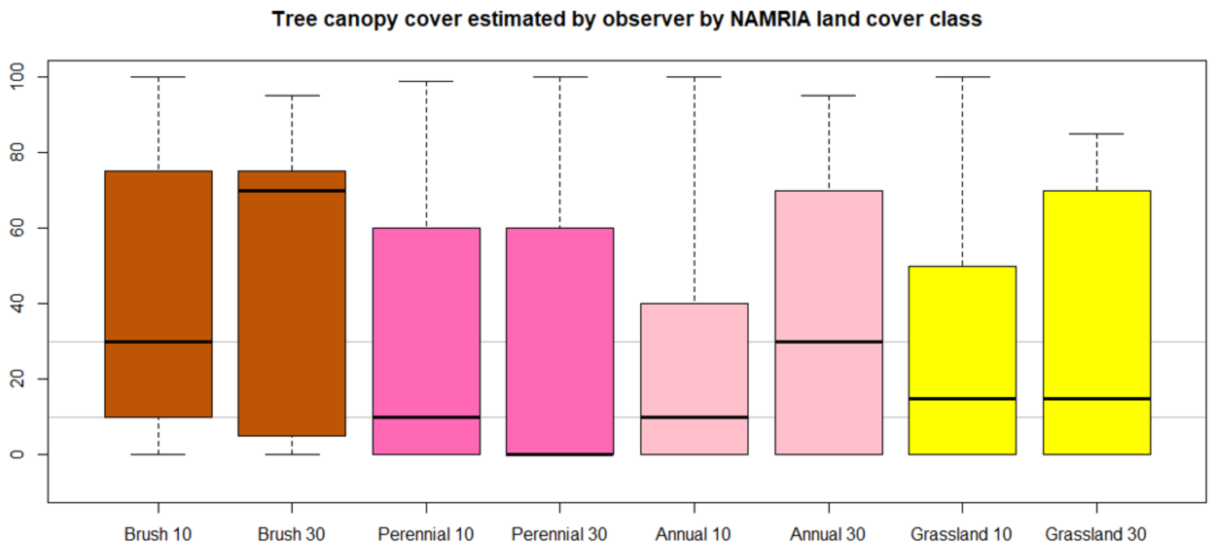

Based on our analysis, the differences between the datasets can be generalized by the following :

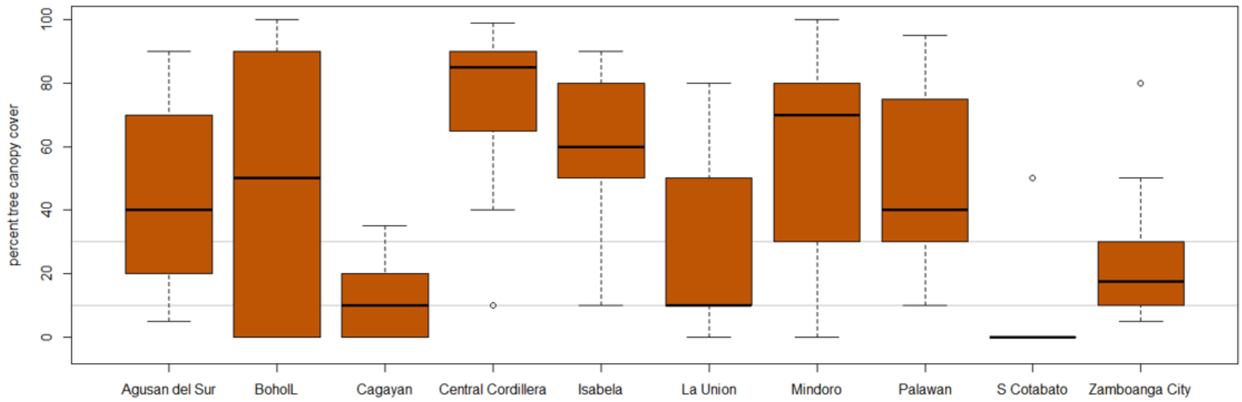
- NAMRIA under-maps forest cover in predominantly non-forested areas (e.g., agriculture areas) and in areas of secondary forest & 'lower' forest cover.
- terraPulse over-maps forest cover in 'extensively managed' areas (e.g., shifting agriculture)
- NAMRIA appears to map plantations and tree crops as Perennial Crop or Annual Crop
- terraPulse generally misses mangroves and other wet/riparian forest types (this only contributes to a small percentage of the difference but is important to note)

Examples of these discrepancies are illustrated in the Examples section below but can be generally attributed to differences in mapping methodology. One example is the differences in the grain at which these products are produced. NAMRIA tends to map only large contiguous areas of forest and does not map small forest patches that are inclusions in other map categories such as Brush/Shrubs or Cropland. The terraPulse products are produced at a 30m pixel resolution and are post-processed to create patches of 0.5ha minimum.




The in-depth comparison revealed that in general, the observer evaluating sites of disagreement found that areas mapped as Brush/Shrubs by NAMRIA had over 10% tree canopy cover for 75% of the samples. Median tree canopy cover estimated by the observer was 30% in the TCC10 and 70% in the TCC30 samples. Conversely, the median tree canopy cover value estimated by the observers in samples mapped as Forest in the terraPulse data and Perennial orAnnual Crops by NAMRIA was at or below 10% (with the exception of the TCC30 in Annual Crop)



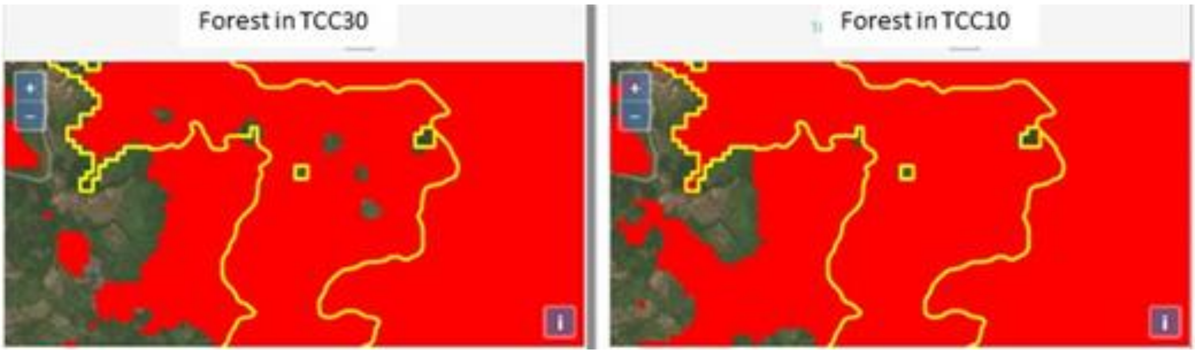



### Observations from the In-Depth Comparison

These examples illustrate the general observations of the in-depth comparison of TCC and NAMRIA data. These examples were picked from the polygons of disagreement from the evaluated sites. The examination of these plots was done using Collect Earth Online tool that allows access to high-resolution imagery and image indexes (e.g. NDVI).

**NAMRIA under-maps forest cover in predominantly non-forested areas (e.g., agriculture areas) and in areas of secondary forest & 'lower' forest cover.**

In this example NAMRIA classifies this as annual crop areas missing on the forest patches within the polygon. Patches of cleared areas that are often signs of small scale cultivation are also missed. TCC data on the other hand over-maps the forest area by identifying the whole polygon as forest both in TCC10 and TCC30.

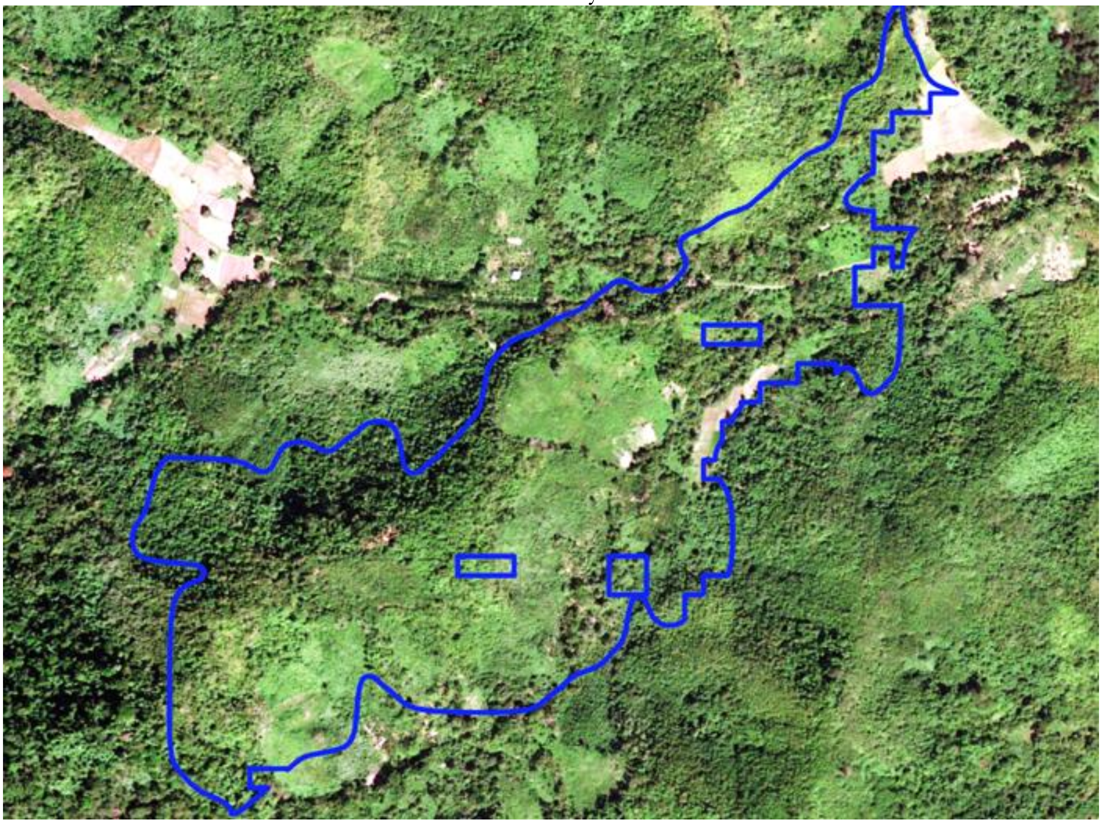



**Differences in data granularity**

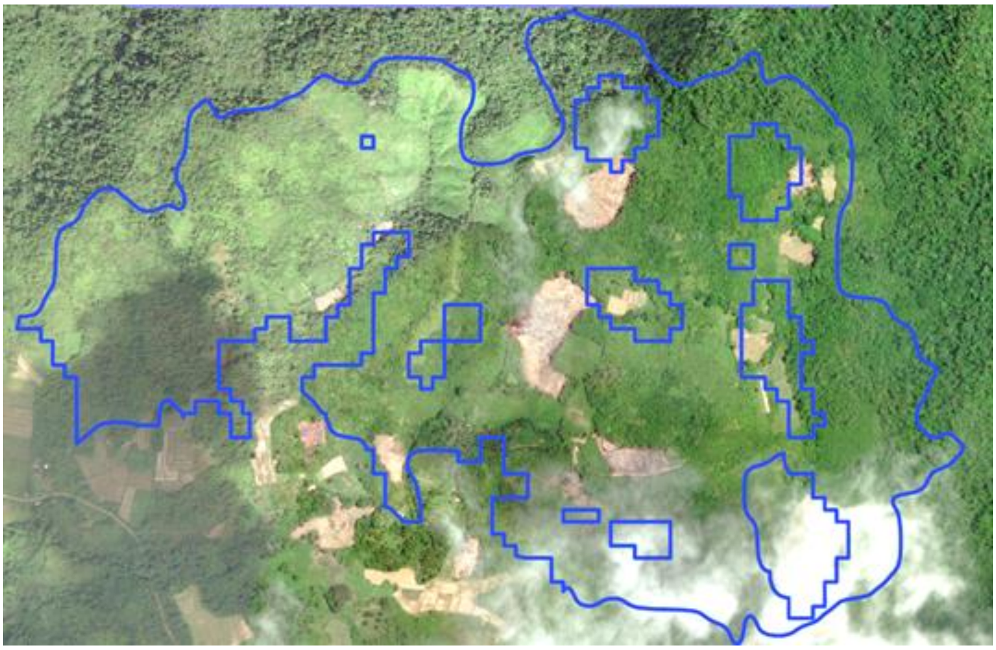
In these two examples differences in data granularity of the datasets is observed. Both the plots are classified as non-forest in both TCC10 and TCC30, but NAMRIA includes this as part of the open forest. These plots are sized approximately nine hectares each and show the ability of the TCC to capture the deforested patches which are not captured in the NAMRIA dataset. This is quite useful in illustrating where and the extent deforestation is in an area.

**TerraPulse over-maps forest cover in 'extensively managed' areas (e.g., shifting agriculture)**

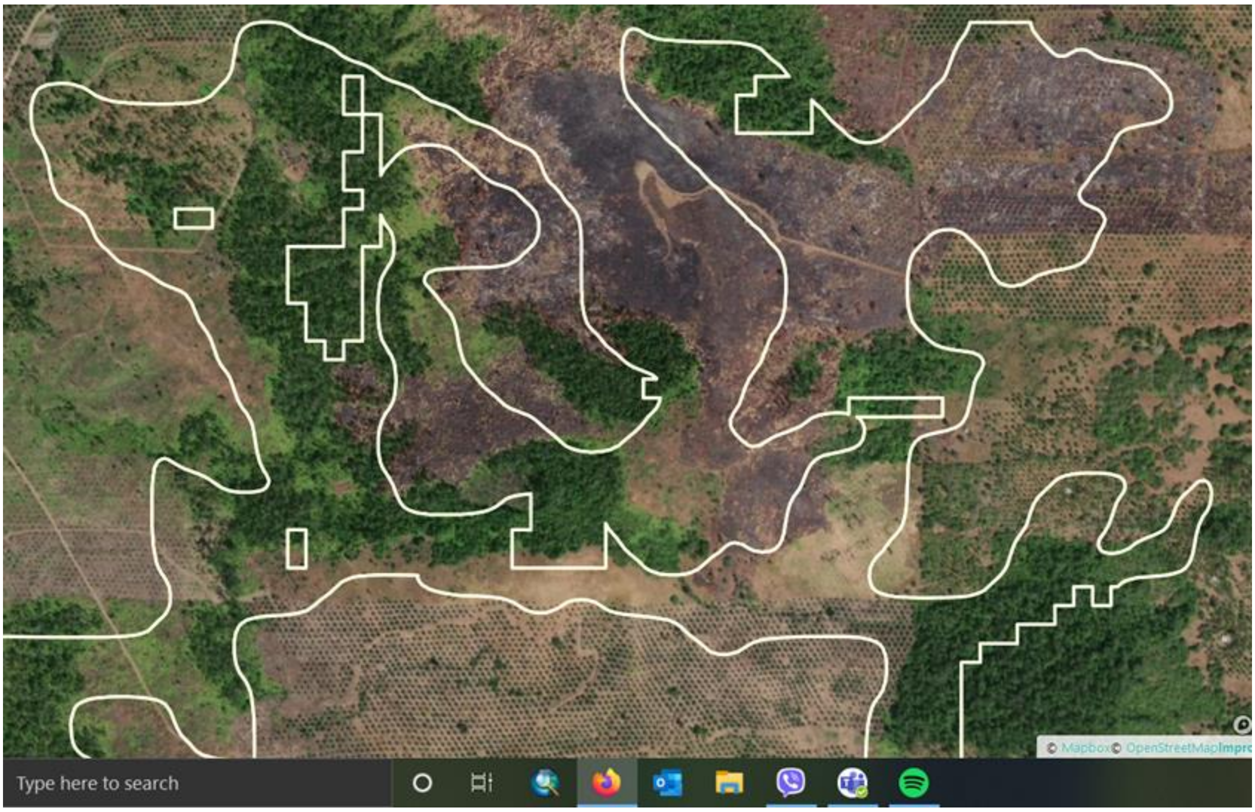
This plot in Zamboanga City is classified as forest in TCC10 and TCC30 but is largely an area that is actively cultivated.



Patchy forests are generalized by NAMRIA as brushland. Patches of land that has been cleared are not recognized by both.



This plot in Palawan also shows that NAMRIA over-maps forests in this actively managed area.

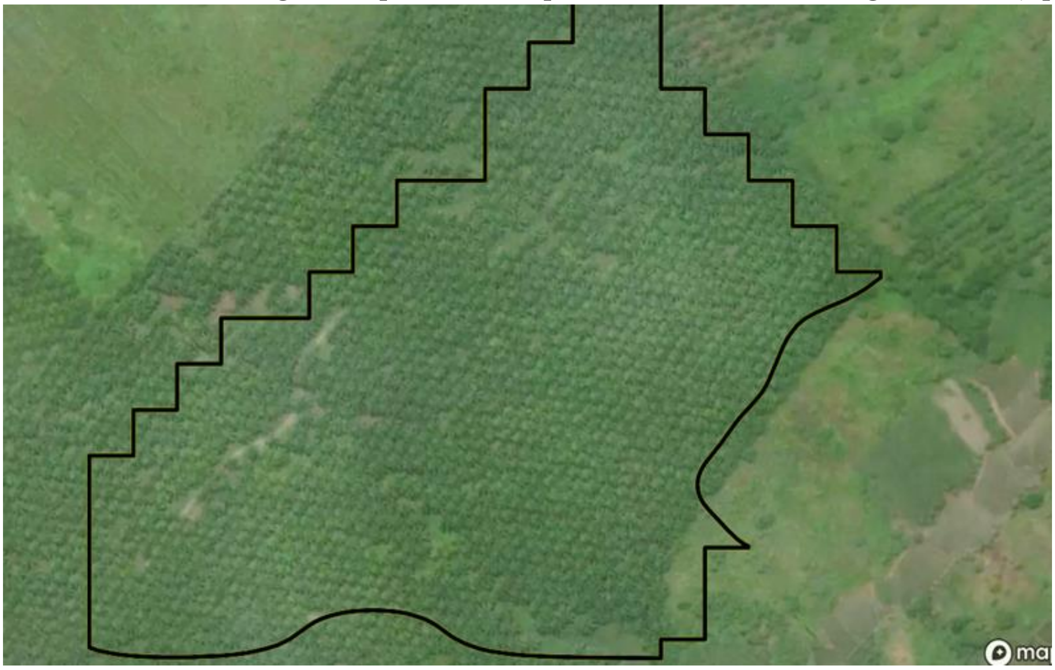



**Perennial (coconut and banana) are identified as forests**

Coconuts in the upland areas are identified as forests in TCC10 and TCC30 and as brushlands in NAMRIA land cover. Instances where there is no clear uniform spacing of coconuts in the uplands in some cases since coconut is often mixed with trees or other crops, patches of forests that are interspersed with these perennial crops are lumped as forests in

TCC and perennial crops in NAMRIA.

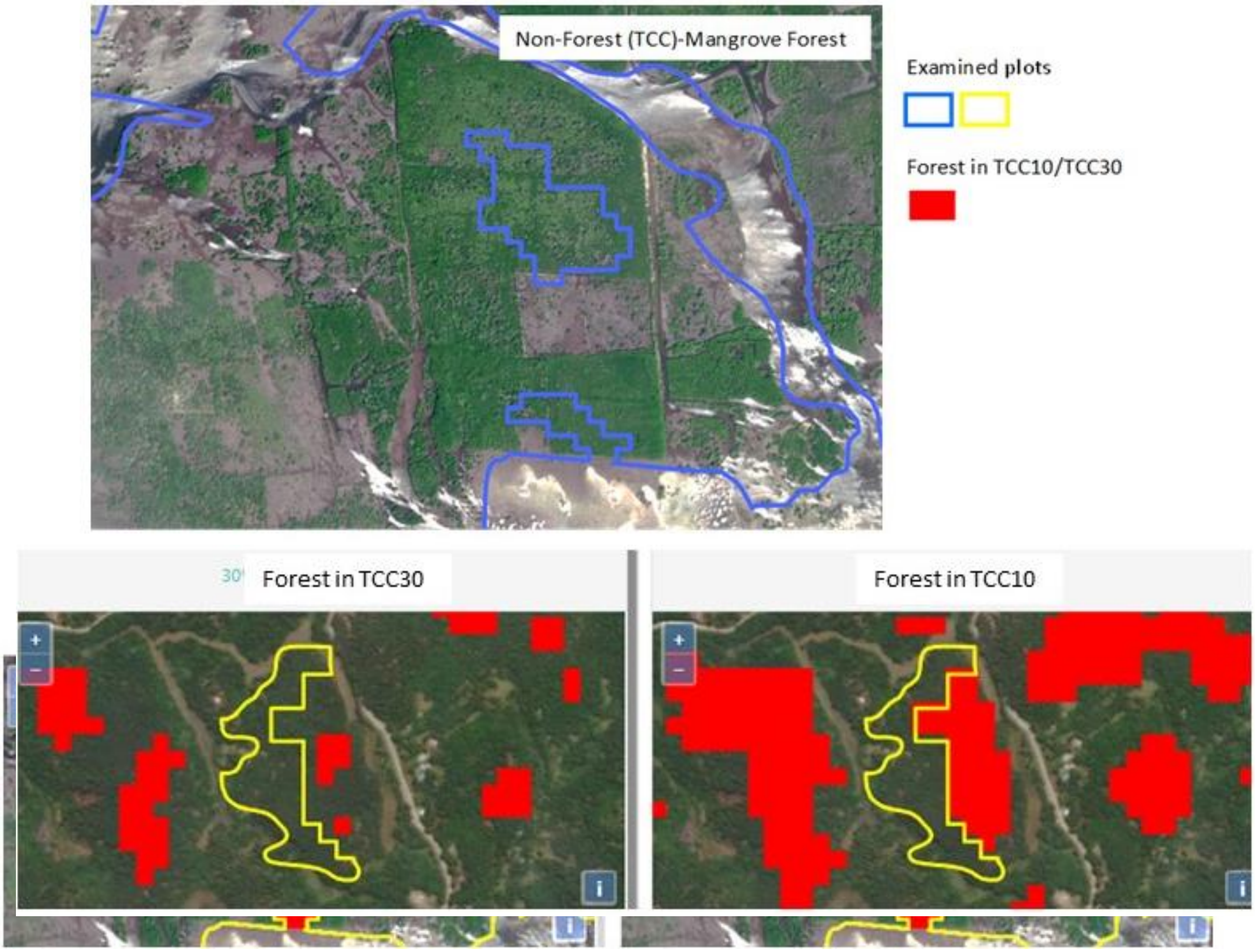
In flatlands and rolling areas, perennial crops such as banana, although are visibly planted TCC.




**TerraPulse generally misses mangroves and other wet/riparian forest types**

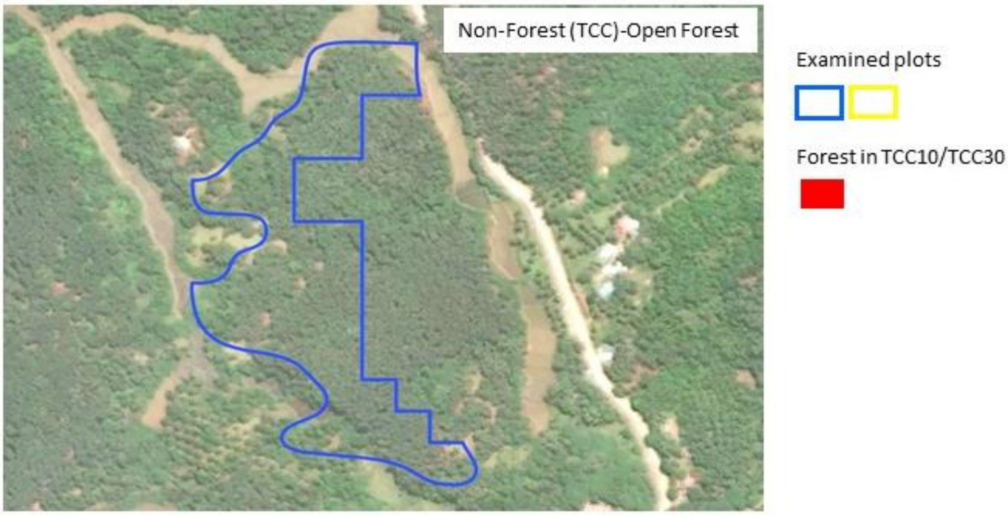
The TCC10 or TCC30 do not recognize the mangrove areas. The presence of the water may have caused the algorithm to classify it as non-forest. In figure below, only the areas that are drier parts of the mangrove are identified as forest by TCC10 (Forest in TCC10 image). The TCC30 (Forest in TCC30 image) identifies a small portion of the same polygon identified by TCC10. The rest of the polygons in blue were identified as non-forest in both TCC data.

The NAMRIA land cover data on the other hand also generalizes the whole area as mangrove forest even if there are clearly bare spots already. In the areas near the shore it could be surmised that there might be growing mangrove propagules which is why it has been generalized as mangroves.


Non-Forest (TCC)-Mangrove Forest
Examined plots
Forest in TCC10/TCC30
Forest in TCC30
Forest in TCC10

**Mangrove associated vegetation (Nipa palm) found along rivers and marsh conditions**

Mangrove associated vegetation (Nipa palm) found along rivers and marsh conditions are also not recognized by either TCC10 or TCC30. Periods of high tide may inundate the banks and affect the interpretation in the TCC. NAMRIA identifies it as Open forest.




**NAMRIA tends to over estimated the river areas**

NAMRIA 2015 land cover tends to overestimate the width of rivers and have included forest areas along the river banks.

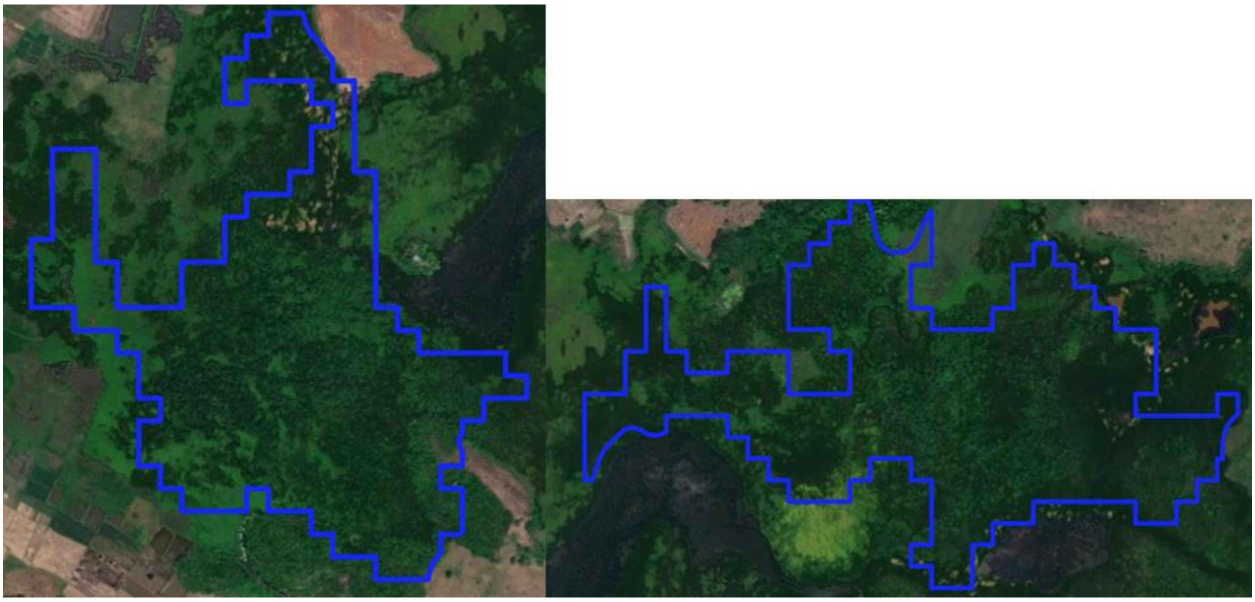
In the TCC10 and TCC30, streams with width below the 30-meter resolution of the TCC data are not captured. These rivers are covered with tree crown cover and will only be recognized as rivers when zoomed-in to the area recognizing the texture and pattern in the image.

**Roads are identified by tP as Forest, NAMRIA identified it built-up but has offset**

For the terrapulse, both TCC10 and 30 didn't identify narrow upland roads as non-forest, instead it is classified forest as both roadsides are covered with forest . Meanwhile the NAMRIA data identified the upland roads built-up but overestimated the width and has an offset with the image.

**Marsh/Swamps in NAMRIA and forest by TCC**

These forested parts of the Agusan Wetlands are identified as marsh/swamps in NAMRIA land cover but should be part of what is counted as forests. There are other portions of the wetlands that are classified as marsh/swamps but only have sedges, grasses and or lakes.



## APPENDICES

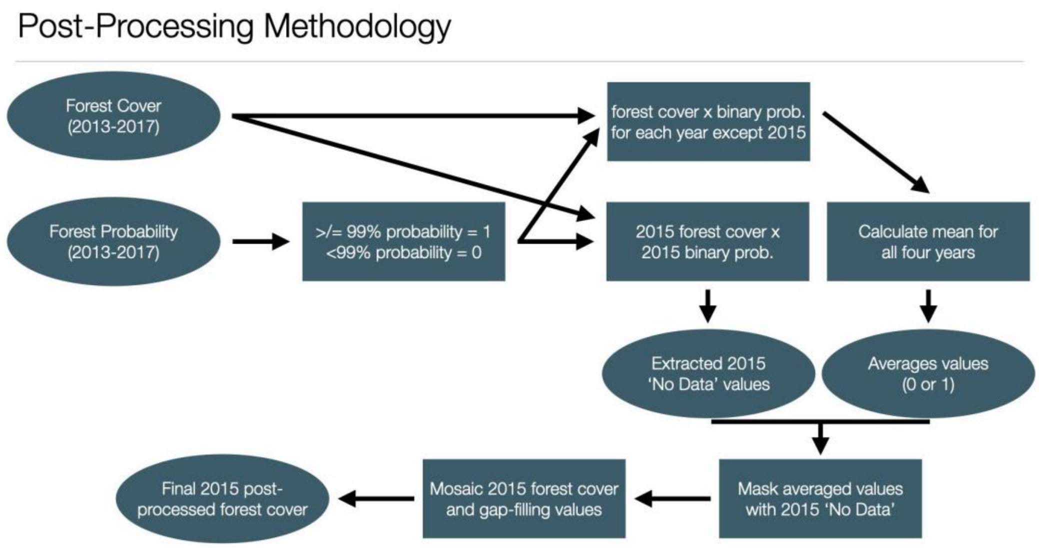
### TerraPulse Product Overview

- link to compiled overview of terraPulse methodology (https://docs.google.com/document/d/1vQKWhvhpNHe0Lcv4pvWJ4Mt8PGs1hjo8NHd0K7S6TaA/edit?usp=sharing)
- include differences between 10 & 30% TCC

- Post-processing done outside of terraPulse

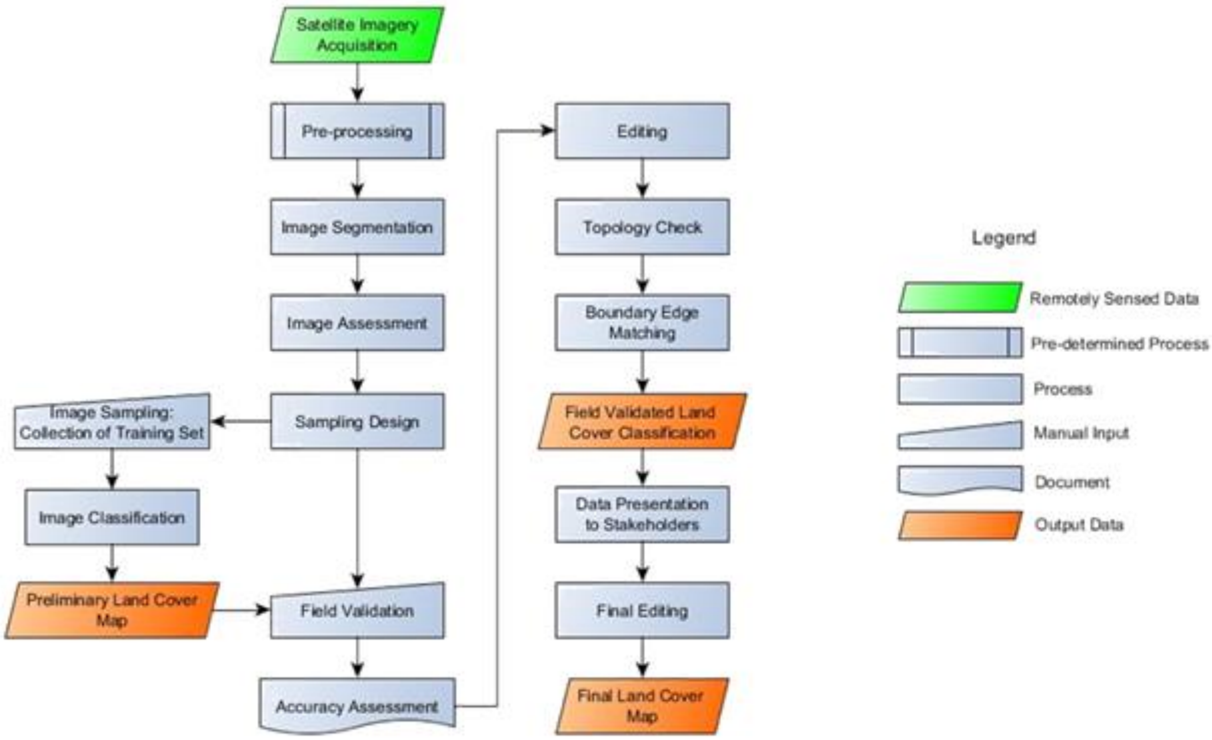
  The terraPulse forest cover data and its corresponding forest cover probability data from 2013 to 2017 were utilized to produce the 2015 Forest Cover. To produce forest cover data with high percent probability, we selected only the data that is greater or equal to 99% probability. To fill in the gaps of areas without probability data for 2015, we used forest data with ≥99% from 2 years before and after 2015. The final post-processed data underwent the 0.5 hectare area filter considering the definition of Forest as given by FAO in 2000, having more than 0.5 hectare and tree crown cover of more than 10%.

The Process Flow Chart of the Post-Processing Method is shown in Figure __.




### NAMRIA Data Overview

The land cover map of the Philippines was produced by the National Mapping and Resource Information Authority (NAMRIA). It is produced every five years. The methodology has changed through the years but essentially follows the process shown in Figure _.




*Source: NAMRIA, 2017*

The 2015 Land Cover Map of the Philippines produced by NAMRIA utilized Landsat 8 (from 2014 onwards). Usual **image pre-processing** (image rectification, image enhancement, cloud masking, and mosaicking) were done on the Landsat 8 data to prepare for initial classification. The **preliminary classification** used visual interpretation by selecting the training set of the 12 land cover categories aggregated from more classes in previous land cover assessments (see Table 1). Other reference data were used to supplement Landsat 8 images and enhance selection of the training data and these include images from Google Earth, topographic maps, ground truth data, and IFSAR data (basis of the coastline data). NAMRIA used an Object-based image analysis (OBIA) software (eCognition) to segment the image into the desired land cover categories based on the training data. eCognition is useful because it can automate using size, shape, texture, and spatial context for land cover classification using training data and defined classification logic rules.

The initial land cover map was subjected to **ground validation** using a stratified sampling design. Ten randomly selected points per land cover class in each province were identified to validate the initially identified land cover. An accuracy assessment of the 7,330 ground validated points were done and the computed classification accuracy was at 93.92%.

After the accuracy assessment, some editing, topology checking, and boundary edge matching were performed to produce the field-validated land cover map. This map was presented to Provincial LGU and field DENR staff for final checking before the publication of the final map.

It was noted that NAMRIA did not apply a canopy height model (CHM) to delineate the trees which based on definition should be a minimum height of 5 meters. Although it was indicated that IFSAR data was used as reference data in the land cover class delineation, it was not used to generate CHM (obtained by deducting digital terrain model (DTM) from the digital surface model (DSM).

*Table 1: Aggregation of Land Cover Categories from the FRA categories to categories used in the NAMRIA 2015 Land Cover Map*

| FRA 21 Land Cover Classes (in 2005 Land Cover Map) | Aggregated to 14 Classes (in 2010 Land Cover Map) | Aggregated to 12 classes (in 2015 Land Cover Map) |
|---|---|---|
| Closed forest, broadleaved | Closed forest | Closed forest |
| Closed forest, mixed | | |
| Closed forest, coniferous | | |
| Open forest, broadleaved | Open forest | Open forest |
| Open forest, mixed | | |
| Open forest, coniferous | | |
| Forest plantation, broadleaved | Closed or Open Forest | Closed or Open Forest |
| Forest plantation, coniferous | | |
| Mangrove forest | Mangrove forest | Mangrove forest |
| Other wooded land, shrubs | Shrubs | Shrubs |
| Other wooded land, fallow | Fallow | |
| Other wooded land, wooded grassland | Wooded grassland | |
| Other land, natural, grassland | Grassland | Grassland |
| Other land, cultivated, pastures | | |
| Other land, cultivated, annual crop | Annual crop | Annual crop |
| Other land, cultivated, perennial crop | Perennial crop | Perennial crop |
| Other land, natural, barren land | Open/Barren | Open/Barren |
| Other land, built-up area | Built-up | Built-up |
| Other land, natural marshland | Marshland/Swamp | Marshland/Swamp |
| Other land, fishpond | Fishpond | Fishpond |
| Inland water | Inland water | Inland water |

Source: Integrated from Manuel, 2014 and Rizaldia, 2018

## In-Depth Comparison Methodology

Ten sites were chosen for more in-depth comparison and validation. These sites are geographically spread across the Phillipines and represent different biophysical settings. Map overlay of the TCC data and the NAMRIA data was done to look at the level of coincidence of the forest areas and examine more closely what is happening in the areas of disagreement between the two datasets.

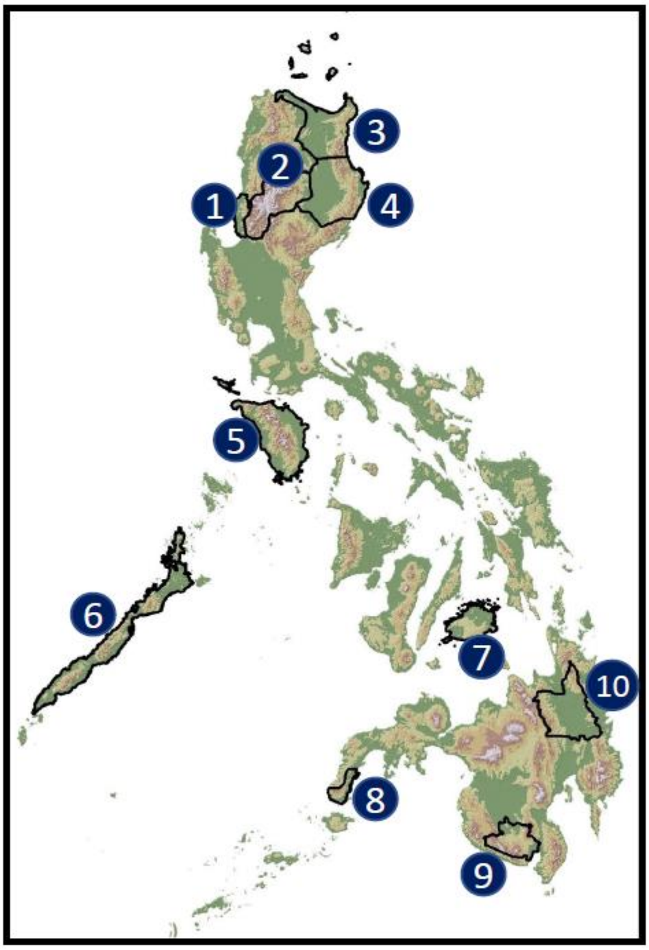



*Table 2: Summary of sites, site characteristics and rationale for including in the comparison of TerraPulse TCC 10 and 30% coverage*

| Subset Region | Description (ecosystem & geography) | Canopy Type | Why Chosen |
|---|---|---|---|
| 1 La Union | - Relatively dry part of the Luzon Island | - Mostly broadleaved dipterocarp | - To have representative of a fairly dry area of the country |
| 2 Central Cordillera | - About 70% of the area has elevation 500 masl and above. | - Presence of pine forest aside from broadleaved dipterocarp forest | - A representative of highland conditions |
| 3 Cagayan | - Western part of the area is quite dry being in the leeward side of the | - Predominantly broadleaved dipterocarp forest | - Familiarity with area since it is one of the sites where FMB did field work recently |
| 4 Isabela | - Rainfall is evenly distributed throughout the year<br>- Presence of the Sierra Madre Mt. range make the eastern side wetter than usual<br>- Is along the usual path of tropical storms entering the country | - Predominantly broadleaved dipterocarp forest | - A site which is moist all year round. |

| Subset Region | Description (ecosystem & geography) | Canopy Type | Why Chosen |
|---|---|---|---|
| 5 Mindoro | - A mountainous island with narrow coastlines | | - Familiarity with the area since it is the second site where FMB did their field work recently |
| 6 Palawan | - Palawan is one of the provinces with extensive forests, mostly occupying the mountain ranges and the island's southern section, where extensive mangroves are found. | | - Familiarity with the site |
| 7 Bohol | - Representative of the smaller islands in the central part of the country<br>- Karst topography | | - To see how tP data performs in smaller islands with forest growth affected by the karst landscape. |
| 8 Zamboanga City | - Part of the drier areas of the country<br>- Mangrove area are relatively extensive | | - Familiarity with the site |
| 9 South Cotabato | - Southern part of the province is part of the area's highlands<br>- Area is main agro-industrial plantation | | - Familiarity with the site |
| 10 Agusan del Sur | - Province is located in a major valley in Mindanao and huge wetlands are also found in the area.<br>- From Nov to Feb water level in the wetlands could rise by 1.5 meters submerging trunks of trees | | - To see how the tP data classifies the forests in the marshland |

## Spatial Overlay & Coincidence

**Interpretation key**
An interpretation key was prepared prior to the workshop assessing

Link: https://docs.google.com/document/d/13ek3V1t9pS7EDNriPycG8EjhpUpqwfGKIvvGNNwLw6g/edit#heading=h.i4doj098bum6

**Process of interpretation** A one-day Collect Earth Online Workshop was conducted to examine selected plots where there is disagreement in classification between the tree canopy cover and NAMRIA data using the CEO platform. There were fourteen (14) staff from the Forest Management Bureau and each participant was assigned to work on a site project. The participants are familiar with the use of CEO and evaluating images since they have attended similar workshops/training in the past.

Presentations on the rationale of the workshop, overview of the CEO and the interpretation key were done prior to the assessment.

For the assessment of tP data (TCC10 and TCC30) and NAMRIA, 30 Collect Earth Online Projects were created for the 10 sites. Each site has three projects each consisting of the different data combinations of the data (i.e. TCC10 - NAMRIA, TCC 30 - NAMRIA and

TCC10 -TCC30). The Projects have a range of 40 to 90 sample plots each. For each project, there are four (4) survey questions, as written below:

***<u>Survey Questions:</u>***

1. Is this area forest?
    a. Yes
    b. No
    c. Partially

    (If partially forested, estimate % cover) ____

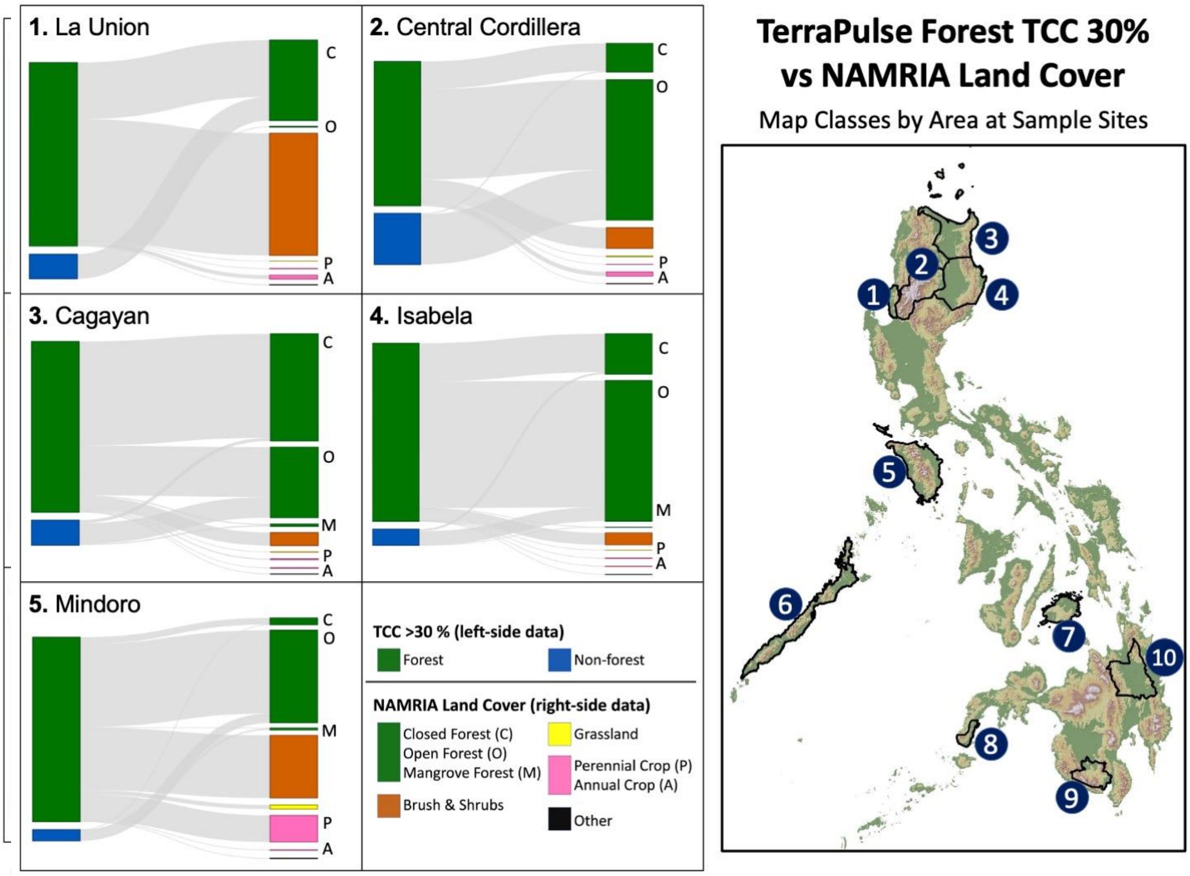
2. What is your confidence level in your answer?
    a. Very high
    b. High
    c. Medium
    d. Low
    e. Very Low
3. Notes on why this area may have been a site of disagreement or mislabeled?
4. Would this plot be a good candidate example for any of the following data issues?
    a. If Yes, which among the following best characterize the issue
        i. Edge issues
        ii. Grain issues
        iii. Mis-classification
        iv. Others

        If others, specify the issue

***Questions and Comments from the CEO Assessment Workshop:***

1. Why do we need to do assessment on these sites? Where can we use the result of the report?
2. How will we characterize the different data issues? Can we have examples?
3. Clarification on how to put in some notes. What should we be looking for and needs to be indicated in the notes for question 3. Example.
4. More examples of an image having brush land and grassland.
5. The discrimination of brushland and forests was a challenge for the participants. One of them shared that in one of the training that they had with FAO on CEO, an FMB staff identified an area as forest. However, the staff was corrected by the FAO resource person to identify it instead as brushland. They were told that similar areas that are identified as forests but are adjacent to an agricultural area should be classified as brushland instead.
6. Do we consider areas planted with forest trees as Forest? How about the fruit tree plantation, are they considered forest?
7. For the interpretation, do we only use Mapbox Satellite or can we use other images like Bing and NICFI?

## Map overlay results



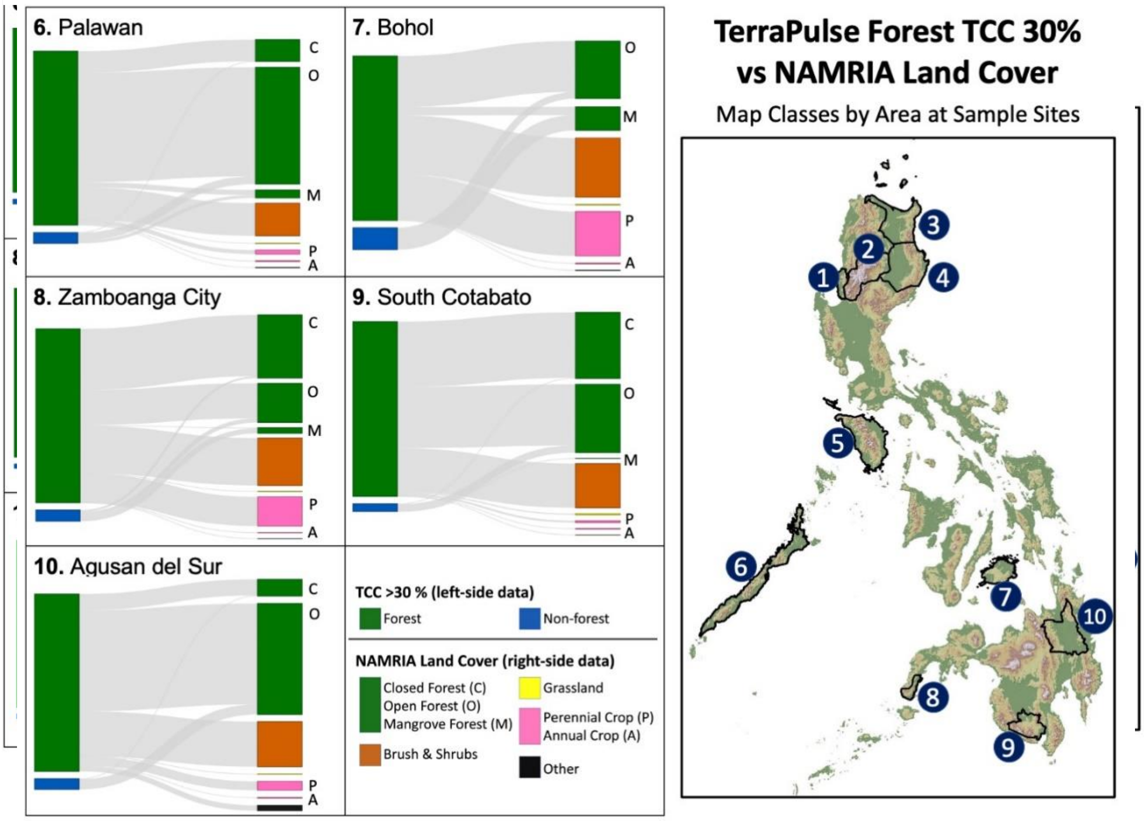



Table 1. Area of coincidence of TCC 10% and NAMRIA land cover map

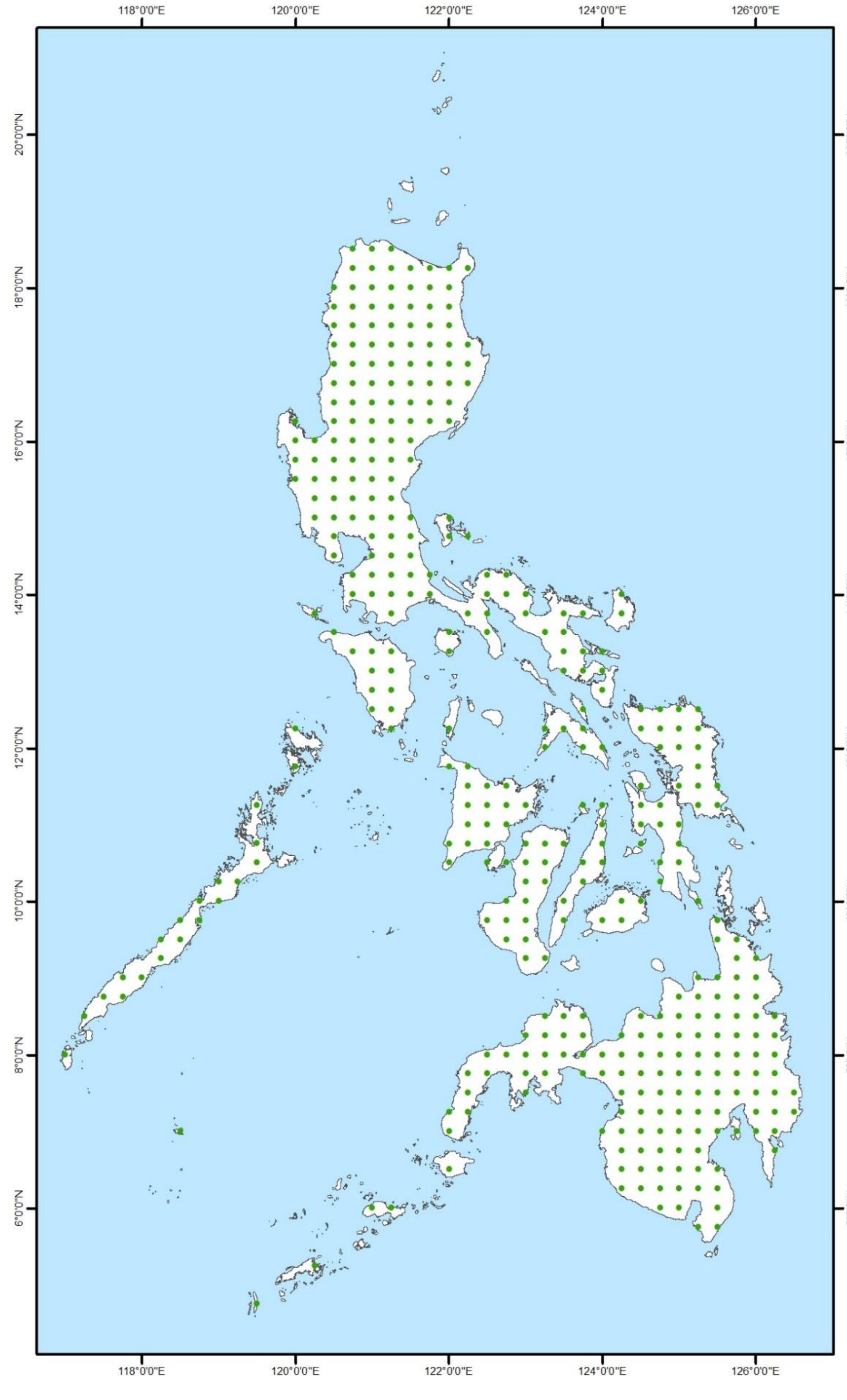
| TCC 10% AND NAMRIA LAND COVER | LA UNION | | CENTRAL CORDILLERA | | CAGAYAN | | ISABELA | | MINDORO | | PALAWAN | | BOHOL | | ZAMBOANGA CITY | | SOUTH COTABATO | | AGUSAN DEL SUR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % |
| **Forest in tP and NAMRIA** | **7,795** | **15.81** | **279,418** | **64.19** | **332,235** | **80.84** | **372,349** | **84.97** | **197,649** | **37.55** | **566,772** | **67.20** | **22,647** | **22.37** | **23,360** | **35.00** | **59,962** | **53.98** | **359,926** | **57.08** |
| Closed Forest | | | 51,951 | 11.93 | 205,924 | 50.11 | 83,615 | 19.08 | 13,715 | 2.61 | 87,467 | 10.37 | | | 14,455 | 21.66 | 30,390 | 27.36 | 48,379 | 7.67 |
| Open Forest | 7,794 | 15.81 | 227,468 | 52.25 | 123,311 | 30.01 | 288,381 | 65.81 | 182,197 | 34.61 | 455,582 | 54.02 | 18,682 | 18.46 | 8,679 | 13.00 | 29,573 | 26.62 | 311,547 | 49.41 |
| Mangrove Forest | 1 | 0.00 | | | 2,999 | 0.73 | 353 | 0.08 | 1,737 | 0.33 | 23,723 | 2.81 | 3,965 | 3.92 | 226 | 0.34 | | | | |
| **Forest (tP)-Non-Forest (Nam)** | **40,545** | **82.26** | **128,223** | **29.46** | **61,695** | **15.01** | **53,662** | **12.25** | **316,945** | **60.21** | **252,013** | **29.88** | **73,377** | **72.49** | **41,729** | **62.52** | **48,212** | **43.41** | **253,080** | **40.14** |
| Brush/Shrubs | 37,371 | 75.82 | 95,575 | 21.96 | 46,797 | 11.39 | 46,065 | 10.51 | 199,680 | 37.93 | 200,236 | 23.74 | 34,899 | 34.48 | 23,082 | 34.58 | 40,223 | 36.21 | 172,057 | 27.29 |
| Perennial Crop | 214 | 0.44 | 139 | 0.03 | 6,138 | 1.49 | 2,146 | 0.49 | 88,509 | 16.81 | 37,058 | 4.39 | 36,225 | 35.79 | 17,953 | 26.90 | 4,872 | 4.39 | 44,848 | 7.11 |
| Grassland | 150 | 0.30 | 8,486 | 1.95 | 2,950 | 0.72 | 665 | 0.15 | 22,209 | 4.22 | 2,626 | 0.31 | 858 | 0.85 | 594 | 0.89 | 1,332 | 1.20 | 1,650 | 0.26 |
| Annual Crop | 2,622 | 5.32 | 22,077 | 5.07 | 4,493 | 1.09 | 3,530 | 0.81 | 4,246 | 0.81 | 9,276 | 1.10 | 1,159 | 1.15 | 48 | 0.07 | 1,615 | 1.45 | 5,627 | 0.89 |
| Built-up | 67 | 0.14 | 1,126 | 0.26 | 168 | 0.04 | 34 | 0.01 | 972 | 0.18 | 633 | 0.08 | 164 | 0.16 | 7 | 0.01 | 78 | 0.07 | 1,222 | 0.19 |
| Fishpond | 1 | 0.001 | 0 | 0.00 | 20 | 0.00 | 0 | 0.00 | 39 | 0.01 | 70 | 0.01 | 15 | 0.01 | 29 | 0.04 | 0 | 0.00 | | |
| Inland Water | 118 | 0.24 | 756 | 0.17 | 882 | 0.21 | 1,105 | 0.25 | 1,195 | 0.23 | 2,014 | 0.24 | 55 | 0.05 | 6 | 0.01 | 86 | 0.00 | 4,207 | 0.67 |
| Marshland/Swamp | | | | | 111 | 0.03 | | | 29 | 0.01 | 1 | 0.00 | | | 11 | 0.02 | | | 23,456 | 3.72 |
| Open/Barren | 2 | 0.004 | 65 | 0.01 | 136 | 0.03 | 117 | 0.03 | 66 | 0.01 | 99 | 0.01 | 2 | 0.00 | 0 | 0.00 | 6 | 0.01 | 12 | 0.00 |
| **Non-forest (tP)-Forest (Nam)** | **950** | **1.93** | **27,665** | **6.36** | **17,038** | **4.15** | **12,188** | **2.78** | **11,788** | **2.24** | **24,599** | **2.92** | **5,198** | **5.13** | **1,657** | **2.48** | **2,900** | **2.61** | **17,538** | **2.78** |
| Closed Forest | | | 339 | 0.08 | 1,908 | 0.46 | 2,255 | 0.51 | 443 | 0.08 | 675 | 0.08 | | | 175 | 0.26 | 528 | 0.48 | 1,312 | 0.21 |
| Open Forest | 853 | 1.73 | 27,326 | 6.28 | 13,372 | 3.25 | 9,712 | 2.22 | 8,931 | 1.70 | 14,998 | 1.78 | 1,087 | 1.07 | 401 | 0.60 | 2,352 | 2.12 | 16,226 | 2.57 |
| Mangrove Forest | 97 | 0.20 | | | 1,758 | 0.43 | 221 | 0.05 | 2,414 | 0.46 | 8,926 | 1.06 | 4,111 | 4.06 | 1,082 | 1.62 | 20 | 0.02 | | |
| **Total Area per site** | **49,290** | | **435,307** | | **410,968** | | **438,199** | | **526,382** | | **843,383** | | **101,222** | | **66,746** | | **111,075** | | **630,544** | |

Table 1. Area of coincidence of TCC 10% and NAMRIA land cover map

| TCC 30% and NAMRIA LAND COVER | LA UNION | | CENTRAL CORDILLERA | | CAGAYAN | | ISABELA | | MINDORO | | PALAWAN | | BOHOL | | ZAMBOANGA CITY | | SOUTH COTABATO | | AGUSAN DEL SUR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % |
| **Forest in tP and NAMRIA** | **6,099** | **27.29** | **214,300** | **60.47** | **300,695** | **79.16** | **349,981** | **84.99** | **186,166** | **46.02** | **548,188** | **73.65** | **20,362** | **31.88** | **22,423** | **52.33** | **59,196** | **69.37** | **345,555** | **62.17** |
| Closed Forest | | | 50,189 | 14.16 | 201,745 | 53.11 | 81,300 | 19.74 | 13,735 | 3.40 | 87,366 | 11.74 | | | 14,171 | 33.07 | 30,571 | 35.83 | 47,710 | 8.58 |
| Open Forest | 6,099 | 27.29 | 164,111 | 46.31 | 96,668 | 25.45 | 268,438 | 65.19 | 171,421 | 42.37 | 440,013 | 59.12 | 17,500 | 27.40 | 8,113 | 18.93 | 28,625 | 33.55 | 297,845 | 53.59 |
| Mangrove Forest | | | | | 2,282 | 0.60 | 243 | 0.06 | 1,010 | 0.25 | 20,809 | 2.80 | 2,862 | 4.48 | 139 | 0.32 | | | | |
| **Forest (tP)-Non-Forest (Nam)** | **13,601** | **60.87** | **47,305** | **13.35** | **30,603** | **8.06** | **27,235** | **6.61** | **195,110** | **48.23** | **152,895** | **20.54** | **36,024** | **56.40** | **17,836** | **41.62** | **22,469** | **26.33** | **178,367** | **32.09** |
| Brush/Shrubs | 13,089 | 58.58 | 37,446 | 10.57 | 25,204 | 6.63 | 25,261 | 6.13 | 129,319 | 31.97 | 130,978 | 17.60 | 20,249 | 31.71 | 10,980 | 25.62 | 20,646 | 24.20 | 133,306 | 23.98 |
| Perennial Crop | 52 | 0.23 | 11 | 0.00 | 2,406 | 0.63 | 786 | 0.19 | 55,101 | 13.62 | 15,855 | 2.13 | 15,202 | 23.80 | 6,739 | 15.73 | 914 | 1.07 | 26,198 | 4.71 |
| Grassland | 10 | 0.04 | 1,646 | 0.46 | 964 | 0.25 | 99 | 0.02 | 8,658 | 2.14 | 1,245 | 0.17 | 216 | 0.34 | 90 | 0.21 | 568 | 0.67 | 1,012 | 0.18 |
| Annual Crop | 416 | 1.86 | 7,650 | 2.16 | 1,351 | 0.36 | 458 | 0.11 | 1,003 | 0.25 | 3,298 | 0.44 | 289 | 0.45 | 17 | 0.04 | 296 | 0.35 | 1,952 | 0.35 |
| Built-up | 7 | 0.03 | 303 | 0.09 | 70 | 0.02 | 2 | 0.00 | 343 | 0.08 | 163 | 0.02 | 47 | 0.07 | 0 | 0.00 | 8 | 0.01 | 511 | 0.09 |
| Fishpond | | | | | 5 | 0.00 | | | 13 | 0.00 | 33 | 0.00 | 4 | 0.01 | 8 | 0.02 | | | | |
| Inland Water | 27 | 0.12 | 228 | 0.06 | 488 | 0.13 | 559 | 0.14 | 647 | 0.16 | 1,276 | 0.17 | 15 | 0.02 | 2 | 0.00 | 33 | 0.04 | 2,982 | 0.54 |
| Marshland/Swamp | | | | | 41 | 0.01 | | | 5 | 0.00 | | | | | | | | | 12,399 | 2.23 |
| Open/Barren | | | 20 | 0.01 | 74 | 0.02 | 71 | 0.02 | 24 | 0.01 | 48 | 0.01 | 1 | 0.00 | | | 3 | 0.00 | 8 | 0.00 |
| **Non-forest (tP)-Forest (Nam)** | **2,647** | **11.84** | **92,783** | **26.18** | **48,578** | **12.79** | **34,557** | **8.39** | **23,271** | **5.75** | **43,182** | **5.80** | **7,483** | **11.72** | **2,594** | **6.05** | **3,667** | **4.30** | **31,909** | **5.74** |
| Closed Forest | | | 2,101 | 0.59 | 6,087 | 1.60 | 4,570 | 1.11 | 423 | 0.10 | 776 | 0.10 | | | 458 | 1.07 | 347 | 0.41 | 1,980 | 0.36 |
| Open Forest | 2,549 | 11.41 | 90,682 | 25.59 | 40,015 | 10.53 | 29,656 | 7.20 | 19,707 | 4.87 | 30,567 | 4.11 | 2,268 | 3.55 | 966 | 2.25 | 3,300 | 3.87 | 29,929 | 5.38 |
| Mangrove Forest | 98 | 0.44 | | | 2,475 | 0.65 | 331 | 0.08 | 3,140 | 0.78 | 11,840 | 1.59 | 5,215 | 8.16 | 1,169 | 2.73 | 20 | 0.02 | | |
| **Total Area per site** | **22,346** | | **354,388** | | **379,876** | | **411,773** | | **404,548** | | **744,266** | | **63,868** | | **42,853** | | **85,332** | | **555,831** | |

| TCC10 and TCC30 | LA UNION | | CENTRAL CORDILLERA | | CAGAYAN | | ISABELA | | MINDORO | | PALAWAN | | BOHOL | | ZAMBOANGA CITY | | SOUTH COTABATO | | AGUSAN DEL SUR | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % | Area | % |
| Forest in TCC 10&30 | 19,681 | 40.70 | 261,518 | 64.14 | 331,164 | 84.04 | 376,956 | 88.43 | 378,866 | 73.28 | 699,344 | 85.23 | 56,092 | 58.24 | 40,086 | 61.42 | 80,504 | 73.63 | 519,981 | 84.28 |
| Forest in TCC10 only | 28,659 | 59.26 | 146,124 | 35.84 | 62,765 | 15.93 | 49,055 | 11.51 | 135,728 | 26.25 | 119,440 | 14.56 | 39,932 | 41.46 | 25,003 | 38.31 | 27,671 | 25.31 | 93,024 | 15.08 |
| Forest in TCC30 only | 19 | 0.04 | 86 | 0.02 | 134 | 0.03 | 261 | 0.06 | 2,411 | 0.47 | 1,739 | 0.21 | 293 | 0.30 | 174 | 0.27 | 1,161 | 1.06 | 3,940 | 0.64 |
| Grand Total | 48,359 | | 407,728 | | 394,063 | | 426,271 | | 517,005 | | 820,524 | | 96,317 | | 65,263 | | 109,336 | | 616,946 | |

## Annex 6: Map of the Philippine National Inventory Plots and Field Forms



1. NFI Philippines
2. **Tract No** .......

**- F1 -**
**TRACT**

## A. Tract Location

7. State ..................
8. Province ..................
9. District ..................
10. Locality ..................

11. GEZ .................. C

12. Altitude Tract centre ....... m

*Co-ordinates Tract south-west corner*
14a. Latitude _ _ ° _ _ _ _ _ °
14b. Longitude _ _ ° _ _ _ _ _ °

## B. Crew/Owner/Informant list

| 15. Name | 16. Address | 17. Phone number | 18. Crew | 19. Owner | 20. Informant* C |
|---|---|---|---|---|---|
| | | | | | |
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| | | | | | |

* Code indicates the informant's relation to the area, i.e. O=Estate Owner, E=Employee, M=Manager of site, S=Settler, X= External key informant

## C. Population

21. Population on track ☐
22. Population since ☐
23. Population dynamics ☐ C
24. Population main activity ☐ C
25. Settlement history ☐ C

## D. Proximity to Infrastructure

*Distance from Tract centre to:*

26. All weather road _ _ , _ km
27. Seasonal road _ _ , _ km
28. Settlement _ _ , _ km
29. Hospital _ _ , _ km
30. School _ _ , _ km
31. Market _ _ , _ km

## E. Tract Access

*Position when leaving road*
32a. Latitude _ _ ° _ _ _ _ _ °
32b. Longitude _ _ ° _ _ _ _ _ °

*Time:*
33. When leaving road _ _ _ _
34. When getting to plot N° ☐ _ _ _ _

*Reference points of access path*

| 35. ID | 36. Description | 37a. Latitude | 37b. Longitude |
|---|---|---|---|
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38. *Notes:*
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1. NFI Philippines

2. **Tract No** ...... 3. **Plot No** ☐

**- F2 -**

**PLOT**

## A. Plot start point description

*Plot starting point (calculated):*

39a. Latitude _ _ ° _ _ _ _ _ °

39b. Longitude _ _ ° _ _ _ _ _ °

*Marker position (GPS reading):*

40a. Latitude _ _ ° _ _ _ _ _ °

40b. Longitude _ _ ° _ _ _ _ _ °

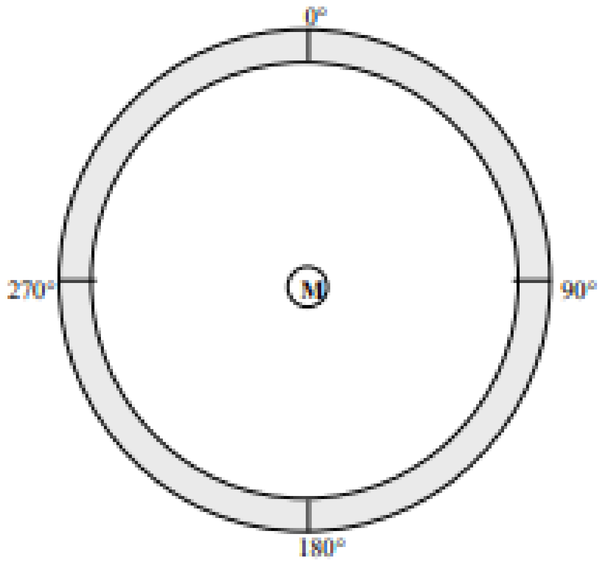
41. Distance from Marker to Plot start point ☐ m

42. Bearing from Marker to Plot start point ☐ °

Central line bearing:
Plot # 1 = 0°
Plot # 2 = 90°
Plot # 3 = 180°
Plot # 4 = 270°

M = Marker position
P = Plot starting point, if P ≠ M for any reason

43. Plot starting point plan




*Reference points surrounding Marker position*

| 44. W | 45. Description | 46. Bearing* (°) | 47. Distance* (m) |
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* From Marker position

53. *Notes:*

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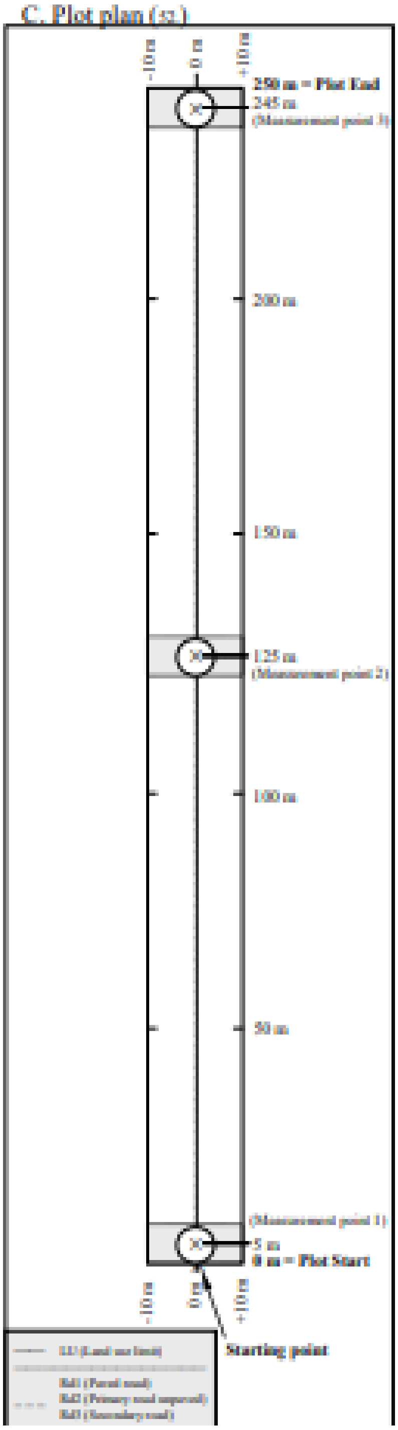
## B. Time record of work within

| *Starting:* | *Ending:* |
|---|---|
| 48. Date _ _ / _ _ / _ _ | 50. Date _ _ / _ _ / _ _ |
| 49. Time _ _ _ _ | 51. Time _ _ _ _ |

## C. Plot plan (52)



1. NFI Philippines

2. **Tract No** .......      3. **Plot No** ☐

**- F3a -**
**PLOT**

## D. Tree measurement

| 4. Sub-plot No | 54. Nested Plot L1 Width | 54. Nested Plot L1 Length | 55. Tree No | 56. Species: 56a. Common name | 56b. Scientific name | 57. Tree/Stump location: 57a. Along Plot axis | (−) 57b. Left axis | (+) 57c. Right axis | 58. Dbh[1] | 59. Dbh height[2] | 60. Year(s) since cut | 61. Total height | 62. Commercial height | 63. Stem quality | Health: 64. Health state | 65. Crowding element[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | (m) | (m) | (m) | (cm) | (m) | | (m) | (m) | C | C | C |
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[1] Stump diameter respectively   [2] Stump height respectively   [3] Multiple choice

66. *Notes:*

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# BAMBOO, ERECT PALMS and RATTAN

**(For 10m x 20m Nested Plot only)**

1. NFI Philippines
2. **Tract No .......** 3. **Plot No** ☐

**- F3b -**
**PLOT**

| Sub-plot No | Nested Plot L1 Width | Nested Plot L1 Length | Clump No | Species | | Clump location | | | Average Stem Diameter | Total No. of stems/clump |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Common name | Scientific name | Along Plot axis | (−) Left axis | (+) Right axis | | |
| | | | | | | (m) | (m) | (m) | (cm) | (m) |
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*Notes:*..............................................................................................................................................
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1. NFI Philippines

2. **Tract No** ...... 3. **Plot No** ☐

**- F4a -**

**NESTED PLOTS**

A. Topography and soil

| **Measurement point No 1** | | **Measurement point No2** | | **Measurement point No3** | |
|---|---|---|---|---|---|
| 4a. Sub-Plot No | ☐ | 4b. Sub-Plot No | ☐ | 4c. Sub-Plot No | ☐ |
| 70a. Aspect | ☐ ° | 70b. Aspect | ☐ ° | 70c. Aspect | ☐ ° |
| 71a. Slope | ☐ % | 71b. Slope | ☐ % | 71c. Slope | ☐ % |
| 72a. Relief | ☐ C | 72b. Relief | ☐ C | 72c. Relief | ☐ C |
| 73a. Soil texture | ☐ C | 73b. Soil texture | ☐ C | 73c. Soil texture | ☐ C |
| 74a. Soil drainage | ☐ C | 74b. Soil drainage | ☐ C | 74c. Soil drainage | ☐ C |

B. NESTED PLOTS LEVEL 2 – Tree measurements (0cm < Dbh < 10cm)

| 6. L2 No (1-3) | 4. Supplot N | 75. Area (m²) | 77. Species | | 78a. Counts | 78b. Total number |
|---|---|---|---|---|---|---|
| | | | 77a. Common name | 77b. Scientific name | | |
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79. *Notes:*

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# OTHER MINOR FOREST PRODUCTS

**(For 3.99m-radius Nested Plot, L2)**

1. NFI Philippines — **- F4b -**

2. **Tract No** ....... 3. **Plot No** ☐ — **PLOT**

| Stem N°/Clump N° | Species | | Average Stem Diameter | Total N° of stems/clump | Average Stem Diameter | Total N° of stems/clump | Average Stem Diameter | Total N° of stems/clump |
|---|---|---|---|---|---|---|---|---|
| | 56bb. Listed Species | 56ab. Not Listed Species | (cm) | | (cm) | | (cm) | |
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1. NFI Philippines ☐
2. Tract No ....... 3. Plot No ☐
4. Sub-plot No

**- F5 -**
**SUB-PLOT**

A. General

80. Land use ☐ C

81a. Width ☐ m

81b. Length ☐ m

82. Designation/ Protection status ☐ C

83. Land tenure C

| | **84. Environmental problems** | |
|---|---|---|
| ☐ | 0 | Not Applicable (urban areas…) |
| ☐ | 1 | Not existing |
| ☐ | 2 | Loss of water levels in rivers and other sources |
| ☐ | 3 | Drought |
| ☐ | 4 | Inundation |
| ☐ | 5 | Poor water quality |
| ☐ | 6 | Pests |
| ☐ | 7 | Erosion |
| ☐ | 10 | Landslide |
| ☐ | 11 | Windthrow |
| ☐ | 90 | Not known |
| ☐ | 99 | Other ..................................... |

85. Fire occurrence ☐ C

86. Fire area ☐ $m^2$

88. Lianas ☐

89. Epiphytes ☐

B. Forest management and structure

90. Stand origin* N | P | C | n

91. Stand structure ☐ C

92. Canopy coverage ☐ C

93. Management plan ☐ C

| | **95. Timber exploitation** | |
|---|---|---|
| ☐ | 0 | No felling |
| ☐ | 1 | Clearing |
| ☐ | 2 | Selective felling |
| ☐ | 3 | Group felling |
| ☐ | 4 | Strip felling |
| ☐ | 99 | Other |

| | **96. Silviculture** | |
|---|---|---|
| ☐ | 0 | No practice |
| ☐ | 1 | Improvement |
| ☐ | 2 | Release of desirable superior tree |
| ☐ | 3 | Release of lianas and tropical plants |
| ☐ | 4 | Enrichment |
| ☐ | 5 | Sanitary cutting |

| | **97. Technology used** | |
|---|---|---|
| ☐ | 0 | Not Applicable |
| ☐ | 1 | Manual |
| ☐ | 2 | Chainsaw |
| ☐ | 3 | Mechanised (tractors etc.) |
| ☐ | 90 | Not known |
| ☐ | 99 | Other (oxen etc.) |

* N=Natural regeneration; P=Plantation; C=Coppice; nk= not known

98. *Notes:* .............................................................................................................

4. **Sub-plot No** ☐

A. General

80. Land use ☐ C

81a. Width ☐ m

81b. Length ☐ m

82. Designation/ Protection status ☐ C

83. Land tenure C

| | **84. Environmental problems** | |
|---|---|---|
| ☐ | 0 | Not Applicable (urban areas…) |
| ☐ | 1 | Not existing |
| ☐ | 2 | Loss of water levels in rivers and other sources |
| ☐ | 3 | Drought |
| ☐ | 4 | Inundation |
| ☐ | 5 | Poor water quality |
| ☐ | 6 | Pests |
| ☐ | 7 | Erosion |
| ☐ | 10 | Landslide |
| ☐ | 11 | Windthrow |
| ☐ | 90 | Not known |
| ☐ | 99 | Other |

85. Fire occurrence ☐ C

86. Fire area ☐ $m^2$

*Future trees:*

88. Expected ☐ C

89. Desired ☐ C

B. Forest management and structure

90. Stand origin* N | P | C | n

91. Stand structure ☐ C

92. Canopy coverage ☐ C

93. Management plan ☐ C

| | **95. Timber exploitation** | |
|---|---|---|
| ☐ | 0 | No felling |
| ☐ | 1 | Clearing |
| ☐ | 2 | Selective felling |
| ☐ | 3 | Group felling |
| ☐ | 4 | Strip felling |
| ☐ | 99 | Other |

| | **96. Silviculture** | |
|---|---|---|
| ☐ | 0 | No practice |
| ☐ | 1 | Improvement |
| ☐ | 2 | Release of desirable superior tree |
| ☐ | 3 | Release of lianas and tropical plants |
| ☐ | 4 | Enrichment |
| ☐ | 5 | Sanitary cutting |

| | **97. Technology used** | |
|---|---|---|
| ☐ | 0 | Not Applicable |
| ☐ | 1 | Manual |
| ☐ | 2 | Chainsaw |
| ☐ | 3 | Mechanised (tractors etc.) |
| ☐ | 90 | Not known |
| ☐ | 99 | Other (oxen etc.) |

* N=Natural regeneration; P=Plantation; C=Coppice; nk= not known

1. NFI Philippines
2. **Tract No** ...... 3. **Plot No** ☐ 4. **Sup-plot No** ☐

**- F6 -**
**SUB-PLOT**

D. Products / Services

| 99. Product/Service | 100. Rank | 101. End use* | 102. Harvester** | | | | | | | 103. User right | 104. User conflicts | 105. Demand Trend | 106. Supply Trend | *Harvesting/ Activity* | | | | 111. Species** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Children | Women | Men | Local organisations & comp. | National companies | International companies | Other | | | | | 107. Season activity | 108. Last activity | 109. Trend | 110. Change reason | |
| C | | | | | | | | | | C | C | C | C | C | C | C | C | |
| | | d / c / nk | | | | | | | | | | | | | | | | |
| | | d / c / nk | | | | | | | | | | | | | | | | |
| | | d / c / nk | | | | | | | | | | | | | | | | |
| | | d / c / nk | | | | | | | | | | | | | | | | |
| | | d / c / nk | | | | | | | | | | | | | | | | |
| | | d / c / nk | | | | | | | | | | | | | | | | |
| | | d / c / nk | | | | | | | | | | | | | | | | |

* Multiple choice: d = domestic use; c = commercial use; nk = destination not known
** Multiple choice

112. *Notes:*
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## Annex 7. Proposed REDD+ Safeguards

| Principles 1: Complies with National and International Laws and Agreements | | |
|---|---|---|
| Criteria No. | Outcome Indicator | Output Indicator |
| Criteria 1: Supports the advancement of the country's international commitments and national targets for sustainable development. | • Activities and projects of REDD+ are aligned with international agreements and national targets. | • Reported contribution of REDD+ activities to Millenium Development Goals (MDGs) 1,3,7,8; Philippine Development Plan (PDP); Convention on Biological Diversity (CBD) Aichi targets 5,7,11,12,14 and 15; Philippine Biodiversity Strategy Action Plan (PBSAP) and Post-2030 Sustainable Development Goals (SDGs). |
| | • Activities and projects of REDD+ are aligned with international agreements and national targets | • Number of reports regularly submitted to proper authorities |
| Criteria 2: Supports the advancement of the country's international commitments and national targets for sustainable development. | • Official governance bodies give clearance and sustained support to REDD+ related activities: National Multi-Stakeholder REDD+ Councils (NMRC), Provincial Multi-Stakeholder REDD+ Councils (PMRC). | • Number of clearance and expressed support to REDD+ related activities issued by concerned bodies (NMRC, PMRC).<br>• Percentage of activities integrated/interfaced/harmonized with relevant policies, programs and commitments. |
| Criteria 3: Ensures consistency with and contribution to national poverty reduction strategies and other sustainable development goals, including alignment with departmental and sub-national strategies and plans that may have an impact on, or be affected by the forest sector and/or land use change. | • Activities related to or in support of REDD+ are interfaced with relevant policies, programs and commitments. | • Percentage of activities integrated/interfaced/harmonized with relevant policies, programs and commitments. Presence of the following:<br>- Delineation map of protection and production forest land use;<br>- Demarcation map of protection and production forest land use;<br>- Demarcation of national parks;<br>- Zonal land use map for REDD+ eligible activities: conservation; and<br>- Enhancement of forest carbon; sustainable management of forests.<br>• Percentage of tracked REDD+ activities by Forest Management Unit (FMU) (by title or tenure or aggregation thereof) |
| | • Forestry Information System (FIS) responsive to all forestry-related activities including REDD+ is functioning | • Percentage of forestry -related databases including REDD+ Integrated to the FIS. |
| | • Living conditions of rights-holders are improved. | • Percentage of Indigenous Cultural Communities/Indigenous Peoples (ICCs/IPs), Local Communities (LCs) and households with tenure/recognition of ownership.<br>• Percentage of increase of communities and households with access to food security, basic education, primary and reproductive health services. |
| Criteria 4: Promotes the rights, equality and non-discrimination of vulnerable sectors and people | • Rights, cultural sensitivity, and gender equality-based Information and Education Campaign (IEC) activities are held before the implementation of the REDD+ project. | • Number of REDD+ IEC activities conducted with awareness-raising and training programs on rights and gender equality in planning before and during REDD+ implementation.<br>• Number of REDD+ plans and programs that integrate a rights-based approach in accordance with the PNRPS.<br>• Number of gender-responsive, culturally-sensitive and rights-related policies and manuals issued. |

| | | |
|---|---|---|
| Criteria 5: Seeks FPIC of ICCs/IPs and LCs and respects and upholds the decision taken (whether consent is given or withheld) | • Free and Prior Informed Consent (FPIC) is obtained from rights holders and stakeholders. | • Percentage of REDD+ activities compliant with FPIC and LGC processes. |
| Criteria 4: Promotes the rights, equality and non-discrimination of vulnerable sectors and people | • Rights, cultural sensitivity, and gender equality-based Information and Education Campaign (IEC) activities are held before the implementation of the REDD+ project. | • Number of REDD+ IEC activities conducted with awareness-raising and training programs on rights and gender equality in planning before and during REDD+ implementation.<br>• Number of REDD+ plans and programs that integrate a rights-based approach in accordance with the PNRPS.<br>• Number of gender-responsive, culturally-sensitive and rights-related policies and manuals issued. |
| Criteria 5: Seeks FPIC of ICCs/IPs and LCs and respects and upholds the decision taken (whether consent is given or withheld) | • Free and Prior Informed Consent (FPIC) is obtained from rights holders and stakeholders. | • Percentage of REDD+ activities compliant with FPIC and LGC processes. |
| Principles 2: Implemented Under Transparent, Effective and Accountable Governance | | |
| Criteria 6: Ensures legitimacy of governance structure that recognizes representation of the vulnerable groups | • Governance structure for RED+ is functional. | • Number of mandated agencies with REDD+ focal persons officially designated through a special order or resolution.<br>• Presence of Operations Manual |
| | • REDD+ plans and programs are timely, consistently and properly communicated to rights and stakeholders. | • Number of REDD+ areas reached by information dissemination.<br>• Number of stakeholders informed. |
| Criteria 7: Supports efforts to reduce and eradicate government corruption in the implementation of REDD+ through transparent and accountable fund management | • Conditions for the management of project funds are in place. | • Presence of proper and accurate accounting and auditing of the project funds.<br>• Number and Extent of Performance and integrity audit regularly conducted and reported. |
| | • Diverse, long-term and resilient financing opportunities are set for REDD+. | • Presence of working agreements with financing institutions. |
| Criteria 8: Promotes and supports the rule of law, access to justice, and effective remedies to ensure legitimacy and accountability of all bodies representing the vulnerable groups | • A grievance mechanism is installed and functional. | • Presence of grievance mechanism that receives feedback from ICCs/IPs, LCs and the nine (9) major groups and to resolve conflicts. |
| | • Number of complaints or grievances received by the mechanism. | |
| | • Number of grievances resolved or addressed. | |
| Criteria 9: Ensures coordination, efficiency and effectiveness among all agencies and implementing bodies in natural resource management relevant to REDD+ | • REDD+ plans and programs are interfaced in relevant natural resources policies, programs and integrated into national and local land use plans. | • Number of REDD+ programs and plans approved nationally and locally in accordance with established planning processes.<br>• Presence of established planning processes for land use and natural resource EDU investments.<br>• Percentage of natural resource investments compliant with established planning processes. |
| | • Coordination and steering mechanisms are in place. | • Number and Frequency of coordination meetings held on a regular basis among all agencies and implementing bodies.<br>• Presence of established NMRC.<br>• Presence of NMRC operations manual. |

| | | |
|---|---|---|
| | • REDD+ finance is sustainable and predictable. | • Percentage of leveraged funding REDD+. |
| | • Private investments follow FLUPs and Comprehensive Land Use Plans (CLUP) where REDD+ activities are integrated through Ancestral Domains Sustainable Development Protection Plans (ADSDPPs) and Community Resource Management Frameworks (CRMF). | • Number of private investments in natural resource exploitation, utilization and development consistent with CLUP, FLUP and ADSDPPs. |
| Principles 3: Ensure the Recognition and Respect of Rights of ICCs/IPs and LCS Over Lands, Territories, and Resources | | |
| Criteria 10: Ensures that institutionalized system, mechanism, and local community capacities are in place with engagement of ICCs/IPs, LCs, and other vulnerable and marginalized groups | • NCIP and LGC prescribed involvement of ICCs/IPs and LCs are followed in REDD+ project sites. | • Presence of institutionalized system, mechanism, and local community capacities. |
| Criteria 11: Respects and protects traditional knowledge practices, and cultural heritage | • REDD+ implementation uses and enhances IP traditional knowledge, skills and practices. | • Number of documented indigenous knowledge, skills and practices (IKSP) that may be tapped or enhanced for REDD+ implementation |
| | • FPIC is obtained from rights holders and stakeholders. | • Percentage of IPs/ICCs that have signified FPIC to REDD+ activities, whether according to NCIP protocols. Or their traditional community processes. |
| Principles 4: Involves, Consults and Ensures Sustained and Enabled Participation of Stakeholders, with Particular Attention to ICCs/IPs and LCs, and Other Vulnerable and Marginalized Groups | | |
| Criteria 12: Ensures the full and effective participation of the nine (9) major groups in designing, planning and implementation of REDD+ activities | • Participatory process is established to inventory and map existing statutory and customary lands, land use, territories and resources. | • Presence of participatory process established to inventory and map existing statutory and customary lands, land use, territories and resources.<br>• Percentage of REDD+ activities that have conducted a process for identification of rights holders. |
| | • Sustained engagement of authorized representatives of indigenous peoples, local communities and other vulnerable and marginalized groups are ensured with enabling support. | • Number of enabling support activities and mechanisms for sustained engagement of authorized representatives of ICCs/IPs, LCs and other vulnerable and marginalized groups provided. |
| Principles 5: Builds and Strengthens the Capacity of Stakeholders, Especially the ICCs/IPs and LCs and Government Entities in Managing the Lands and Resources | | |
| Criteria 13: Supports vulnerable groups especially ICCs/IPs, LCs, and Government entities with appropriate technical assistance | • Vulnerable and traditional communities are capacitated to effectively participate in REDD+ processes. | • Percentage of communities and organizations representing vulnerable groups that have been capacitated or received training in the following areas:<br>- Assessment of forest lands status, effect of industrial pressures, notably from the mining and agricultural sectors, and natural resources valuation;<br>- Resource management planning;<br>- Implementation; and<br>- Monitoring and Evaluation<br>• Number of re-echo trainings conducted by communities and organizations in their respective areas. |

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| Criteria 14: Supports development of adequate and appropriate low-emission rural livelihood strategies that harmonize REDD+ objectives with local needs and livelihoods | • Low-emission rural livelihoods are developed. | • Percentage of rural livelihoods certified by the appropriate authorities as low emission livelihoods;<br>• Percentage of rural livelihood initiatives receiving assistance on available technologies, business management and market access;<br>Number of integrated, diversified, forest-based, low-GHG emission livelihood projects and enterprises implemented and supported by REDD+ finance. |
| Principles 6: Ensures Adequate and Equitable Sharing of Benefits Among All Identified Stakeholders Who Protected the Forests | | |
| Criteria 15: Ensures that REDD+ effectively identifies the different rights holders (statutory and customary) and their rights to lands, territories and resources | • Ecosystem based functions and services are sustained and enhanced in benefit sharing arrangements through mutually supportive mitigation and adaptation. | • Presence of institutionalized Ecosystems-based Approach in government structures, planning and budget allocation.<br>• Percentage of communities with recognized tenurial rights to their lands and resources. |
| | • Carbon rights clarified based on statutory and customary laws. | • Presence of clarified carbon ownership in an official document. |
| Criteria 16: Ensures Equitable, Non-Discriminatory and Transparent Benefit Sharing Among the Vulnerable Groups | • Mutually agreed, binding and enforceable benefit-sharing schemes are followed in implementation of REDD+ projects. | • Presence of mutually agreed, binding and enforceable schemes.<br>• Number of REDD+ areas implementing mutually agreed benefit sharing schemes.<br>• Presence of Members from a broad range of stakeholders in participatory processes. |
| Criteria 17: Ensures that Projected Costs, Potential Benefits and Associated Risks of the REDD+ Activities Are Identified for ICCs/IPs, LCs and other Vulnerable Groups at All Levels Using a Participatory Process | • Appropriate economic studies contribute to the advancement of REDD+ projects. | • Number of appropriate economic studies done prior to project implementation. |
| Criteria 18: Ensures that REDD+ Identifies and Uses a Process for Effective Resolution of Any Disputes Over Rights to Lands, Territories, and Resources Related to the Program | • Sustained support for capacity building in negotiating agreements to set fair and equitable arrangements. | • Presence of continuous support services and technical assistance for communities undertaking negotiations for fair and equitable arrangements.<br>• Number of IEC activities carried out before implementation of REDD+. |
| Criteria 19: Ensures There is No Involuntary Resettlement as a Result of REDD+ | • Presence of genuine community consent or FPIC to any resettlement. | • Number of accessible health care providers. |
| | • Improved living conditions. | • Number of communities assisted<br>• Number of accessible education and training service providers |
| Principles 7: Addresses Climate Change in Risk of Reversals and Displacement of Reduced Emissions Through Ecosystem-Based Adaptation and Mitigation | | |
| Criteria 20: Ensures Consistency with and Contribution to National Climate Policy Objectives including those of Adaptation and Mitigation Strategies and International Commitments in Climate Change | • Coordinated, mutually supportive and enhanced synergy in climate change adaptation and mitigation are mainstreamed in REDD+. | • Percentage of areas with regularly monitored reduced GHG emission, enhanced carbon stocks and implemented adaptation strategies.<br>• Percentage of upland families practicing sustainable forest management. |
| Criteria 21: Addresses the Risk of Reversals of REDD+ Achievements Including | • An MRV system is institutionalized. | • Presence of institutionalized MRV system.<br>• Percentage of REDD+ activities tracked by the FMU. |

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| Potential Future Risks to Forest Carbon Stocks and Other Benefits to Ensure the Efficiency and Effectiveness of REDD+ | • Deforested land is reforested for protection or production purposes as appropriate. | • Percentage of reforested degraded forest lands and forest areas within ancestral domains and PAs. |
| | • Avoided deforestation and degradation activities are supported by local ordinances. | |
| Criteria 22: Ensures that Planted Areas and Natural Forests are Managed to Maintain and Enhance Ecosystem Services and Biodiversity Conservation in Both Local and National Contexts | • Landscape pattern is maintained. | • Percentage of FRI/FRA completed;<br>• Percentage of planted areas and forests properly maintained; and<br>• Percentage of the decrease in deforestation and forest degradation. |
| | • Comprehensive forest land use plan (FLUP) is presented and updated. | • Presence of comprehensive FLUP adopted, implemented, and updated. |
| | • A forest resources inventory is available. | • Presence of FIS at municipal and provincial levels. |
| Criteria 23: Ensures that REDD+ Activities Lessen Incidence of Leakage and Displacement of Emissions | • Relevant LGU ordinances are in place for all disallowed types of investments, land and resource uses. | • Number of activities supported by local ordinances to avoid deforestation and forest degradation; and<br>• Number of relevant LGU ordinances in place for all disallowed types of investments, land and resource uses. |
| | • Incidence of leakage and displacement of emissions decreases. | • Percentage of decrease in the incidence of leakage and displacement. |
| | • Environmental Impact Assessment results guide REDD+ implementation. | • Percentage of programs, projects, and activities in REDD+ areas that conducted a verified EIA. |
| | • Conflicts in current laws on mining, agrarian reform, agricultural development, biofuels and plantations, harvest of forest products, and renewable energy are addressed. | • Number of conflicts in current laws on mining, agrarian reform, agricultural development, biofuels and plantations, harvest of forest products, and renewable energy addressed/resolved. |
| Criteria 24: Energy Efficiency through Low Carbon Technology Supports REDD+ | • Emission-producing activities are reduced. | • Percentage of national targets and timelines met for enhanced carbon stocks and emission reductions from reduced deforestation and forest degradation.<br>• Number of emissions reducing activities such as survey/RE system established. |
| | • Renewable energy and efficient energy utilization systems established support REDD+ projects. | • Number of activities with private sector participation and support for REDD+. |
| | • Integrated, diversified, forest-based, low-GHG emission livelihood projects and enterprises are implemented and supported by REDD+ finance. | • Number of integrated, diversified, forest-based, low-GHG emission livelihood projects and enterprises implemented and supported by REDD+ finance. |
| | • Measures to pre-empt risk of reversals are in place. | • Number of mitigation options studied to address risk of reversals. |
| Principles 8: Conserves Biodiversity and Maintains Ecosystem Functions and Services | | |
| Criteria 25: REDD+ Activities and Projects Contribute to National Biodiversity Conservation and Protection of Ecosystems | • Natural forest ecosystem types are effectively maintained and enhanced in REDD+ areas. | • Percentage increase in total terrestrial area effectively managed through NIPAS and other conservation measures, i.e. IPs and Community Conserved Territories and Areas (ICCA), Long-term Cooperative Action (LCA);<br>• Percentage of total area effectively managed as terrestrial Pas that overlap with key biodiversity areas (KBA) representative of faunal regions and natural habitat types of the country; and |

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| | | • Area of maintained land cover in natural forests, whether closed, open and mixed forest based on NAMRIA land cover classification. |
| | • Ecosystem services provided by protected areas are enhanced. | • Volume of estimated carbon stocks in forest areas in the Philippines;<br>• Number of sites in KBAs that serve as ecotourism destinations;<br>• Number of IP communities with identified sacred places and/or ICCAs within KBA; and<br>• Number of maps produced and disseminated. |
| Criteria 26: Ensures that Conservation Status of Threatened Species is Improved and of Non-Threatened Species is Maintained | • Conservation Status of Threatened species is improved, and non-threatened species maintained. | • Presence of baseline on threatened and invasive species in REDD+ project areas;<br>• Presence of opportunities created for critical habitats;<br>• Presence of adaptive management strategies for habitats and ecosystem resilience;<br>• Number of regular monitoring and assessment activities being implemented; and<br>• Presence of mechanisms for volunteers to support conservation. |
| | • Model sites for demonstration (REDD+ readiness) are pursued to compare high and low biodiversity REDD+ projects | • Presence of described results from comparison of methodologies in different model sites. |