National REDD+ Forest Reference Emission Level / Forest Reference Level

Ministry of Natural Resources and Environment (MNRE)
Forestry Division

Government of Samoa

December 2023

Table of Contents

List of Figures

List of Tables

List of Acronyms

AGB	Above Ground Biomass
AD	Activity Data
AFOLU	Agriculture, Forestry and Other Land Use
ART	Architecture for REDD+ Transactions
BGB	Below Ground Biomass
BTR	Biennial Transparency Report
BUR	Biennial Update Report
CCDA	Climate Change and Development Authority
COP	Conference of the Parties
CSO	Civil Society Organizations
EF	Emission Factor
FAO	Food and Agriculture Organisation of the United Nations
FRA	Forest Resources Assessment
FREL	Forest Reference Emission Level
FRL	Forest Reference Level
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GIS	Geographical Information System
GoS	Government of Samoa
IPCC	Intergovernmental Panel on Climate Change
JICA	Japanese International Cooperation Agency
JICS	Japanese International Cooperation System
LULUCF	Land Use, Land Use Change and Forestry
MNRE	Ministry of Natural Resources and Environment
MRV	Measurement, Reporting and Verification
NDC	Nationally Determined Contribution
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NGO	Non-Governmental Organizations
QA/QC	Quality Assurance/Quality Control
REDD+	Reduced Emissions from Deforestation and Degradation and Conservation, Sustainable management of forests and Enhancement of Forest Carbon Stocks
tCO_2eq/year	Tonnes of Carbon Dioxide Equivalent per year
TREES	The REDD+ Environmental Excellence Standard
UNFCCC	United Nations Framework Convention on Climate Change

1. Introduction

1.1. Samoa and global efforts to combat climate change

Samoa is a small island country in the central South Pacific. It's known for being independent. It's located around latitude 14 degrees south and longitude 170 degrees west, near the international dateline. Samoa has two main islands, Upolu and Savaii, with Savaii being the biggest. The total land area is about 2,930 square kilometers. These islands were formed by volcanoes. Inland, beyond the coastal areas, there are steep mountains, with the highest being 1,860 meters on Savaii and 1,100 meters on Upolu. Most of the country is covered by forests, making up 60% of the land[1]. Samoa has a tropical climate with lots of rainfall. It's humid, around 80 percent, and the average monthly temperature is about 27 degrees Celsius, not changing much throughout the year. In Samoa, land ownership is based on customary title, where the chief (matai) manages the land. Around 80% of land is customary land. In 2021, Samoa's population was 205,557 according to the census[2].

Samoa faces the significant challenge of climate change, exposing it to rising sea levels, tropical cyclones, and heavy rainfall. In response, the country has formulated national plans such as the Samoa Climate Change Policy 2020-2030 and the Agriculture and Fisheries Sector Plan 2022-2027, focusing on climate-resilient infrastructure and sustainable land use. Notably, Samoa is committed to global climate efforts, participating in initiatives like the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. The government aims to increase mangrove and agroforestry areas, boost overall forest coverage, and achieve 100% renewable energy by 2025. Samoa's proactive approach includes submitting reports to track progress, aligning with its commitments under the UNFCCC and the Paris Agreement. This concerted effort reflects Samoa's dedication to addressing and adapting to the impacts of climate change on its vulnerable island nation.

1.2. Background on the MRV for REDD+ under the UNFCCC

The UNFCCC calls for developing countries aiming to access performance-based payments for the implementation of REDD+ activities to develop four REDD+ design elements as part of the Warsaw Framework for REDD+:

i. A national strategy or action plan.
ii. A national forest reference emission level and/ or forest reference level (FREL/FRL).
iii. A national forest monitoring system.

[1] Samoa Bureau of Statistics (2014), Table 4, https://www.sbs.gov.ws/digi/FOREST%20STATISTICS.pdf
[2] SAMOA POPULATION AND HOUSING CENSUS 2021 Basic Tables: https://sbs.gov.ws/documents/census/2021/Census-2021-Final-Report_221122_051222.pdf

iv. A system for providing information on how the REDD+ safeguards are being addressed throughout the implementation of REDD+ activities.

The national forest monitoring system provides transparent information on the status of forests and REDD+ implementation in a country. It has two core functions:

1. Monitoring national policies and measures for REDD+.
2. Measuring, Reporting and Verifying (MRV) national scale GHG emissions and removals in the forest sector.

The UNFCCC has defined FREL/FRLs as benchmarks for assessing each country's performance in implementing and reducing emissions and increasing removals associated with the implementation of REDD+ activities. The Conference of the Parties (COP16) in Cancun in 2010 encouraged developing country parties to contribute to mitigation actions in the forest sector, in accordance with their respective capabilities and national circumstances, and stated that, "more broadly, FREL/FRLs are considered relevant to assess country's performance in contributing to mitigation of climate change through actions related to their forests." According to UNFCCC COP decision 12/CP.17, developing countries aiming to implement REDD+ activities are invited to submit a national forest reference level to the secretariat, on a voluntary basis and when deemed appropriate. The information contained in the submission should be transparent, accurate, complete, and consistent. It also be developed pursuant to the IPCC guidelines.

In agreement with these decisions, Samoa has held extensive consultations with national stakeholders from government, Non-Governmental Organizations (NGO), Civil Society Organizations (CSO) and Private Sector and strengthened the national capacity for the development of its FREL/FRL.

An inception workshop was held on 13 February 2023 to explain the requirements of FREL/FRL and LULUCF assessment and draft plan and methodology (including data and tools) were proposed and discussed. This workshop was crucial in designing and customizing assessment tools and approach/methodolgy. Training sessions followed in March, followed by three rounds of assessment from April to August 2023. A consultation and validation workshop was held on 31 October 2023 to explain the draft results of LULUCF assessment and FREL/FRL to the relevant organisation and stakeholders that were involved in the inception workshop. Participants validated the LULUCF assessment and discussed areas for improvement.

1.3. Objectives of developing the National FREL/FRL

Samoa understands different countries can have different reasons for using FREL/FRLs in various ways. But, for Samoa, the Forest Reference Level is made to achieve specific goals both within the country and on the global stage:

Within Samoa:

- To see how well Samoa is doing in carrying out activities to reduce deforestation and forest degradation (REDD+ activities).
- To see how Samoa is contributing to actions that help fight climate change within the country, especially related to its forests.

On the Global Scale (Internationally), following COP 17's decision:

- To get payments based on the results achieved through REDD+ actions.
- To check how well the policies and measures taken in Samoa's forestry sector are working to fight climate change at home.
- To play a part in the global efforts to reduce the impact of climate change by taking actions related to REDD+ under the UNFCCC.

1.4. Background on work towards developing the FREL/FRL

This marks Samoa's inaugural submission of the Forest Reference Emission Level / Forest Reference Level (FREL/FRL), showcasing its dedication to addressing climate change. In 2023, the Government of Samoa, Ministry of Natural Resource and Environment made effort to develop Samoa's National Forest Monitoring System (NFMS) and FREL/FRL, with technical and financial support of the Food and Agriculture Organization of the United Nations (FAO).

In Feb 2023, Samoa held its first consultative meeting and inception workshop aimed to introduce the development of Samoa's National Forest Monitoring System (NFMS) and FREL/FRL for REDD+ to all relevant national stakeholders. The primary goal was to ensure key stakeholders, including relevant government representatives, NGOs, and the private sector, understood the technical and financial aspects and benefits of establishing an NFMS and FREL/FRL for Samoa such as accessing REDD+ finance, contributing to sustainable community development, and safeguarding Samoa's native forests. This meeting informed stakeholders about international guidance for designing REDD+ FREL/FRLs and established a roadmap for its development.

For the FREL/FRL development, national capacity for Land Use Change and Forestry Assessment (LULUCF) was strengthened through technical assistance and training provided by FAO experts. Two rounds of training were conducted in February and March 2023, with three subsequent LULUCF assessments in April, May, and August 2023, each followed by QA/QC assessments. The LULUCF results served as the activity data for this FREL/FRL report.

Subsequently, two more consultative meetings and two working sessions were held in October 2023, involving technical teams from the government and national stakeholders. One consultative meeting was organised only with internal MNRE participants while the other consultative meeting involved national stakeholders. The meetings had several objectives: to introduce a summary of the Land-Use and Land Use Change and Forestry (LULUCF) assessment, provide updates on the National Forest Monitoring System (NFMS) Web-Portal and Forest Reference Emission Level / Forest Reference Level (FREL/FRL), validate the LULUCF assessment with a focus on future improvements for FREL/FRL submission, and consult on the NFMS Web-Portal and FREL/FRL for ongoing progress and the planned submission to UNFCCC in 2023/2024. The main objectives of the two working sessions were to discuss the internal setup of Samoa's own NFMS web portal.

For the consultative meetings, each meeting had over 20 participants from various sectors, ensuring broad representation from the government, non-governmental entities, private sector, and local communities in Samoa. The outcomes of these gatherings formed the basis for advancing the continued development of the FREL/FRL and NFMS for Samoa.

Samoa has previously conducted National Forest Inventories (NFI) in 2003 and 2013, with the current Forest Reference Emission Level / Forest Reference Level (FREL/FRL) report being crucial as Samoa enters its next 10-year NFI phase, particularly considering the Land-Use and Land Use Change and Forestry (LULUCF) assessment. The 2013 NFI, funded by the Japanese International Cooperation System (JICS) through a grant-aid called the Forest Preservation Programme (FPP), included the determination of biomass carbon for various forest land use classes.

However, when it is considered to use for emission factor tables, it is concluded to use global data (IPCC default values with consideration for Samoa's context) due to significant differences between Samoa's NFI values and regional values, with inconsistencies in land use class values (the explanation with examples can be found in Chapter 6. Emission and Removal Factors Estimate).

Samoa reaffirmed its commitment to the Paris Agreement by submitting its Second Nationally Determined Contribution (NDC)[3] to the UNFCCC on July 30, 2021. This NDC outlines policies, sectorial targets, and actions tailored to meet Samoa's defined national contribution, emphasizing mitigation in energy, waste, and agriculture, forestry, and other land use (AFOLU) sectors. Adaptation priorities focus on marine and AFOLU sectors, aiming to reduce overall greenhouse gas emissions by 26% in 2030 compared to 2007 levels.

As of December 2023, Samoa is in the process of developing its first BUR for the UNFCCC, and the results from this first FREL/FRL submission will play a vital role in meeting reporting requirements for Samoa's NDC within the BUR report.

[3] Samoa's Second Nationally Determined Contribution (2021) - - https://unfccc.int/sites/default/files/NDC/2022-06/Samoa%27s%20Second%20NDC%20for%20UNFCCC%20Submission.pdf

2. Definition

2.1. Forest Definition

To understand deforestation, afforestation, and reforestation, it's essential to define what qualifies as a forest. The IPCC (Intergovernmental Panel on Climate Change) in 2006 defines a forest as any land with woody vegetation meeting specific thresholds used in a country's greenhouse gas inventory. This includes managed or unmanaged forests and areas with vegetation expected to become forests in the future. The IPCC emphasizes quantitative thresholds for countries to define their forests, and these definitions were adopted under international agreements. It is important to highlight that all forests in Samoa are considered as managed forest since 80% of Samoa's land is customary owned and the government of Samoa is responsible for sustainable management of the forest.

The Food and Agriculture Organization (FAO) defines forests as land exceeding 0.5 hectares with trees taller than 5 meters and a canopy cover of over 10 percent.

In Samoa, the national forest definition, used in the Global Forest Resource Assessment (FRA) reports, involves minimum tree height of 5m, land with a tree crown cover of more than 10% and a minimum area of 1 hectare. This includes man-made plantation forests, mangrove forests, and other natural forests with varying canopy densities. The chosen threshold values are crucial for legal interpretations, assessing forest area and resources, and developing policies and conservation plans.

In Samoa's 2010 FRA report[4] the forest definition is "Land with a tree crown cover (or stocking level) of more than 10% and a minimum area size of 1 hectare. Includes man-made plantation forests, mangrove forests and other natural forests of various canopy densities". For the FREL/FRL, the forest definition used aligns with Samoa's National Forest Resource Assessment (FRA) definition (as shown in Table 2-1).

Table 2-1: Forest definition for FRL

Elements	FREL/FRL definition
Minimum Land Area	1 ha
Minimum Tree Height	5 m
Minimum Canopy Cover Rate	10 %

[4] GLOBAL FOREST RESOURCES ASSESSMENT 2010 - COUNTRY REPORT SAMOA - https://www.fao.org/4/al617E/al617E.pdf

2.2. Land Use Categories

The FREL/FRL employs a land use classification scheme based on the same 16 classes used nationally for the Global Forest Resource Assessment (FRA) in 2015 and 2020. These classes are grouped into six primary categories aligned with the IPCC's 2006 report for National Greenhouse Gas (GHG) inventories. The six categories are Forest Land, Cropland, Grassland, Other Land, Settlements, and Wetlands, each further subdivided into subtype and subdivision/classes. The classification scheme was developed in consultation with stakeholders, including the Food and Agriculture Organization (FAO), the Samoa Forestry Division, and the Climate Change Division of the Ministry of Natural Resources and Environment (MNRE) in Samoa. For instance, Forest Land includes Mangrove Forest, Closed Forest, Medium Dense Forest, Open Forest, Secondary Forest, and Forest Plantation. Cropland comprises Plantations and Mixed Crops, Grassland includes Scrub and Grassland, Other Land represents Barren land, Settlements include Built-Up areas and Infrastructure, and Wetlands encompass Wetlands, Rivers, and Lakes. Table 2-2 provides an overview of the main categories and the definitions for the 16 land-use classes.

Table 2-2: Land-use classification for Forest and Land Use 2023 (by Category, Sub-Type and Class).

IPCC land use Category	Sub type	Land use Class	Brief description
Forest	Natural Forest	Mangrove Forest	Low-lying coastal areas inundated by saline or brackish water and containing mangrove vegetation, dominated by either Brugguiera or Rhizophora tree spp.
		Closed Forest	Forest formations with various storeys and total crown coverage of more than 70%. Includes primary forests as well as forests in an advanced status of reconstitution after logging, farming or other natural causes (fire, cyclone, etc.) (apparently) undisturbed, logged over, formerly cultivated, windfall, other natural causes, swampy
		Medium Dense Forest	Medium dense forest formations with discontinuous tree layer with one or more storeys and with a crown coverage of more than 40% and less than 70%. (apparently) undisturbed, logged over, formerly cultivated, windfall, other natural causes, swampy, Merremia vines, presence of secondary spp. (eg Albizzia)
		Open Forest	Forest formations with a discontinuous tree layer but with a crown coverage of at least 10% and less than 40%. Includes

			highly degraded and depleted forest due to recent logging, farming or natural disasters (storms, fire, etc.) (apparently) undisturbed, logged over, formerly cultivated, windfall, other natural causes, swampy, Merremia vines, presence of secondary spp. (eg Albizzia)
		Secondary Forest	Secondary forest formations after clearing by man (agriculture, logging), wind, fire or other. Tree remnants and juvenile regeneration may be covered by climbing/creeping vines (Merremia and Mikania). Albizzia (tamaligi), logged over, formerly cultivated, windfall, burnt land, other natural causes, Merremia vines, presence of scattered coconut trees, presence of mixed crops (eg. bananas, taamu, taro, breadfruit etc), presence of remnant, vegetation of primary forest species
	Plantation Forest	Forest Plantation	Man-made forest stands established by planting and/or seeding, where trees are planted in a systematic and organized manner, often in straight, orderly lines. Common species are exotic tree species which are: Broad-leaf Mahogany (*Swietenia macrophylla*), few *Eucalyptus territicornis*, *Eucalyptus delupta*, *Toona ciliata* and *Toona australis*, *Tectona grandis*, and native tree species such as: *Pometia pinnata, Terminalia richii, Syzygium inophylloides, Instia bijuga*
Cropland	Plantation Agriculture	Plantations	Permanent agricultural installations, mostly tree crops or continued / repeated planting of e.g. coconuts or banana (agro-industrial). coconut, coconut with livestock production, coffee / cocoa, banana, coconut mixed with other crops , coconuts overgrown with secondary species
	Gardening Agriculture	Mixed Crops	Land currently and recently cultivated with a mixture of herbaceous and tree crops such as root crops, taro, yam, cassava, breadfruit etc. This includes areas of current cropping and adjacent areas recently abandoned and now

			overgrown with secondary shrub and tree species. coconut coconuts overgrown with secondary species
Grassland	Other wooded land	Scrub	Areas with dominance of woody perennial shrubs of less than 5-7m height and without a definite crown. ground ferns, littoral scrub; native shrubby vegetation occurring on the seaward side of coastal forests; dominated by dwarf shrubs up to 2-3m height, hibiscus, tree ferns, volcanic lava flow, burnt land
	Grassland	Grassland	Open land dominated by herbaceous or grassy vegetation but often with scattered trees ground ferns, marsh wetland with predominantly herbaceous vegetation covering flat areas of soil saturated with freshwater (inland craters) or brackish water (coastal marshes). livestock production, presence of mixed crops (eg. bananas, taamu, taro, breadfruit etc), presence of secondary species, presence of tree ferns.
Other Land	Otherland	Barren land	All land lacking any vegetation cover; except for infrastructure and built-up areas. rocky, sandy (incl. beaches), quarry site, burnt land, volcanic lava flow
Settlements	Settlements	Built-Up area	All settlement areas, encompasses continuous developments, industrial or commercial built-up areas and scattered isolated houses including gardens and inner-city parks. residential, commercial development (eg new hotels), governmental, school, other.
		Infrastructure	All roads (hard surfaced or loose) and infrastructure related facilities (e.g. airports / airstrips, ports, wharves, sports compounds etc.) wharf, Sports compound, airport, logging mill
Wetlands	Wetlands	Wetlands	Areas of wetlands (ss- mangroves, marshes, swamps)
		Rivers	Major rivers and creeks
		Lakes	Lakes and water bodies

(a) Forest Land

According to the IPCC's 2006 report on National Greenhouse Gas (GHG) inventories, Forest Land is defined as any land with woody vegetation meeting a country's specific criteria for classifying it as Forest Land in their greenhouse gas inventory. This definition includes areas with a vegetation structure that may not currently meet the criteria but have the potential to do so according to the country's standards.

In Samoa, Forest Land is divided into two types: Natural Forest and Plantation Forest.

- Natural Forest: It refers to a forest with indigenous trees and is not considered a forest plantation.
- Plantation Forest: This type is established through planting or seeding during afforestation or reforestation. It can include introduced species or intensively managed stands of indigenous species, meeting criteria such as one or two species at planting, even age class, and regular spacing. This definition aligns with the Forest Resource Assessment (FRA) Terms and Definitions 2020, excluding forests planted for protection or ecosystem restoration.

Samoa has 9 vegetation types, with 6 of them falling under the Forest Land category. More details on these vegetation types can be found in Table 2-2.

Table 2-3: Vegetation types for Samoa (by Category, Sub-type and Class).

IPCC category	Sub-type	Class
Forest land	Natural Forest	Mangrove Forest
		Closed Forest
		Medium Dense Forest
		Open Forest
		Secondary Forest
	Plantation Forest	Forest Plantation
Cropland	Plantation Agriculture	Plantations
	Gardening Agriculture	Mixed Crops
Grassland	Other	Scrub

(b) Land Use Other Than Forest Land

Cropland in Samoa, defined by the IPCC, includes arable and tillage land, as well as agro-forestry systems not meeting forest land thresholds. Samoa's cropland encompasses three farming categories: subsistence, semi-commercial, and commercial, further divided into Plantation Agriculture (tree crops) and Gardening Agriculture (mixed crops). Plantation Agriculture involves large-scale tree cultivation, like coconut and banana plantations, while Gardening Agriculture includes mixed crop cultivation associated with subsistence farming.

Grassland, per IPCC, includes rangelands and pasture lands distinct from croplands, often with vegetation below forest land thresholds. In Samoa, grassland refers to open areas dominated by herbaceous vegetation, featuring scattered trees, wetlands, and livestock production. Two sub-categories exist: grassland and others.

Other land encompasses areas not under forest, cropland, grassland, settlement, or wetland, such as bare soil, sand, and rock.

Settlement, following IPCC guidelines, includes developed land and infrastructure. In Samoa, it includes built areas like villages, commercial developments, and associated infrastructure.

Wetlands, according to IPCC, includes water-saturated areas not fitting other categories, divided into managed (reservoirs) and unmanaged (natural rivers and lakes) wetlands. Samoa's wetland category includes rivers, lakes (including dams), and other types like swamps and mangroves.
It is important that a mangrove forest is a specific type of forest made up of mangrove trees, while mangroves in wetlands can be found in various wetland areas and play important roles in those ecosystems. As there may be some wetlands areas which have mangrove vegetation but do not meet the mangrove forest definition, which can then be classified as wetlands.

2.3. REDD+ Activities Definition

Reducing emissions from Deforestation: The conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10% threshold (FAO, 2007).

Reducing emissions from Forest Degradation: The long-term reduction of the overall potential supply of benefits from the forest, which includes carbon, wood, biodiversity and other goods and services (FAO, 2007), whilst maintaining a tree canopy cover above 10%. For the historical annual land use and forest cover change assessment, forest degradation is the result of different types/drivers of forest disturbance.

Enhancement of Forest Carbon Stocks: The creation or improvement of carbon pools and reservoirs and their ability to sequester and capacity to store carbon. A key component of the REDD+ strategy, it includes forest management activities such as restoring existing but degraded forests and increasing forest cover through environmentally appropriate afforestation and reforestation.

3. Scope

The FREL/FRL's scope is set in terms of the REDD+ activities, the carbon pools and the greenhouse gases included in the FREL/FRL.

3.1. REDD+ Activities

There are five REDD+ activities as shown in Figure 3-1.
The REDD+ activities covered in this FREL/FRL are:

- Deforestation
- Forest degradation
- Enhancement of forest carbon stocks

The REDD+ activities not currently covered for this FREL/FRL are:

- Sustainable management of forests
- Conservation of forest carbon stocks

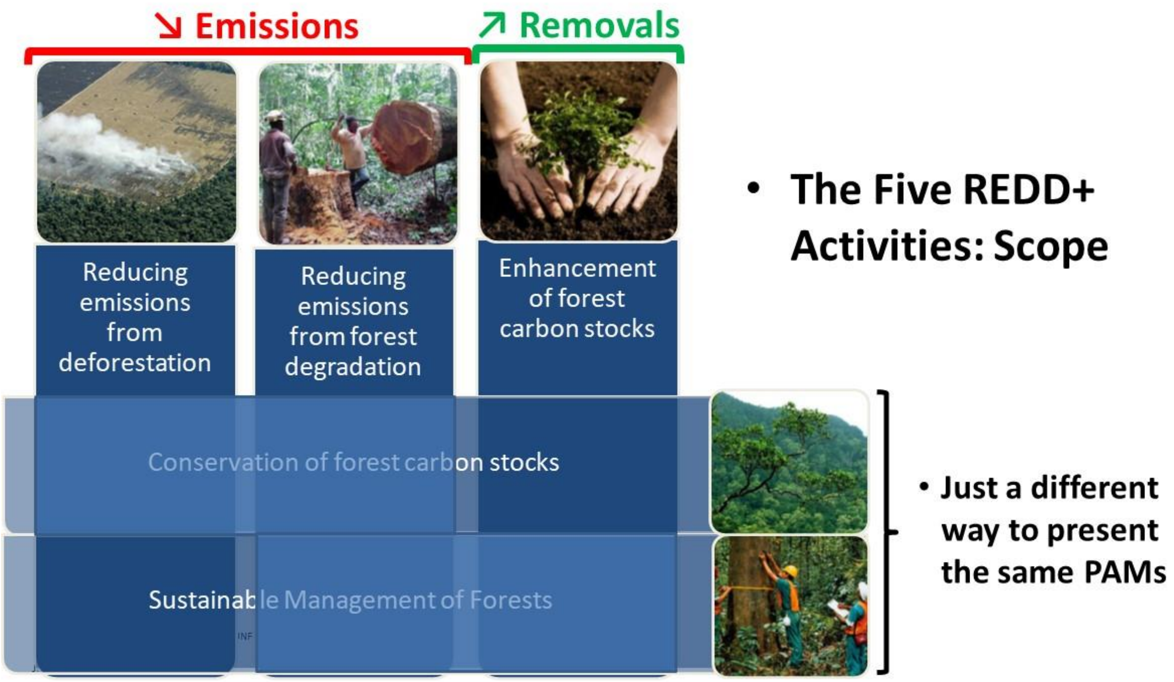

Figure 3-1: The Five REDD+ Activities: Scope (Source: Reference: South-South Learning): "The FRL Assessment Process in Asia and the Pacific "Pokhara, Nepal, April 2017

By including deforestation, degradation and carbon stock enhancement, all the activities resulted in the area changes are covered. As results of conservation or sustainable management of forest land, reducing deforestation or degradation might be implemented and they will be measured.

Regarding enhancement of forest carbon stocks, the MNRE's Forestry Division has conducted replanting campaigns since 2015, aiming to restore Samoa's forests after a decline caused by climate change, infrastructure, and the 2009 tsunami. The ongoing Three Million Trees campaign builds on the success of the One and Two Million Trees initiatives. As of 2020, over 2 million trees were planted by various groups, including school children, community-based organizations, NGOs, sports enthusiasts, and other stakeholders. Given the government's commitment to environmental priorities, such as reducing carbon emissions, carbon stock enhancement is integrated into REDD+ activities. Samoa is currently rolling out its Three Million Trees campaign.

Efforts for sustainable management of forests and conservation of forest carbon stocks focus on accumulating carbon in existing forests, particularly those managed sustainably. While current data lacks estimates (no boundaries available), Samoa aims to incorporate them in future updates to the Forest Reference Emission Level / Forest Reference Level (FREL/FRL).

3.2. Carbon Pools

The carbon pools covered in this FREL/FRL are:

- Above-ground biomass
- Below-ground biomass

The carbon pools not currently covered in this FREL/FRL are:

- Litter
- Deadwood
- Soil-organic carbon

The 2006 IPCC Guidelines provide methods for estimating deadwood, litter, and soil organic carbon in the context of land-use changes. For deadwood, these estimates are essential for deforestation and carbon stock enhancement, but Samoa lacks country-specific data for reliable estimation. Deadwood, also an essential carbon pool in degraded forests but deadwood remains unaccounted for in Samoa's Forest Reference Emission Level / Forest Reference Level (FREL/FRL), as specific carbon stock values seams not reliable (the NFI values of AGB is much smaller than IPCC default and regional example in PNG).

Similarly, litter, treated similarly to deadwood in the IPCC guidelines, has default carbon stock values only for specific forest types. Samoa does have country-specific values for its forest land use classes from the NFI 2013 study but will not include litter in national emission calculations for the FREL/FRL as the same reason with the deadwood. Deadwood and litter are considered non-tree biomass.

Soil organic carbon, affected by land-use changes, particularly from Forest Land to Cropland, may be essential emissions potential. There are also soil organic carbon (SOC) data from the past NFI data in 2013 but the value of SOC was much larger than the value of AGB+BGB (about 4-5 times larger) which needs further investigation. Therefore it is currently unfeasible to estimate emissions accurately and Samoa excludes soil organic carbon from the FREL/FRL, with hopes of incorporating it in the future, pending advancements in technology and technical capabilities at the national level.

Which IPCC default values were used is explained in 6.1.3 Application of IPCC guidelines. IPCC default values are used for all the classes but which values to use and how to use are considered in contexts of Samoa and refereed to the data of NFI 2013.

3.3. Greenhouse Gases (GHG)

Carbon dioxide (CO_2) is the only GHG included in this FREL/FRL. The emissions from non-CO2 GHG are not included in the FREL/FRL because the reliable data is lacking and also, they are likely insignificant. In principle, these would occur due to burning during the forest degradation, drainage of organic soils upon deforestation and mineralization of carbon after deforestation. There are not so many fires in Samoa (at least no large scale), also there are almost no livestock industry (at least no large scale). There is no reliable data of distribution of organic soil and their drainage, which could cause CH4 and N2O emissions. Considering the situation, it is considered that non-CO2 GHGs are not significant although there are no quantitative estimation.

4. Scale

The Government of Samoa recognizes the significant threats posed by climate change and emphasizes the crucial role of forests in mitigating and adapting these challenges. To address this, Samoa places a key focus on REDD+ at the national level, prioritizing the reduction of emissions from the forest sector. In alignment with this commitment, Samoa has opted to develop its first Forest Reference Emission Level / Forest Reference Level (FREL/FRL) on a national scale. The monitoring and measurement of all REDD+ initiatives will be facilitated through the integration of geographical information system (GIS) and remote sensing technologies such as the Open Foris tools (Collect Earth, SEPAL, etc). These tools have been introduced to the existing national agencies, particularly the Forestry Division with the ongoing strengthened support on building national capacity provided by FAO. This strategic approach aims to align with the country's policy directions and provide essential guidance for the formulation of effective forest policies.

Prior to the utilisation of the Open Foris tools used for the assessment of this FRL, Samoa utilized Very High Resolution (VHR) satellite imagery from QuickBird and WorldView, along with airborne data provided as grant aid by the Japan International Cooperation System (JICS). The MNRE Forestry Division is currently using MapInfo, which was instrumental in updating SamFRIS 2013. The new tool does not replace the older ones, allowing MNRE to continue using them for routine work. Instead, it enhances their ability to conduct consistent land use assessments and monitoring.

5. Reference Period

Following extensive two stakeholder consultations in October 2023, it was collectively decided that Samoa's preferred reference period for its inaugural FREL/FRL submission would span from 2013 to 2022, covering a decade. This period was chosen due to the availability of the most reliable national land use data, quality of available satellite imagery, and international trend of reference period for FREL/FRL.

While Samoa selected the reference period of 2013-2022, they provided information and data for the years 2000-2022 because the reference period had not been decided when the land use assessment began. The recent trend for FREL/FRL reference periods has focused on recent years, typically covering 10 or even 5 years. Samoa opted for a 10-year period but chose to assess all available data since 2000 to ensure a comprehensive understanding of land use changes and trends over a longer timeframe.

The latest available national land cover/ land use data is Samoa's National Land Cover Map (NLCM) 2013. The NLCM 2013 was developed when MNRE conducted NFI in 2013 based on the GIS based database (SamFRIS) using 1999 aerial photos, with high resolution satellite imagery (QuickBird). But it is difficult to conduct the same assessment with consistent manner over the considered reference period so these information use as reference information.

The primary data sources for this assessment are satellite imagery (Landsat 7 & 8 and Sentinel 2 imagery), reflecting Samoa's commitment to utilizing the advanced and improved satellite technology over the past decade (such as Google Earth Engine etc). The satellite imagery, consistent and accurate since the launch of Landsat 8 in 2013, provides reliable land use change data from 2013 onwards.

The reference period submitted by the other countries to UNFCCC vary, depending on the countries context and available data. But the shorter reference period and frequently updating it recommended recently in the latest REDD+ carbon financing standards such as GCF Scorecard (over 20 years is fail), FCPF Carbon Fund Methodological Framework (10-15 years), and ART-TREES Standard (5 years).

Despite the potential influence of recent REDD+ activities on greenhouse gas emissions in the Land Use, Land-Use Change, and Forestry (LULUCF) sector, investigating the impact requires additional time. However, it is unlikely that REDD+ interventions is represented by the data up to 2013. The selected period, 2013-2022, is considered the most appropriate historical reference for predicting future emissions, serving as the initial baseline for Samoa's efforts.

6. Emission and Removal Factors Estimate

An emission factor (EF) serves as a coefficient to measure emissions per unit of activity. Estimating emissions and removals from forest land involves multiplying the EF by activity data (AD), which indicates the extent of human activities. The IPCC (2006) offers three tiers for developing greenhouse gas (GHG) emissions and removals, with each tier representing increasing levels of expected accuracy of emission factors. The choice of tier depends on a country's data availability and capacity:

- Tier 1: Default EF provided through the Emission Factor Database or IPCC Guidelines, recommended as feasible for all countries.
- Tier 2: Country-specific EF or non-default factors, including EF from the Emission Factor Database if specific for the country.
- Tier 3: Advanced methods using models and inventory measurement systems tailored to national circumstances, driven by high-resolution activity data.

After thorough stakeholder consultations in October 2023, it was decided to consider the Tier 2 method for Samoa's Forest Reference Level (FRL) due to the availability of country-specific EF from its 2013 National Forest Inventory (NFI) study. However, investigation into the NFI data revealed inconsistencies, leading to the consideration of IPCC default values for certain aspects. The challenge arises from the much smaller values compared to the IPCC default and regional values in the 2013 NFI study.

For example, AGB of “Closed Forest” can be taken from 2006 IPCC GL, Table 4.12 & 4.4 “Tropical rain forest”, whose value is 300(t/ha). The value of Carbon (t/ha) of NFI 2013 is 45.10(t/ha) then calculated back to AGB is 70.4(t/ha). This is the similar size with IPCC default value of grassland and much smaller than other regional value of PNG (223t/ha).

Therefore, it was concluded that the further investigation and analyses is necessary. Considering the situation, the EF used for this FREL/FRL is Tier 1, using the biomass data with default values of IPCC for forest land use classes.

To estimate the EF for Samoa, the following steps were taken:

- Stratify the forest in Samoa using the national forest definition and land use categories
- Review existing Samoa data to identify country-specific carbon stock for each forest stratum and other land use.
- Refer to the IPCC Guidelines (2006) to determine appropriate default values for carbon stock when country-specific data is unavailable or insufficient.

The subsequent sections provide detailed descriptions of each step in this process.

6.1. Forest Stratification

6.1.1. Forest stratification in Samoa

Samoa's natural forest is categorized into six land use class types and stratified based on canopy cover percentage, as outlined in Table 6-1. The stratification is defined by the forest criteria stated in Section 2, which specifies a minimum land area of 1 ha, a minimum tree height of 5, and a minimum canopy cover rate of 10% for classification as forest in Samoa. Given that the assessment relies on satellite imagery and remote sensing with limitied ground truthing, this stratification results in five forest land use classes based on canopy cover percentage.

The Samoa assessment team conducted some ground truth surveys using drones to foster a common understanding among the interpreters. However, these surveys were not planned and implemented comprehensively or with statistically valid levels due to budget and human resource constraints. Samoa proposes to conduct a comprehensive ground truth survey as an area for improvement based on this FREL/FRL.

Apart from the natural forest, there are also forest plantations. In total, the forests in Samoa are stratified into six strata, as detailed in Table 6-1.

Table 6-1: Forest land use types for Samoa (by Category, Sub-type and Class).

IPCC category	Sub-type	Class
Forest land	Natural Forest	Mangrove Forest
		Closed Forest
		Medium Dense Forest
		Open Forest
		Secondary Forest
	Plantation Forest	Forest Plantation

6.1.2. Review of above ground biomass

Above ground biomass of a unit forest area of each forest type and different type of disturbances needs to be estimated to calculate emissions from deforestation and forest degradation. Samoa had collected this information as part of its National Forest Inventory (NFI) in 2013 of each forest strata or forest land use class at national level.

It is important to note that during the two stakeholder consultations in October 2023, it was collectively considered to utilize the Tier 2 method for this Forest Reference Emission Level / Forest Reference Level (FREL/FRL) since Samoa possesses country-specific Emission Factor (EF) data from its 2013 NFI study. However, upon investigating the Samoa NFI data, it turned out that using Global Data (IPCC default values, considering Samoa's context) might be more appropriate.

This shift is prompted by significant disparities between the values of Samoa NFI and regional values, leading to inconsistencies, such as the size of various land use categories (FC, FM, FO, FS, and FP) in different regions (e.g., FO in Upolu being the largest, FP in Upolu being small in Upolu but significant in Savaii, and FS in Upolu being larger than FC and FM). Notably, the value of the mangrove forest in the NFI report is not derived from a survey in Samoa but from research literature in the region and the value is much larger than the value of FC.

A challenge with the 2013 NFI study results is the ambiguity about whether the values pertain to Carbon or Biomass. Upon thorough examination, when substituting the NFI results, it was observed that using Samoa NFI values as biomass yielded a forest value smaller than the global values for cropland and grassland. Alternatively, when applying the Samoa NFI values as carbon, the forest value remained similar in size to grassland, and the mangrove value needed to be used for biomass.

Other pacific islands countries, like Papua New Guinea (PNG) and the Solomon Islands, have utilized IPCC default values for calculating emission factors (PNG uses their country's specific values for certain forest types). Samoa will consider drawing from these experiences, tailoring them to its national context, particularly considering Samoa's ecological and climate zone.

6.1.3. Application of IPCC guidelines

The IPCC Guidelines (2006: Table 4.1) present above-ground biomass per unit forest area for each Global Ecological Zone described by FAO (2001), detailed in Table 6-2. To estimate biomass for each land-use stratum, understanding Samoa's climatic and ecological zoning is crucial. Extracting information from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 4, Forest land, Table 4.1, Samoa's forest land use classes, primarily classified as Tropical, utilize Tropical rain forest (Tar) for forest strata and Tropical shrubland (TBSh) for shrubland in the FREL/FRL.

Table 6-2: Summary of Climate Domains and Ecological Zone (FAO 2001) relevant to Samoa
(from 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 4, Table 4.1).

Climate domain	Ecological zone

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

Grassland data is derived from Table 3.4.2 in the 'Good Practice Guidance for LULUCF.' For Cropland, specifically the Mixed Crop land use class, the climatic zone is set to 'Tropical Moist', this information is extracted from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 4, Chapter 5, Cropland, Table 5.1.

The default values from the IPCC Guidelines for above-ground biomass in the associated Ecological Zone were utilized for all other forest types, as outlined in Table 6.2. Additionally, the root-to-shoot ratio and carbon fraction from the IPCC guidelines (2006) were applied to estimate below-ground biomass and carbon contents for both above and below-ground biomass (refer to Table 6.3). Table 6.4 and Table 6.5 presents Samoa NFI values as biomass and, alternatively, as carbon (this is probably correct understanding, considering the size).

It is recommended for Samoa to update all its Emission Factors associated with the relevant carbon pools for its five forest land use classes in the next National Forest Inventory (NFI) assessment. This update will serve to validate and address any ambiguities especially when the NFI 2013 study results (as shown in Table 6.4 and Table 6.5) were compared to regional values and IPCC global default values.

Once more, it is crucial to highlight that the emission factor (EF) applied in FREL/FRL is Tier 1, utilizing biomass data along with the default values provided by IPCC for forest land use classes (Table 6-3).

Table 6-3: Above ground biomass calculations using IPCC guideline default values

IPCC Land use	Class	Above-ground biomass			
		Source (Calculation)	IPCC Ecological Zone	Dry matter (t/ha)	Root-to-shoot ratio
Forest (primary)	Mangrove Forest	2006 IPCC GL: Wetlands, Table 4.2 & 4.5	Tropical wet	192	0.49
	Closed Forest	2006 IPCC GL, Table 4.12 & 4.4	Tropical rain forest	300	0.37
	Medium Dense Forest	Calculated based on Canopy Cover percentage of FC and FM (FC * ((70+40)/(100+70)	Tropical rain forest	194	0.37
	Open Forest	Calculated based on Canopy Cover percentage of FC and FO (FC * ((40+10)/(100+70)	Tropical rain forest	88	0.37
	Secondary Forest	Aapplied ratio of growing stock reported in FRA2020: FS/FM =	Tropical rain forest	166	0.37

		62.3/72.9 based on SamFRIS 2003 and 2013			
	Forest Plantation	2006 IPCC, Table 4.12	Tropical rain forest	150	0.37

Table 6-4: Above ground biomass calculations, with Samoa NFI values as biomass

IPCC Land use	Class	Above-ground biomass			
		Source (Calculation)	**IPCC Ecological Zone**	**Dry matter (t/ha)**	**Root-to-shoot ratio**
Forest	Mangrove Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical wet	208.39	0.49
	Closed Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	32.92	0.37
	Medium Dense Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	26.17	0.37
	Open Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	19.21	0.37
	Secondary Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	33.64	0.37
	Forest Plantation	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	57.02	0.37

Table 6-5: Above ground biomass calculations for Samoa forest, with Samoa NFI values as carbon

IPCC Land use	Class	Above-ground biomass			
		Source (Calculation)	**IPCC Ecological Zone**	**Dry matter (t/ha)**	**Root-to-shoot ratio**
Forest	Mangrove Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical wet	208.39	0.49
	Closed Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	70.04	0.37
	Medium Dense Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	55.68	0.37
	Open Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	40.88	0.37
	Secondary Forest	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	71.58	0.37
	Forest Plantation	National Forest Inventory Report, 2014, JICS, MNRE	Tropical rain forest	121.32	0.37

In addition, the above ground biomass and carbon stock in degraded forests had to be estimated but there is no reliable data in Samoa for this estimation of degraded forest stock. Therefore, Samoa reviewed and considered to use the regional data in Papua New Guinea (PNG).

Fox et al. (2010) reported the average of above ground biomass of primary lowland tropical rainforest in PNG as 222.8 t/ha based on ten 1 ha permanent sample plots (PSP) managed by PNG Forest Research Institute (FRI). Fox et al. (2010) also reported 146.0 t/ha as the average of 115 1-ha PSP plots across the country for AGB of logged over lowland tropical rainforest. The percentage reduction from primary forest to degraded forest was estimated at 146/223 (65.47%) and it was used for their 1st and 2nd Forest Reference Level.

Samoa used this percentage reduction based on PNG PSP to calculate above ground biomass of degraded forests in Samoa.

Table 6-6: Above ground biomass calculations for Samoa forest using IPCC guideline default values

IPCC Land use	Class	Above-ground biomass			
		Source (Calculation)	**IPCC Ecological Zone**	**Dry matter (t/ha)**	**Root-to-shoot ratio**
Forest (degraded)	Mangrove Forest	Primary forest AGB value multiply the percentage reduction of PNG (192*146/223)	Tropical wet	126	0.49
	Closed Forest	Primary forest AGB value multiply the percentage reduction of PNG (300*146/223)	Tropical rain forest	196	0.37
	Medium Dense Forest	Primary forest AGB value multiply the percentage reduction of PNG (194*146/223)	Tropical rain forest	127	0.37
	Open Forest	Primary forest AGB value multiply the percentage reduction of PNG (88*146/223)	Tropical rain forest	58	0.37
	Secondary Forest	Primary forest AGB value multiply the percentage reduction of PNG (166*146/223)	Tropical rain forest	109	0.37
	Forest Plantation	Primary forest AGB value multiply the percentage reduction of PNG (150*146/223)	Tropical rain forest	98	0.37

6.2. Carbon Stock Estimation

6.2.1. Carbon stock in forest land

The Samoa calculated the carbon of each forest strata, using the following formula based on IPCC guideline:

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

Where:

A is the forest stratum area in hectares
B is the unit total living biomass in tons per hectare
C is the carbon stock in tons per hectare
R is the root-to-shoot ratio
CF is the carbon fraction (0.47 from 2006 IPCC guidelines)

6.2.2. Carbon stock in non-forest land

Above ground biomass were calculated per unit area of Samoa non-forest

Table 6-7: Above ground biomass calculations per unit area of Samoa non-forest

IPCC Land use	Class	Above-ground biomass			
		Source	**IPCC Ecological Zone**	**Dry matter (t/ha)**	**Root-to-shoot ratio**
Cropland	Plantations	2006 IPCC GL, Table 5.3 & 5.2 (Average of Coconut & SE Asia: Humid tropical: Agrosilvicultural = (196+120/2))		158	0.37
	Mixed Crops	2006 IPCC GL, Table 5.1	Tropical moist	45	0.00

Grassland	Scrub	2006 IPCC GL, Table 4.12 & 4.4	Tropical shrubland	70	0.40
	Grassland	Good Practice Guidance for LULUCF, Table 3.4.2	Tropical Moist & Wet	6	1.60
Other land	Barren land	0	0	0	0
Settlements	Built-Up area	0	0	0	0
	Infrastructure	0	0	0	0
	Wetlands	0	0	0	0
Wetlands	Rivers	0	0	0	0
	Lakes	0	0	0	0
	Sea/Ocean	0	0	0	0

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

The relative areas of different land-use types after deforestation are the starting point for calculating post-deforestation biomass and its growth. The IPCC guidelines include default values for biomass and the growth duration, which allows to recover mean annual increments for these.

Table 6-8: Above-ground biomass and mean annual increment of cropland and grassland

Item	Unit	Post-Deforestation Land Use				
		Plantation	Mixed Crops	Scrub	Grassland	Other Non Forest
Relative area	%	17.5	20.9	15.6	27.1	18.9
Above-ground biomass (AGB)	t d.m.	158	45	70	6.2	0.0
Root-Shoot ratio	BGB/AGB	0.37	0.00	0.40	1.60	0.0
Source		Table 5.3, IPCC 2006	Table 5.1, IPCC 2006	Table 4.12, IPCC 2006	Table 3.4.2, GPF LULUCF	-
Growth duration	years	20	8	-	-	-
Mean Annual Increment (MAI) in AGB	t.d.m./yr	7.90	5.59	1.0	0.0	0.0

Note: The average mean annual increment in living biomass 2.71 t.d.m./yr/ha, based on a weighted mean of the mean of the annual increments in above-ground biomass and a root-to-shoot ratio of 0.56.

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

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

6.3. Emissions and Removals

6.3.1. Calculation of emission and removal factors

The Emission Factors for emissions in the Samoa forest land use classes are as follows:

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

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

Table 6-9: Emission factors for deforestation of primary, degraded forest and forest degradation

IPCC Land use	Class	Emission Factors ($tCO_2e/ha/yr$)		
		Deforestation (primary forest)	Deforestation (degraded forest)	Forest degradation
Forest	Mangrove Forest	473.1	309.7	163.4
	Closed Forest	708.3	463.7	244.6
	Medium Dense Forest	458.3	300.1	158.2
	Open Forest	208.3	136.4	71.9
	Secondary Forest	391.7	256.4	135.2
	Forest Plantation	354.1	231.9	122.3

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

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

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

For carbon stock enhancement, this calculation was carried out for plantations, since these were the only areas where conversion from non-forests to forests was observed. The removal factor amounts to 25.85 $tCO_2e/ha/yr$, based on a default increment of 15.0 t.d.m./ha/yr, and conversion factor of 1.72 (0.47*44/12), as per the 2006 IPCC guidelines (Table 4.12 Above ground net biomass growth in forest plantation: tropical rain forest.

Table 6-10: Removal factors for carbon stock enhancement

RF carbon stock enhancement	Increment	t d.m. /ha /yr	15.00
	Conversion	tCO_2e /t d.m.	- 1.72
	Removal factor (Increment*Conversion)	tCO_2e /ha /yr	- 25.85

Although Removal Factor (RF) carbon stock enhancement was considered and prepared as explained above and in Table6-10, it was decided not to use this RF in Samoa's first FREL/FRL modified submission because the actual areas of forest plantation is not available, instead to use simple Emission Factor (carbon stock value of forest minus non-forest carbon stock).

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

Table 6-11: Calculation of Average Mean Annual Increment (MAI) in AGB and BGB

Average MAI in AGB	t d.m. /ha /yr	2.71
Root-shoot ratio	BGB / AGB	0.56
Average MAI in AGB+BGB	t d.m. /ha /yr	4.23

The removal factor amounts to 7.28 tCO_2e/ha/yr, based on the value 4.23 t.d.m./ha/yr (Average MAI in AGB+BGB of Table 6-11 (4.23)), and conversion factor of 1.72 (0.47*44/12), as per the 2006 IPCC guidelines.

Table 6-12: Removal factors for post-deforestation regrowth

RF post-deforestation regrowth	Increment	t d.m. /ha /yr	4.23
	Conversion	tCO_2e /t d.m.	- 1.72
	Removal factor (Increment*Conversion)	tCO_2e /ha /yr	- 7.28

Values for post-deforestation land use types were derived from IPCC default values. The values of "cropping systems containing perennial species" were applied to four of Samoa's land use categories, "Plantation", "Mixed Crops", "Scrub", and "Grassland" based on the values from Table 6-8.

Table 6-13: Calculation of Average AGB and BGB in post-deforestation landuse

Average AGB in post-deforestation landuse	t d.m. /ha /yr	49.61
Root-shoot ratio	BGB / AGB	0.56
Average AGB+BGB in post-deforestation landuse	t d.m. /ha /yr	77.42
Average AGB+BGB in post-deforestation landuse	tCO_2 / ha / yr	133.42

6.3.2. Calculation of emissions and removals

The emissions and removals are calculated as follows:

Emissions and Removals = Emission and Removal Factor x Activity Data

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

For deforestation, the emissions from deforestation, as well as the removals from post-deforestation regrowth need to be considered. For forest degradation, the emissions from forest degradation are calculated using the equation above.

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

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

7. Land Use, Land Use Change and Forestry

7.1. Assessment Methodology

7.1.1. Assessment Overview

The activity data used for this FREL/FRL was developed through Land Use, Land Use Change and Forestry (LULUCF) assessment utilizing the remote sensing point-sampling method, employing Open Foris Collect Earth as a data collection platform for the land use change and forest assessment. Collect Earth played a crucial role in collecting specific information and attributes related to land use change and forest characteristics, ensuring the accuracy and comprehensiveness of the assessment data. The tool utilized satellite imagery from sources such as Google Earth and Bing Maps to identify LULUCF for the sample points.

Across Samoa, a total of 1310 training data points (sampling plots) were selected, representing six land use categories and 16 land use classes. To conduct the assessment, analysts accessed archived satellite imagery through various web mapping services, including Google Earth, Google Earth Engine, Bing Map, NICFI Planet Imagery, and OpenForis Earth Map. Additional information and datasets, such as Samoa's National Land Cover Map (NLCM) 2013, were used to assist interpreters in making precise judgments about land use activity.

The assessment was carried out by nine operators from Samoa's Ministry of Natural Resources and Environment (MNRE), with six operators from the MNRE Forestry division and three from the MNRE's Spatial Information Agency - Technical Services Division. Operators initially worked on the plots from some of forest strata (310 plots), followed by plots generated using SEPAL's Stratified Area Estimator-Design Tool (1000 plots), divided into two rounds. Each operator was assigned a specific set of plots.

Before the assessment, operators received comprehensive training on the tools used, the purpose behind them, and how to effectively utilize them, including hands-on practice with Collect Earth, Google Earth, and Google Earth Engine. The training covered critical interpretation skills related to land use conversion and forest disturbance. Three rounds of assessments were conducted to enhance operators' familiarity and expertise, minimize bias, and provide a systematic approach for data quality assurance and control, aligning with IPCC-Guideline’s concepts and methodologies. Two training sessions and three rounds of assessment were conducted over six months from March to August 2023. It is important to note that during the assessment activities, the operators discussed complex plots, particularly those with mixed land use, as a team to ensure consistency across the assessment exercise.

In terms of forest degradation methodology, Samoa estimated forest degradation by assessing areas identified as remaining forest and focusing on visible disturbances. This methodology involves using high-resolution satellite imagery and time series data on tree cover loss. Interpreters scrutinize these satellite images to detect changes in forest cover, particularly looking for disturbances such as logging, land conversion, or natural events that degrade forest integrity. The interpreters use the key features (Table 7-6) and local knowledge of the land for assessing the disturbance type. By comparing images over time, they can quantify the extent of degradation. The assessment combines visual interpretation with automated techniques, specifically utilizing Saiku, which analyzes the data to accurately detect and measure changes in forest areas. More details on the quantitative method used to identify forest areas that were accounted as degradation are in Annex 1: Section 2.4.1. Assessment Methodology in Subsection (f) Forest Disturbance / Impact Assessment.

In terms of enhancement of forest carbon stock, Afforestation/Reforestation is assessed for non-forest area converting to forest land, using high resolution satellite (Google or Bing) and time series of satellite (cloud free Landsat) in the area. NMRE officers also aware of the areas of plantation campaign in general so use the local knowledge for interpretation.

Samoa did not prepare a Standard Operating Procedure (SOP) for this FRL assessment however this is considered Samoa's second FRL submission. Samoa plans to produce a Standard Operating Procedure in preparation for future FRL to guide present and future assessments especially for Deforestation and Degradation using visual interpretation to ensure consistency.

Figures 7-1 and 7-2 illustrate the process of the land use, land use change and forestry assessment.

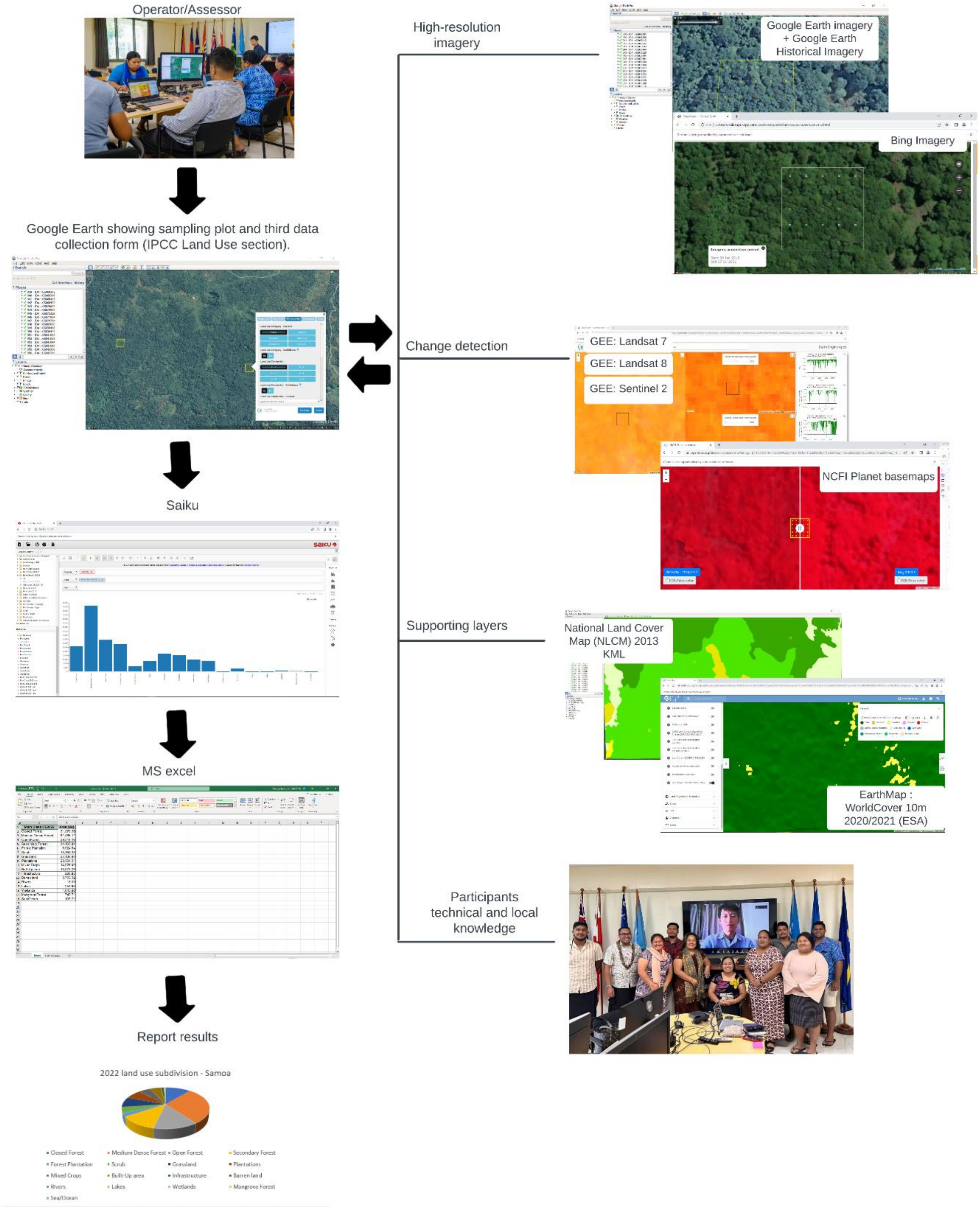

Figure 7-1: Illustration of the land use, land use change and forestry assessment.

Regarding disturbance assessment, Stable forest have two types, Stable Forest (Primary), which are no disturbance during the periods and Stable Forest (Secondary), which had disturbance before and continues. All the Forest plots (and some other type) need to go to Forest Disturbance assessment.

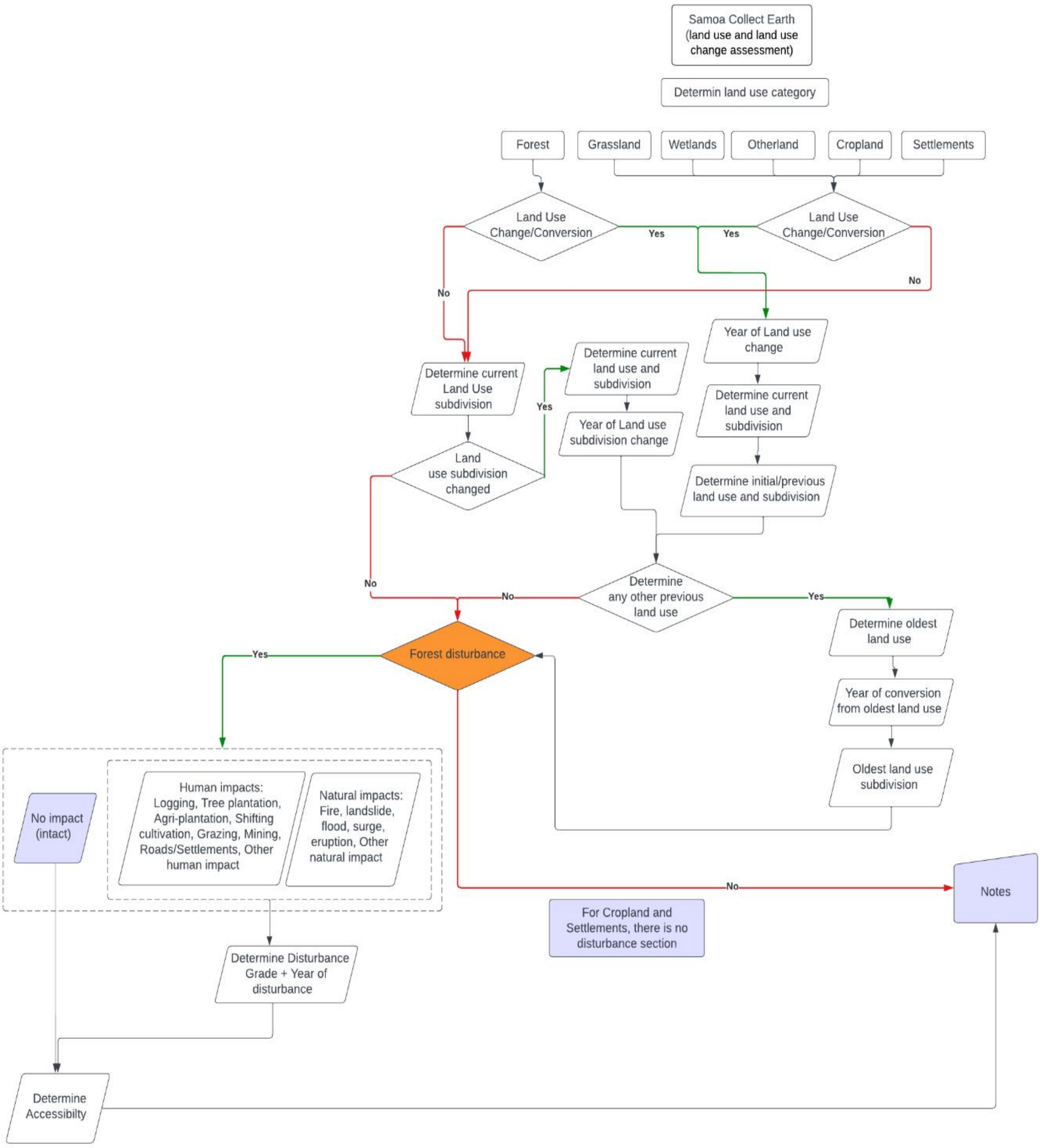

Figure 7-2: Overall steps of the land use and land use change assessment.

7.1.2. Data Sources

(a) Satellite Imageries

This assessment heavily relied on satellite imagery, also known as Earth observation imagery or space-borne photography. These images of Earth are captured by imaging satellites operated by governments and large commercial companies worldwide. To conduct the assessment, the analysts accessed archived satellite imagery through various web mapping services, including Google Earth, Google Earth Engine, Bing Map, NICFI Planet Imagery, and Open Foris Earth Map. Table 7-1 provides detailed information about the satellite imagery utilized in the assessment.

Table 7-1: Satellite imagery, source, type, year and purpose.

Source	Imagery type	Resolution	Acquisition Year	Purpose
Google Earth	World-View, QuickBird, IKONOS, SPOT, Landsat etc.	High (0.5-2.5m) Low (30m)*	1999-2022	Land cover, land use change and disturbance
Bing Maps	World-View, QuickBird, IKONOS, SPOT, Landsat etc.	High (0.5-2.5m) Low (30m)*	1999-2022	Land cover, land use change and disturbance (used as a second reference)
Google Earth Engine	Landsat 5, 7, 8 and 9	Low (30m)	Landsat 5 (1984-2013), Landsat 7 (1999-), Landsat 8 (2013–), Landsat 9 (2022-)	Historical land use change and Check Current Situation (using NDVI, etc)
	Sentinel 2	Low (10m)	2015-2022	Check Current Situation
NICFI Planet Imagery	Planet Scope - Doves, SkySats, and RapidEye.	Low (3-5m) need to confirm products	2015-2022	Check Latest Situation
Earth Map	Landsat 5, 7, 8, 9 and Sentinel 2	Low (10-30m)	2020 and 2021	Check land cover (e.g. WorldCover 10m 2020/2021 (ESA) – under Land Cover / Land Use)

* High resolution images are available for coastal areas but often only low-resolution images are available inner land and mountainous areas

(b) Existing Data in Samoa

The assessment also used ancillary information. To assist the interpreters in making precise judgments about the type of land use activity, the assessment utilized additional information sourced from nationally developed datasets. One such dataset used was the National Land Cover Map (NLCM) 2013.

Samoa's NLCM 2013 was developed as part of the update for the Samoa NFI in 2013, the NLCM was created by digitizing land use information obtained from WorldView satellite images. The NLCM provides coverage for six forest types and ten non-forest classes, as detailed in Table 7-2.

Table 7-2: Land Cover Classes in NLCM 2013

Long form	Code	Type
Mangrove Forest	M	Forest
Closed Forest	FC	Forest
Medium Dense Forest	FM	Forest
Open Forest	FO	Forest
Secondary Forest	FS	Forest
Forest Plantation	FP	Forest
Scrub	SC	Non-forest
Plantations	P	Non-forest
Mixed Crops	MC	Non-forest
Grassland	G	Non-forest
Barren land	B	Non-forest

Built-Up area BU	BU	Non-forest
Infrastructure	I	Non-forest
Rivers	R	Non-forest
Lakes	L	Non-forest
Wetland	WL	Non-forest

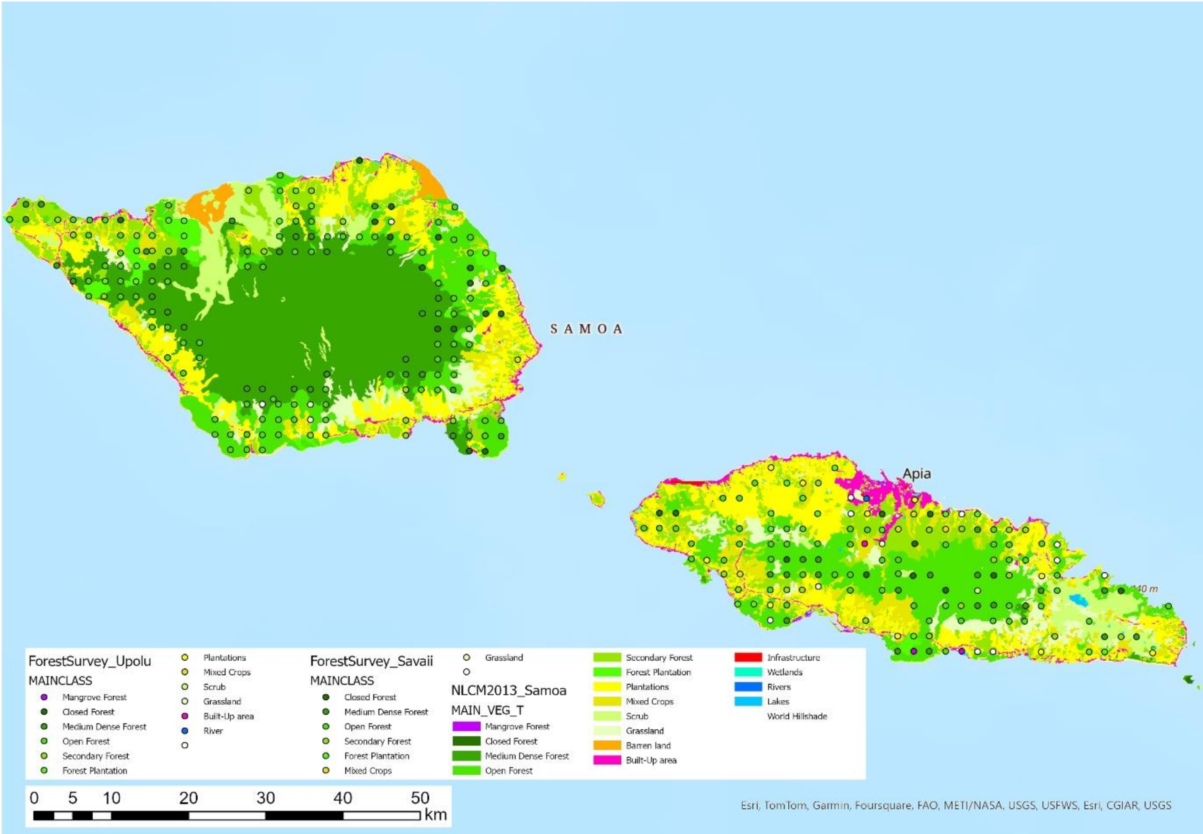

Figure 7-3: National Land Cover Map (NLCM) and NFI 2013

(c) Global Land Cover Data

The assessment also used global data as reference data for LULUCF assessment in Samoa. NLCM 2013 is great existing data in Samoa but it is the data developed almost ten years ago. Therefore, global datasets freely available were reviewed to identify useful datasets for the new LULUCF assessment in Samoa. It concluded that there is only one global data useful (relatively new with good resolution) for the new LULUCF assessment in Samoa (The famous dataset such as Global Forest Change used in Global Forest Watch is not available in Samoa).

The European Space Agency (ESA) WorldCover 10 m 2021 product [5]provides a global land cover map for 2021 at 10 m resolution based on Sentinel-1 and Sentinel-2 data. The WorldCover product comes with 11 land cover classes that appropriately describe the land surface at 10m: "Tree cover", "Shrubland", "Grassland", "Cropland", "Built-up", "Bare / sparse vegetation", "Snow and Ice", "Permanent water bodies", "Herbaceous Wetland", "Mangrove" and "Moss and lichen".

[5] ESA's "Trees" definition is a canopy cover of 10% or more, but not considering minimum area and tree height. Canopy cover % is identical with Samoa's definition. The details can be find here (link).

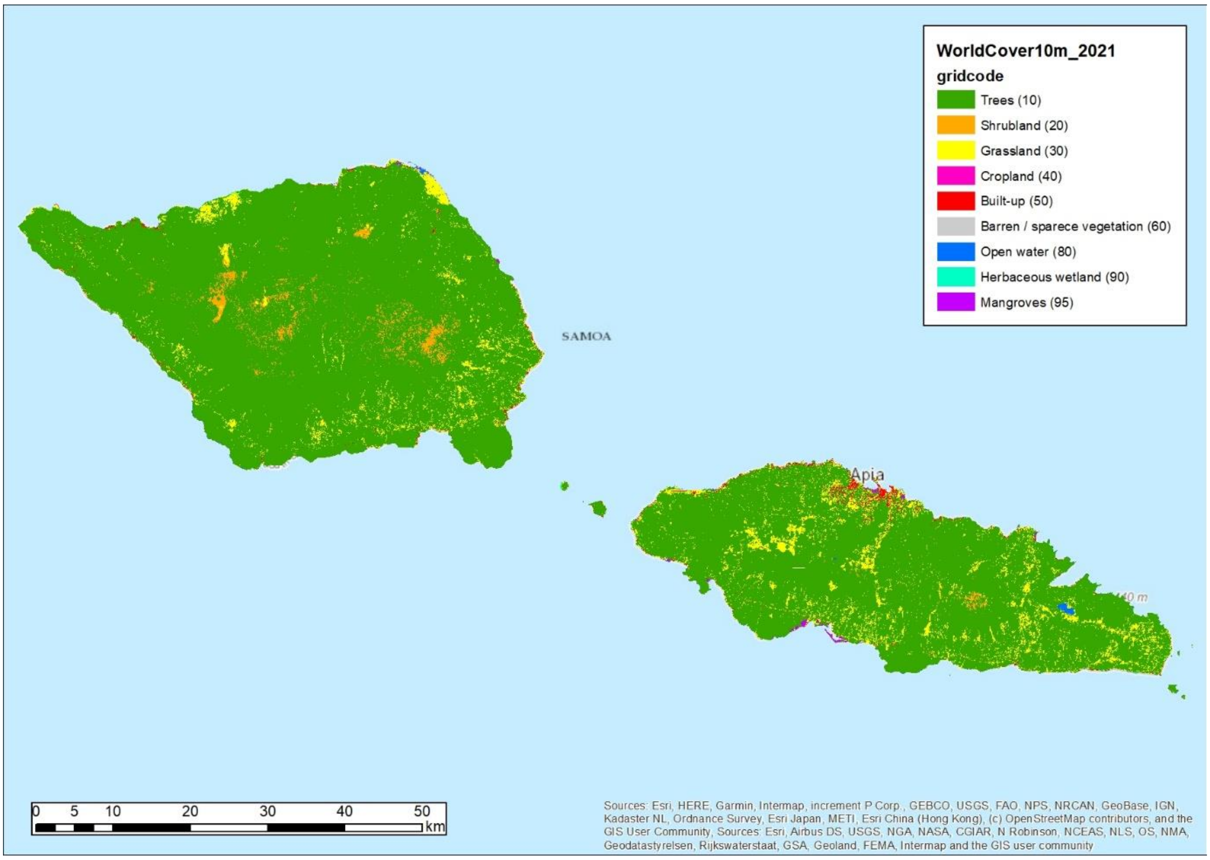

Figure 7-4: ESA WorldCover (10m) 2021

Although ESA WorldCover does not have detail classifications of forest (only one class: Trees, which also includes cropland) unlike NLCM2013, as land cover map classified by remote sensing, the accuracy of classification is generally good and reliable, Also, since the resolution of the product is relatively good (10m) based on Sentinel imagery, it will be useful and appropriate to use this data for reference data collection. But it should be noted that this is not land use data therefore cropland is not classified accurately.

7.1.3. Sampling Design

Considering international trend and recommendations for the methodology of area estimation, sample based area estimation was considered for the new LULUCF assessment in Samoa. Initially, systematic sampling approach was considered and the required sample size (number of samples) was estimated using ESA WorldCover 2021. As a result, even though a high density sampling (1x1km intervals with 2383 samples in total) was applied, for example, only 2 samples were distributed for Mangrove and it is not good enough for area estimation.

Therefore, stratified random sampling approach was considered using existing Samoa's NLCM 2013. But there were several challenges in the NLCM 2013 to use for the stratified map for area estimation as follow; (1) The area of Closed Forest is only 72 ha in a small island of Upolu and not existing in Savaii, that is not true, (2) The area of Cropland (e.g. Plantations) contains the other land use areas including Forest Land. Considering these challenges, developing a new strata map was recommended.

To develop the new strata map, supervised classification was used. For supervised classification, training data needed to be prepared. For the training data preparation, three kinds of information were used; (1) Landsat 8 & 9 mosaic NDVI reclassified map for the forest classes (FC, FM, FO, and FS) (2) ESA WorldCover 2021 for mainly non-tree classes (SC, G, BU, I, WL, R, L, and M) and (3) NLCM 2013 of Samoa for land use classes (FP, P, MC, and B). About 100 samples were prepared per class.

The prepared training data was used in the supervised classification in SEPAL. The parameter and value used for satellite mosaic and classification are summarized in the table below. By this classification, the latest land cover map was developed but there are some errors due to the quality of the satellite mosaic (such as clouds, haze) so post classification process were applied. Detection of land use (such as plantation) are challenging by remote sensing so those areas were identified by referencing NLCM.

Table 7-3: Satellite Mosaic Parameter and Value in SEPAL

Category	Parameter	Value
AOI (Area of Interest)	Country	Samoa
	Buffer	1km
DAT (Date)	Past Seasons	5
	Future Seasons	0
	Target Date	Dec.31 2023
	Season	Jan. 01-Dec.31
SRC (Sources)	Date Sets	L9, L8, L8T2, L9T2
	Max Cloud Cover	90%
SCN (Scenes)	Scene Selection	Use All Scenes

Table 7-4: Classification Parameter and Value in SEPAL

Category	Parameter and Value
IMG (Images to Classify)	Earth Engine Asset
LEG (Legend)	Map Code from NLCM2013
TRN (Training Data)	CSV Samples prepared with LS2022 NDVI reclass, WorldCover 2021, NLCM2013
AUX (Ancillary Sources)	Terrain, Water
CLS (Classifier Config.)	Type: Random Forest, Number of Trees: 25, Others: Default

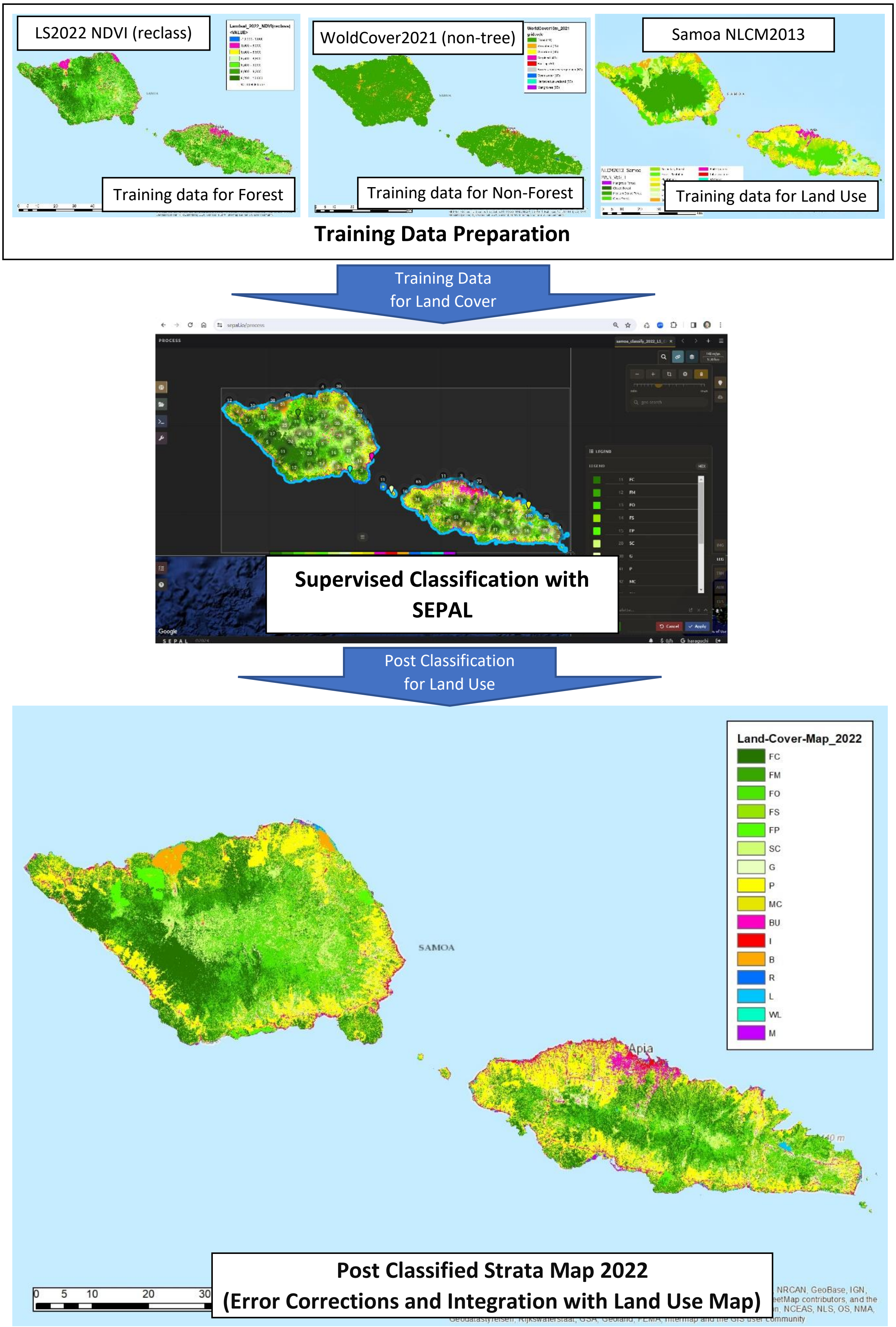

Figure 7-5: Training data preparation and supervised classification

The sample size was calculated using the formula (1), which is implemented in the SEPAL stratified area estimation or can be in the spreadsheet. The area of each stratum is based on the prepared strata map 2022. For the expected users accuracy, 90% is set for M, FC, FM, FO, FP, SC, G, B, BU, I, W, R, L, and SO, and 70% is set for FS, P and MC. The target SE (Standard Error) for overall accuracy was set 0.01. Total number of samples estimated was 1,307.

$$n = \frac{(\sum W_i S_i)^2}{[S(\hat{O})]^2 + (1/N)\sum W_i S_i^2} \approx \left(\frac{\sum W_i S_i}{S(\hat{O})}\right)^2 \qquad (1)$$

	M	FC	FM	FO	FS	FP	P	MC	SC	G	B	BU	I	W	R	L	SO	Total
Area in pixels	400	21,869	67,705	45,408	50,017	3,963	41,132	19,028	4,731	16,439	3,069	8,475	90	160	15	238	431	283,170
Wi (Mapped proportion)	0.14%	7.72%	23.91%	16.04%	17.66%	1.40%	14.53%	6.72%	1.67%	5.81%	1.08%	2.99%	0.03%	0.06%	0.01%	0.08%	0.15%	100.00%
Ui (Expected user's accuracy)	90%	90%	90%	90%	70%	90%	70%	70%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Si (Standard deviation)	0.30	0.30	0.30	0.30	0.46	0.30	0.46	0.46	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	
*Wi*Si*	0.00	0.02	0.07	0.05	0.08	0.00	0.07	0.03	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.36
															SE overall accuracy			0.01
															Total number of samples			1307

Figure 7-6: Sample size calculation with spreadsheet

Based on the estimated sample size above, 1310 sample plots were randomly distributed based on the prepared stratified map 2022 for LULUCF assessment plots in Collect Earth.

Table 7-5: The number of points per land use class

Land use class	Number of samples	Base Strata Areas (ha)
Mangrove Forest	68	1,182
Closed Forest	163	47,257
Medium Dense Forest	188	46,505
Open Forest	136	43,374
Secondary Forest	79	20,261
Forest Plantation	15	4,101
Plantations	206	50,474
Mixed Crops	74	18,247
Scrub	37	15,937
Grassland	123	19,265
Barren land	7	2,847
Built-Up area	91	9,012
Infrastructure	46	2,348
Wetlands	53	1,559
Rivers	17	525
Lakes	7	276
Total	1,310	283,170

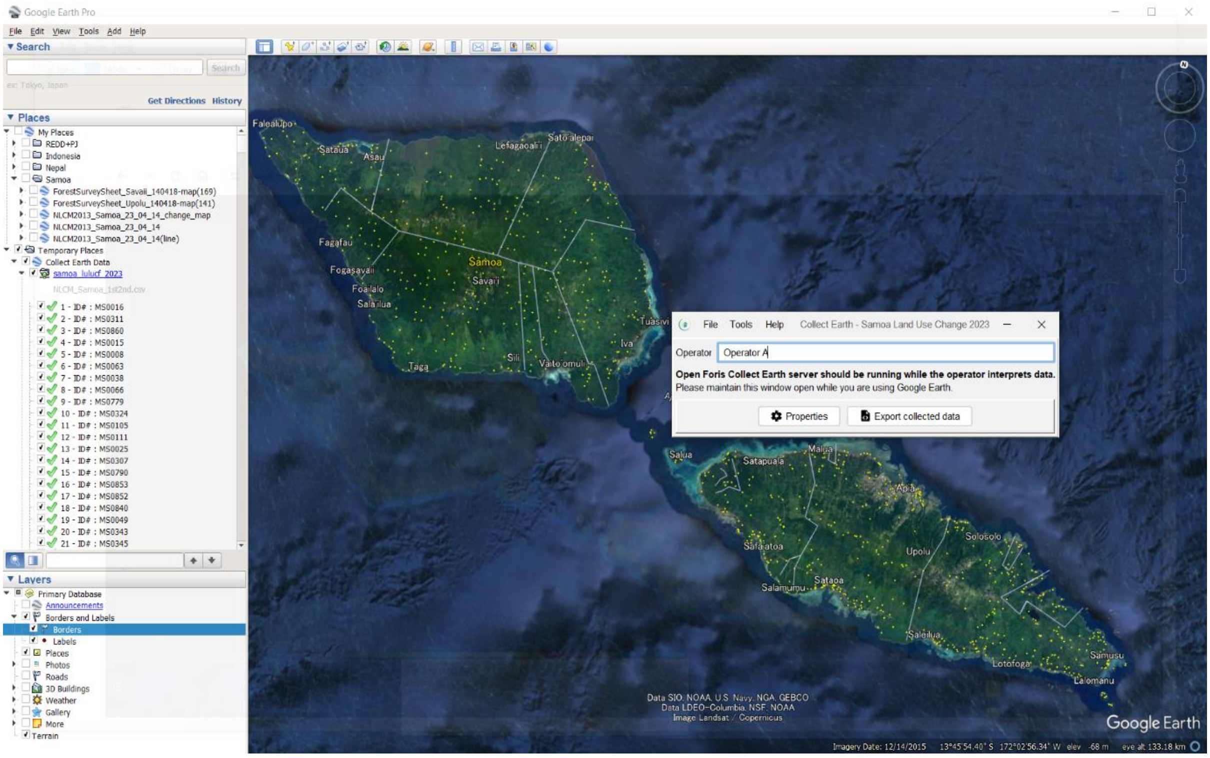

Figure 7-7: Distributed random sample plots in Collect Earth

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

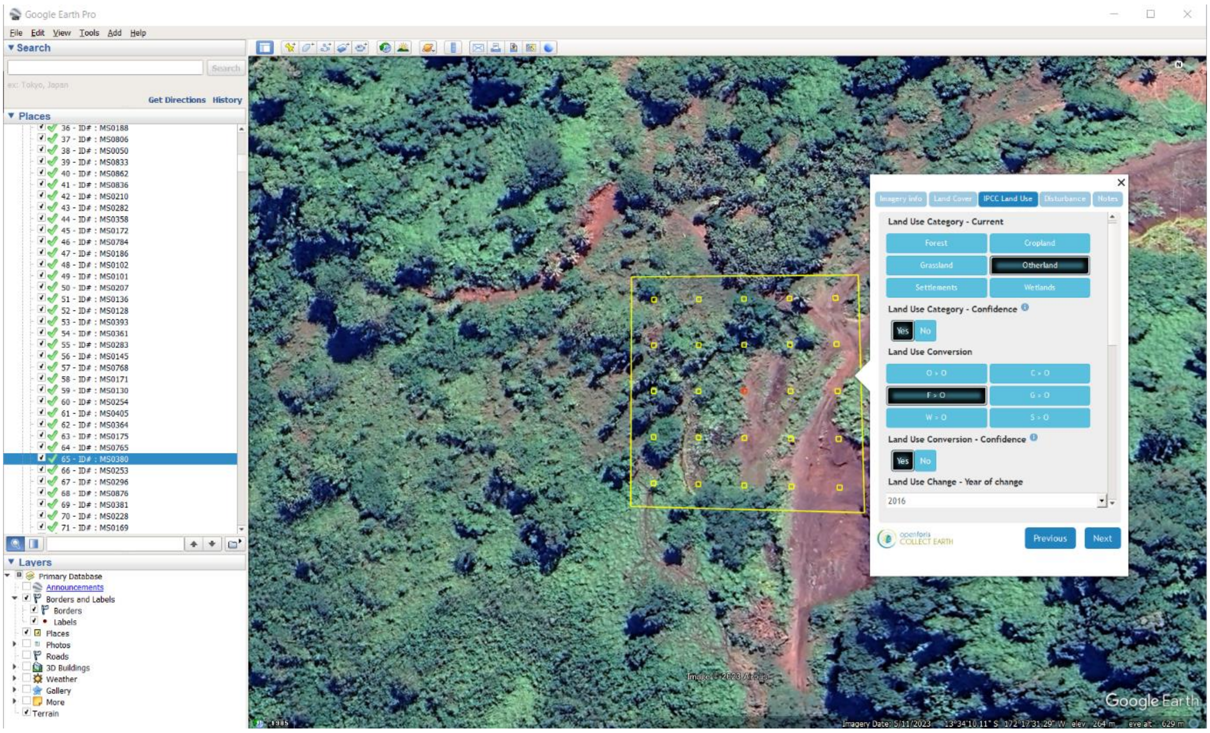

Figure 7-8: Image of the spatial sampling unit of the assessment plots

7.1.4. LULUCF Assessment

(a) Land Cover Assessment

The initial step entails employing remote sensing analysis by viewing the satellite imagery through Google Earth. The operator quantifies the land cover by tallying the elements found within each of the 25 points in the plot. The elements considered include:

- Trees (in forest/grassland)
- Trees (in agriculture/settlement)
- Crops
- Grass
- Scrubs
- Plantation
- Barren land
- Built-up
- Infrastructure
- Water body

(b) Land Use / Change Assessment

The subsequent step involved identifying the current primary land use category using medium to very high-resolution images known as "land key elements." These key land elements represent physical components of the land that characterize one or more land cover classes and/or land use categories, as outlined in Table 2-8. To determine the land use category, a combination of the following factors is taken into consideration, followed, and applied:

- The land key elements
- Forest definition and land use class definitions
- Tree count and coverage data obtained in the Land Cover section of the plot

For forest land use classes, for instance, if the percentage of forest canopy cover aligns with the forest definition (with a minimum tree height of 5 meters and a minimum forest tree canopy coverage of 10%), and if the operator observes that the tree count/coverage exceeds 10%, then the land use category is classified as "Forest." However, in cases where the land classification is complex (indicating the presence of less than one predominant land class in the area of interest), the hierarchical threshold criteria (as detailed in Table 2-11) would be employed.

Table 7-6: Land key elements for the six IPCC Land Use categories

IPCC Land Use Category	Land Key Elements
Forest land	Tree crown cover
Settlement	Building, paved roads and bridges
Cropland	Cash crops
Wetland	Water, rivers, swamp, dam, lake
Grassland	Grasses, scrubs
Other Land	Rocky outcrop, barren land, sand

The next step is dedicated to determining the land use conversion for the land, based on a combination of the following data sources and methods:

- Google Earth Engine (Landsat 7 and Landsat 8): Operators use Landsat 7 and Landsat 8 Annual Greenest Pixel data through Google Earth Engine to identify the year of change in land use by visually inspecting imagery. Operators are advised to zoom into the plot area, cursor through different years on both Landsat 7 and Landsat 8, and look for changes in land use. Darker orange imagery indicates more vegetation, while lighter imagery suggests less vegetation. Operators also consider trends and patterns in the Landsat 7/8 NDVI (Normalized Difference Vegetation Index) graph. For example, a downward trend in the NDVI graph indicates a loss in vegetation, while a stable trend with few outliers suggests no significant change. Operators avoid using years with black and white imagery due to cloud coverage. Landsat 7 data covers the period from 2000 to 2022, hile Landsat 8 data spans from 2013 to 2022.
- NICFI Planet map: This resource is used to compare recent imagery from 2020 to 2022. Operators can choose from two options: two Biannual Mosaics (from 2015/12 to 2020/08) or Monthly Mosaics (extending from September 2020 to May 2023). Similar to Landsat data, darker red imagery indicates more vegetation.
- Open Foris Earth Map global data: Specifically, WorldCover 10m 2020/2021 (ESA) under Land Cover/Land Use is used as a reference to identify land use in 2020/2021 for the plot's location. Note that this information does not replace the operator's input but aids in understanding land use in 2020/2021 on a global scale.
- Bing Map: If operators require clearer satellite imagery for reference, Bing Maps can be utilized.
- Google Earth Historical Imagery: Historical imagery available on Google Earth is used for remote sensing purposes, particularly for assessing land use changes over different years.
- National Land Cover Map (NLCM) 2013 KML layer: This resource is used to provide insight into land use class in 2013 based on national data.

The operator then inputs whether there has been any "land use conversion" based on their analysis, personal knowledge, and assessment using other relevant data sources, as mentioned earlier. The available land use conversion options depend on the current land use category. For each land use category, the options presented under land use conversion include six possibilities, representing the initial land use category converted to the current land use category.

The next step aims to determine the current land use subdivision using the land use classes/subdivision definitions (refer to Table 2-5: Brief Descriptions of Land Use Classes/Subdivisions in Samoa). This determination is supported by the tree count and coverage data obtained in the Land Cover section of the survey for consistency. For forest land, specific guidelines are provided: if the trees (in forest/grassland) cover 70% or more, operators are advised to select "closed forest"; if the coverage is more than 40% but less than 70%, "medium dense forest" should be selected; and if the coverage is more than 10% but less than 40%, "open forest" is the appropriate choice. If any disturbances are identified during the land use change assessment, the forest option must be "secondary forest."

(c) Forest Disturbance Assessment

If the land use was classified as forest, grassland, wetlands and other lands, the next step was to assess if it had been disturbed and identify the key features that causes this change as shown in Table 7-6. The detail steps or workflow of the assessment is illustrated in Figure 7-2.

Table 7-7: Disturbances Key Features

Type of disturbances	Disturbances	Key features
Human impacts	Logging	- Decreased vegetation density in forested areas - Clear-cut patches or linear patterns of deforestation - Presence of logging roads or skid trails - Distinctive spectral signature of logging activities (e.g., changes in infrared reflectance)
	Tree plantation	- Uniform patterns of vegetation cover - Regular spacing between tree rows - High spectral reflectance in near-infrared bands due to the presence of healthy vegetation
	Agri-plantation	- Patchy patterns of vegetation cover with distinct geometric shapes - Crop rows or field boundaries visible in satellite imagery - Variation in spectral reflectance depending on crop type and health
	Shifting cultivation	- Cyclic patterns of land use, with areas of recent cultivation surrounded by regenerating vegetation - Visible evidence of swidden fields, such as patchy areas of bare soil or regrowth after cultivation
	Grazing	- Sparse vegetation cover with visible signs of trampling or grazing trails - Circular or irregular patches of bare ground surrounded by vegetation
	Mining	- Distinctive patterns of excavation, such as open pits, tailings, or spoil heaps - Altered topography and removal of vegetation cover - Spectral reflectance variations due to different minerals or soil types exposed
	Roads/Settlements	- Linear features indicating road networks or infrastructure development - Dense clusters of buildings or human structures - Distinctive spectral reflectance of built-up areas compared to natural vegetation
	Other human impact	- Unnatural patterns or geometric shapes indicating land modification or land cover change - Industrial areas, quarries, or landfills with distinctive characteristics
Natural impacts	Fire	- Areas with a sudden increase in temperature or heat anomalies - Darkened or charred vegetation patches - Smoke plumes visible in satellite imagery
	Landslide	- Sudden changes in topography or terrain, including scarps or displaced vegetation - Disturbed soil or debris deposits downslope from the source area - Altered spectral reflectance due to exposed geological materials
	Flood	- Expanded water bodies or changes in water extent

		- Darkened or submerged vegetation - Displaced or eroded soil visible along the riverbanks or floodplains
	Surge	- Coastal areas with sudden changes in water level or inundation - Flooding of low-lying coastal regions - Changes in shoreline or coastal morphology
	Eruption	- Volcanic ash plumes or volcanic clouds visible in satellite imagery - Darkened or ash-covered land surfaces - Thermal anomalies associated with volcanic activity
	Other natural impact	- Distinctive patterns or signatures associated with natural events like earthquakes, hurricanes, or tsunamis - Changes in topography, vegetation cover, or water bodies after the event

(d) Hierarchical Rule

The land class was evaluated and visually interpreted by recognizing the land key elements; the assessment of their socio-economic functions and the adoption of the 'predominant land use' criteria in the classification scheme settled by rules. The notion is that the land use function of land can be expressed through hierarchical relationships among key land elements, and that these functional relationships are based on thresholds (Table 7-5) reflecting the relevance and predominance of key land elements in the observed area. Operators were advised to use the Hierarchical Rules for the Land Use Assessment category for each plot.

Table 7-8: Land use Hierarchical Rules threshold for the LULUCF assessment

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

The single land class or land use is simple to assess but becomes difficult when there is multiple classes. In this situation hierarchical sequence of settlement > cropland > forestland > grassland > wetland > other land was applied with the thresholds being: settlement 20%; cropland 20%; forestland 10%; grassland 20%; wetland 20% to express their pre-dominance.

7.2. Quality Assurance/Quality Control

Three rounds of Quality Assurance/Quality Control (QA/QC) assessments were undertaken as an integral part of the Land Use, Land Use Change, and Forestry (LULUCF) assessment. Each QA/QC assessment was conducted after an assessment round. The QA/QC process and workflow were executed over two sessions as shown in Figure 7-9. Critical factors employed to scrutinize, emphasize, and identify potential issues with sampling plots encompassed Canopy Cover %, Land Use category, presence of disturbances, and subdivision/classes within Forest Type.

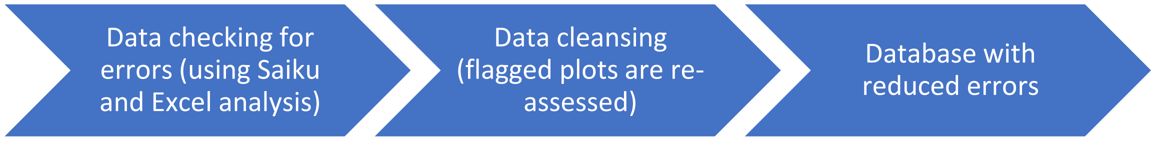

Figure 7-9: Data checking and cleaning general workflow for one session.

7.3. Summary of Assessment Results

7.3.1. Land use in 2022, 2013 and 2003

This section presents a comprehensive analysis of Samoa's forest and land use changes spanning the years 2003 to 2022, based on land unit measurements in hectares. Notably, Samoa has demonstrated remarkable stability in its forested areas, with only a marginal increase from 196,668 hectares in 2003 to 199,661 hectares in 2022, indicating minimal deforestation. Conversely, cropland has witnessed a gradual reduction from 38,281 hectares to 32,104 hectares over the same period, potentially signaling shifts in agricultural practices or reforestation efforts. Grassland and otherland categories have shown relative constancy, implying steady land use patterns. Urban expansion is evident in the steady rise of settlement areas from 6,420 hectares to 8,502 hectares.

Over the span of nearly two decades from 2003 to 2022, Samoa has demonstrated a commendable commitment to forest conservation, as indicated by minimal deforestation and a slight increase in forested areas. Notably, cropland has seen a reduction, potentially reflecting a shift away from agriculture or reforestation efforts on former cropland. While grassland areas have remained relatively stable, otherland and wetlands have shown only marginal changes, suggesting minimal degradation in these categories. However, urban expansion has been noticeable, with an increase in settlement areas, indicating the conversion of natural land for infrastructure development. Overall, Samoa has maintained a relatively stable land use pattern.

Based on the assessment data (in Figure 7-10, 7-11, 7-12 and Table 7-8) on Samoa's forest and land use change from 2003 to 2022, the following findings can be observed:

Forest Cover Remained Steady with Minimal Deforestation Over Time: Samoa's forested land area remained relatively constant throughout the studied years. In 2003, there were 196,668 hectares of forest, which decreased slightly to 196,453 hectares in 2013 but then rebounded to 199,661 hectares in 2022. This indicates that Samoa has managed to maintain its forest cover without experiencing significant deforestation suggesting minimal deforestation during this period.

Decline in Cropland: Cropland in Samoa experienced a notable decline and has shown a decreasing trend, declining from 38,281 hectares in 2003 to 32,104 hectares in 2022. This could imply changes in agricultural practices, land-use policies, or other factors influencing a shift away from cropland usage. This suggests a shift away from agriculture or a potential reforestation effort on former cropland.

Fluctuations in Grassland: Grassland areas showed fluctuations over the years, with a peak of 35,624 hectares in 2022. This could be indicative of changes in land management practices or natural variations in vegetation. This also indicates a consistent use of land for grazing or other purposes.

Minor Changes in Otherland: The area classified as "Otherland" showed a slight decrease over the years, from 3,607 hectares in 2003 to 3,231 hectares in 2022. There is only a slight change in this land use category, suggesting that these land types have not experienced significant degradation or conversion.

Growth in Settlements and Urban Expansion: Settlement areas in Samoa increased from 6,420.95 hectares in 2003 to 8,502.67 hectares in 2022. This indicates urbanization or expansion of human settlements during this period.

Wetland Stability: Wetland areas remained relatively stable, with a slight decrease from 4,187.29 hectares in 2003 to 4,046.36 hectares in 2022. This may be due to natural variations or changes in land use practices near wetlands.

Samoa's land use dynamics from 2000 to 2022 show relatively stable total land area, consistent forest cover, declines in cropland, fluctuations in grassland, minor changes in otherland, growth in settlements, and stable wetland areas. These findings suggest that Samoa has experienced minimal deforestation over the years, with a slight increase in forested areas and reductions in cropland. The land use changes except settlements appear to be relatively stable in other categories. These findings suggest a need for further investigation into the drivers of these land use changes, including economic, environmental, and policy factors, to inform sustainable land management and conservation efforts in Samoa.

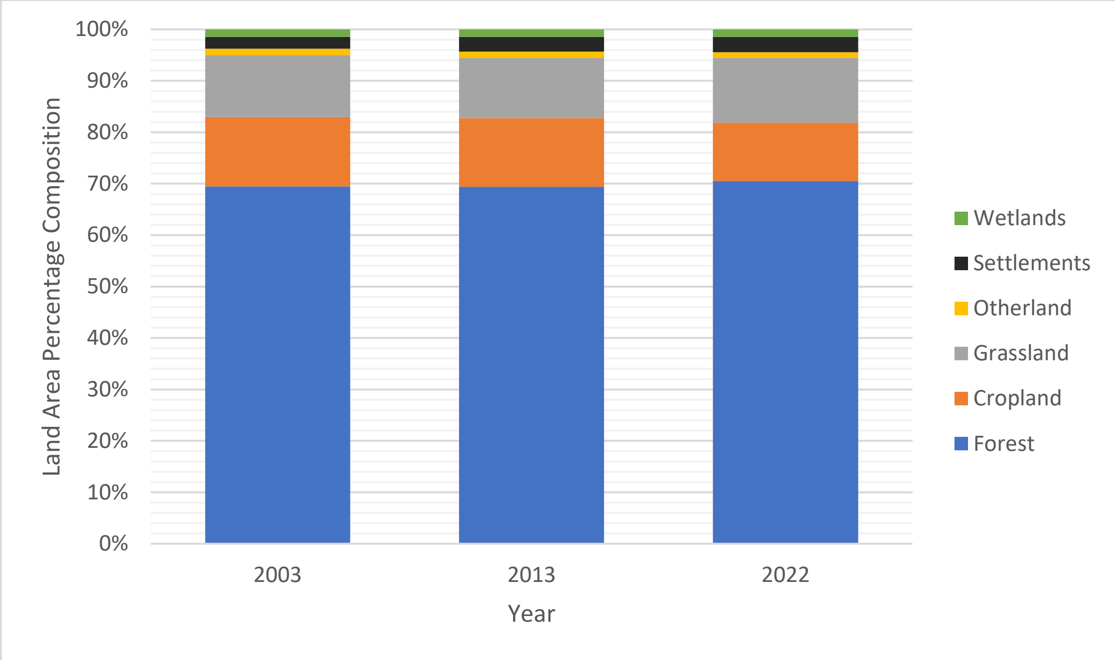

Figure 7-10: Proportion of land use in 2003, 2013 and 2022

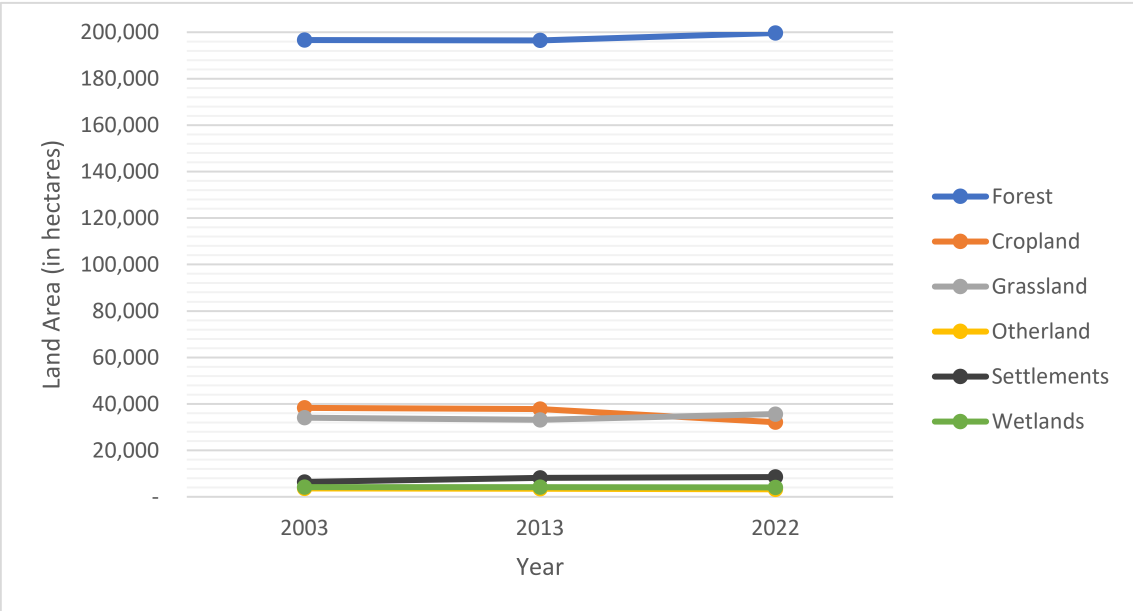

Figure 7-11: Trend per land use category between 2003, 2013 and 2022

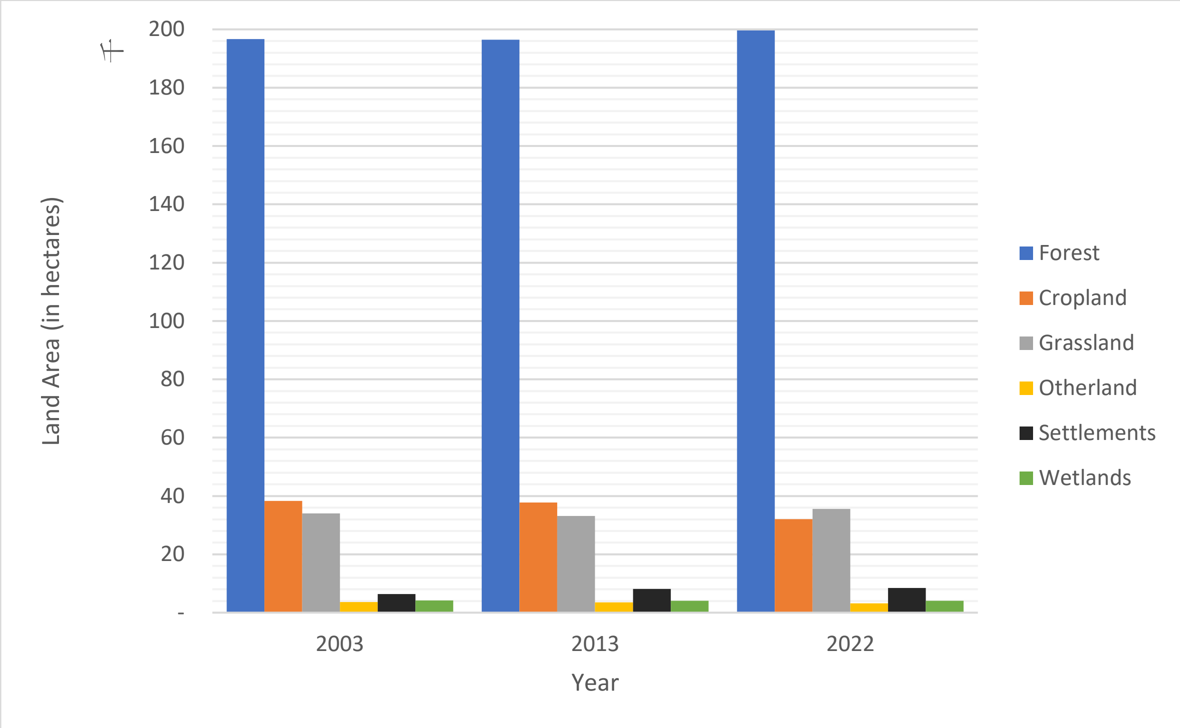

Figure 7-12: Breakdown of total land area (ha) per land use between 2003, 2013 and 2022

Table 7-9: Distribution of land area (ha) across land use categories for 2003, 2013, and 2022

Land Use Category	Land Area (in hectares)		
	2003	**2013**	**2022**
Forest	196,669.0	196,454.0	199,661.0
Cropland	38,281.5	37,818.8	32,104.2
Grassland	34,003.4	33,149.6	35,624.1
Otherland	3,607.9	3,492.3	3,231.7
Settlements	6,420.9	8,141.1	8,502.7
Wetlands	4,187.3	4,114.2	4,046.4
Total land area (in hectares)	**283,170.0**	**283,170.0**	**283,170.0**

The results presented in Table 7-9 and Figure 7-13 provide a comprehensive overview of Samoa's forest land use changes over the period spanning from 2003 to 2022. Over the 20-year period from 2003 to 2022, Samoa's total land area remained relatively stable, with a minor increase from 196,668.97 hectares in 2003 to 199,661.02 hectares in 2022. The most significant change in forest land use was observed in the "Closed Forest" category, which experienced notable growth from 46,396.82 hectares in 2003 to 51,272.74 hectares in 2022. This suggests a positive trend towards preserving closed canopy forests.

Decline in Medium Dense and Open Forests:

- While the "Closed Forest" category expanded, both "Medium Dense Forest" and "Open Forest" exhibited a declining trend in land area over the years.
- "Medium Dense Forest" decreased from 72,460.60 hectares in 2003 to 70,963.38 hectares in 2022, signalling a slight reduction in forest density.

- "Open Forest" showed a more significant decrease, declining from 37,045.03 hectares in 2003 to 28,528.63 hectares in 2022, indicating substantial deforestation and land use change within this category.

Increase in Secondary Forest:

- "Secondary Forest" areas witnessed growth over the studied period, implying active reforestation and afforestation efforts.
- "Secondary Forest" expanded from 34,162.06 hectares in 2003 to 43,792.73 hectares in 2022, indicating an increase in regenerating or second-growth forests.

Decrease in Forest Plantations:

- "Forest Plantation" areas also showed a decline, from 5,274.67 hectares in 2003 to 4,085.98 hectares in 2022, suggesting a decline in the establishment of new forest plantations. .

Stability in Mangrove Forests:

- The "Mangrove Forest" category remained relatively stable, with only minor fluctuations in land area from 1,329.79 hectares in 2003 to 1,017.56 hectares in 2022. This stability may indicate conservation efforts for this vital ecosystem.

These findings on forest land use sub-categories suggest that while Samoa has made progress in preserving closed forests and promoting secondary forests and forest plantations, there is a concerning trend of deforestation in medium dense and open forests. Sustainable land use and conservation strategies should continue to be a priority to maintain the ecological balance and safeguard the valuable ecosystems in Samoa. Monitoring and addressing the drivers behind these land use changes are essential for long-term environmental sustainability.

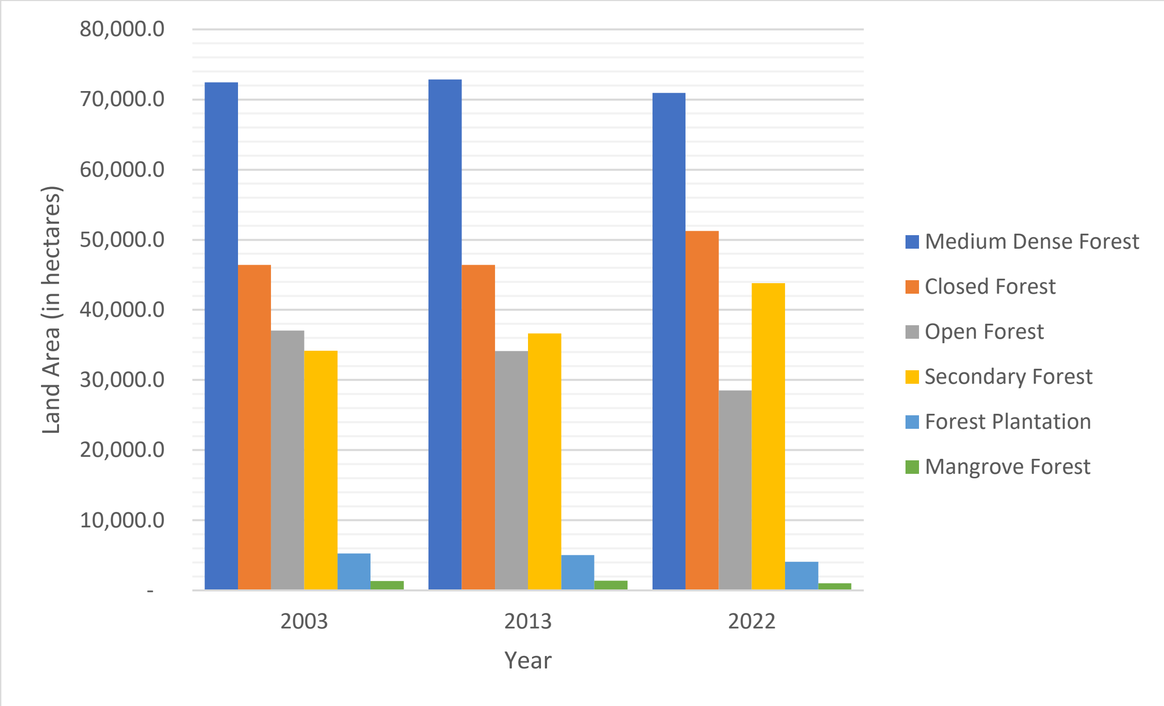

Figure 7-13: Breakdown of total land area (ha) per forest land between 2003, 2013 and 2022

Table 7-10: Distribution of land area (ha) across forest sub-categories for 2003, 2013, and 2022

Land Use Category	Land Area (in hectares)		
	2003	2013	2022
Closed Forest	46,396.8	46,427.3	51,272.7
Medium Dense Forest	72,460.6	72,858.1	70,963.4
Open Forest	37,045.0	34,125.5	28,528.6
Secondary Forest	34,162.1	36,623.6	43,792.7
Forest Plantation	5,274.7	5,054.9	4,086.0
Mangrove Forest	1,329.8	1,364.6	1,017.6
Total land area (in hectares)	**196,668.97**	**196,453.97**	**199,661.02**

Based on the data provided in Table 7-10 and Figure 7-14, detailed below are the key findings for the non-forest land use categories:

- **Scrubland**: The area of scrubland decreased slightly from 14,195.68 hectares in 2003 to 12,908.24 hectares in 2013 but increased to 13,004.84 hectares by 2022. This suggests a modest recovery of scrubland in recent years after a period of decline.
- **Grassland**: The area of grassland increased consistently from 19,807.73 hectares in 2003 to 22,619.22 hectares in 2022. This indicates an expansion of grassland areas, possibly due to changes in land management or land-use practices.
- **Barren Land**: Barren land, decreased from 3,607.88 hectares in 2003 to 3,231.68 hectares in 2022. This suggests that efforts to mitigate land degradation in this category have been somewhat effective.

- **Plantations**: The area of plantations showed a significant decline from 20,780.05 hectares in 2003 to 14,630.50 hectares in 2022. This indicates a notable reduction in plantation land, possibly due to factors such as land conversion or changes in agricultural practices.
- **Mixed Crops**: Mixed crop areas remained relatively stable over the years, with a slight decrease from 17,501.46 hectares in 2003 to 17,473.71 hectares in 2022. This suggests that mixed crop cultivation has been sustained with minor changes.
- **Built-Up Area**: The built-up area consistently increased from 6,038.87 hectares in 2003 to 7,963.97 hectares in 2022, indicating urban expansion and development.
- **Infrastructure**: Infrastructure land also saw a consistent increase from 382.08 hectares in 2003 to 538.70 hectares in 2022, likely reflecting ongoing development and construction projects.
- **Rivers, Lakes, and Wetlands**: The areas covered by rivers, lakes, and wetlands remained relatively stable, with minor fluctuations over the years. This suggests that these natural features have not experienced significant changes in land use.

Samoa has witnessed several changes in non-forest land use categories over the past two decades. Notably, there has been an increase in grassland, built-up areas, and infrastructure, indicating urbanization and development, while plantation areas have decreased significantly. Scrubland and mixed crop areas have shown some fluctuations, and barren land has remained relatively stable.

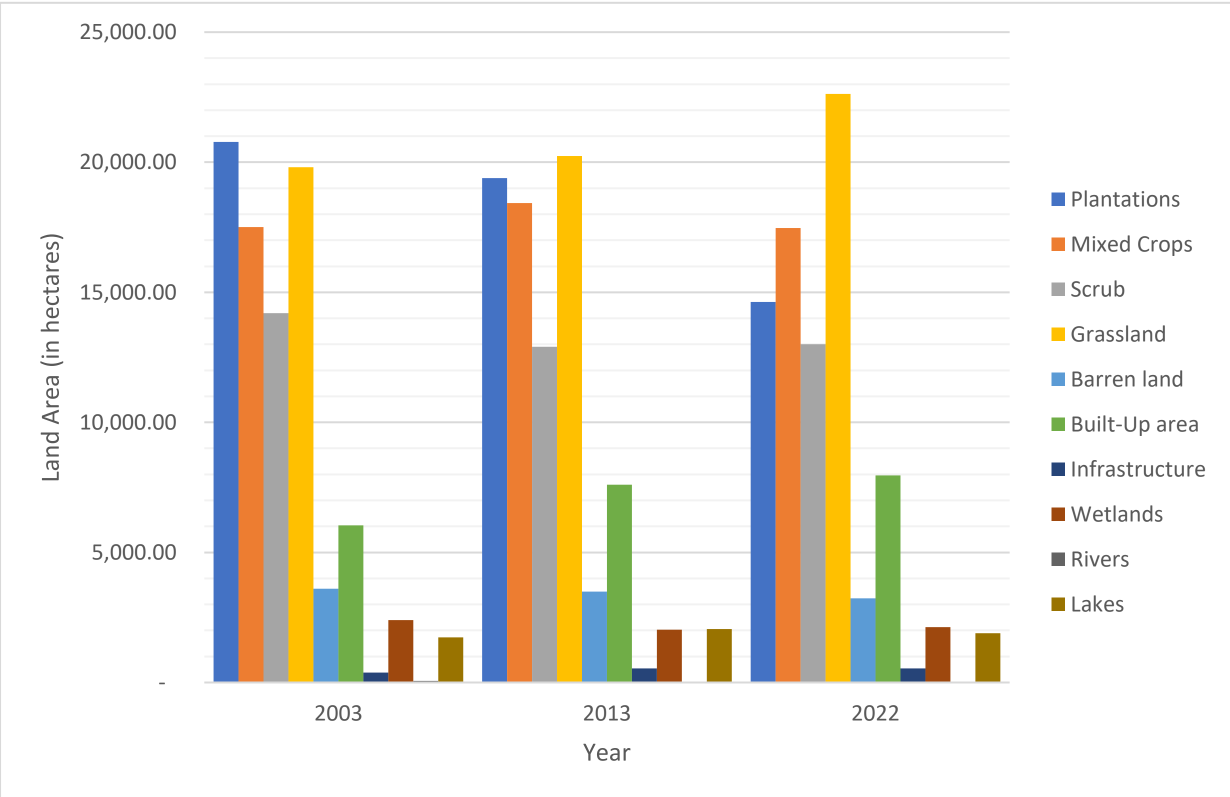

Figure 7-14: Breakdown of total land area (ha) per non-forest land between 2003, 2013 and 2022

Table 7-11: Distribution of land area (ha) for non-forest sub-categories 2003, 2013 and 2022

Land Use Category	Land Area (in hectares)		
	2003	2013	2022
Scrub	14,195.68	12,908.24	13,004.84
Grassland	19,807.73	20,241.38	22,619.22
Barren land	3,607.88	3,492.31	3,231.68
Plantations	20,780.05	19,383.91	14,630.50
Mixed Crops	17,501.46	18,434.93	17,473.71
Built-Up area	6,038.87	7,602.37	7,963.97
Infrastructure	382.08	538.70	538.70
Rivers	60.30	30.88	30.88
Lakes	1,730.22	2,049.15	1,892.52
Wetlands	2,396.77	2,034.18	2,122.95
Total land area (in hectares)	**86,501.03**	**86,716.04**	**83,508.98**

7.3.2. Status of Forest Land in 2022

Over the 20-year period from 2003 to 2022, in terms of forest composition and distribution, while the total forest land area remained relatively constant, the land allocation to Closed Forests, the most pristine and ecologically important forest category, increased significantly by 4,875.92 hectares (approximately 10% increase) from 2003 to 2022. Conversely, Open Forests witnessed a substantial decline in land area, decreasing by 8,516.4 hectares (about 22% decrease) during the same period.

Forest Density Changes:
Medium Dense Forests remained relatively stable, with only minor fluctuations in land area over the years. Secondary Forests displayed a steady increase, expanding by 9,630.67 hectares (around 28% increase) from 2003 to 2022. This suggests natural regeneration and afforestation efforts in secondary forest areas.

Forest Plantations and Mangroves:
Forest Plantations and Mangrove Forests both showed decreasing trends in land area over the study period. Forest Plantations saw a decline of 1,188.69 hectares (about 22% decrease), indicating potential challenges in maintaining or expanding these artificial forest areas. Mangrove Forests also slightly decreased, with a loss of 312.23 hectares (approximately 23%) by 2022, which might be due to environmental pressures.

7.3.3. Deforestation during 2000-2022

The total deforested area in Samoa between 2000 and 2022 can be calculated by summing the values for each year across different land use categories.

Total Deforested Area = Σ (Cropland + Grassland + Other land + Settlements + Wetlands) for all years from 2000 to 2022.

Total Deforested Area = 9,220 hectares

A total of about 9,220 ha of forest was deforested between 2000 and 2022. The percentage of deforestation over the 22-year period is approximately 4.41%. Deforestation increased rapidly in the years 2009 and 2014 where about 2,706.42 ha of forestland was converted to other land uses. The natural disasters that caused rapid deforestation in 2009 & 2014.

- 2009: tsunami disaster
- 2014: Tropical Cyclone Evan

Then human activities such as inland settlements/road constructions during the relocation of lowland communities (especially the affected areas) as per government response to such disasters.

Elaboration on Deforestation by Land Use Subdivision:

According to the data presented in Table 3-5 and illustrated in Figure 3-7, it is evident that the predominant transformation of forestland in Samoa has been into mixed crops, with a substantial 2,908.21 hectares converted into this land use category. Following closely behind is the conversion into grassland, accounting for 2,127.50 hectares of forestland. These findings, detailed in both the table and the corresponding figure, provide a comprehensive breakdown of the land conversion process, shedding light on the specific subdivisions within which forestland has transitioned into alternative land uses.

Plantations and Mixed Crops: These land use subdivisions have experienced significant deforestation, with a total of 2,908.21 ha of mixed crops and 534.94 ha of plantations respectively being converted over the 22-year period. This suggests a substantial expansion of agricultural activities in Samoa.

Scrub and Grassland: These categories have also seen significant deforestation, with 1,312.02 hectares of scrub and 2,028.50 hectares of grassland being converted. The clearance of scrub and grassland for various purposes is contributing to the overall loss of forest cover.

Built-Up Area and Infrastructure: While the area covered by built-up areas and infrastructure is comparatively small (1,333.86 ha of built-up area and 156.63 ha of infrastructure being converted), their impact on deforestation should not be ignored, as they contribute to urbanization and development at the expense of forested land.

Year 2009: This year witnessed a substantial spike in deforestation across multiple land use subdivisions, particularly in plantations and mixed crops. This could be indicative of a significant shift in land use practices.

It is important to note that the year 2021 is missing from the data because no sample plots were identified with no land use change in 2021 in terms of deforestation based on the assessment plots. This represents a limitation of the sampling-based assessment. To improve accuracy, it is necessary to increase the number of samples, which is an improvement that Samoa will take on for future FRL/FREL assessments.

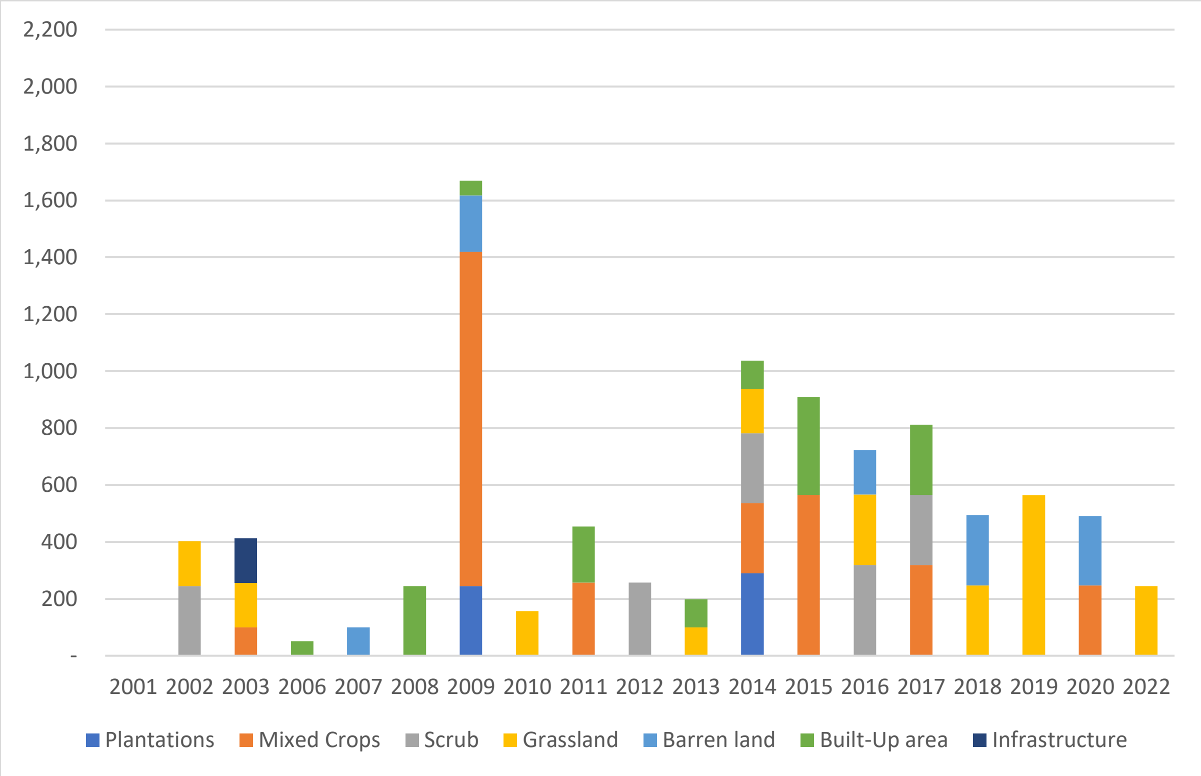

Figure 7-15: Deforestation trend from 2000-2022 per land use subdivision

7.3.4. Forest Degradation during 2000-2022

About 70,737 hectares of forest in 2000 was disturbed or degraded in 22 years being impacted by various human activities (Figure 7-15). Forest degradation/disturbance has been increasing steadily since 2000 and reached its peak in 2004, 2009 and 2013 (Figure 7-15). Forest degradation and disturbance peaked in 2004, 2009, and 2013, driven by human activities such as inland settlements and road construction during the relocation of lowland communities, as part of the government's disaster response. Samoa experienced cyclones in 2004 (Cyclone Heta), and most recently in December 2012 (Cyclone Evan), as well as a tsunami in 2009. These events have significantly impacted the forest areas, with notable forest degradation in 2013 due to the effect from the cyclone in December 2012 (Cyclone Evan).

The data from 2000 to 2022 provides valuable insights into the extent and nature of forest degradation in Samoa, categorized by various factors including logging, tree plantation, agriculture plantation, shifting cultivation, grazing, mining, roads/settlements, and other human impacts.

Total Forest Degradation: Over the 22-year period, Samoa has experienced substantial forest degradation, with a total area of approximately 70,737 hectares affected. This indicates significant pressures on the nation's forests, raising concerns about sustainability and environmental conservation.

Logging and Tree Plantation: Logging activities have had a noticeable impact on Samoa's forests, affecting approximately 11,140.7 hectares. Additionally, tree plantation, often viewed as a potential mitigating factor for deforestation, has impacted 3,175.9 hectares of forested land.

Agriculture Plantation and Shifting Cultivation: Agriculture plantation has had a substantial impact on forested areas, with approximately 16,905.6 hectares converted for agricultural use. Shifting cultivation, often associated with subsistence farming, has also played a significant role, affecting 4,762.4 hectares.

Grazing and Mining: Grazing activities have influenced 3,554.0 hectares of forestland, indicating the need for responsible management of grazing areas to minimize environmental impacts. Mining, a resource extraction activity, has affected 258.4 hectares of forested land, raising concerns about habitat disruption and resource depletion.

Roads/Settlements and Other Human Impacts: The development of roads and settlements has encroached on Samoa's forests, impacting 6,382.6 hectares. Furthermore, various other human impacts have led to forest degradation.

Other Human Impacts: Various other human activities have contributed to forest degradation, impacting 24,558.4 hectares in total. These activities may include unclassified or less-studied factors that require further investigation.

Yearly Variations: While there are fluctuations in the extent of forest degradation from year to year, it is essential to consider long-term trends and cumulative impacts to assess the overall state of Samoa's forests accurately.

The reason why the year 2021 is missing is there is no sample plots as new disturbance in 2021. This is a limitation of the sampling-based assessment. To achieve greater accuracy, it is necessary to increase the number of samples for future FRL/FREL assessments. This is an important lesson that Samoa will improve on for future assessments.

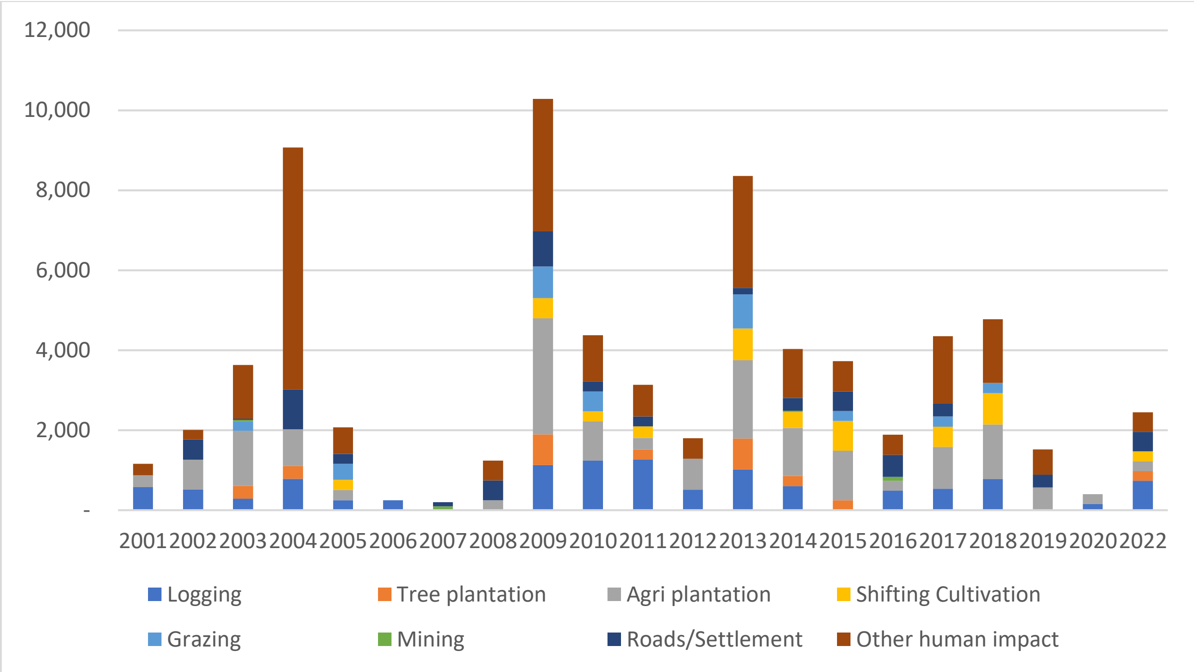

Figure 7-16: Forest degradation by human impact trend from 2000-2022

Note: The data of Figure 7-16 did not separate and treat the previous situation of disturbance. Some plots were already disturbed before new disturbance occurred and recorded (disturbed forest disturbed again). For activity data, disturbance occurred in the disturbed/degraded forest were excluded since there is no difference in the current Emission Factors.

7.3.5. Forest Carbon Stock 2022

Forest Carbon Stock 2022 was calculated using the following formula; A*[(B + (B*R))*CF]

Table 7-12: Forest Carbon Stock 2022 (Above Ground Biomass and Below Ground Biomass)

Forest type	Condition	Area (ha) (A)	AGB (t.d.m/ha) (B)	Root to Shoot ratio (R)	Carbon Fraction (CF)	Carbon Stock (AGB & BGB) (tCO2e)
Mangrove Forest	Primary	858	286.1	0.49	0.47	406,055
Closed Forest	Primary	46,978	411.0	0.37	0.47	33,273,707
Medium Dense Forest	Primary	61,108	265.9	0.37	0.47	28,006,022
Open Forest	Primary	20,129	120.9	0.37	0.47	4,193,285
Secondary Forest	Primary	18,092	227.3	0.37	0.47	7,086,047
Forest Plantation	Primary	2,898	205.5	0.37	0.47	1,026,313
Mangrove Forest	Degraded	159	187.3	0.49	0.47	49,322
Closed Forest	Degraded	4,295	269.1	0.37	0.47	1,991,797
Medium Dense Forest	Degraded	9,856	174.1	0.37	0.47	2,957,232
Open Forest	Degraded	8,400	79.1	0.37	0.47	1,145,620
Secondary Forest	Degraded	25,701	148.8	0.37	0.47	6,590,333
Forest Plantation	Degraded	1,188	134.5	0.37	0.47	275,448
Total		**199,661**				**87,001,180**

8. National Circumstances

Decision 12/CP.17 invites Parties to provide details on how national circumstances have been considered in the construction of the FREL/FRL. The below section reviews the historic trends in drivers of forest cover change and likely future trends based on available evidence.

8.1. National Economic and Policy Context

In Samoa, while the government encourages a conducive environment for private sector growth as the engine of economic development, it retains a central role as the primary developer. Government policies play a key role in resource allocation, extraction, and utilization by profit-making entities, corporations, and resource-owning entities, including villages. These policies also influence individual behaviour at the household level concerning land use, forests, marine areas, technology choices, and disposable income utilization.

Historically, Samoa's economic development heavily relied on natural capital exploitation from the early sixties to the late nineties. However, recent economic growth has been driven by commerce, transport, communications, and construction, supported by increased tourism.

In recent years, Samoa has formulated national development plans and policies with a focus on sustainable land use, such as the Samoa Climate Change Policy 2020-2030[6] and the Agriculture and Fisheries Sector Plan (AFSP) 2022–2027[7], emphasizing climate resilience. These plans prioritize climate-resilient infrastructure, sustainable land use practices, and adaptation measures to address climate change impacts. Samoa aims to increase mangrove forest area by 5%, expand agroforestry by 5%, and raise overall forest coverage by 2%, with a target to achieve 100% renewable energy for electricity by 2025.

The Strategy for the Development of Samoa (SDS) 2016/17-2019/20[8] outlines four priority areas and 14 key outcomes aligned with Sustainable Development Goals and the Small Island Developing States (SIDS) Accelerated Modality of Action (SAMOA) Pathway. The government engages stakeholders to guide development, ensuring a plan, implementation arrangements, and measurable improvements in quality of life. The Pathway for the Development of Samoa FY 2021/22-2025/26[9] focuses on five key strategic outcomes, including improved social development, a diversified and sustainable economy, secure governance, environmental resilience, and structured public works and infrastructure.

---

[6] Samoa Climate Change Policy 2020-2030 - https://www.mnre.gov.ws/wp-content/uploads/2021/03/Samoa-Climate-Change-Policy-2020-2030.pdf
[7] Agriculture and Fisheries Sector Plan (AFSP) 2022–2027 - https://www.mof.gov.ws/wp-content/uploads/2023/05/Agriculture-Fisheries-Sector-Plan-2022-2027.pdf
[8] The Strategy for the Development of Samoa (SDS) 2016/17-2019/20 - https://www.mof.gov.ws/services/economic-policy-planning/national-development-plans-for-samoa/
[9] Pathway for the Development of Samoa FY 2021/22-2025/26 - https://www.mof.gov.ws/wp-content/uploads/2022/02/Pathway-for-the-Development-of-Samoa.pdf

The government, while fostering a supportive environment for private sector growth, remains a central player in resource management through impactful policies. Recent national plans and policies, including the Samoa Climate Change Policy and the Agriculture and Fisheries Sector Plan, underscore Samoa's commitment to climate resilience and sustainable practices. Key targets involve increasing mangrove and overall forest coverage, expanding agroforestry, and achieving 100% renewable energy for electricity by 2025. The Strategy for the Development of Samoa and the subsequent Pathway for the Development of Samoa outline strategic outcomes aligned with global sustainability goals, reflecting a comprehensive approach to improving quality of life and fostering resilient and inclusive development. These most recent national development policies identify a shift in national planning away from strategies focused on economic growth to one that is based around a more sustainable development pathway and utilization of sustainable land resources.

8.2. The drivers of forest cover change in Samoa

As reported in Chapter 7, the results of Collect Earth assessment show that 9,220 hectares (4.41%) hectares of forest was deforested in 22 years (2000 -2022) and 70,737 hectares of forest was degraded in the same period.

Drivers of Deforestation and Forest Degradation

<u>Invasive Species:</u>
Invasive species present a significant threat to Samoa's biodiversity and economy, with repercussions ranging from economic impacts on primary industries to cultural disruptions and threats to ecosystem integrity. Notable invasive species such as Spathodea campanulata (African Tulip) and Merremia vine have adversely affected forest cover, agricultural crops, and key biodiversity areas. The aggressive nature of these invaders, particularly Merremia vine and mile-a-minute (Mikania micrantha), has led to concerns about their smothering effect on growing trees and the potential economic and conservation impacts.

<u>Natural Disasters</u>:
Samoa faces vulnerability to natural disasters, including cyclones, earthquakes, and fires. Climate change exacerbates this vulnerability, making cyclones and extreme weather events more frequent and intense, resulting in forest loss. Cyclones and fires are identified as the main natural disasters contributing to the reduction of forest cover in Samoa.

<u>Unsustainable Exploitation of Resources:</u>
Unsustainable exploitation of resources, documented in agriculture, forestry, fisheries, and water resources, has significantly altered Samoa's forest distribution and composition. Native forest resources are exploited for sawmilling and agriculture, driven by factors such as food production, cash income generation, settlement expansion, and land profiteering. Despite current low levels of logging, concerns arise regarding its impact on water catchment areas, erosion-prone zones, and conservation habitats within approved Key Biodiversity Areas.

Poorly Planned Development Activities:

Despite governmental efforts to provide an environmental sustainability framework for development activities, local initiatives often proceed without proper vetting. Destruction of mangrove areas for construction, unregulated water abstraction, and cultivation in sensitive habitats are observed. The lack of integrated land and resource use planning, compounded by the complexity of the land tenure system, poses challenges. However, positive strides have been made with the implementation of planning frameworks and guidelines to regulate developmental initiatives. The land tenure system, with approximately 80% of land being customary, adds complexity to the issue.

Enhancement and Conservation Areas

Reforestation:

The Forestry Division of the Ministry of Natural Resources and Environment (MNRE) in Samoa has been actively engaged in reforestation efforts since 2015. These campaigns, initiated to counteract the adverse effects of climate change, infrastructure development, and the 2009 tsunami, have been pivotal in rejuvenating Samoa's diminishing forests. The continuous commitment to reforestation is demonstrated through the ongoing Three Million Trees campaign, succeeding the achievements of the One and Two Million Trees initiatives. By 2020, the collaborative efforts of school children, community organizations, NGOs, sports enthusiasts, and various stakeholders resulted in the successful planting of over 2 million trees. Aligning with environmental priorities, such as carbon emission reduction, carbon stock enhancement is seamlessly integrated into these initiatives as part of the broader REDD+ activities.

Conservation:

Samoa has made significant strides in conserving its natural habitats, as outlined in the Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas submitted in 2011[10]. Currently, there are 13 declared protected areas (PAs) in Samoa, including 3 Marine Protected Areas (MPAs), covering extensive land and marine territories totalling 28,000 hectares and 10,000 hectares, respectively. To bolster conservation efforts, Samoa aims to raise its protected areas coverage from 15% to 30%. This objective is set to be achieved with the recent addition of 14,000 hectares of national parklands (NPs) on Savaii Island. However, gaps in information persist, particularly in areas such as the management effectiveness of PAs, legal status of PA, and the area coverage of numerous fisheries marine reserves. Addressing these gaps is crucial for strengthening PA management and advancing progress toward conservation goals, as highlighted in Samoa's Sixth Report to the Convention on Biological Diversity in 2019[11].

[10] Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas - https://www.cbd.int/doc/world/ws/ws-nbsap-powpa-en.pdf

[11] Samoa's Sixth Report to the Convention on Biological Diversity - https://www.cbd.int/doc/nr/nr-06/ws-nr-06-en.pdf

9. Forest Reference Emission Level / Forest Reference Level

Samoa's 1st FREL/FRL is calculated using an historical average approach in accordance with standards, such as the GCF scorecard for the GCF RBP pilot programme, ART TREES2.0, and FCPF Methodological Framework, etc. The 1st FREL/FRL is based on the average historical emissions for the period 2013-2022 as explained in "Chapter 4. Reference Period".

Table 9-1: Annual Historical Emissions in Total and Average 2013-2022 for FREL

Year	Gross Deforestation Emissions	Forest Degradation Emissions	Post Deforestation Regrowth Removals	Net Deforestation Emissions	Total Emissions (Deforestation + Degradation)
Unit	tCO2e/year	tCO2e/year	tCO2e/year	tCO2e/year	tCO2e/year
2013	90,775	461,440	-26,425	64,350	525,789
2014	315,998	159,725	-138,376	177,623	337,348
2015	296,045	210,060	-121,349	174,695	384,756
2016	197,031	224,292	-96,449	100,582	324,874
2017	226,246	190,980	-108,345	117,901	308,881
2018	96,968	312,143	-65,900	31,068	343,211
2019	117,482	127,055	-75,239	42,243	169,297
2020	114,197	44,402	-65,587	48,610	93,013
2022	73,520	83,897	-32,689	40,830	124,727
Total	1,528,261	1,813,994	-730,359	797,903	2,611,896
Average	152,826	181,399	-73,036	79,790	261,190

The reason why the year 2021 is missing is there is no sample plots identify as land use change in 2021. This is not necessarily true that there is no land use change in 2021 but this is limitation of the sampling based assessment. If we increase the number of sampling, the area change of the year 2021 may be captured but the size of the representing area will be smaller.

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

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

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

Samoa considered the country as High Forest, Low Deforestation (HFLD) status last 20 years and upwards adjustment to its 1st FREL/FRL. Fonseca et al. 2007 define HFLD as >50% forest cover and <0.22% annual forest loss rate. Samoa's forest cover rate average over the last 20 years is 72.2% and annual forest loss rate is 0.217%. With its high forest cover and low deforestation rate, Samoa can therefore be considered an HFLD country.

The average historical emissions for 2013-2022 were 261,190 tCO2eq/year, therefore 10% of the FRL suggests an allowable upwards adjustment of 287,309 tCO2eq/year.

The total forest carbon stock in Samoa corresponding to the year 2022 was 87,001,180 tCO2eq, therefore 0.1% of the total forest carbon stock divided by the eligibility period (5 years, 0.02%) suggests an allowable upwards adjustment of 278,590 tCO2eq/year. .

After examining the results produced by the two different methods, Samoa decided to use the most restrictive limit or adjustment method which is 0.1% of the total carbon stock over the accounting period (i.e. 5 years and 0.02%).

As such, the recalculated FREL (CO2 emissions from deforestation and forest degradation in Samoa in the period from 2013 to 2022) applied the following formula:

FREL (tCO2e) = historical average emissions 2013-2022 + HFLD adjustment (0.001 x total forest carbon stock)/5

FREL (tCO2e) = 261,190 + (0.001 x 87,001,180)/5
= 261,190 + 17,400
= 278,590

Concerning maintaining HFLD criteria, Samoa has been promoting tree planting campaign for the last several years and the associated policies to promote sustainable management of forest land will be continued in future as well. Such a policy make Samoa to be remained as HFLD country for the crediting period.

In fact, HFLD adjustment is the concept to provide benefit and incentives for the countries which did not have large deforestation and kept forest carbon stock well in the past (REDD+ may provide more benefit for the countries which had large deforestation in the past, which gained benefit already in the past by cutting trees and get benefit again. The SIDS countries like Samoa whose forest area are not very large compared to other large size countries, would like to increase the benefits and incentives for keeping trees and conserving forest.

Removals by carbon stock enhancement from Afforestation/Reforestation were accounted and will be measured separately from the emissions and post-deforestation regrowth since they are additional efforts by Samoa such as tree planting campaign.

Table 9-2: Annual Historical Removals in Total and Average 2013-2022 for FRL

Year	Carbon Stock Enhancement	Carbon Stock Enhancement
Unit	ha/year	tCO2e/year

2013	198	-129,336
2014	1,037	-225,194
2015	910	-317,084
2016	723	-236,970
2017	812	537,229
2018	494	-294,610
2019	564	-40,163
2020	492	-
2022	245	-62,830
Total	5,474	-768,957
Average	547	-76,896

A results/crediting period from 2023-2026 or 2023-2030 (4 or 8 years) will be used but to be aligned with the intervals of the FREL/FRL reporting and Biannual Transparency Reports (BTR) to the UNFCCC, Samoa will try to update the information every 2 years.

Table 9-3. The Forest Reference Emission Level / Reference Level for 2023 to 2030

Year	**Historical Emissions 2013-2022**	**Average Emissions 2013-2022 and FREL 2023-2030**	**HFLD Adjusted Emissions 2013-2022 and FREL 2023-2030**	**Historical Removals 2013-2022**	**Average Removals 2013-2022 and FRL 2023-2030**
Unit	tCO2e/year	tCO2e/year	tCO2e/year	tCO2e/year	tCO2e/year
2013	525,789	261,190	278,590	-129,336	-76,896
2014	337,348	261,190	278,590	-225,194	-76,896
2015	384,756	261,190	278,590	-317,084	-76,896
2016	324,874	261,190	278,590	-236,970	-76,896
2017	308,881	261,190	278,590	537,229	-76,896
2018	343,211	261,190	278,590	-294,610	-76,896
2019	169,297	261,190	278,590	-40,163	-76,896
2020	93,013	261,190	278,590	-	-76,896
2021	-	261,190	278,590	-	-76,896
2022	124,727	261,190	278,590	-62,830	-76,896
2023		261,190	278,590		-76,896
2024		261,190	278,590		-76,896
2025		261,190	278,590		-76,896
2026		261,190	278,590		-76,896
2027		261,190	278,590		-76,896
2028		261,190	278,590		-76,896
2029		261,190	278,590		-76,896
2030		261,190	278,590		-76,896

10. Uncertainty Analysis

The study considered various quality assurance and quality control measures during the development of these assessment results to assure the accuracy of the results as well as to continually enhance the quality of the results.
A qualitative and quantitative uncertainty analysis was undertaken. In elaborating the forest and land use change area and forest carbon stock per unit area that underlie it, the analysis of uncertainties makes it possible to identify opportunities for improvement.

10.1. Methodology of Uncertainty Analysis

10.1.1. Qualitative uncertainty analysis

In terms of area change in forest and land use, several major sources of error in estimating past land-use trends from the Collect Earth exercise are expected.

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

To reduce the uncertainty of classification error, Samoa defines the land use subdivision based on the existing classification system described in Section 2.1 and Section 4 and ensuring it is line with international standard set by IPCC guidelines. The stratification based on the carbon stock amount will be considered in future based on the national forest inventory if it is implemented and the current on-going Samoa's Green House Gas Inventory (which followed key guidance and resources included the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

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

There are also several important error sources to be considered in estimating carbon stocks for Samoa's land use types. The set of emission factors used are derived from IPCC default values and limited information is available on their error. Nonetheless, Samoa expects typical errors to occur for the emission factors, as follows:

- Sampling error (random and systematic error) since the plot-based measurements that underlie estimates reported in the IPCC guidelines only sample the forests.

- Representation error from using IPCC default values that might be imperfectly suitable for Samoa's forests (systematic error).
- Representation error from approximating forest carbon stocks in all of Samoa's forest types from IPCC default values that were developed only for the most abundant types of forests (systematic error).
- Model error from inferring on forest degradation carbon stocks from measurements in one type of forest only (systematic error).

10.1.2. Quantitative uncertainty analysis

Implementation of statistically valid ground truth survey is not practical considering the fact that most part of Samoa's NFI plots and forest areas (which are mainly inland) is not accessible hence estimation of the uncertainties of forest and land use change area is purely statistical with no ground truth. The uncertainty analysis is based on IPCC 2006 GPG, complemented by GFOI (Global Forest Observations Initiative) Methodological Guidance on estimating uncertainties of land areas estimated by proportion without verification (it is always good practice to verify a land classification).

However, for this assessment, no ground truthing was carried out. This assessment is basely solely on visual interpretation through remote sensing and the operator's local knowledge, skills and experience as well as the strengthened capacity for the trainings carried out as part of this assessment.

The uncertainty analysis for the assessment was conducted using the Stratified Area Estimator, an analytical tool available on Sepal. This tool was employed to compare the assessment results with those that would be obtained through a theoretical simple random design sampling approach. Its primary purpose is to offer a user-friendly interface for generating a probability dataset utilizing stratified random sampling techniques.

The following method to calculate and determine the uncertainty analysis. The area estimate of each land use category is calculated by multiplying the total area A and by the proportion of sample plots in the specific land category. The percentage uncertainty associated with the area estimate is calculated as ±1.96 times the standard error of Ai divided by Ai.

The standard error3 of an area estimate is obtained as $A * \sqrt{\ } pi$ (1−) n−1
Where:

- pi is the proportion of points in the particular land-use category (stratum) i; pi = ni n
- A is the total area of Samoa,
- n the total number of sample points,
- ni is the number of point under a particular land-use category.

10.1.3. Approach towards reducing errors

The current estimation of the uncertainties of activity data is statistical with no ground truthing. Conducting statistically-valid ground truthing survey is challenging. But if the national forest inventory is implemented in the future again, the estimation of the uncertainties using ground-truthing data will be considered. Although it is difficult to collect ground truthing data in Samoa, one possibility to estimate the human error is to choose operators who have good experience at ground survey and remote sensing for the QA/QC, who will be evaluating plots that have been assessed by other operators. It is currently under consideration to use the data collected from this QA/QC operators as ground-truthing substitute and compare this to the data collected by "normal operators". Although the current approach to establishing emission factors may include several error sources, Samoa strives to implement a national forest inventory to improve and develop country specific forest carbon stock data and emission factors in future.

10.2. Results of Uncertainty Analysis

10.2.1. Overview of sampling

Table 10-1 shows the sampling plot count and the estimated area of each land use category of Initial land use and current land use. A total of 1,310 plots were assessed, indicating all plots were assessed by the MNRE staff.

Table 10-1: Number of plots for initial and current land use category

	Initial Land Use		**Current Land Use**		
Land use type	**Plot Count**	**Area (ha)**	**Plot Count**	**Area (ha)**	**Difference (current – initial)**
Forest land	775	190,239.31	783	199,661.02	8
Cropland	199	47,518.02	157	32,104.21	-42
Grassland	169	30,760.00	192	35,624.06	23
Wetlands	66	1,485.44	58	4,046.36	-8
Settlements	78	10,451.28	95	8,502.67	17
Other land	23	2,714.95	25	3,231.68	2
Total	**1310**	**283,169.006**	**1310**	**283,170.01**	

10.2.2. Quantitative analysis

Table 10-2 to 10-3 show sampling errors and the uncertainty of area estimates of each land use category and conversion during 2000-2022, using standard error3 of an area estimate as no ground-truth was undertaken. The results suggest that the assessment work overall was exceptionally performed where the uncertainty is generally low. The higher uncertainty of 'Wetland', 'Settlements' and 'Other land' are quite high because only a small area was sampled. The current estimation of the uncertainties is purely statistical with no ground truth. But if the national forest inventory is implemented in future, the estimation of the uncertainties using ground-truth data should be considered.

Table 10-2: Sampling error and uncertainty of area estimate of land use category: Initial land use

Land use type	Plot Count	Area (ha)	pi	Standard Error (proportion)	Standard Error (mil. ha)	Uncertainty %
Forest land	775	190,239.31	0.591603	0.013586	3,847.09	4%
Cropland	199	47,518.02	0.151908	0.009921	2,809.24	12%
Grassland	169	30,760.00	0.129008	0.009265	2,623.56	17%
Wetlands	66	1,485.44	0.050382	0.006046	1,711.93	226%
Settlements	78	10,451.28	0.059542	0.006541	1,852.07	35%
Other land	23	2,714.95	0.017557	0.00363	1,027.92	74%
Total	**1310**	**283,169.006**				

Table 10-3: Sampling error and uncertainty of area estimate of land use category: Current land use

Land use type	Plot Count	Area (ha)	pi	Standard Error (proportion)	Standard Error (mil. ha)	Uncertainty %
Forest land	783	199,661.02	0.60	0.013553301	3,837.89	4%
Cropland	157	32,104.21	0.12	0.008976837	2,541.97	16%
Grassland	192	35,624.06	0.15	0.009775307	2,768.07	15%
Wetlands	58	4,046.36	0.04	0.005685584	1,609.99	78%
Settlements	95	8,502.67	0.07	0.007168179	2,029.81	47%
Other land	25	3,231.68	0.02	0.003781642	1,070.85	65%
Total	**1310**	**283,170.01**				

Table 10-4: Sampling error and uncertainty of area estimate of land use subdivision (Current)

Land use type	Plot Count	Area (ha)	pi	Standard Error (proportion)	Standard Error (mil. ha)	Uncertainty %
Mangrove Forest	26	1,017.56	0.020	0.003855	1,091.6	± 210.27%
Closed Forest	184	51,272.74	0.140	0.009604	2,719.5	± 10.40%
Medium Dense Forest	252	70,963.38	0.192	0.010894	3,084.9	± 8.52%
Open Forest	115	28,528.63	0.088	0.007822	2,214.8	± 15.22%
Secondary Forest	190	43,792.73	0.145	0.009733	2,756.1	± 12.34%
Forest Plantation	16	4,085.98	0.012	0.003036	859.7	± 41.24%
Plantations	67	14,630.50	0.051	0.006089	1,724.2	± 23.10%
Mixed Crops	90	17,473.71	0.069	0.006991	1,979.7	± 22.21%
Scrub	63	13,004.84	0.048	0.005914	1,674.6	± 25.24%
Grassland	129	22,619.22	0.098	0.008235	2,332.0	± 20.21%
Barren land	25	3,231.68	0.019	0.003782	1,070.8	± 64.95%
Built-Up area	88	7,963.97	0.067	0.006919	1,959.2	± 48.22%
Infrastructure	7	538.70	0.005	0.002015	570.6	± 207.60%
Wetlands	44	2,122.95	0.034	0.004980	1,410.1	± 130.19%
Rivers	1	30.88	0.001	0.000763	216.2	± 1371.89%
Lakes	13	1,892.52	0.010	0.002740	775.8	± 80.35%
Total	**1310**	**283,170.01**				

(a) Uncertainty analysis for Activity Data

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

2013-2022 (FREL/FRL Reference Period: latest 10 years)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, Forest Degradation, and Afforestation/Reforestation from 2013 to 2022 are respectively 4.30%, 9.56%, 37.58%, 22.96% and 31.25%. Forest Restoration are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	691.00	178,114.49	0.527	149,366.8	0.013799	3,907.4	± 7,658.5	± 4.30%
Stable Non-Forest	503.00	78,034.65	0.384	108,728.6	0.013442	3,806.5	± 7,460.8	± 9.56%
Deforestation	24.00	5,474.33	0.018	5,187.8	0.003707	1,049.6	± 2,057.3	± 37.58%
Forest Degradation	58.00	13,741.77	0.044	12,537.3	0.005686	1,610.0	± 3,155.6	± 22.96%
Forest Restoration	0.00	0.00	0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!
Afforestation/Reforestation	34.00	7,804.76	0.026	7,349.5	0.004395	1,244.4	± 2,439.1	± 31.25%

As references, the uncertainty analysis of the other periods were summarized below.

2003-2012 (FREL/FRL Reference Period: previous 10 years)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, Forest Degradation, and Afforestation/Reforestation from 2003 to 2012 are respectively 4.20%, 9.90%, 57.61%, 19.19%, and 50.36%. Forest Restoration are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty (%)
Stable Forest	707.00	182,207.47	0.540	152,825.3	0.013776	3,901.0	± 7,645.9	± 4.20%
Stable Non-Forest	482.00	74,690.41	0.368	104,189.3	0.013329	3,774.4	± 7,397.8	± 9.90%
Deforestation	21.00	3,344.24	0.016	4,539.4	0.003471	983.0	± 1,926.6	± 57.61%
Forest Degradation	84.00	19,581.73	0.064	18,157.5	0.006771	1,917.3	± 3,757.9	± 19.19%
Forest Restoration	0.00	0.00	0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!
Afforestation/Reforestation	16.00	3,346.15	0.012	3,458.6	0.003036	859.7	± 1,685.0	± 50.36%

2003-2022 (FREL/FRL Reference Period: latest 20 years)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, Forest Degradation, and Afforestation/Reforestation from 2003 to 2022 are respectively 4.92%, 9.90%, 31.68%, 14.31%, and 26.36%. Forest Restoration are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	591.00	155,186.60	0.451	127,750.7	0.013754	3,894.6	± 7,633.4	± 4.92%
Stable Non-Forest	482.00	74,690.41	0.368	104,189.3	0.013329	3,774.4	± 7,397.8	± 9.90%
Deforestation	45.00	8,818.57	0.034	9,727.2	0.005034	1,425.5	± 2,793.9	± 31.68%
Forest Degradation	142.00	33,323.51	0.108	30,694.8	0.008593	2,433.2	± 4,769.0	± 14.31%
Forest Restoration	0.00	0.00	0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!
Afforestation/Reforestation	50.00	11,150.91	0.038	10,808.0	0.005296	1,499.6	± 2,939.2	± 26.36%

2001-2022 (Full LULUCF Assessment Period for FREL/FRL)

The uncertainties of Stable Forest, Stable Non-Forest, Deforestation, Forest Degradation, and Afforestation/Reforestation from 2001 to 2022 are respectively 4.96%, 9.95%, 30.94%, 14.77%, and 25.70%. Forest Restoration are assessed at zero.

Land Use Change Stratification	Plot Count	Area	pi	Area [Ai] (mil. ha) [A*pi]	Standard Error (proportion)	Standard Error (mil. ha)	Confidence Intervals (mil. ha)	Uncertainty %
Stable Forest	558.00	152,840.35	0.426	120,617.5	0.013667	3,870.2	± 7,585.6	± 4.96%
Stable Non-Forest	480.00	74,288.76	0.366	103,756.9	0.013317	3,771.1	± 7,391.3	± 9.95%
Deforestation	47.00	9,220.22	0.036	10,159.5	0.005141	1,455.6	± 2,853.1	± 30.94%
Forest Degradation	173.00	35,168.27	0.132	37,395.7	0.009358	2,649.8	± 5,193.6	± 14.77%
Forest Restoration	0.00	0.00	0.000	0.0	0.000000	0.0	± 0.0	#DIV/0!
Afforestation/Reforestation	52.00	11,652.40	0.040	11,240.3	0.005396	1,528.1	± 2,995.1	± 25.70%

(b) Uncertainty analysis for Emission Factors

In terms of emission factors, there is incomplete quantitative information available on error in estimating forest carbon stocks and emission factors. Those estimates taken from the IPCC guidelines do not come with detail quantitative information on errors.

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

a. Uncertainty of AGB due to the use of IPCC default values (2006 IPCC guidelines)
b. Uncertainty of Root ‐ to ‐ Shoot ratios due to the use of IPCC default values (2006 IPCC guidelines)
c. Uncertainty of Carbon Fraction value due to the use of IPCC default values (2006 IPCC guidelines)

(c) Estimation method for multiple uncertainties

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

EQUATION 3.1
COMBINING UNCERTAINTIES – APPROACH 1 – MULTIPLICATION

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

Where:

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

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

EQUATION 3.2

COMBINING UNCERTAINTIES – APPROACH 1 – ADDITION AND SUBTRACTION

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

Where:

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

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

(d) Uncertainty of carbon stock for forest class

The following table shows the total uncertainty of carbon stock for each forest class estimated through the propagation of error approach. The values are based on the 2006 IPCC guidelines.

Table 10-5: Total uncertainty of carbon stock for each forest class

LU	STR	Land Use Subdivision	Global Ecological Zone	Source	tC/ha	tCO2/ha	Area(ha) 2022	a	b	c	Uncertainty (%)
Forest	Primary	Mangrove Forest	Tropical wet Mangrove	IPCC Guideline (2006)	286.1	473.1	858	21.4%	5.6%	2.7%	22.2%
		Closed Forest	Tropical rain forest		411.0	708.3	46,978	21.4%	7.4%	2.7%	22.8%
		Medium Dense Forest			265.9	458.3	61,108	30.0%	7.4%	2.7%	31.0%
		Open Forest			120.9	208.3	20,129	30.0%	7.4%	2.7%	31.0%
		Secondary Forest			227.3	391.7	18,092	30.0%	7.4%	2.7%	31.0%
		Forest Plantation	Tropical rainforest (plantation)		205.5	354.1	2,898	30.0%	14.9%	2.7%	33.6%
	Degraded	Mangrove Forest	Tropical wet Mangrove	IPCC Guideline (2006)	187.3	309.7	159	28.4%	11.2%	2.7%	30.6%
		Closed Forest	Tropical rain forest		269.1	463.7	4,295	28.4%	14.9%	2.7%	32.1%
		Medium Dense Forest			174.1	300.1	9,856	30.0%	14.9%	2.7%	33.6%
		Open Forest			79.1	136.4	8,400	30.0%	14.9%	2.7%	33.6%
		Secondary Forest			148.8	256.4	25,701	30.0%	14.9%	2.7%	33.6%
		Forest Plantation	Tropical rainforest (plantation)		134.5	231.9	1,188	30.0%	14.9%	2.7%	33.6%
Non--Forest		Cropland	-	-	0.0	0.0	32,104	N/A	N/A	N/A	0.0%
		Grassland	-	-	0.0	0.0	35,624	N/A	N/A	N/A	0.0%
		Wetlands	-	-	0.0	0.0	4,046	N/A	N/A	N/A	0.0%
		Settlements	-	-	0.0	0.0	8,503	N/A	N/A	N/A	0.0%
		Other lands	-	-	0.0	0.0	3,232	N/A	N/A	N/A	0.0%

(e) Uncertainty of Emission / Removal Factors

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

Uncertainty in carbon stock/ha by stratum

Strata	Mean tCO_2/ha	Uncertainty (tCO_2/ha)	Uncertainty (%)
Forest (Primary)	493.1	78.7	16.0%
Forest (Degraded)	262.3	51.2	19.5%
Non-Forest	0.0	N/A	N/A

Strata Change and REDD+ Activity

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

Emission/Removal Factors (tCO_2/ha)

		Current		
		Forest (Primary)	**Forest (Degraded)**	**Non-Forest**
Previous	Forest (Primary)	0.0	-230.8	-493.1
Previous	Forest (Degraded)	230.8	0.0	-262.3
Previous	Non-Forest	493.1	262.3	0.0

Emission/Removal Factor Uncertainty (%)

		Current		
		Forest (Primary)	**Forest (Degraded)**	**Non-Forest**
Previous	Forest (Primary)	0.0%	12.4%	16.0%
Previous	Forest (Degraded)	12.4%	0.0%	19.5%
Previous	Non-Forest	16.0%	19.5%	0.0%

(f) Aggregated / Total Uncertainty Analysis

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

2013-2022 (FRL Reference Period: latest 10 years)

	SF	SNF	DF	DG	AR	RS
AD Uncertainty	4.30%	9.56%	37.58%	22.96%	31.25%	N/A
EF Uncertainty	N/A	N/A	12.43%	12.43%	12.43%	12.43%
Total Uncertainty	N/A	N/A	39.58%	26.11%	33.63%	N/A

As references, the other aggregated / total uncertainty analysis were summarized below.

2003-2012 (FRL Reference Period: previous 10 years)

	SF	SNF	DF	DG	AR	RS
AD Uncertainty	4.20%	9.90%	57.61%	19.19%	50.36%	N/A
EF Uncertainty	N/A	N/A	12.43%	12.43%	12.43%	12.43%
Total Uncertainty	N/A	N/A	58.94%	22.87%	51.87%	N/A

2003-2022 (FRL Reference Period: latest 20 years)

	SF	SNF	DF	DG	AR	RS
AD Uncertainty	4.92%	9.90%	31.68%	14.31%	26.36%	N/A
EF Uncertainty	N/A	N/A	12.43%	12.43%	12.43%	12.43%
Total Uncertainty	N/A	N/A	34.03%	18.96%	29.14%	N/A

2001-2022 (Full LULUCF Assessment Period for FRL)

	SF	SNF	DF	DG	AR	RS
AD Uncertainty	4.96%	9.95%	30.94%	14.77%	25.70%	N/A
EF Uncertainty	N/A	N/A	12.43%	12.43%	12.43%	12.43%
Total Uncertainty	N/A	N/A	33.35%	19.30%	28.55%	N/A

Finally, the uncertainty in emissions from deforestation and emissions from forest degradation (95% CI (%)) are combined by using the 2006 IPCC Equation 3.2. This results in the following uncertainty estimates:

	Emissions	Removals
Uncertainty FREL/FRL (2013-2022)	**21.99%**	**32.80%**

As references, the uncertainty analysis of the other periods were summarized below.

	Emissions	Removals
Uncertainty FREL/FRL (2003-2012)	20.94%	51.33%
Uncertainty FREL/FRL (2003-2022)	16.47%	28.18%
Uncertainty FREL/FRL (2001-2022)	16.65%	27.56%

11. Proposed improvements

According to the stepwise approach to setting out the FREL/FRL, Samoa proceeds to submit the current report with the anticipation that several aspects of the FREL/FRL will require further improvement in the near future. In the future it is anticipated that Samoa's FREL/FRL report will include some of the following key improvements as indicated below:

- Improving measurement of the area of forest degradation by remote sensing approach. It turned out it is challenging to identify the area of forest degradation by wall-to-wall mapping approach in Samoa due to the quality of the mosaic satellite imagery even using cloud-based tool such as SEPAL, but if there is better approach to overcome those challenges, Samoa would like to improve the current approach
- Development of degradation Emission Factors. In the current FREL/FRL, Samoa used degradation rate from regional data (the one of Papua New Guinea's Permanent Sample Plots analysis) but it is recommended to develop country specific degradation rate. It would be good if Samoa also could distinguish drivers of degradation. It is anticipated this data will become available if another NFI is implemented in future.
- The inclusion of other carbon pools apart from living biomass such as, deadwood, litter and soil organic carbon. The current FREL/FRL only includes above-ground biomass and below-ground biomass due to limitation and reliability of available data (the existing NFI 2013 data have the information of those carbon pools but it is needed further investigation and analysis to use them as Tier2 data)
- Improving accounting post-deforestation regrowth. After deforestation, some lands are covered by crops and grass. The FREL/FRL deducts removals from post-deforestation regrowth in such lands but there is currently no reliable information available on the rates of increment in those crops and grass. Therefore default increment factors and averaging techniques were used. As better data become available, this approach may be improved.
- There is some potential improvements regarding some aspects of carbon stock enhancement. Notably tree planting has been promoted in Samoa but the current methods to estimate removals of tree planting is. It is hoped that in the future better data will become available in Samoa, which will generate better information on the results of tree planting campaigns throughout the country.
- Broadening the scope of the FREL/FRL to include other REDD+ activities such as sustainable management of forests or conservation of forest carbon stocks. With regard to the sustainable management of forests, there is no current data available that would allow for quantifying emissions from conventional forest management as opposed to sustainable forest management.

References

<Footnoted references>

Samoa Bureau of Statistics (2014), Table 4, https://www.sbs.gov.ws/digi/FOREST%20STATISTICS.pdf

SAMOA POPULATION AND HOUSING CENSUS 2021 Basic Tables: https://sbs.gov.ws/documents/census/2021/Census-2021-Final-Report_221122_051222.pdf

Samoa's Second Nationally Determined Contribution (2021) - https://unfccc.int/sites/default/files/NDC/2022-06/Samoa%27s%20Second%20NDC%20for%20UNFCCC%20Submission.pdf

Samoa Climate Change Policy 2020-2030 - https://www.mnre.gov.ws/wp-content/uploads/2021/03/Samoa-Climate-Change-Policy-2020-2030.pdf

Agriculture and Fisheries Sector Plan (AFSP) 2022–2027 - https://www.mof.gov.ws/wp-content/uploads/2023/05/Agriculture-Fisheries-Sector-Plan-2022-2027.pdf

The Strategy for the Development of Samoa (SDS) 2016/17-2019/20 - https://www.mof.gov.ws/services/economic-policy-planning/national-development-plans-for-samoa/

Pathway for the Development of Samoa FY 2021/22-2025/26 - https://www.mof.gov.ws/wp-content/uploads/2022/02/Pathway-for-the-Development-of-Samoa.pdf

Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas - https://www.cbd.int/doc/world/ws/ws-nbsap-powpa-en.pdf

Samoa's Sixth Report to the Convention on Biological Diversity - https://www.cbd.int/doc/nr/nr-06/ws-nr-06-en.pdf

<Other references>

Bey, A., Diaz, A.S., Maniatis, D., Marchi, G., Mollicone, D., Ricci, S., Bastin, J., Moore, R., Federici, S., Rezende, M., Patricia, C., Turia, R., Gamoga, G., Abe, H., Kaidong, E. & Miceli, G. (2019) Collect Earth: Land use and land cover assessment through augmented visual interpretation. Remote Sensing, 8, 807-830.

Brown, S., & Lugo, A. E. (1984). "Biomass of tropical forests: a new estimate based on forest volumes." Science.

Don, A., Schumacher, J., & Freibauer, A. (2011). "Impact of tropical land-use change on soil organic carbon stocks – a meta-analysis." Global Change Biology.

GFOI (2020) The GFOI's Methods and Guidance Documentation (MGD) Edition 3.1

Fox, J.C., Yosi, C.K., Nimiago, P., Oavika, F., Pokana, J.N., Lavong, K., & Keenan, R.J. (2010) Assessment of aboveground carbon in primary and selectively harvested tropical forest in Papua New Guinea. Biotropica, 42, 410-419.

FAO (2015) Emerging Approaches to Forest Reference Emission Level and/or Forest Reference for REDD+.

FAO (2015) Technical considerations for Forest Reference Emission Level and/or Forest Reference Level construction for REDD+ under the UNFCCC.

FAO (2010) Global Forest Resources Assessment 2010 Country Report, Samoa. Food and Agriculture Organization.

FAO (2015) Global Forest Resources Assessment 2015 Country Report, Samoa. Food and Agriculture Organization.

FAO (2020) Global Forest Resources Assessment 2020 Country Report, Samoa. Food and Agriculture Organization.

FAO (2017) From reference levels to results reporting: REDD+ under the UNFCCC

FAO (2018) From reference levels to results reporting: REDD+ under the UNFCCC 2018 update

FAO (2019) From reference levels to results reporting: REDD+ under the UNFCCC 2019 update

FAO (2020) From reference levels to results reporting: REDD+ under the UNFCCC 2020 update

FAO (2022) From reference levels to results REDD+ reporting by countries 2022 update

IPCC (2006) IPCC Guidelines for National Greenhouse Gas Inventories.

IPCC (2003) Good Practice Guidance for Land Use, Land Use Change and Forestry.

IPPC (2013) Supplement to 2006 IPPC Guidelines for National GHG Inventories: Wetlands.

IPCC (2018) Emission Factor Database. https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

IPCC (2019) 2019 Refinement to the 2006 IPCC Guidelines

Pan, Y., et al. (2011). "A Large and Persistent Carbon Sink in the World’s Forests." Science.