Forest Carbon Partnership Facility (FCPF)
Carbon Fund

ER Monitoring Report (ER-MR)

ER Program Name and Country:	Emission Reduction Programme - Fiji
Reporting Period covered in this report:	11 July 2019 – 31 December 2020
Number of FCPF ERs:	810,667
Quantity of ERs allocated to the Uncertainty Buffer:	76,882
Quantity of ERs to allocated to the Reversal Buffer:	106,159
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	48,253
Date of Submission:	4 April 2023
Version:	3.0

Contents

1 IMPLEMENTATION AND OPERATION OF THE ER PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the ER Program and changes compared to the ER-PD

The Emission Reduction Program (ER-Program) did not begin as planned due to the following:

The delay in the finalization of two key conditions, which were the endorsement of the Emission Reduction Payment Agreement (ERPA) that was signed by the Fiji Government on the 28th January 2021 and the enactment of the Climate Change Act (2021) that was passed in parliament on the 23rd September 2021.

Two tropical cyclones struck Fiji consecutively in late 2020 and early 2021, followed by the 2nd wave of the COVID-19 pandemic, restricting Government functions and further delayed the finalization of the review of the Forest Act and the Benefit Sharing Plan. The Benefit Sharing Plan has been endorsed by Government on the 28th April 2023. The Bill to review the Forest Act will be submitted for Cabinet decision in May and expected to be tabled in Parliament in the June session.

1.1.2 Update on the strategy to mitigate and/or minimize potential Displacement.

The land areas excluded from the ER-Program Accounting Area are predominately made up of sparsely populated islands (practicing subsistence agriculture) or unhabituated islands and atolls. As the National Forest Monitoring Systems is expected to effectively capture all forestry related activities, so any potential displacement will be captured through the established national MRV process.

As outlined in the Emission Reduction Program Document (ER-PD), the overall potential risk of domestic displacement is characterized as low (4 drivers as low risk and 1 driver as medium risk). The medium displacement risk identified relates to unplanned forest conversion to agriculture (shifting cultivation). An update is tabulated below.

Table 1: Update of Degradation Drivers

Driver of deforestation or degradation	Risk of Displacement	Explanation/ justification of risk assessment
Planned conversion to agricultural land	Low	The islands included in the ER-Program have traditionally been the location of planned conversion to agriculture. This is primarily because of its scale and proximity to markets. The large distances between ports and relatively small land areas suitable for agriculture on the outer islands make then economically infeasible for planned agricultural conversion. Therefore, displacement of planned conversion to agriculture to the outer islands which are not included in this ER-Program is unlikely. The rating for the monitoring period remains Low
Unplanned forest conversion to agriculture (shifting cultivation)	Medium	Shifting agriculture practices involving cash crops such as Taro and Kava pose a risk for displacement of emissions from the proposed ER Program activities to islands outside the ER-Program area. A medium risk of market displacement to islands outside the ER-Program areas was identified however this is considered small considering the remoteness of islands resulting in prohibitive cost of access to market. The combination of landownership structures, monitoring and reporting of program implantation over 90 percent of the national geographic area and remoteness of islands not covered by the program to markets has led to classifying this risk as Medium. The extensive national awareness campaign to educate the general public on sustainable management of forests and lands land resources and the opportunities and options available through carbon trading is considered complimentary to addressing this displacement risk. As this program has not yet been rolled out due to challenges in the COVID period the risk remains Medium.
Planned and unplanned natural forest conversion to planted forest	Low	Establishment of plantations is only approved by the government on the three islands included within the ER-Program areas. As a result, displacement of emissions from the proposed ER Program activities to islands outside the ER-Program area are not considered likely. The rating for the monitoring period remains Low

Driver of deforestation or degradation	Risk of Displacement	Explanation/ justification of risk assessment
Planned and unplanned conversion related to infrastructure	Low	Drivers of planned and unplanned conversions to infrastructure in the ER-Program area include settlement expansion, as people move from villages to urban areas in search of employment, expanding road infrastructure and tourist related investments such as resorts. The ER Program aim to develop a national land use plan which will include consideration for infrastructure development to minimize conversion of natural forests from infrastructure development. The risk of displacement of these activities to islands not covered under the ER-Program is unlikely as most of the population reside on the islands included in the ER-Program. Impacts from any displacement of tourist related infrastructure as a result of this ER-Program is considered small as maintaining the natural environment is part of the experience that attracts visitors to Fiji. The rating for the monitoring period remains Low
Unsustainable legal and illegal selective logging for commercial and subsistence purposes .	Low	The project area covers the three islands where commercial logging is permitted. No commercial logging is conducted on the islands not included in the ER program, therefore there will be no national displacement of commercial logging. Displacement of unsustainable subsistence logging outside of the project area is not likely due to the logistical and cost issues of moving forest resources between the outer islands and those islands included in the ER Program Area. The rating for the monitoring remains Low

1.1.3 Three (3) actions are recommended under the ER-Program to prevent and minimize potential displacements and an update is provided below.

Action 1: Strengthening enabling conditions for emission reduction

1.1.4 **Integrated District Land Use Planning (IDLUP):** Twenty (20) districts have been selected in which the ER-Program will be implemented and district-level integrated land use plans will be developed. To-date, ten (10) plans for the ten districts in Vanua Levu have been developed. The remaining ten (10) plans for Viti Levu will be completed by December 2023 and all plans will be uploaded onto the National Forest Monitoring System (NFMS).

Awareness raining has begun and by December 2023, a total of 129 villages will be visited (out of the 177 ER villages). The Vanua Levu plans are currently being used during community engagement and consultation work that is ongoing and an update will be provided in the next monitoring period.

1.1.5 **Strengthening Forest Governance and Law Enforcement:** Very little progress on the implementation of the activities/actions was made during the period due to the COVID-19 restrictions. However, the Ministry of Forestry continues to issue licenses and monitor all forest operations and programs during the period.

Three (3) divisional-level training on the FFHCOP (Code) including Monitoring, SFM, SOP on Carbon Enhancement Activities: Training will commence by July and completed by December 2023. An update will be provided in the next report.

Fire Management Strategy Training: Training for the Director-level was conducted from April 11-13 2023. A training report (and resolutions) will be provided in the next report.

Forest Care Groups (FCG): Most, if not all, villages in Fiji have established village-led committee that are registered with the Ministry of iTaukei Affairs. These committees will be strengthened, supported and aligned to perform the functions of Forest Care Groups under the ER-Program. A registry of all FCG will be developed and reported on in the next period.

Capacity building on forest laws enforcement at industry and trade level: Similar training[1] for inter-agency was conducted under the GEF PAS 4 FPAM project and training material and training reports

[1] The Australian Centre for Environmental Compliance (ACEC) had conducted similar training for Non-Compliance and Reporting of Breaches in 2017-2019 under the GEF 4 FPAM Project

are available. Participants included MOF, TLTB, Min of iTaukei Affairs Cons. Officers), National Trust of Fiji, Min of Environment, NGOs. The need for conducting refresher training will be reviewed and an update will be provided in the next reporting period.

1.1.6 **Forest Information System (FIS):** The NFMS was reconstructed and this work was completed in January 2023. The previous NFMS encountered technical issues and was no longer accessible. The integration platform has also been completed. Key ministry personnel (managers, operators and users) have assisted in the reconstruction and integration work, as part of their hands-on training, and are currently populating the NFMS platform, which will be completed by July 2023.

Action 2: Promoting Integrated Landscape Management (ILM)

1.1.7 **Forest Management License (FML):** The framework for the issuance of the FML (including the ER Lease and Carbon Sequestration Property Right (CSPR) certificate will be finalized by May 2023. All ER activities will be required to acquire a lease and license, subject to the development of a Forest Management Plan.

Forest Management Plan (FMP): A template for the Forest Management Plan has been developed and a combined training on its application for the three (3) Divisional Directors Operations (including ADD and Senior Foresters) was conducted from 17th – 21st April 2023 in the Northern Division. 0The second combined divisional-level training is scheduled for late-May to early-July 2023.

1.1.8 **Sustainable Management of Natural Forests:** The targeted area of 8,500 Ha spread across eight (8) districts, as stated in the ER-PD remains unchanged. In general, the level of forest degradation due to forest harvesting has reduced during the period due to the COVID-19 restrictions as recorded in the forest cover change analysis.

Application of the Diameter-Limit-Table under the FFHCOP (2013): The DLT has not been applied nationally due to the economic downturn during the COVID-19 period. Only three (3) licenses issued from 2019 – 2020 in the northern division have adopted the DLT regime. Consultations with the Harvesting Companies were conducted prior to the issuance of these licenses. The operations are ongoing. An update will be provided in the next period.

Co-Management of FML: The co-management arrangements for monitoring is a mandatory requirement under the Forest Harvesting License conditions and the FFHCOP. Monitoring of harvesting operations is conducted bi-annually and reports on performance are submitted through the License Area Report (periodic), Harvest Area Report (Annually). Further development and strengthening in terms of training and capacity building will be conducted in July 2023 and an update will be provided in the next report.

Multi-stakeholder Dialogue and Decision-making Platform: This has not been possible due to the COVID-19 restrictions. The Divisional Working Group (DWG) for each division were established during the REDD+ Readiness phase and will require revisiting and strengthening. An update will be provided in the next report.

1.1.9 **Afforestation (Plantation Forests):** The target of 7,532 Ha as stated in the ER-PD remains unchanged. In general, the performance of the Fiji Pine Limited (FPL) [target of 6,095 Ha] and the Fiji Hardwood Corporation Limited (FHCL) [target of 1,437 Ha] has made positive contributions during the period, as recorded in the forest cover change analysis.

Capacity Building & Training on FFHCOP: The FPL staff are trained and fully versed with the requirements of the FHHCOP and have been conducting internal auditing and reporting as required under the FSC certification. The MOF is assisting FHCL progress towards attaining FSC certification and training for the field staff will be conducted in July 2023. An update will be provided in the next period.

Strengthening of Monitoring & Evaluation of Planted Area: The 2 companies have assisted in the compilation of activity-datasets for this monitoring period. The Government is reviewing the Mahogany Industry Development Decree (2010), which restricts the MOF's M&E work in the mahogany plantation forests. The MOF will establish MOUs with the 2 companies for the sharing of data. An update will be provided in the next period.

Implementation of the Fire Management Strategy: Fires are more predominant in the pine plantation forests. The FPL have a Fire Management program that is implemented regularly to control forest litter volumes. Threats from adjacent cane farms are rife and training for cane farmers is planned for August 2023. An update will be provided in the next period.

1.1.10 **Carbon Enhancement Community Tree-Planting:** The target of 5,750 Ha spread over 11 districts as stated in the ER-PD remains unchanged. For the 2019 and 2020 period, an area of 1,028 Ha of tree-planting under the Ministry's 30-million tree-planting target have been included in the forest cover change analysis for this period.

Community Awareness on 4-Million Tree-Planting Program: The national target has been increased to 30-Million trees in 15-years. To-date, over 18 million trees have been planted, and there is an increasing interest received for participation each year. The MOF have developed a national dashboard that provides an update of the achievements and location of planting sites. The MOF has created a database for all interests (EOI) received and serviced - communities that are interested in participating in the ER-Program will be revisited. An update will provided in the next period.

Community Consultation on Land Use Planning, Planning Workshop, ER-Program consent, M&E: This was not possible due to the COVID-19 restrictions. Community consultations that have been conducted have been limited to awareness raising at this stage. As stated, a total of 129 villages (out of 177 ER villages) will be visited by December 2023 and an update will be provided in the next period.

Desk top assessment of the land – map layers – forest, soil classes, road/infrastructure, settlement, water catchment, titles & registry check to ensure land is unencumbered: This work is being conducted during the development of the district-level integrated land use plans.

1.1.11 **Afforestation/Reforestation (Riparian restoration, Shade Grown Agriculture, Alternative Livelihood):** The target of 7,500 hectares spread across the 20 ER districts as stated in the ER-PD remains unchanged.

Flood Mitigation (Riparian Restoration) - Increase Service & Intervention through Advice & Supply of Planting Material **(Target of 5,000 Ha across 7 districts)**: An assessment of the current status of the major water-ways and riparian systems is being conducted. An update will be provided in the next period.

Shade Grown Agriculture - Introducing shade tolerant crops through agroforestry **(Target of 1,500 Ha across 7 districts)** / **Alternative Livelihood Ventures -** Introducing community-based ventures, value chain assessment, **(Target of 1,000 Ha across 7 districts)**: Potential sites identified in the provinces of Naitasiri and Siagtoka , which will be visited in June 2023. An update will provided in the next period.

1.1.12 **Forest Conservation:** The target of 9,500 Ha spread across six (6) priority areas as stated in the ER-PD remains unchanged. However, given the delay in the start-up and the time remaining for the implementation of the ER-Program, the implementation of this activity will be reassessed and an update will be provided in the next period.

Action 3: Program Management and Emission Monitoring.

1.1.13 **Project Coordination and Management**

The Gender Action Plan (GAP) and Environmental Social Management Framework (ESMF) studies have been completed and their respective implementation arrangements identified. The socializing and setting up of MRV structures are currently being conducted, as part of the community engagement and consultation program that is currently ongoing. By December 2023, a total of 129 villages (out of the 177 ER villages) will be visited during which MRV structures will be established. Similarly, capacity building and support for the development of MRV systems for the Provincial and District-level institutions will also be completed by December 2023. An update will be provided in the next period.

The REDD+ Unit, under the Forest Resource Assessment (FRA) Division, is assigned the responsibility of managing the implementation of the ER-Program and the training of staff and transitioning/alignment of the systems and activities into the MOF institutional structure is ongoing. An update will be provided in the next period.

1.1.14 **Monitoring & Evaluation (includes monitoring of safeguards):** A Safeguard Officer has been appointed. Three (3) other staff have been identified and their reassignment will be finalized by July 2023. The first training for the MOF Staff was conducted from 17th – 21st April. A second training is scheduled for June 2023. An update will be provided in the next report.

Assessment of Safeguards for Retroactive Carbon (July 11 2019 – December 31 2020): A draft report, based on a desk-top analysis, was submitted to the RSS-World Bank. The field verification, including personal interviews and onsite inspection, to complete the report could not be conducted due the COVID-19 restriction, which resulted in the suspension of this work. The report has been completed and will be submitted to the FMT (World Bank) by May 2023.

1.1.15 **Management and Processing of MRV Activities: a) MRV Equipment -** All offices are equipped with computers and have been collecting and submitting activity data on a regular basis. By June 2023, fifty (50) hand-held tablets will be procured and programmed with data-collection templates to improve the efficiency and maintain consistency in the submission of field data. The first training for field officers was conducted in April 17th – 21st 2023. A second training is scheduled for June 2023. **b) NFMS -** the NFMS has been reconstructed and currently being populated (integration work) and will fully operational by July 2023. **c) Reporting –** the ER for the first monitoring period has been completed through sub-automated (offline) means, as the interfacing work was incomplete.

1.1.16 **Effectiveness of the organizational arrangements and involvement of partner agencies**

The organizational arrangements as stated in the ER-PD remains unchanged. The main platform for discussion is the national REDD+ Steering Committee (RSC) meeting that is convened at least twice a year. RSC-Technical Work Groups (TWG) meetings are convened to provide technical vetting for studies and assessments and advise the RSC. The decision to maintain the RSC structure will be finalized by July 2023.

The Divisional Working Groups (DWG) headed by the divisional Commissioners will be maintained. By June 2023, all four (4) DWG will be revisited to reaffirm the structure and functions.

The involvement of partner agencies noted during the period include:

a. The leadership role of the Climate Change and International Cooperation Division (CCICD) of the Ministry of Foreign Affairs in the finalization of the Framework for the issuance of the Lease/License/CSPR certificate;
b. The support of the Ministry of Finance to the recommendations of the Benefit Sharing Plan;
c. The involvement and leadership of the fourteen (14) Provincial Offices (under the Ministry of iTaukei Affairs) in the awareness raising.
d. The confirmed support of the Ministry of Agriculture in the implementation of the Climate Smart Agriculture intervention activities. The CSA activities are programmed for implementation in the Ministry's Annual Operation Plan.
e. The support of the iTaukei Land Trust Board (TLTB) to lead the development of the district-level integrated land use plans for the 20 ER districts. To-date, 10 district level integrated plans have been developed and the remaining 10 plans will be ready by December 2023.
f. The support of the Fiji Pine Limited and Fiji Hardwood Corporation Limited in the provision of field activity data towards the analysis and calculation of the FRL and net emission for the period;
g. The support of the Civil Society and Non-government organizations to participate in the rolling out of the national ER-Program awareness campaign.

It is anticipated that the organizations will continue to support and contribute to the implementation of the ER-Program.

1.1.17 **Updates on the assumptions in the financial plan and any changes in circumstances that positively or negatively affect the financial plan and the implementation of the ER Program.**

The Investment Plan and funding sources identified in the ERPD and their status (assumptions) are tabulated below:

Table 2: Investment Plan

Financing Sources	Currency	Amount	Assumption
Fiji Government	USD	13,327,244	Government's support remains unchanged.
External Sources (anticipated)	USD	8,889,071	The Ministry of Forestry, with assistance of the FAO (UN) Suva Office, is developing the project proposal to the GCF to secure this fund. This funding is expected to be delayed. The Fiji Government (Cabinet Approval) will bridge the funding gap.
Carbon Fund results-based payment	USD	12,573,154	Remains unchanged.
Fiji Pine Ltd.	USD	6,704,500	Remains unchanged.
Fiji Hardwood Corporation	USD	1,140,978	Remains unchanged.
Logging Industry (private)	USD	549,140	Remains unchanged.
TOTAL sources	**USD**	**43,184,087**	

1.2 Update on major drivers and lessons learned

In 2019 and 2020, the rate of deforestation and forest degradation decreased, which can be attributed to the nationwide suspension of field operations due to the restriction of movement during the COVID-19 lockdown period. No major developments for mining and infrastructure sectors were recorded.

The impact of the COVID-19 pandemic has affected Fiji's economy and the downturn in employment in particular, from the Hotel and Catering industries and the tourism sector. To cushion this impact, the Fiji Government, through the Ministry of Agriculture, has provided nationwide livelihood programs, which has encouraged the establishment of family farms and there is every likelihood that there will be an increasing number of farms established during and after 2020 and possible removal and conversion of forest land. Similarly, increasing trends are also expected for demand for timber for residential (house building) and resettlement purposes and for firewood, in particular for jobless families returning to the sanctuary of the rural and village setting.

Under the Ministry of Forestry's Annual Work Programme, a budget of USD 1 million is assigned for the "rehabilitation of degraded forests" (RDF Tree planting program), which began in 2018-2019. This allocation remains unchanged and to-date 4,122.65 [ha] of barren land have been replanted with native and plantation (pine and mahogany) and fuelwood tree species. The national target is to plant 30 million trees over the next 10-years, which is expected to re-establish approximately 30,000 hectares of barren land with forest cover.

With the rolling out of the national ER Program, the monitoring of the drivers of deforestation will be improved through the data & information sharing arrangements with key ministries that will be established by December 2023, which includes: -

a) The Ministry of Lands and Mineral Resources – regarding mining;
b) The Ministry of Rural & Maritime Development – regarding road infrastructure;
c) The Ministry of Agriculture – regarding agricultural development.

2 SYSTEM FOR MEASUREMENT, MONITORING AND REPORTING EMISSIONS AND REMOVALS OCCURRING WITHIN THE MONITORING PERIOD

2.1 Forest Monitoring System

Fiji's National Forest Monitoring System is in the early stages of operationalization. The system consists of institutional arrangements, data collation and processes, integration and estimation and finally data recording and archiving.

Organizational structure, responsibilities and competencies

Fiji's institutional hierarchy related to National Forest Monitoring shown in Figure 1. The **authority** for reort submission lies with the Ministry of Economy Climate Change and International Cooperation Division is the UNFCCC National Focal Point and Designated National Authority for the National Communication (NC) and the biennial update reports (BUR).

The Ministry of Forestry is **responsible** for overall management and operation of Fiji's National Forest Management System which generates annual Activity Data related to land use change, oversees the adoption of National Emissions factors and collates other auxiliary data used in the reporting on information relating to greenhouse gas emissions and removals from forests. The Ministry is also responsible for the collation and reporting of safeguards and biodiversity indicators. These two Ministries **inform and consult** a range of stakeholders, including the REDD+ Steering Committee, which represents a cross section of civil society and business interests, as well as other government Ministries. The key roles and responsibilities are summarised in Table .

There are no changes to the structure of the MRV elements or roles and responsibilities from that listed in the Emission Reduction Program Document, with the exception the name of the Management Services Division being changed to the Forest Resource Assessment Division. A number of elements of the NFMS have matured during the period between the ERPD and this first Monitoring Report as a result of the REDD Readiness Grant extension. These include the:

- Development of the Forest Information Management System which has created a user friendly data integration platform and document control and archiving structure. The FIMs Design and User Manual have been provided as supplementary documentation to this Monitoring Report.
- National Forest Inventory data collection field work has been designed and teams have commenced data collection
- Additional work to monitor and report land use change in mangrove ecosystems

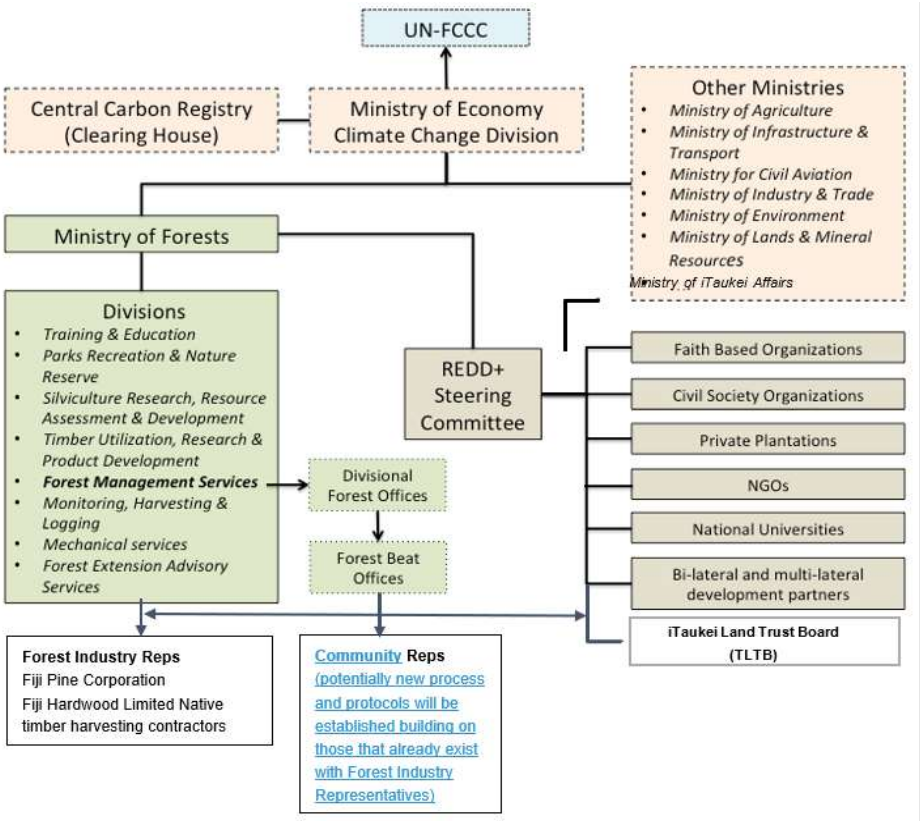


Figure 1: Institutional coordination related to National Forest Monitoring System

Table 3: Roles and Responsibilities related to Operation of the National Forest Monitoring System

Task	Conservator of Forests	REDD+ Steering Committee	DCF Operations	DCF Services	Forest Resource Assessment Division	ER Licence Holder	Ministry of Agriculture	Fiji Hardwood Corporation	Fiji Softwood Limited	Ministry of Economy	*iTaukei* Land Trust Board
Land Use Change Activity Data Generation	A	I	C	C	R	C		C	C	I	C
Emission Factor Generation / Selection	A	I	C	C	R	C		C	C	I	C
Timber Extraction Data Collation	A	I	C	C	R	C		C	C	I	C
Other auxiliary data collation	A	I	C	C	R	C	C	C	C		C
Data Processing	A	I			R					C	
Integration to produce reports	A	I	C	C	R	C	I			C	I
Production of Reports	A	I	C	C	R	C	C	C	C	C	C

A - Authority; R - Responsible; C - Consulted; I – Informed

Measurement, Reporting and Verification (MRV) relies on data collection and analysis procedures and reporting outputs from the National Forest Management System (NFMS) managed by the Ministry of Forestry Forest Resource Assessment (FRA) Division (Figure 2).

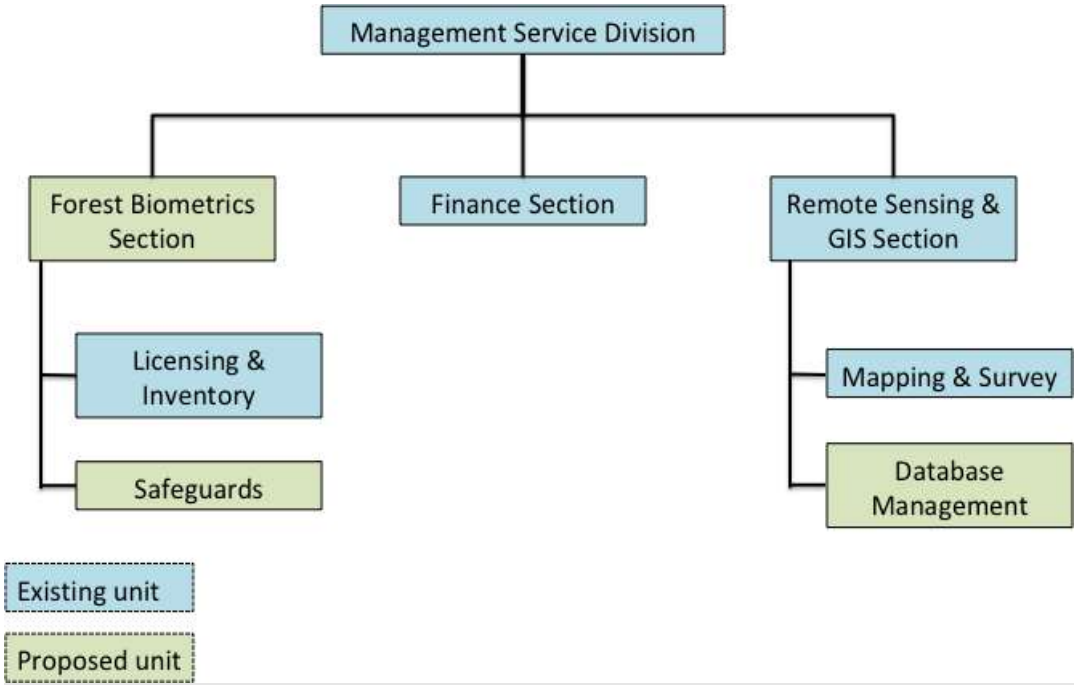


Figure 2: Existing and proposed institutional arrangements of Forest Resource Assessment Division of the Ministry of Forest

The selection and management of GHG related data and information

Data and information required for the generation of estimates for the Carbon Fund Monitoring Report are collated from a number of sources. The following table outlines the key monitored data for each Monitoring Period.

Table 4: Monitored data for each Period

Activity Data	**Source of Data**	**Format of Data**
Areas of deforestation/reforestation	Ministry of Forestry, Management Services Division / Remote Sensing and GIS Division	Raster layers and change matrices GIS layers
Areas of Forest Degradation	External consultant	Areas as hectares
Natural forest volume extracted, open stocked area, areas harvested, areas planted	Ministry of Forestry, Divisional Forest Offices	Tables as word files
Softwood volume extracted, open stocked area, areas harvested, areas planted, areas burnt	Fiji Pine Limited	Tables as word files
Hardwood volume extracted, open stocked area, areas harvested, areas planted, areas burnt	Fiji Hardwood Corporation	Tables as word files

Processes for collecting, processing, consolidating and reporting GHG data and information

The NFMS has the following core functions which rely on collaboration across a number of stakeholders:

- Data collection
- Data collation and processing
- Integration to produce estimates
- Production of reports

The core elements/processes that support these functions and the documented SOPS are listed in the Table below. These SOP documents are living documents and continue to be expanded and improved as part of Fiji's Continuous Improvement Process. All SOPs are stored on Fiji's Forest Information Management System and have been extracted and provided as supplementary documentation to this Monitoring Report.

Table 5: List of Standard Operating Procedures

Element/Process	Standard Operating Procedures
Remotely sensed data analysis	SOP – How to create an image dates display in ERMapper SOP -Setting Up Multi-Temporal Classification (CPN) Runs SOP – Creating a 7-band TIFF image for Classification SOP - Fiji Mosaic Areas for Classification and CPN SOP - Visual Interpretation using Collect Earth online SOP - Elimination of Polygons Smaller than MMU SOP - Procedure for Final Sample Selection SOP - Procedures for preparing the interpreted data from Collect Earth Online: When using a Preliminary Sample SOP - Procedures for preparing the interpreted data from Collect Earth Online: When NOT using a Preliminary Sample SOP - Procedure for Sample Size Analysis using USFS Tool SOP - Procedure for Preparing Strata using Changed Hardwood, Mangrove and Island Boundaries
Ground data collection	SOP - SOP - NFI Data Collection SOP – NFI Data Analysis SOP – Recording of volumes extracted from Natural Forest SOP – Recording of areas harvested in Natural Forest SOP – Collection and review of activity data from Fiji Pine Limited SOP – Collection and review of activity data from Fiji Hardwood Corporation
Integration	SOP – Running ER Estimates in the Forest Information Management System
Document Management	SOP – Operating the Forest Information Management System SOP – Editing and creating Operational Documents in the Forest Information Management System SOP – Archiving Documents in the Forest Information Management System

Systems and processes that ensure the accuracy of the data and information

Data and information accuracy is embedded in the processing and collating of data that are described in the SOPs listed above. Each data set or process has a number of checks and balances that specific to the type of data to maintain the quality and integrity of the reported information. These processes have proven to be effective as material mistakes in the data were found during the development of this Monitoring Period information. The processes have been improved to avoid future mistakes including increased capacity building of the local team.

Design and maintenance of the Forest Monitoring System

The National Forest Monitoring System (NFMS) has been developed with an integrated approach to data capture and use, by creating relationships, operational structures (i.e. roles and responsibilities) and documentation to

consolidate and formalize the regular collection of information to enable consistent monitoring and reporting of carbon stock changes over time.

Whilst forestry related data capture had historically incorporated both GIS and ground data elements, the NFMS adopts an integrated approach using remote sensing data and periodic ground measurements throughout all major forest types in Fiji.

MSD has a long history of collecting/generating data related to forest management in Fiji from remote sensing analysis and ground inventories. Some of this data is necessary to estimate emissions and removals from deforestation, forest degradation and enhancement of carbon stocks. Data collection is conducted in the field by staff as well as through established relationships with several agencies and corporations including SPC-GSD Geoscience Division of the Pacific Community, Fiji Pine Limited and Fiji Hardwood Corporation Limited.

In the past this data collection was undertaken for operational purposes related to the timber industry with some data collected on a regular basis (e.g. reporting of volumes extracted from timber harvest operations) and others on an 'ad hoc' basis as funds allowed (e.g. mapping of forest cover, measuring permanent sample plots and national forest inventory plots). It is acknowledged that the REDD+ MRV will build on the existing data collection structures but will lead to a maturing of the National Forest Monitoring System through a series of planned improvements in the short, medium and long term.

The datasets described below serve as the basis of Fiji's National Forest Monitoring System (NFMS), which incorporates methods and approaches consistent with IPCC guidelines for the estimation of emissions and removals from Forest lands.

Planned improvements to this existing system will strengthen the capacity to consistently report forest related information to internal and external agencies such as the United Nations Framework Convention on Climate Change (UNFCCC) and the FAO Forest Resource Assessment, among many others. In particular, the REDD+ MMR requirements have prompted the pan to include safeguards and biodiversity indicators to support such reporting, both to nationally and to relevant external stakeholders.

To achieve these expanded aims, the Ministry of Forestry has strengthened the quality of the data collected and reported through the development of the Forest Information Management system and through the improvement of documentation relating to data collection and collation and associated QA/QC protocols. Comprehensive training of staff associated with monitoring related responsibilities in the application of the data collection protocols is now an ongoing part of the NFMS.

The system can be diagrammatically represented as follows:

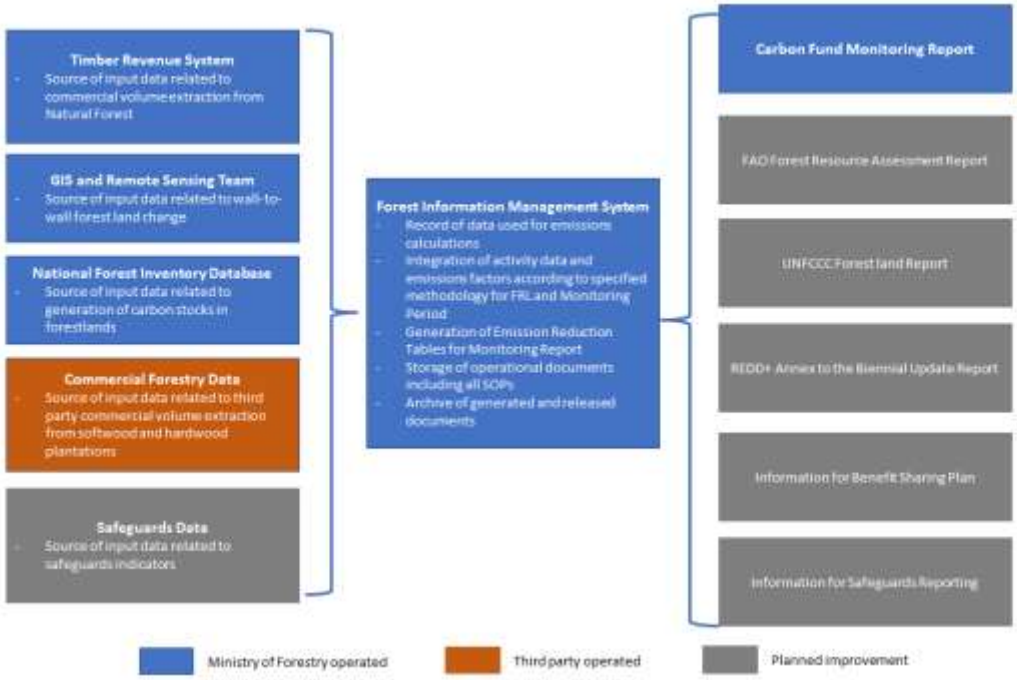


Figure 3: Design of Fiji's National Forest Monitoring System

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures

The standard operating procedures related to the NFMS are listed in the Table above. These SOPs outline QA/QC procedures for each data source and process and include a number of sampling checks and logic checks in the process before data and reports are released. These procedures are active and utilised and experiences/outcomes from the procedures feed into the continuous improvement process of the NFMS.

Role of communities in the forest monitoring system

The main role of the community in Fiji's forest monitoring system is through the role of NGOs on the REDD+ Steering Committee. The committee include a number of community organisations including faith based organisations and the iTaukei Land Trust Board. The Steering Committee is heavily involved in the design of the system and in the outreach to the community groups in relation to REDD+ activities of the ER Program. The community does not have an active role in data collection for the monitoring system.

Use of and consistency with standard technical procedures in the country and the National Forest Monitoring System

Fiji's National Forest Monitoring System is a first of its kind in Fiji. The system is being considered as the basis for a National Land Monitoring System which would result in the collaboration of the Ministry of Agriculture, Ministry of Lands and the Ministry of Fisheries with the aim of supporting the Ministry of Economy to report to the UNFCCC changes in the six IPCC land categories.

Ministry of Forestry is further supported in the delivery of REDD+ Activities outlined in the Emissions Reduction Program Document by the institutions listed in

Table .

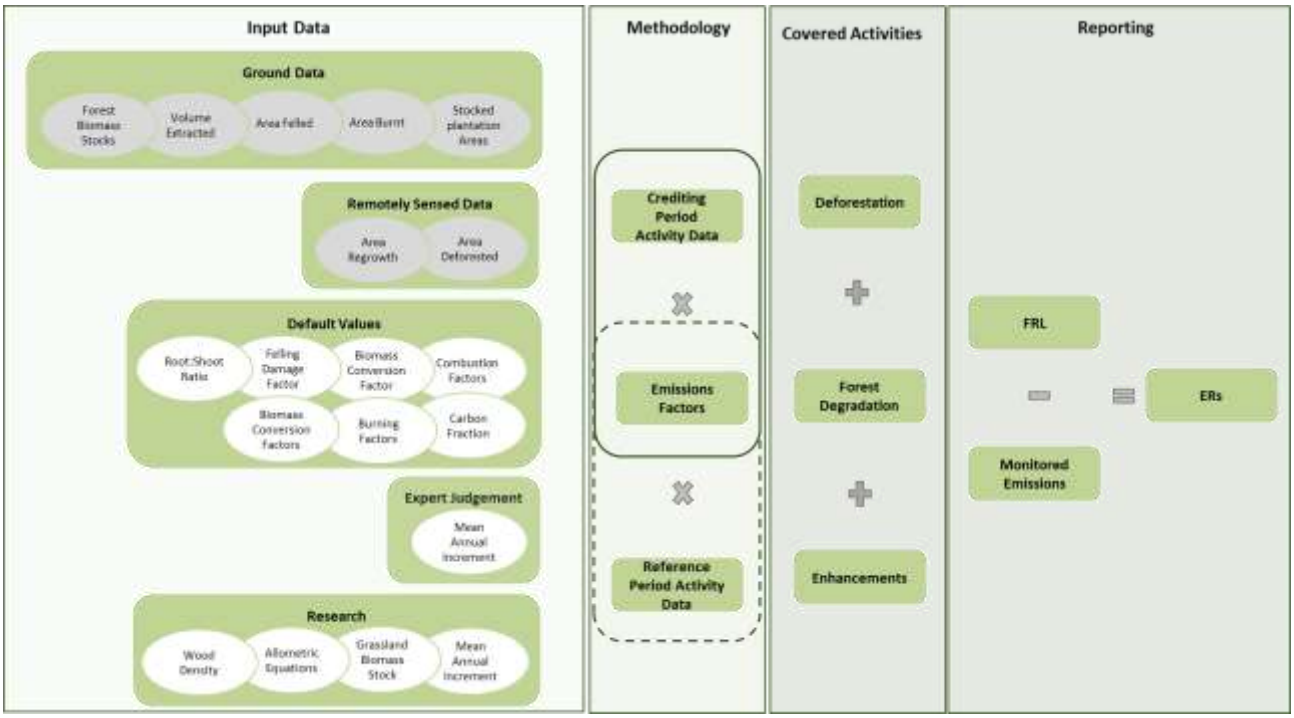
Table 6: Collaborators in the delivery of the REDD+ activities.

Institutions	New Responsibilities under REDD+	Report to
Ministry of Forestry	• Monitor and Report of GHG emissions and removals by sinks to National Designated Authority (Ministry of Economy)	Ministry of Economy Climate Change and International Cooperation Division
Silviculture Research, Resource Assessment & Development Division	• Undertaking applied research to develop knowledge and skill to improve the ways in which forest owners manage and use forest resource to meet current and future demand of the expanding population. • Undertake research on silviculture to generate knowledge and technology for sustainable management of forests • Develop guidelines for sustainable forest management • Building capacity of government and community members on sustainable forest management • Develop allometric equations for the major tree species, including Mangrove • Develop yield and growth models for the major forest types and species	Permanent Secretary, Ministry of Forestry
Timber Utilization, Research & Product Development Division	• Carry out research on harvesting and utilization of timber, value added products from timber • Timber seasoning and preservation • Conduct research on utilization of lesser-known species for timber and other uses	Permanent Secretary, Ministry of Forestry
Management Services Division	• Provide Forest Management Information needs and services to the Ministry Forestry (forest areas, standing forest stocking, logged areas & volume**)** • Provide technical support and services to members of the public relating to natural forest management (volume estimate, logging plan maps, forest inventory) • Management of Forest Information System and Database (forest cover change analysis of satellite image & updating information into our database) • Measurement of permanent sample plots • Mapping & surveying of forest boundaries, forest functions & services • Coordination & facilitation of International, regional conventions & agreements on forests • Regulate Quality control and quality assurance of forest monitoring and measurement • Carry out National Forestry Inventory	Permanent Secretary, Ministry of Forestry
Forestry Training Centre	• Carry out capacity building activities related to forest inventory, yield and growth, remote sensing and GIS, land use classification,	Permanent Secretary, Ministry

Institutions	New Responsibilities under REDD+	Report to
	accuracy and uncertainty assessment	of Forestry
Divisional Forest Offices	• Carry out pre-harvesting inventory and assessment of logging operation • Monitoring and surveillance of harvesting activities • Participate in community awareness and outreach to NGO and communities in rural areas associated with NGOs • Reporting on forest management activities including logging operation to Forestry Department • Maintaining divisional level database system	Conservator of Forests, Ministry of Forestry
Ministry of Forest		
Divisional Forest Offices	• Carry out pre-harvest inventory and assessment of logging operations • Monitoring and surveillance of harvesting activities • Participate in awareness and outreach to NGOs and communities in rural areas • Report on development activities including, logging operations to Forestry Department • Maintaining division level database system	Conservator of Forests, Ministry of Forestry
Communities and Landowner Groups/ Programmes		
Communities	• Provide land for Programme activities • Adopt new land and forest resource management practices • Attend capacity building activities related to REDD+ socialisation and forest monitoring • Collect and report ground data related to monitoring of forest resources and safeguard indicators	Communities (Village/District/ Provincial Council Meeting)
International Development Partners		
SPC Geoscience, Energy & Maritime Division	• Provide technical support particularly on Remote Sensing and GIS to MINISTRY OF FORESTRY and its sub-ordinate organizations • Provide technical support to estimate activity data using remote sensing techniques • Provide technical support on forest inventory • Carry out capacity building activities related to forest assessment and RS and GIS application	Government of Fiji as a member of the Pacific Community
GIZ	• Provide technical support for forest assessment. • Carry out capacity building activities. • Provide financial support to carry out research and development activities.	Government of Fiji
Conservation International	• Provide technical and financial support to community for afforestation and reforestation • Support to develop livelihood options	Permanent Secretary, Ministry of Forestry

2.2 Measurement, monitoring and reporting approach

2.2.1 Line Diagram



Greyed input data represents data collected for each Monitoring Period. All other input data remain the same between the FRL and the Monitoring Period. Input data can be categorsied into data categories which are applied in the calculation methodology. These data are integrated in simplistic terms by multiplying activity data by emission factors to generate estimates for three REDD+ activities; deforestation, Forest Degradation and Enhancements for the FRL and the Monitoring period from which ERs are estimated and reported.
Standard Operating Procedures are available outlining the processes for all the collected Input Data, implementation of the methodology through the Integration Tool and Generation of Reports from the Forest Information Management System.

2.2.2 Calculation

The methodology for estimating emissions and removals during the Monitoring Period (July 2019 – December 2020) encompassed the same activities as those included in the Reference Period (2006-2016). A combination of direct and proxy methods is applied to generate emissions and removals from: i) Deforestation; ii) Forest Degradation; and iii) Enhancements of Carbon Stocks (see Figure below).
The estimates are generated by running a Monte Carlo simulation, where values are sampled at random from the input probability distributions for each variable.

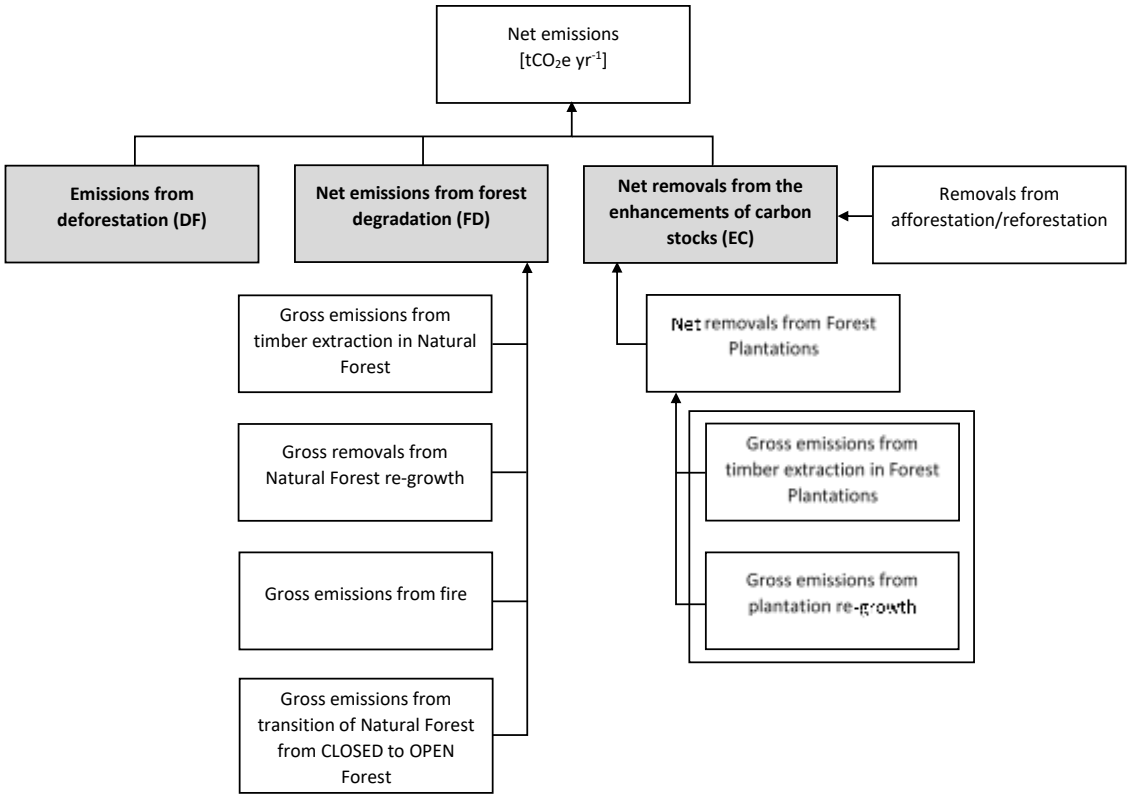


Figure 4: Overview of the sources and sinks considered in Fiji's Forest Reference Level (FRL), including the sub-sources and sinks for forest degradation and enhancement of forest carbon stocks

The calculation of emissions reductions is conducted by subtracting the actual emissions/removals over the Reporting Period from the predicted emissions/removals from the estimation of the Forest Reference Level (FRL) for each activity and then adding the ERs from each activity together to arrive at the total ER number.

Reference Level

The FRL estimation method is presented in Annex 4 of this Monitoring Report. Technical corrections have been made to the FRL presented in the Emission Reduction Program Document. A summary of these technical corrections is detailed in Annex 4 to this Monitoring Report. Annex 4 provides extensive justification for the submission of an updated Reference Level including all additional and updated methods and data used to generate the reference level.

Accounting for Emissions and Removals in the Monitoring Period

Emissions and removals[†] as a result of REDD+ Activities are estimated based on the following principles:

- calculation of the emission reductions are based on comparing the emission associated with the land use changes, extractive and regrowth activities in the reference period and the monitoring period;
- As such it is assumed that the average annual rates of area change and extractive or regrowth activities during the Reference Period would have applied during the Crediting Period; and
- therefore the emission reductions are calculated as the difference between the expected emissions and removals under the Reference Level and the actual emissions and removals.

[†] Legacy emissions have been assessed following FMT Note CF2020-5 dating 29 January 2021

Deforestation

Emission Removals from deforestation were estimated as:

$$ER_{Def} = \left[(\mathrm{AD}_{FRLDef,i} \times \mathrm{EF}_{CS,i}) - (\mathrm{AD}_{MPDef,i} \times \mathrm{EF}_{CS,i})\ \right] \quad \textbf{(1)}$$

Where:

ER_{Def}	=	Emission reductions from deforestation during the monitoring period; tCO_2e
AD_{FRLDef}	=	Average area of deforestation in strata i in the FRL period; ha
AD_{MPDef}	=	Area of deforestation in strata i (either lowland or upland) in the monitoring period; ha
EF_{CS}	=	Deforestation emission factor for strata I (either Lowland or Upland); $tCO_2e\ ha^{-1}$

Forest Degradation

Emissions from degradation are estimated as the combination of the net emissions/removals from logging in Natural Forests managed by the Ministry of Forestry, transitions from Closed to Open Forest in Natural Forests and emissions from fire in Pine Plantations.

Felling in Natural Forest

Emissions related to logging practices in natural forest were estimated using the approach proposed by Pearson et al. (2014) which converts volumes extracted during logging operations to total carbon loss including loss from the felled tree itself (AGB and BGB), logging residues of the felled tree, logging damages to the remaining stand (AGB and BGB), and losses due to the establishment of logging infrastructure (e.g., skid trails, logging roads and log landings). Gross emissions from forest degradation were estimated using the IPCC generic equation where the volumes recorded in the Timber Revenue systems served as Activity Data and the Total Emission Factor (TEF) (multiplied by n_{cc}) served as the Emissions Factor.

$$\begin{aligned} ER_{FD} = \{[[&((\mathrm{AD}_{FRLNFHvol} \times \mathrm{EF}_{NFH}) + ((\mathrm{AD}_{FRLNFH} \times \mathrm{EF}_{NFHrem})) + ((\mathrm{AD}_{FRLNFF} \times \mathrm{EF}_{NFF}) \\ &+ (AD_{FRLFSW} \times EF_{FSW}))] \\ &- [((\mathrm{AD}_{MPNFHvol} \times \mathrm{EF}_{NFH}) + (\mathrm{AD}_{MPNFH} \times \mathrm{EF}_{NFHrem})) \\ &+ ((\mathrm{AD}_{MPNFF} \times \mathrm{EF}_{NFF}) + (AD_{MPFSW} \times EF_{FSW}))]\} \end{aligned} \quad \textbf{(2)}$$

Where:

ER_{Def}	=	Emission reductions from forest degradation during the monitoring period; tCO_2e
$AD_{FRLNFHvol}$	=	Average volume of timber harvested in Natural Forest during the FRL period; $m^3\ ha^{-1}$
AD_{FRLNFH}	=	Average area harvested in Natural Forest during the FRL period; ha
AD_{FRLNFF}	=	Average area of Natural Forest converted from Closed to Open forest during the FRL period; ha
AD_{FRLFSW}	=	Average area a of fire in Softwood Plantations during the FRL period; ha
$AD_{MPNFHvol}$	=	Volume of timber harvested in Natural Forest during the monitoring period; m^3
AD_{MPNFH}	=	Area of timber harvest in Natural Forest during the monitoring period; ha
AD_{MPNFF}	=	Area of Natural Forest converted from Closed to Open forest during the monitoring period; ha
AD_{MPFSW}	=	Area of fire in Softwood Plantations during the monitoring period; ha
EF_{NFH}	=	Forest degradation emission factor resulting from timber extraction from natural forest; $tCO_2e\ m^{-3}\ ha^{-1}$
EF_{NFH}	=	Forest degradation removal factor resulting from regrowth following timber extraction from natural forest; $tCO_2e\ m^{-3}\ ha^{-1}$
EF_{NFF}	=	Emission factor for the conversion of Closed Forest to Open Forest; $tCO_2e\ ha^{-1}$
EF_{FSW}	=	Emission factor for fire in softwood plantations; $tCO_2e\ ha^{-1}$

Where there are removals, the legacy removals in the FRL are not carried forward into the monitoring period. The accounting is completed as described in the FCPF Guidance Note for accounting of legacy emissions/removals; March 2021.

The sink "enhancement of forest carbon stocks" includes removals from afforestation/reforestation (AR), as well as gross emissions and removals from forest plantation management.

Afforestation/Reforestation

Afforestation/Reforestation is defined as the conversion of land in the land-use sub-category Non-Forest to land in the sub-category Natural Forest (Low- or Upland) and Plantations (Softwood and Hardwood). Afforestation/reforestation cannot occur within lands defined as plantations as this land is classified as Forest Land regardless of canopy cover as it primarily land use is forest. It is assumed that afforestation/reforestation always has anthropogenic causes in Fiji. Initial carbon stocks on land afforested/reforested is considered to be zero.

Forest Plantation Management

Fiji's forest definition lists two types of Forest Plantations, namely Hardwood Plantations and Softwood (or Pine) Plantations. By definition, deforestation and afforestation/reforestation are not possible within Forest Plantations. Forest Plantations remain in the land-use category Forest Land even if the crown-cover is completely removed following harvest, e.g., temporarily unstocked.

To estimate gross emissions from Forest Plantations, records on the timber volumes extracted are provided by the plantation management companies. Timber volumes extracted are converted to total tree biomass, to total carbon and finally to CO_2e emissions.

Removals from Forest Plantations are estimated based on the mean annual increment (MAI) reported for Hard- and Softwood Plantations.

Enhancement of Carbon Stocks

$$\begin{aligned} ER_{EN} = \{\big[&(\mathrm{AD}_{FRLAR} \times \mathrm{EF}_{NF}) \\ &+ \big((\mathrm{AD}_{FRLHWPharvest} \times \mathrm{EF}_{HWPharvest}) - (\mathrm{AD}_{FRLHWPreplant} \\ &\times \mathrm{EF}_{HWPreplant})\big) \\ &+ (\mathrm{AD}_{FRLSWPharvest} \times \mathrm{EF}_{SWPharvest}) - (\mathrm{AD}_{FRLSWPreplant} \times \mathrm{EF}_{SWPreplant})\big] \\ &- \big[(\mathrm{AD}_{MPAR} \times \mathrm{EF}_{NF}) \\ &+ \big((\mathrm{AD}_{MPHWPharvest} \times \mathrm{EF}_{HWPharvest}) - (\mathrm{AD}_{MPHWPreplant} \times \mathrm{EF}_{HWPreplant})\big) \\ &+ (\mathrm{AD}_{MPSWPharvest} \times \mathrm{EF}_{SWPharvest}) - (\mathrm{AD}_{MPSWPreplant} \times \mathrm{EF}_{SWPreplant})\big] \ \} \end{aligned} \quad \textbf{(3)}$$

Where:

ER_{EN}	=	Emission reductions from forest removals during the monitoring period; tCO_2e
AD_{FRLAR}	=	Average area of afforestation/reforestation during the FRL period; ha
$AD_{FRLHWPharvest}$	=	Average volume extracted from hardwood plantation during the FRL period; m^3
$AD_{FRLHWPreplant}$	=	Average area of replanted hardwood plantation during the FRL period; ha
$AD_{FRLSWPhavest}$	=	Average volume extracted from softwood plantation during the FRL period; m^3
$AD_{FRLSWPreplant}$	=	Average area of replanted softwood plantation during the FRL period; ha
AD_{MPAR}	=	Area of afforestation/reforestation during the monitoring period; ha
$AD_{MPHWPharvest}$	=	Volume extracted from hardwood plantation during the monitoring period; m^3
$AD_{MPHWPreplant}$	=	Area of replanted hardwood plantation during the monitoring period; ha
$AD_{MPSWPharvest}$	=	Volume extracted from softwood plantation during the monitoring period; m^3
$AD_{MPSWPreplant}$	=	Area of replanted softwood plantation during the monitoring period; ha
EF_{NF}	=	Removal factor for replanted natural forest; $tCO_2e\ ha^{-1}$
$EF_{HWPharvest}$	=	Removal factor for harvested hardwood forest; $tCO_2e\ m^{-3}$

$EF_{HWPreplant}$	=	Removal factor for replanted hardwood forest; $tCO_2e\ ha^{-1}$
$EF_{SWPharvest}$	=	Removal factor for harvested softwood forest; $tCO_2e\ m^{-3}$
$EF_{HWPreplant}$	=	Removal factor for replanted hardwood forest; $tCO_2e\ ha^{-1}$

Where there are removals, the legacy removals in the FRL are not carried forward into the monitoring period. The accounting is completed as described in the FCPF Guidance Note for accounting of legacy emissions/removals; March 2021.

Emission reductions

$$\widehat{\emptyset}_{ER,MP} = \mathrm{ER}_{Def} + \mathrm{ER}_{FD} + \mathrm{ER}_{EN} \quad (4)$$

Where:

$\widehat{\emptyset}_{ER,MP}$	=	Total Emission Reductions under the ER Program in the Monitoring Period; tCO_2e.
ER_{Def}	=	Emission reductions from deforestation during the monitoring period; tCO_2e
ER_{FD}	=	Emission reductions from forest degradation during the monitoring period; tCO_2e
ER_{EN}	=	Emission reductions from enhancement of carbon stocks during the monitoring period; tCO_2e

Emission Reductions calculated for this Reporting Period are based on a pro-rata basis over a longer Monitoring Period.

- The Reporting Period is 11 July 2019 until the 31 December 2020 (i.e. 540 days).
- The Monitoring Period is two years from 1 January 2019 - 31 December 2020 (i.e. 730 days).

As such, the ERs are estimated for the Monitoring Period by multiplying the net ERs during the monitoring period by the ratio of the length of the Reporting Period and the length of the Monitoring Period.

$$\widehat{\emptyset}_{ER,RP} = \widehat{\emptyset}_{ER,MP} \times \frac{RP}{MP} \quad (5)$$

Where:

$\widehat{\emptyset}_{ER,RP}$	=	Emission Reductions under the ER Program in the Reporting Period; tCO_2e.
$\widehat{\emptyset}_{ER,MP}$	=	Emission Reductions under the ER Program in the Monitoring Period; tCO_2e.
RP	=	Days in the Reporting Period; days
MP	=	Days in the Monitoring Period; days

The calculations were based on the differences between the average activity data over the FRL period compared to the realised activity data over the Monitoring Period.

The table below provides a summary of how each of the Activity data sources compared between the projected FRL value and the actual monitoring period. This table is simply for information purposes to assist in understanding the variation in the activities during the Monitoring period compared to the 10 year historical average.

Table 7: Summary of Activity Data (Project FRL Vs Monitoring Period)

Activity Data	**Projected FRL value**		**Monitoring Period Value**		**Increased/Decreased in Monitoring Period compared to FRL expectation**
	2019	**2020**	**2019**	**2020**	
Area of deforestation in Natural Forest, Lowland (ha)	1,459	1,459	253	253	**Decreased (positive)**
Area of deforestation in Natural Forest Upland (ha)	79	79	4	4	**Decreased (positive)**
Wood volume extracted from Natural Forest (m^3)	50,731	50,731	27,583	22,088	**Decreased (positive)**
Area of Natural Forest logged (ha)	1,798	1,798	1,350	1,083	**Decreased (positive)**
Area Burnt in softwood plantations (ha)	1,454	1,454	179	161	**Decreased (positive)**
Area of natural forest transition from Closed to Open forest (ha)	875	875	214	214	**Decreased (positive)**
Area of afforestation/reforestation in Natural Forest (ha)	2883	2883	616	667	**Reduced (negative)**
Wood volumes harvested in softwood plantations (m^3)	334,463	334,463	386,985	479,959	**Increased (negative)**
Area planted in softwood plantations (ha)	371	371	2,008	1,910	**Increased (positive)**
Wood volumes harvested in hardwood plantations (m^3)	62,200	62,200	19,802	21,441	**Reduced (positive)**
Area planted in hardwood plantations (m^3)	301	301	4,008	0	**Increased (positive)**

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Parameter:	$EF_{CS,i}$
Description:	Deforestation emission factor for strata i (either Lowland or Upland);
Data unit:	tC ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Emission factors for the source 'deforestation' were estimated from the difference between average C stocks in Lowland and Upland Natural Forest [tC ha^{-1}] and the average C stocks in grassland [tC ha^{-1}]. The IPCC default equation was used to compute the C stock change [IPCC;2006, Vol. 4, Chap. 2, Eq. 2.16]. $\Delta C_{B,i} = \Delta C_G + \Delta C_{CONVERSION,i} + \Delta C_L$ where; $\Delta C_{B,i}$ = change in carbon stocks in biomass in Natural Forest stratum I converted to Non-Forest; tC ha^{-1} ΔC_G = annual increase in carbon stocks in biomass due to growth in Non-Forest; tC ha^{-1} yr^{-1} ΔC_L = annual decrease in carbon stocks in biomass due to disturbances in Non-Forest; tC ha^{-1} yr^{-1} And $\Delta C_{CONVERSION,i} = C_{AFTER} - C_{BEFORE_i}$ where; $\Delta C_{CONVERSION,i}$ = initial change in carbon stocks in biomass in Natural Forest stratum i converted to Non-Forest; tC ha^{-1} C_{AFTER} = carbon stocks in biomass in Non-Forest; tC ha^{-1} C_{BEFORE_i}= carbon stocks in biomass in Natural Forest stratum i; tC ha^{-1} ΔC_G and ΔC_L are assumed to be zero; the change in C stock in biomass due to the conversion of Natural Forest to grassland is captured in $\Delta C_{CONVERSION,i}$, hence $\Delta C_{B,i} = \Delta C_{CONVERSION,i}$. C_{AFTER} is the peak C stock in grassland as estimated by Rounds [2013] to be 17.11 ± 10.81 tC ha^{-1}. A description of the data and methods used to estimate C_{BEFORE_i} is provided in Philip Mundhenk, Prem Raj Neupane & Michael Köhl 2016 - Fiji's Forest Reference Level. Reference Period 2006 — 2016 World Forestry — University of Hamburg. September 2019 - Appendix A2 - Fiji FRL Report, 2018 The carbon stock change due to deforestation was computed by: $\Delta C_{B,Lowland} = C_{AFTER} - C_{BEFORE,Lowland}$ $-70.74 = 17.11 - 87.85$ (Example) $\Delta C_{B,Upland} = C_{AFTER} - C_{BEFORE,Upland}$ $-54.45 = 17.11 - 71.56$ (Example)

	Where; $\Delta C_{B,Lowland}$ = change in C stock in biomass in Lowland Natural Forest due to deforestation; tC ha^{-1} $\Delta C_{B,Upland}$ = change in C stock in biomass in Upland Natural Forest due to deforestation; tC ha^{-1} C_{AFTER} = average carbon stock in grasslands in Fiji (Rounds, 2013); tC ha^{-1} $C_{BEFORE,Lowland}$ = average carbon stock in Lowland Natural Forest in Fiji; tC ha^{-1} $C_{BEFORE,Upland}$ = average carbon stock in Upland Natural Forest in Fiji; tC ha^{-1} Carbon losses from deforestation are converted to emission factors by: $EF_{CS,Lowland} = \Delta C_{B,Lowland} \times n_{cc}$ $-259.38 = -70.74 \times (\frac{44}{12})$ (Example) Where; $EF_{CS,Lowland}$ = emission factor for deforestation in Lowland Natural Forest, tCO$_2$e ha^{-1} $\Delta C_{B,Lowland}$ = change in carbon stock in biomass in Lowland Natural Forest due to deforestation; tC ha^{-1} n_{cc} = ratio of molecular weights of CO_2 and carbon; tCO$_2$e (tC^{-1}) And $EF_{CS,Upland} = \Delta C_{B,Upland} \times n_{cc}$ $-199.65 = -54.45 \times \left(\frac{44}{12}\right)$ (Example) Where; $EF_{CS,Upland}$ = emission factor for deforestation in Upland Natural Forest, tCO$_2$e ha^{-1} $\Delta C_{B,Upland}$ = change in carbon stock in biomass Upland Natural Forest due to deforestation; tC ha^{-1} n_{cc} = ratio of molecular weights of CO_2 and carbon; tCO$_2$e (tC^{-1}) from the IPCC
Value applied:	$EF_{CS,Upland}$ = -199.65 $EF_{CS,Lowland}$ = -259.38
QA/QC procedures applied	C_{BEFORE} Some QA/QC procedures were applied in the field data collection for the NFI and Permanent sample plots including hot and cold field checks. Additionally the calculations values were checks independently by a third party from FAO. C_{AFTER} value was sourced from published literature and therefore unclear of QA/QC procedures applied
Uncertainty associated with this parameter:	$C_{BEFORE,Upland}$ Lower Confidence Interval [66.45] Upper Confidence Interval [78.58] $C_{BEFORE,Lowland}$ Lower Confidence Interval [84.25] Upper Confidence Interval [93.21]

	The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. C_{AFTER} Lower Confidence Interval [8.31] Upper Confidence Interval [25.96] The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. This residual uncertainty was applied in the Monte Carlo simulation.
Any comment:	Equation 1

Parameter:	EF_{NFH}
Description:	Forest degradation emission factor resulting from timber extraction from natural forest;
Data unit:	$tCO_2e\ m^{-3}ha^{-1}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Haas, M., 2015. Carbon Emissions from Forest Degradation caused by Selective Logging in Fiji. Regional project Climate Protection through Forest Conservation in Pacific Island Countries, GIZ, SPC. The emission factor was calculated as: $$EF_{NFH} = [TEF] \times n_{cc} = [1.05] \times \left(\frac{44}{12}\right)$$
Value applied:	3.85
QA/QC procedures applied	This value was sourced from published literature and therefore unclear of QA/QC procedures applied.
Uncertainty associated with this parameter:	Large source of uncertainty, highly relevant; included in the quantification of uncertainty. Sampled from a triangular distribution with lower bound a = TEF - TEF x 0.25, upper bound b = TEF + TEF x 0.25, and mode c = TEF The mode of TEF was determined from a small-scale study within the ER Program area (Haas, 2015), however the upper and lower bounds were estimated from expert judgement.

Any comment:	Equation 2

Parameter:	EF_{NFH}
Description:	Forest degradation removal factor resulting from regrowth following timber extraction from natural forest;
Data unit:	tC m^{-3} ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Removals Emission Factors are computed based on mean annual increment (MAI) in logged forests in year t is estimated by the molecular weight of: $MAIC_{FD} \times \frac{44}{12}$ *Where;* $MAIC_{FD}$ = mean annual C increment after logging (above ground and belowground; sourced from Personal Communication from the Ministry of Forestry, Fiji; Based on unpublished measurements from projects within Fiji
Value applied:	3.63
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Representative raw data not available. Considered to have large uncertainty based on expert judgement. Triangular distribution with lower bound $a = \mathrm{MAIC_{FD}} - \mathrm{MAIC_{FD}} \times 0.5$ upper bound $a = \mathrm{MAIC_{FD}} + \mathrm{MAIB_{SW}} \times 0.5$, mode $c = \mathrm{MAIC_{FD}}$.
Any comment:	Equation 2

Parameter:	EF_{NFF}
Description:	Emission factor for the conversion of Closed Forest to Open Forest;
Data unit:	tCO_2e ha^{-1}
Source of data or description of the method	The methodology applied to generate the emission factor for native forest degradation outside of harvested areas would be considered a Tier 1 Emission Factor.

for developing the data including the spatial level of the data (local, regional, national, international):	Development of a National Tier 2 emission factor for canopy cover change was not possible with the available data sets. Instead a model-based approach to estimating biomass density (for example Ståhl et al. 2010) was used based on the GEDI data set. A model was developed that relates field measurements to auxiliary data (in this case remote sensing data) as the basis for statistical estimation. The previous forest inventory was used to calibrate a GEDI-to-biomass model, then biomass was predicted at every GEDI observation in Fiji. Hybrid statistical inference was used to calculate mean biomass density and confidence intervals. The statistical framework for using GEDI and hybrid inference is described in Patterson et al. 2019. The country was divided into Open and Closed forests using the forest type classification. Then the difference between the two classes is considered the emission factor. This process led to the development of an emissions factor of 121 tCO_2e +/-22 tCO_2e resulting from the transition from Closed to Open Forest.
Value applied:	121
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Lower Confidence Interval [99] Upper Confidence Interval [143] The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated.
Any comment:	Equation 2

Parameter:	EF_{FSW}
Description:	Emission factor for fire in softwood plantations;
Data unit:	tC ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional,	Data from Fiji Pine Limited (FPL) combined with IPCC default methods were used to develop Emissions Factors from fire in Softwood Plantations. GHGs included in the estimation of emissions are: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). To estimate the emission factor, the biomass available for combustion in a compartment was estimated first. It is assumed that the entire above-ground biomass (AGB) is available for combustion. AGB in a compartment that burnt in year tb, with Tb = {2015;…..; tb;….; 2018}, was predicted as follows (note that this is the amount of AGB that is available for combustion — it is not to be confused with the AGB that actually burns during a fire). $$AGB_{l,t_b} = \Lambda_{l,t_b} \times \frac{MAIB_{SW}}{(1+R_{all})}$$ where;

national, international):	Λ_{l,t_b}= the age of a compartment that burnt in year tb, L = {1; 2;…..;l; ….; L} L = the total number of compartments \ $MAIB_{SW}$= the mean annual total biomass (above-and below-ground biomass) increment [tB ha^{-1} yr^{-1}] Source: Waterloo, M., 1994. Water and Nutrient Dynamics of Pinus caribaea plantation forests on former grassland soils in Southwest Viti Levu, Fiji. Ph.D. thesis, Vrije Universiteit Amsterdam. R_{dll} = root-to-shoot ratio in tropical moist deciduous forest < 125 tAGB ha^{-1}. If AGB burns some amount of below-ground biomass (BGB) is also lost, e.g., if the stem and crown of a tree is lost, the BGB of the tree is, in the majority of cases, also lost. It is assumed that only CO_2 is released from the BGB (since it does not burn, or at least only a small fraction of it burns). The amount of BGB available for combustion was predicted as follows: $$BGB_{l,t_b} = \Lambda_{l,t} \times MAIB_{SW} \times R_{dll}.$$ CO_2 emissions from AGB in compartment that burnt in year tb was estimated as follows (cf. IPCC [2006, Vol. 4, Chap. 2, Eq. 2.27]) $$EACO2_{l,t_b} = A_{l,t_b} \times AGB_{l,t} \times C_f \times G_{ef,CO_2}$$ where; A_{l,t_b}= the area burnt [ha] in compartment l at time tb, C_f = the combustion factor, i.e., the proportion of prefire biomass consumed (the value was taken from IPCC 2006, Vol. 4, Chap. 2, Tab. 2.6, young secondary tropical forest (3-5) year]) G_{ef,CO_2}= the emission factor [g kg^{-1}] taken from IPCC [2006, Vol. 4, Chap. 2, Tab. 2.5, Tropical forest]. Carbon dioxide (CO_2) emissions from BGB were estimated by: $$EBCO2_{l,t_b} = A_{l,t_b} \times BGB_{l,t_b} \times C_f \times \eta_{CF} \times [\eta_{CC} \times -1]$$ Where; n_{CF}= 0:47 and n_{CC}= 44/12 are the conversion factors of biomass to carbon and carbon to carbon dioxide equivalents, respectively. Methane (CH_4) emissions were estimated as follows: $$ECH4_{l,t_b} = A_{l,t_b} \times AGB_{l,t_b} \times C_f \times G_{ef,CH_4} \times GWP_{CH_4}$$ where: G_{ef,CH_4}= the emission factor for CH_4 GWP_{CH_4} = the global warming potential of CH_4 , taken from IPCC [2014, Box 3.2, Tab. 1]. Nitrous oxide (N_2O) emissions in compartment l that burnt in year tb were estimated by

	$$EN2O_{l,t_b} = A_{l,t_b} \times AGB_{l,t_b} \times C_f \times G_{ef,N_2O} \times GWP_{N_2O}.$$ where: G_{ef,N_2O}= the emission factor for N_2O GWP_{N_2O} = the global warming potential of N_2O , taken from IPCC [2014, Box 3.2, Tab. 1]. Total GHG emissions from compartment were computed by: $$E_{l,t_b} = EACO2_{l,t_b} + EBCO2_{l,t_b} + ECH4_{l,t_b} + EN2O_{l,t_b}$$ The core component applied in this emission factor was $MAIB_{SW}$ which had a value of 10 from the literature and units of tB ha^{-1} yr^{-1}. Therefore this had to be converted to tCO_2e ha^{-1} yr^{-1} by multiplying by 0.47 to convert to carbon an multiplying by 44/12 to get to CO_2e ha^{-1} yr^{-1}
Value applied:	17.23
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Triangular distribution with lower bound $a = \mathrm{MAIB_{SW}} - \mathrm{MAIB_{SW}} \times 0.25$ upper bound $a = \mathrm{MAIB_{SW}} + \mathrm{MAIB_{SW}} \times 0.25$, mode $c = \mathrm{MAIB_{SW}}$. The distribution is based on the sample taken as published in the reference. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated.
Any comment:	Equation 2

Parameter:	EF_{NF}
Description:	Removal factor for replanted natural forest;
Data unit:	tCO_2e ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The removal factor for replanted natural forest, including both aboveground and belowground, was estimated by: $$EF_{NF} = \left[\underline{MAIV}_{HW} \times BCEF_{HW,I} \times (1 + R_{wl})\right] \times \eta_{CF} \times \frac{44}{12}$$ where; EF_{NF} = mean annual carbon increment in Hardwood Plantations; tB ha^{-1} yr^{-1} $\underline{MAIV}_{HW}$ = average mean annual increment in Hardwood Plantations; m^3 ha^{-1} yr^{-1}. Derived from data provided from Fiji Hardwood Corporation Limited. $BCEF_{HW,I}$ = biomass conversion and expansion factor for increment taken from IPCC, 2006, Vol. 4, Chap. 4. Tab. 4.5; $BCEF_I$ for humid tropical natural forest; growing stock level 21-40 m^3 ha^{-1}; tB $(m^3)^{-1}$ R_{wl} = Root-to-shoot ratio for tropical rainforest; Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4

Value applied:	$\boldsymbol{MAIV_{AR}} = 3.71$ $\boldsymbol{BCEF_{HW,I}}$ = 1.1 $\boldsymbol{R_{wl}}$ = 0.37
QA/QC procedures applied	None
Uncertainty associated with this parameter:	$\boldsymbol{MAIV_{AR}}$ Assumed to have a high uncertainty due to a lack of QA/QC procedures applied. 50% uncertainty estimated to include systematic and random error. Sampled from a Triangular distribution with lower bound $a = \mathrm{MAIV_{AR}} - \mathrm{MAIV_{AR}} \times 0.5$ upper bound $b = \mathrm{MAIV_{AR}} + \mathrm{MAIV_{AR}} \times 0.5$ and mode $c = \mathrm{MAIV_{AR}}]$ $\boldsymbol{BCEF_{HW,I}}$ Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value. Sampled from a triangular distribution with lower bound $a = BCEF_{HW,I} - BCEF_{HW,I} \times 0.25$ upper bound $b = BCEF_{HW,I} + BCEF_{HW,I} \times 0.25$, mode $c = BCEF_{HW,I}$ $\boldsymbol{R_{wl}}$ Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value. Sampled from a Triangular distribution with lower bound $a = R_{wl} - R_{wl} \times 0.25$ upper bound $b = R_{wl} + R_{wl} \times 0.25$ and mode $c = R_{wl}$
Any comment:	Equation 3

Parameter:	$EF_{HWPharvest}$
Description:	Emission factor for harvested hardwood forest;
Data unit:	tC m^{-3}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional,	Gross emissions from hardwood plantations utilise annual logged volume data reported by Fiji Hardwood Corporation Limited (FHCL). $AGB_{\substack{HW \\ ,L,t}} = [BCEF_{HW,R} \times (1 + R_{wl})] \times \eta_{CF} \times \frac{44}{12}$ where; $AGB_{HW,L,t}$= aboveground biomass removed in hardwood plantations in year t; tAGB $V_{HW,L,t}$ = volume of hardwood extracted in year t; m^3 $BCEF_{HW,R}$ = biomass conversion and expansion factor for logging; tAGB m^{-3} Source: Source: IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level >200 m^3 ha^{-1}) R_{wl} = root-to-shoot ratio for tropical rainforests; dimensionless Source: Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4 n_{CF} = conversion factor for dry matter to C; tC $(tB)^{-1}$

national, international):	
Value applied:	$\boldsymbol{BCEF_{HW,R}}$ = 1.05 $\boldsymbol{R_{wl}}$ = 0.37
QA/QC procedures applied	None
Uncertainty associated with this parameter:	$\boldsymbol{BCEF_{HW,R}}$ Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value. Sampled from a triangular distribution with lower bound $a = BCEF_{HW,R} - BCEF_{HW,R} \times 0.25$ upper bound $a = BCEF_{HW,R} + BCEF_{HW,R} \times 0.25$, and mode $c = BCEF_{HW,R}$ $\boldsymbol{R_{wl}}$ Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value. Sampled from a Triangular distribution with lower bound $a = R_{wl} - R_{wl} \times 0.25$ upper bound $b = R_{wl} + R_{wl} \times 0.25$ and mode $c = R_{wl}$
Any comment:	Equation 3

Parameter:	$EF_{HWPreplant}$
Description:	Removal factor for replanted hardwood forest;
Data unit:	tC ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Total carbon increment, including both aboveground and belowground, was estimated by: $MAIC_{HW} = \left[\underline{MAIV}_{HW} \times BCEF_{HW,I} \times (1 + R_{wl})\right] \times \Pi_{CF} \times \frac{44}{12}$ where; $MAIC_{HW}$ = mean annual carbon increment in Hardwood Plantations; tB ha^{-1} yr^{-1} $\underline{MAIV}_{HW}$ = average mean annual increment in Hardwood Plantations; m^3 ha^{-1} yr^{-1}. Derived from data provided from Fiji Hardwood Corporation Limited. $BCEF_{HW,I}$ = biomass conversion and expansion factor for increment taken from IPCC, 2006, Vol. 4, Chap. 4. Tab. 4.5; $BCEF_I$ for humid tropical natural forest; growing stock level 21-40 m^3 ha^{-1}; tB $(m^3)^{-1}$
Value applied:	$\underline{MAIV}_{HW}$ = 5.85

QA/QC procedures applied	None
Uncertainty associated with this parameter:	$\underline{MAIV_{HW}}$ Assumed to have a medium uncertainty due to a lack of QA/QC procedures applied. 50% uncertainty estimated to include systematic and random error. Sampled from a Triangular distribution with lower bound $a = \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$, upper bound $= \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$, mode $c = \overline{\mathrm{MAIV}}_{\mathrm{HW}}$.
Any comment:	Equation 3

Parameter:	$EF_{SWPharvest}$
Description:	Removal factor for harvested softwood forest;
Data unit:	$tCO_2e\ zz^{-3}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The emissions factor from logging in softwood plantations were estimated from data on recovery rates and wood density and root to shoot ratio which are multiplied by the extracted volumes (the activity data) provided by Fiji Pine Limited (FPL) to get above ground biomass loss in each year. $AGB_{SW,L,t} = [V_{SW,L,t} \times \frac{1}{\lambda_{Pine}} \times \rho_{Pine}) \times (1 + R_{dlh})] \times 0.47 \times \frac{44}{12}$ where; $AGB_{SW,L,t}$= aboveground biomass loss in year t in softwood plantations; tAGB $V_{SW,L,t}$ = wood volumes harvested in softwood plantations in year t; m^3 λ_{Pine} = recovery rate in softwood plantations; dimensionless; Taken from: Waterloo, M., 1994. Water and Nutrient Dynamics of Pinus caribaea plantation forests on former grassland soils in Southwest Viti Levu, Fiji. Ph.D. thesis, Vrije Universiteit Amsterdam. ρ_{Pine} = wood density of pine wood harvested in softwood plantations; g cm^{-3} R_{dlh} = root-to-shoot ratio for tropical moist deciduous forest >125 tB ha^{-1}, taken from IPCC, 2006, Vol.4, Chap. 4, Tab. 4.4; dimensionless
Value applied:	$\boldsymbol{\lambda_{Pine}}$ = 0.76 $\boldsymbol{\rho_{Pine}}$ = 0.47 $\boldsymbol{R_{dlh}}$ = 0.25
QA/QC procedures applied	$\boldsymbol{\lambda_{Pine}}$ – None $\boldsymbol{\rho_{Pine}}$ – None $\boldsymbol{R_{dlh}}$ – None
Uncertainty associated with this parameter:	$\boldsymbol{\lambda_{Pine}}$ Drawn from a Normal distribution with $\mu = \lambda_{\mathrm{Pine}}$ and $\sigma^2 = [\lambda_{\mathrm{Pine}} \times 0.1]^2$ The distribution is based on the sample taken as published in the reference. It is unlikely that measurement and random error have been considered. $\boldsymbol{\rho_{Pine}}$

	Drawn from a Normal distribution with $\mu = \rho_{\text{Pine}}$ and $\sigma^2 = 0.0031$ The distribution is based on the sample taken as published in the reference. It is unlikely that measurement and random error have been considered. $\boldsymbol{R_{dlh}}$ Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value. Sampled from a Triangular distribution with lower bound a = 0.22, upper bound b = 0.33, mode c = 0.24; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].
Any comment:	Equation 3

Parameter:	$EF_{SWPreplant}$
Description:	Removal factor for replanted softwood forest;
Data unit:	$tCO_2e\ ha^{-1}yr^{-1}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Removal factors from softwood plantations were estimated based on the mean annual increment of above and belowground biomass, $MAIB_{SW}$ (taken from Waterloo [1994]) which are multiplied by areas planted each year. $MAIC_{SW} = [MAIB_{SW} \times \eta_{CF}] \times \frac{44}{12}$ where; $MAIC_{SW}$ = mean annual C increment in Softwood Plantations; $tCO_2e\ ha^{-1}\ yr^{-1}$ $MAIB_{SW}$ = mean annual biomass increment (AGB + BGB) in Softwood Plantations; $tB\ ha^{-1}\ yr^{-1}$ η_{CF} = conversion factor biomass to C; dimensionless
Value applied:	
QA/QC procedures applied	
Uncertainty associated with this parameter:	*Quantify the residual uncertainty for this parameter propagating the main sources of uncertainty. For example, propagate the main sources of error for the estimation of EF and quantify the resulting uncertainty.* *Refer to criterion 7 and indicator 9.1 of the Methodological Framework*
Any comment:	Equation 3

3.1 Monitored Data and Parameters

Monitored Data and Parameters for Deforestation

Parameter:	$A_{DF,Lowland,t\ i}$
Description:	Area of deforestation in Natural Forest, Lowland stratum in year t;
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	**2019:** 253 **2020:** 253
Source of data and description of measurement/calculation methods and procedures applied:	This data is generated using a sample based approach using a wall-to-wall map as a stratifyer. The wall-to wall maps were constructed from Landsat imagery and a machine learning algorithm.
Quality Assurance/Quality Control procedures to be applied:	QA/QC will be accomplished in a two-step process: i) A set of SOPs for land use change classification have been developed and all interpreters trained in the classification process. These SOPs are available on the Fijis Forest Information Management System. ii) Remote sensing analysis is verified using ground data and/or other independent remote sensing data that is available.
Uncertainty for this parameter:	**2019** Lower Confidence Interval – 183 ha Upper Confidence Interval – 327 ha **2020** Lower Confidence Interval – 183 ha Upper Confidence Interval – 327 ha
Any comments:	Equation 1

Parameter:	$A_{DF,Upland,t\ i}$
Description:	Area of deforestation in Natural Forest Upland stratum in year t;
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019: 4 2020: 4
Source of data and description of measurement/calculation methods and procedures applied:	This data is generated using a sample based approach using a wall-to-wall map as a stratifyer. The wall-to wall maps were constructed from Landsat imagery and a machine learning algorithm
Quality Assurance/Quality Control procedures to be applied:	QA/QC will be accomplished in a two-step process— i) A set of SOPs for land use change classification has been developed and all interpreters trained in the classification process. These SOPs are available on the Fijis Forest Information Management System. ii) Remote sensing analysis is verified using ground data and/or other independent remote sensing data that is available.
Uncertainty for this parameter	**2019:** Lower Confidence Interval – 2 ha Upper Confidence Interval – 6 ha **2020:** Lower Confidence Interval – 2 ha Upper Confidence Interval – 6 ha
Any comments:	Equation 1

Monitored Data and Parameters for Forest Degradation

Parameter:	$AD_{MPNFHvol}$
Description:	Volume of timber harvested in Natural Forest during the monitoring period
Data unit:	m^3
Value monitored during this Monitoring / Reporting Period	2019 – 27,583 2020 – 22,088
Source of data and description of measurement/calculation methods and procedures applied:	The total wood volume of logs extracted annually from Natural Forests subject to logging activities is collected by the Management Services Divisions of the Ministry of Forestry through Division of Forest Offices (DFO) staff, known as Log Scalers. On issuance of a licence to log, logging companies can proceed to extract the agreed volume. The logging contractors haul the timber to the log-landings and log-scalers from the Division Forest Offices (DFOs) assess the amount of timber extracted and enter the data into the Timber Revenue System (TRS) database. This volume is used to determine the amount of royalty fees the logger has to transfer to the Ministry of Forestry. As the accuracy of the data is linked to royalties there is confidence in these figures. The volume estimates are derived from diameter measurements at both ends of the bole in cm as well as the length of the bole in meters. The parameters measured are then used to estimate the volume.
Quality Assurance/Quality Control procedures to be applied:	Standard operating procedures exist for field measurement and data by Forest Beat Staff who collect the data and staff from the Forest Divisional Offices who conduct the data collation. Staff from the Management Services Division conduct a QA/QC check at the data entry point and any issues are rectified in collaboration with Beat Staff and Divisional Officers. All staff are trained in their roles and responsibilities. These SOPs are available on the Fiji's Forest Information Management System.
Uncertainty for this parameter	Data from this census of actual timber volume extracted is considered to have small uncertainty — most likely as measurement error of the logs (diameters, lengths and number of logs). The staff (i.e. log-scalers) from the Division of Forest Offices (DFOs) are trained in the collection of this information which is also linked to royalty collection. It is on the basis of these points that the uncertainty was considered small and the residual uncertainty was considered zero.
Any comments:	Equation 2

Parameter:	AD_{MPNFH}
Description:	Area of timber harvest in Natural Forest during the monitoring period; ha
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019 – 1,350 2020 – 1,083

Source of data and description of measurement/calculation methods and procedures applied:	Annual data on the areas harvested are available from digital logging maps which are provided by logging companies to the Ministry of Forests as part of the process of obtaining a logging licence. This data is collected from all sites issued with a logging licence throughout Fiji, however only areas of natural forest logged within the Fijian islands of Viti Levu, Vanua Levu and Taveuni will be included for monitoring in the ER program.
Quality Assurance/Quality Control procedures to be applied:	Maps/GIS layers are checked and if necessary, corrected by staff from the Management Service Division (MSD) where discrepancies are found. SOPs describing these checks are available on the Fiji's Forest Information Management System.
Uncertainty for this parameter	The data for the areas logged are census data (i.e., no sampling error). There may be some small errors in boundaries because of GPS instruments. The residual random uncertainty was considered to be zero.
Any comments:	Equation 2

Parameter:	AD_{MPFSW}
Description:	Area of fire in Softwood Plantations during the monitoring period; ha
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019

Year	Age	Area
2019	2	10
2019	3	3
2019	4	3
2019	2	2
2019	2	49
2019	2	0.6
2019	5	11.3
2019	2	57.639
2019	2	17.31
2019	2	4.71
2019	3	20.42

2020

Year	Age	Area
2020	3	8.25
2020	3	39.2
2020	3	12.1
2020	3	25.9
2020	4	33.4
2020	2	4
2020	2	9.86
2020	2	4.56
2020	2	10.77
2020	3	13

Source of data and description of measurement/calculation methods and procedures applied:	Annual areas of burnt plantations have been historically collected by Fiji Pine Limited. The information collected includes the spatial location (forest coup), the year of planting, the year of burn and the total hectares burnt.

Quality Assurance/Quality Control procedures to be applied:	The Ministry of Forests continue to work with FPL to establish data collection protocols for this data to be supplied to the Management Services Division.
Uncertainty for this parameter	The main sources of uncertainty relate to the measurement of areas burnt using the field GPS and random and systematic errors in data entry. However these were considered small and assumed to be zero.
Any comments:	Equation 2

Parameter:	AD_{MPNFF}
Description:	Area of Natural Forest converted from Closed to Open forest during the monitoring period
Data unit:	ha
Value monitored during this Monitoring / Reporting Period	Total for Monitoring period 428
Source of data and description of measurement/calculation methods and procedures applied:	This data is generated using a sample based approach using a wall-to-wall map as a stratifier. The wall-to wall maps were constructed from Landsat imagery and a machine learning algorithm.
Quality Assurance/Quality Control procedures to be applied:	QA/QC will be accomplished in a two-step process— i) A set of SOPs for land use change classification has been developed and all interpreters trained in the classification process. These SOPs are available on the Fijis Forest Information Management System. ii) Remote sensing analysis is verified using ground data and/or other independent remote sensing data that is available.
Uncertainty for this parameter	Standard error 88.5
Any comments:	Equation 2

Monitored Data and Parameters for Enhancement of Carbon Stocks - Afforestation/Reforestation

Parameter::	AD_{MPAR}
Description:	Area of afforestation/reforestation during the monitoring period;
Data unit:	ha
Value monitored during this Monitoring / Reporting Period	2019 – 615.8 2020 – 666.6
Source of data and description of measurement/calculation methods and procedures applied:	Areas planted are recorded by the Ministry of Forestry
Quality Assurance/Quality Control procedures to be applied:	GIS layers are checked and if necessary, corrected by staff from the Management Service Division (MSD) where discrepancies are found. SOPs describing these checks are available on the Fiji's Forest Information Management System.
Uncertainty for this parameter	The data for the areas logged are census data (i.e., no sampling error). There may be some small errors in boundaries because of GPS instruments. The residual random uncertainty was considered to be zero.
Any Comments:	Equation 3

Monitored Data and Parameters for Enhanced Carbon Stocks - Forest Plantation

Parameter:	$AD_{MPSWPharvest}$
Description:	Volume extracted from softwood plantation during the monitoring period;
Data unit:	m^3
Value monitored during this Monitoring / Reporting Period	2019 – 386,985 2020 – 479,959
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Pine Limited manages the plantations of softwood. The company provides volume of softwood (Pine) and green weight of harvested wood annually to the Ministry of Forests. Harvesting details are published annually in the Ministry of Forests annual progress report and all relevant data are inputted into the TRS database system.
Quality Assurance/Quality Control procedures to be applied:	Ministry of Forests staff from the Management Services Division will check samples of the measurement to assess the accuracy of the data provided. The Ministry of Forests continue to work with FPL to establish data collection protocols for this data to be supplied to the Management Services Division.
Identification of sources of uncertainty for this parameter	Harvested volume is census hence small source of uncertainty and no sampling error. The residual random uncertainty was considered to be zero.
Any comments:	Equation 3

Parameter:	$AD_{MPSWPreplant}$
Description:	Area of replanted softwood plantation during the monitoring period;
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019 – 2,008 2020 – 1,910
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Pine Limited manages the plantations of softwood. The company provides area of softwood (Pine) planted annually to the Ministry of Forests. Simultaneously, Fiji Pine Limited provides polygons for the area planted annually.
Quality Assurance/Quality Control procedures to be applied:	Fiji Pine Limited uses an internal monitoring system to report the area of pine planted. Ministry of Forests staff visit a sample of sites to check the quality of the data reported by Fiji Pine. The residual random uncertainty was considered to be zero.
Identification of sources of uncertainty for this parameter	Areas of forest harvested are census data (no sampling error) therefore only source of uncertainty is instrumental error (GPS).
Any comments:	Equation 3

Parameter:	$AD_{MPHWPharvest}$
Description:	Volume extracted from hardwood plantation during the monitoring period; ha
Data unit:	m^3
Value monitored during this Monitoring / Reporting Period	2019 – 19,802 2020 – 21,441
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Hardwood Corporation Limited will provide wood volume harvested annually. The data on wood volume harvested also include harvested plantation area with area polygons (with spatial information).

Quality Assurance/Quality Control procedures to be applied:	Fiji Hardwood Corporation Limited will monitor volume harvested internally and Ministry of Forests staff will monitor the volume of wood harvested taking samples. The processes applied are outlined in SOP – Collection and review of activity data from Fiji Hardwood Corporation.
Identification of sources of uncertainty for this parameter	Harvested volume will be census based hence small source of uncertainty and no sampling error. Uncertainty in weighing machine.
Any comments:	Equation 3

Parameter:	$AD_{MPHWPreplant}$
Description:	Area of replanted hardwood plantation during the monitoring period.
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019 – 4,008 2020 – 0
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Hardwood Corporation Limited provides hardwood area planted with area polygons (with spatial details) annually to the Ministry of Forests.
Quality Assurance/Quality Control procedures to be applied:	Fiji Hardwood Corporation Limited will monitor the area of hardwood harvested internally. The processes applied are outlined in SOP – Collection and review of activity data from Fiji Hardwood Corporation. Management Service Division of Ministry of Forests will also identify the area of hardwood harvested using satellite images.
Identification of sources of uncertainty for this parameter	The area of hardwood is census data hence there is no sampling error. However main source of uncertainty is GPS equipment. GPS is used to calculate the hardwood harvested area.
Any comments:	Equation 3

4 QUANTIFICATION OF EMISSION REDUCTIONS

4.1 ER Program Reference level for the Monitoring / Reporting Period covered in this report

Technical corrections were made to the FRL as a result of:

- improvements to quality assurance/quality control procedures relating to the generation of the activity data for deforestation,
- improvements to the modelling of Pine Plantation activity data,
- inclusion of new data and methods for estimating Forest Degradation across all natural forests in Fiji.

The technical corrections have not compromised the consistency of GHG emissions and removals estimates between the Reference Period and monitoring periods as the FRL has been recalculated with the updated datasets and ER calculations conducted based upon the consistent methodology and datasets between the FRL Period and the Monitoring Period. For more detail on the technical corrections made and the impact on the FRL refer to Annex 4.

The FRL estimates provided in the Table below covers the Monitoring Period.

Year of Monitoring/Reporting period *t*	**Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)**	**If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)**	**If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)***	**Adjustment, if applicable (tCO_{2-e}/yr)**	**Reference level (tCO_{2-e}/yr)**
2019	394,121	495,654	555,001		1,466,776
2020	394,121	489,126	538,613		1,421,859
Total	**788,242**	**984,780**	**1,115,614**		**2,888,635**

*Note that figures placed in the column "removals by sinks" relates to net emissions/removals from the REDD+ activity Enhancement of Carbon Stocks which is not only or always removals by sinks (i.e. in any one year there could be an emission from these activities as they include harvesting and replanting in a long term sustainable harvest management plan).

4.2 Estimation of emissions by sources and removals by sinks included in the ER Program's scope

The estimates provided in the Table below is for the Monitoring Period.

The Removals by Sinks column is the net emissions from Enhancement of Carbon Stocks, so includes emissions/removals from plantations as well as removals from Afforestation/Reforestation. Positive numbers are emissions, negative numbers removals.

Year of Monitoring/Reporting Period	**Emissions from deforestation (tCO_{2-e}/yr)**	**If applicable, emissions from forest degradation (tCO_{2-e}/yr)***	**If applicable, removals by sinks (tCO_{2-e}/yr)***	**Net emissions and removals (tCO_{2-e}/yr)**
2019	66,331	143,094	509,782	719,208
2020	66,331	116,819	577,700	760,850
Total	**132,662**	**259,913**	**1,087,483**	**1,480,058**

*Note that figures placed in the column "removals by sinks" relates to net emissions/removals from the REDD+ activity Enhancement of Carbon Stocks which is not only or always removals by sinks (i.e. in any one year there could be an emission from these activities as they include harvesting and replanting in a long term sustainable harvest management plan).

4.3 Calculation of emission reductions

Emission Reductions calculated for this Reporting Period are based on a pro-rata basis over a longer Monitoring Period.

- The Reporting Period is 11 July 2019 until the 31 December 2020 (i.e. 540 days).
- The Monitoring Period is two years from 1 January 2019 - 31 December 2020 (i.e. 730 days).

As such, the ERs are estimated for the Monitoring Period by multiplying the net ERs during the monitoring period by the ratio of the length of the Reporting Period and the length of the Monitoring Period.

	Total Emission Reductions*	**Forest degradation**
Total Reference Level emissions during the Monitoring Period (tCO_2-e)	2,196,084	692,551
Net emissions and removals under the ER Program during the Monitoring Period (tCO_2-e)	1,220,145	259,913
Emission Reductions during the Monitoring Period (tCO_2-e)	975,939	432,639
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	540/730	540/730
Emission Reductions during the Reporting Period (tCO_2-e)	**721,927**	**320,034**

*The component of Forest Degradation related to harvesting activity by the Ministry of Forestry in Native Forest and burning in Softwood plantations has been removed from these values and listed in the neighbouring column as it has been estimated with proxy data.

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

The application of the pro-rata approach to Fijis ER calculations has had no impact on the uncertainty as the emission removals are averages of the year's land use land use change activities.

5.1 Identification, assessment and addressing sources of uncertainty

Table 10: Uncertainty

Sources of Uncertainty	**Systematic**	**Random**	**Analysis of contribution to overall uncertainty**	**Contribution to overall uncertainty (High/Low)**	**Addressed through QA/QC?**	**Residual uncertainty estimated?**
Measurement	Y	Y	The sources of uncertainty associated with the use of satellite imagery include: 1) the quality and suitability of the satellite data in terms of spatial and temporal resolutions, 2) the consistency and quality of radiometric and geometric pre-processing of annual images, 3) the thematic and cartographic standards such as the land cover type and the minimum mapping unit, and 4) the interpretation procedure from either automatic classification of the imagery or the visual interpretation, 5) the error for visual interpretation of sampling in the accuracy assessment. This error is reduced by extensive QA/QC procedures by trained staff working together and discussing any classification issues with each other. Additionally, the methodology and processes are documented in a series of standard operating procedures to ensure	High	Y	N

			consistency in the interpretations which are available on Fiji's Forest Information Management System. It is not included in the Monte Carlo simulation.			
Representativeness	Y	N	Annual deforestation maps are used as the basis for stratification, to ensure the sample used to estimate the areas is representative of the area of interest. A probabilistic-based sampling design is applied, where all areas have an inclusion probability larger than zero.	Low	Y	N
Sampling	N	Y	SRS (Stratified random sampling) method was applied for AD sampling design. It is included in the Monte Carlo simulation.	High	N	Y
Extrapolation	NA	NA	Estimates of deforestation and reforestation per forest type, based on reference data.	NA	NA	NA
Approach 3	Y	N	IPCC Approach 3 was used to develop spatially disaggregated activity data using annual forest cover maps generated from Landsat imagery. It is not included in the Monte Carlo simulation.	Low	Y	N
Emission Factors						
DBH Measurement	Y	Y	Measurement of DBH and plot delineation are subject to errors. Errors may be caused by multiple factors such as poor training, poor measurement protocols, etc. While measurement errors are significant at the tree level, they usually average out at plot level and inventory level (Chave et al. 2014). Picard et al. (2015) also found the measurement error to be small when compared to the other errors. Indications are that the data used from the 2005 inventory have a high level uncertainty. This is being addressed in the current phase of NFI data collection and associated QA/QC procedures (refer to SOPs on the Fiji's Forest Information System). The high levels of uncertainty in the 2005 data set which was used for this FRL and Monitoring Period are currently propagated using Monte Carlo methods through the estimates. Fiji expect that this source of uncertainty will reduce in the future but the new NFI data will not be available for updating the emission factors generated from NFI field data in this ERPA period. It is included in the Monte Carlo simulation.	High	N	Y
H Measurement	Y	Y	H parameter is used in the estimation of aboveground biomass stock. This parameter has been shown to be highly uncertainty in the current NFI dataset and is being addressed with training and improved collection methods in the new NFI collection phase ongoing now. The high levels of uncertainty in the 2005 data set which was used for this FRL and Monitoring Period are currently propagated using Monte Carlo methods through the estimates. The residual uncertainty associated with H measurements form the 2005 NFI cannot be addressed in this ERPA period. It is included in the Monte Carlo simulation.	High	N	Y

Plot delineation	Y	Y	See analysis in column "DBH measurement" above.	High	Y	N
Wood density estimation	Y	Y	Wood density is used in the estimation of aboveground biomass stock. Wood density is collected from a range of National and Internationally published data sets. The recording of species information from the NFI pots is considered of low uncertainty as trained local personal record this information. The High uncertainty is associated with the application of published datasets to the Fiji situation. The residual uncertainty associated with wood density values cannot be addressed in this ERPA period. It is included in the Monte Carlo simulation. It is included in the Monte Carlo simulation.	High	N	Y
Allometric model	Y	N	Global allometric equations published by Chave et al 2014 were applied in Fiji. The selection of the equations was discussed with experts from the University of Hamburg who conducted a study into the most appropriate equation to apply. Associated uncertainty is expected to be low, as emission factors remain constant from reference to monitoring period. The Chave allometric equation has not been validated with data from Fiji, which presents a potential a source of bias. The residual uncertainty associated with applying a global allometric model cannot be addressed in this ERPA period. It is not included in the Monte Carlo simulation.	High	Y	N
Sampling	Y	Y	Sampling error relating to emissions factors is the statistical variance of the estimate. This source of error is random and is considered to be high. The estimation of mean and their respective uncertainties (standard error, sampling error, and confidence interval) for the variables of aboveground biomass were estimated form the 2005 forest inventory data. The residual uncertainty associated with the 2005 Inventory data cannot be addressed in this ERPA period. It is included in the Monte Carlo simulation.	High	N	Y
Other **This represents IPCC default values listed in section 5.2 below.**	Y	Y	Other parameters used to estimate emission factors include aboveground biomass in non-forest land, carbon fraction and root-to-shoot ratios. Some of these are sourced from the 2006 IPCC Guidelines and others collected from National research studies or expert judgement. This can lead to both random and systematic errors. The random error of each individual parameter might be low but the aggregated effect might be high. Confidence intervals of all default values are included and propagated in Fiji's Monte Carlo simulations. These confidence intervals have been taken from the IPCC Guidelines for	High	N	Y

			default values and published research papers used for National values. Expert judgement from local sources was used in the absence of peer reviewed publications. Such values are included in the Monte Carlo simulation.			
Integration						
Modelling	Y	Y	The simple linear modelling approach applied leads to the combination of AD & EF. This method is considered to be IPCC Tier 2 given there are national specific emissions factors and activity data applied. In this case the modelling approach itself would be considered appropriate to model the changes in the forest landscape and the uncertainty with the models ability to estimate change is considered low. It is not included in the Monte Carlo simulation.	Low	Y	N
Integration	Random / Systematic		This source of uncertainty is related to the lack of comparability between the transition classes of the Activity Data and those of the Emission Factors. In Fiji, Activity Data is estimated from remotely sensed data, whereas Emission Factors for a specific forest type are based on ground-based observations. Fiji has stratified the landscape to maintain consistency with its National forest classes and its National Forest Inventory program. These transition classes and emission factors are considered comparable and as such uncertainty related to integration is considered Low. It is not included in the Monte Carlo simulation.	Low	Y	N

5.2 Uncertainty of the estimate of Emission Reductions

Uncertainty in estimates of emission reductions were quantified using a Monte Carlo approach, based on 1.5million random permutations of model parameters. Conversion factors from biomass to carbon and carbon to carbon dioxide equivalents were not included in the Monte Carlo propagation of error. All are parameters included are detailed in the table below.

For the MC simulations, inputs were sampled from different probability density functions (PDFs). The PDFs used for the uncertainty analysis of the FRL included the Normal (or Gaussian) distribution, the Triangular distribution, and the Uniform distribution. The Normal distribution is described by its mean, μ, and its variance, σ^2 and was used for inputs when an estimate of the standard deviation, σ, for an input was available.

For many inputs an estimate of the precision was not available, i.e., a value of the standard deviation or standard error was not reported by the study from which the estimate for the input was taken. However, for some inputs the range (lower and upper limits) and the mode was available (e.g., root-to-shoot ratios R that can be found in Vol. 4, Chap. 4, Tab. 4.4 in IPCC [2006]). For these inputs the Triangular distribution was used which is denoted by *Tri (c,a,b)*, where *c* is the mode (the peak of the Triangular distribution; i.e., the most frequent value), a is the lower bound, and *b* is the upper bound.

The Triangular distribution was also used if no quantitative information at all was available for the uncertainty attached to the input. If the uncertainty was assumed to be "moderate" for an input, a was defined as $a = c - c \times \phi$ and $b = c + c \times \phi$, where $\phi = 0.25$. The value for *c* was the value reported for the input in IPCC [2006] or other studies. If the uncertainty was assumed to be "large" $\phi = 0.5$ and if "very large" $\phi = .75$. Whether the uncertainty attached to the input was "moderate", "large" or "very large" was determined by expert judgement (e.g., REDD+ Steering Committee or authors that conducted the study from which the value of the input was taken). If an expert's opinion was not available, $\phi = 0.75$ was used. It should be noted that the choice of whether the uncertainty of the parameter estimate of the input was moderate, large or very large was entirely subjective and

was frequently taken without having sufficient data and information on the system under consideration. This highlights the fact that measures of uncertainty (i.e., standard errors) should be more rigorously assessed in future studies, given their profound influence on subsequent estimates of uncertainty. For the Uniform distribution the support is defined by a lower bound a and an upper bound b. All values within this range are assumed to be equally probable.

5.2.1 Parameters Used In Monte Carlo

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
EF_{co} $tCO_2e\ ha^{-1}$	Emission Factor for Closed to Open Forest	121	sampling	Sampled from a normal distribution with Lower CI [99] and Upper CI[143]	Global data set appropriate and representative of actual stocks in Fiji.
R_{wl} dimensionless	Root-to-shoot ratio for tropical rainforest	0.37 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	sampling	Sampled from a Triangular distribution with lower bound $a = R_{wl} - R_{wl} \times 0.25$ upper bound $b = R_{wl} + R_{wl} \times 0.25$ and mode $c = R_{wl}$	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.
R_{dll} dimensionless	Root-to-shoot ratio for tropical moist deciduous forest < 125 tB ha^{-1}	0.20 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	sampling	Sampled from a Triangular distribution with lower bound a = 0.09, upper bound b = 0.25, mode c = 0.20; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.
R_{dlh} dimensionless	Root-to-shoot ratio for tropical moist deciduous forest > 125 tB ha^{-1}	0.24 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	sampling	Sampled from a Triangular distribution with lower bound a = 0.22, upper bound b = 0.33, mode c = 0.24; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
R_u dimensionless	shoot ratio for tropical mountain systems	0.27 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	sampling	Sampled from a Triangular distribution with lower bound a = 0.269, upper bound b = 0.0.28, mode c = 0.27; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.
$BCEF_{AR,I}$ tB $(m^3)^{-1}$	biomass conversion and expansion factor for volume increments in humid tropical natural forests	1.1 Source: IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level 21-40 m^3 ha^{-1})	sampling	Sampled from a triangular distribution with lower bound $a = BCEF_{AR,I} - BCEF_{AR,I} \times 0.25$ upper bound $a = BCEF_{AR,I} + BCEF_{AR,I} \times 0.25$and mode $c = BCEF_{AR,I}$	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.
$BCEF_{HW,R}$ tB $(m^3)^{-1}$	biomass conversion and expansion factor for logging;	1.05 Source: IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level >200 m^3 ha^{-1})	sampling	Sampled from a triangular distribution with lower bound $a = BCEF_{HW,R} - BCEF_{HW,R} \times 0.25$ upper bound $a = BCEF_{HW,R} + BCEF_{HW,R} \times 0.25$, and mode $c = BCEF_{HW,R}$	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
$BCEF_{HW,I}$ **tB. $(m^3)^{-1}$**	biomass conversion and expansion factor for increment taken from	1.1 Source: IPCC, 2006, Vol.4, Chap. 4, Tab. 4.5; growing stock level 21-40 m^3 ha^{-1})	sampling	Sampled from a triangular distribution with lower bound $a = BCEF_{HW,I} - BCEF_{HW,I} \times 0.25$ upper bound $b = BCEF_{HW,I} + BCEF_{HW,I} \times 0.25$, mode $c = BCEF_{HW,I}$	Representative raw data not available. Considered to have moderate uncertainty based on being an IPCC default value.
COMF i dimensionless	Combustion factor – proportion of pre-fire fuel biomass consumed)	0.46 Source: (IPCC 2006 Vol. 2, Table 2.6)	sampling	Sampled from a Triangular distribution with lower bound a and b were 50% and 150% of the mode c.	Representative raw data not available. Upper and lower bound of value provided and therefore applied in triangular distribution.
$G_{g,CO2}$ g CO_2 kg^{-1} Dry matter burnt	Emission factor, gCO_2 kg^{-1} dry matter burnt	1580 Source: IPCC 2006 Vol. 4, chapter 2, Table 2.5)	sampling	Sampled from a normal distribution N(μ= $G_{g,CO2;}$ σ^2=902; see Table 2.5 in IPCC, 2006, Vol 4, Chap. 2, Tropical Forest).	Representative, raw data not available. Normality assumption on the basis figure comes from the IPCC database.
$G_{g,N2O}$ g N_2O kg^{-1} Dry matter burnt	Emission factor, gN_2O kg^{-1} dry matter burnt	0.2 Source: (IPCC 2006 Vol. 4, chapter 2, Table 2.5)	sampling	Sampled from a Triangular distribution with lower bound a and b were 50% and 150% of the mode c	Representative raw data not available. Upper and lower bound of value provided and therefore applied in triangular distribution.

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
$G_{g,CH4}$ **g CH_4 kg^{-1} Dry matter burnt**	Emission factor, gCH_4 kg^{-1} dry matter burnt	6.8 Source: IPCC 2006 Vol. 4, chapter 2, Table 2.5)	sampling	Sampled from a Triangular distribution with lower bound a and b were 50% and 150% of the mode c	Representative raw data not available. Upper and lower bound of value provided and therefore applied in triangular distribution.
C_{AFTER} **tC ha^{-1}**	C stock in biomass due to the conversion of Natural Forest to grassland	17.11 Source: Rounds [2013]	measurement and sampling error	Sampled from a normal distribution with Lower CI [8.31] and Upper CI[25.96]	Representative, raw data available. Central limit theorem: binomial approaches normal.
$C_{BEFORE,Lowland}$ **tC ha^{-1}**	Estimated C stocks stored in AGB and BGB in Lowland Natural Forest	87.86 Source: Appendix A2 - Fiji FRL Report, 2018	measurement and sampling error	Sampled from a normal distribution with Lower CI[84.25] and Upper CI[93.21]	Representative, raw data available. Central limit theorem: binomial approaches normal.
$C_{BEFORE,Upland}$ **tC ha^{-1}**	Estimated C stocks stored in AGB and BGB in Upland Natural Forest	71.57 Source: Appendix A2 - Fiji FRL Report, 2018	measurement and sampling error	Sampled from a normal distribution with Lower CI[66.45] and Upper CI[78.58]	Representative, raw data available. Central limit theorem: binomial approaches normal.
EM_{FELL} **tC $(m^3)^{-1}$**	carbon loss from the extracted logs, including logging residues	0.69 Source: Haas [2015]	measurement and sampling error	Assessed in uncertainty emission factor TEF. Sampled from a triangular distribution with lower bound a = TEF - TEF x 0.25, upper bound b = TEF + TEF x 0.25, and mode c = TEF	Representative raw data not available. Considered to have moderate uncertainty based on expert judgement.

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
EM_{DAM} tC $(m^3)^{-1}$	damage to the remaining stand (all killed [snapped and up-rooted] trees 10 cm DBH), crown damage	0.15 Source: Haas [2015]	measurement and sampling error	Assessed in uncertainty emission factor TEF. Sampled from a triangular distribution with lower bound a = TEF - TEF x 0.25, upper bound b = TEF + TEF x 0.25, and mode c = TEF	Representative raw data not available. Considered to have moderate uncertainty based on expert judgement.
EM_{INFR} tC $(m^3)^{-1}$	infrastructure development (all trees _ 10 cm DBH on logging roads, skid trails and log landings)	0.21 Source: Haas [2015]	measurement and sampling error	Assessed in uncertainty emission factor TEF. Sampled from a triangular distribution with lower bound a = TEF - TEF x 0.25, upper bound b = TEF + TEF x 0.25, and mode c = TEF	Representative raw data not available. Considered to have moderate uncertainty based on expert judgement.
$MAIV_{AR}$ m^3 ha^{-1} yr^{-1}	mean annual volume increment for afforestation/ reforestation	3.71 Source: Derived from data provided from Fiji Hardwood Corporation Limited	measurement and sampling error	Sampled from a Triangular distribution with lower bound $a = \mathrm{MAIV_{AR}} - \mathrm{MAIV_{AR}} \times 0.5$ upper bound $b = \mathrm{MAIV_{AR}} + \mathrm{MAIV_{AR}} \times 0.5$ and mode $c = \mathrm{MAIV_{AR}}$	Representative raw data not available. Considered to have large uncertainty based on expert judgement.

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
$MAIC_{FD}$ tC ha^{-1} yr^{-1}	mean annual C increment after logging (above ground and belowground)	0.99 Source: Personal Communication Based on measurements from projects within Fiji	measurement and sampling error	Triangular distribution with lower bound $a = \mathrm{MAIC_{FD}} - \mathrm{MAIC_{FD}} \times 0.5$ upper bound $a = \mathrm{MAIC_{FD}} + \mathrm{MAIB_{SW}} \times 0.5$, mode $c = \mathrm{MAIC_{FD}}$.	Representative raw data not available. Considered to have large uncertainty based on expert judgement
λ_{Pine} dimensionless	Softwood plantation recovery rate following harvest	0.76 Source: Waterloo [1994]	measurement and sampling error	Drawn from a Normal distribution with $\mu = \lambda_{\mathrm{Pine}}$ and $\sigma^2 = [\lambda_{\mathrm{Pine}} \times 0.1]^2$	Representative, raw data available. Central limit theorem: binomial approaches normal.
ρ_{Pine} g cm^{-1}	Pine tree wood density (dry weight over fresh volume)	0.47 Source: Crown [1981]	measurement and sampling error	Drawn from a Normal distribution with $\mu = \rho_{\mathrm{Pine}}$ and $\sigma^2 = 0.0031$	Representative, raw data available. Central limit theorem: binomial approaches normal.
$MAIB_{SW}$ tB ha^{-1} yr^{-1}	mean annual increment of above and belowground biomass in softwood plantations	10 Source: Waterloo [1994]	measurement and sampling error	Triangular distribution with lower bound $a = \mathrm{MAIB_{SW}} - \mathrm{MAIB_{SW}} \times 0.25$ upper bound $a = \mathrm{MAIB_{SW}} + \mathrm{MAIB_{SW}} \times 0.25$, mode $c = \mathrm{MAIB_{SW}}$.	Representative raw data not available. Considered to have medium uncertainty based on expert judgement.

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
CC_{SW} **Yrs.**	length of the harvest cycle in softwood plantations	20 Source: Personal communication Fiji Pine Limited (FPL) indicated that most pine plantations are harvested around 20 years ranging between 15 to 25 years.	measurement	Sampled from a Triangular distribution with lower bound $a = CC_{SW} - 5$, upper bound $a = CC_{SW} + 5$, mode $c = CC_{SW}$	Representative raw data not available. Upper and lower bound of value provided by expert judgement and therefore applied in triangular distribution
$\overline{MAIV}_{HW}$ **m^3 ha^{-1} yr^{-1}**	Average mean annual increment in Fiji hardwood plantations	5.85 Source: derived from data provided from Fiji Hardwood Corporation Limited	measurement	Sampled from a Triangular distribution with lower bound $a = \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$, upper bound $b = \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$, mode $c = \overline{\mathrm{MAIV}}_{\mathrm{HW}}$	Representative raw data not available. Considered to have medium uncertainty based on expert judgement.
$\widehat{A}_{DF,Lowland}$ **ha**	Forest area loss in the strata Lowland Natural Forest	2019 – 179 2020 – 179	sampling	Sampled using bootstrapping technique with sample replacement.	
$\widehat{A}_{DF,Upland}$ **Ha**	forest area loss in the strata Upland Natural Forest	2019 – 4 2020 – 4	sampling	Sampled using bootstrapping technique with sample replacement.	

Parameters and assumptions used in the Monte Carlo method Parameter included in the model	Description	Parameter Value	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
AD_{MPNFF}	Forest area converted from Closed to Open forest	2019 – 214 2020 - 214	measurement and sampling error	Standard error for each year is 62 ha	

5.2.2 Quantification of the uncertainty of the estimate of Emission Reductions

		Reporting Period		Crediting Period	
		Total Emission Reductions*	**Forest degradation ****	**Total Emission Reductions***	**Forest degradation ****
A	**Median**	1,055,135	426,319	1,055,135	426,319
B	**Upper bound 90% CI** (Percentile 0.95)	1,338,129	488,563	1,338,129	488,563
C	**Lower bound 90% CI** (Percentile 0.05)	784,475	356,760	784,475	356,760
D	**Half Width Confidence Interval at 90% (B – C / 2)**	276,827	65,902	276,827	65,902
E	**Relative margin (D / A)**	26.24%	15.46%	26.24%	15.46%
F	**Uncertainty discount**	4%	15%	4%	15%

*Forest degradation has been removed from these values and listed in the neighbouring column as it has been estimated with proxy data.

This table presents values for the full Monitoring Period, rather than the Reporting Period. The default 15% uncertainty discount is applied to Forest Degradation as proxy methods are used.

5.3 Sensitivity analysis and identification of areas of improvement of MRV system

Sensitivity analysis was and identified that the main source of uncertainty is the Activity Data for deforestation and afforestation estimated for the forest reference period.
Following that, two default values had the next highest influence on uncertainty; namely 'Recovery' rate of softwood volume to total tree volume (from published literature Waterloo, 1994) and the root:shoot ratio for dry land natural forest (IPCC, 2006). Finally work being undertaken with the National Forest Inventory (NFI) will eventually lead to the adoption of National data related to mean annual increment in Plantation (MAIV) and Natural (MAIC) Forest.

Table 11: Sensitivity Analysis

Factor	V
ErpaYearlyFRLDefor	0.4448
ErpaYearlyFRLEnh	0.3112
Recovery	0.0575
RootToShootDryLandBig	0.0252
DeforAreaLow	0.0221
MAIVar	0.0196
MAICFell	0.0177
FPlnAreaPlantSwd	0.0168
MAIVhw	0.0168
ErpaYearlyFRLFDeg	0.0145
ErpaYearlyFRL	0.0143
BiomassConvExpansionIncHW	0.0135
DeforAreaUp	0.0132
BiomassConvExpansionARefor	0.0126
FPlnAreaPlantHwd	0.0125
MAIBsw	0.0124
TEF	0.0121
NFDegArea	0.012
EFNFDeg	0.0117
EFDeforUp	0.0114
BiomassConvExpansionHW	0.0111
FDegFellArea	0.0108
RootToShootTropRain	0.01
RootToShootDryLandSmall	0.009
EFDeforLow	0.0035

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

The Climate Change Act (2021) provides the legal framework for the transfer of Titles to ERs. Under part 10, Section 45 (1): refers to the Carbon Sequestration Property Right (CSPR) and its distinct and exclusive right to the carbon sequestration and carbon stock. Under S.45 (2) (a): this right must be registered with the Office of the Registrar of Titles. Under S.45 (2) (e), the right is registered in the form of a certificate to the right-holder, which, under S.45 (2) (f), allows the right-holder to to deal with the right whether by sale, transfer, mortgage, charge or pledge.

Under S.46, only persons holding a lease from the respective leasing authority (for free-hold or private owned land, shows evidence of ownership or legal right to the land) or license from the Conservator of Forests over the area may register and obtain a certificate. Under S.46 (4), a CSPR certificate can be registered and issued for the ER-Program, if the right-holder has acquired the consent of the Conservator of Forests, which is in the form of a License. Under S.46 (9) only one certificate can be registered and issued in respect to a particular area of land and S.46 (10) all issued certificate must be registered as an **encumbrance** in a **Registry** by the Office of the Registrar of Titles, which negates the incidence of **double-counting.** Under S.47, no mining, logging, exploration or extractive activity is to be approved on land over which (a) a certificate has been registered and/or (b) an international REDD+ program or emissions reduction project, program or activity involving forests, blue carbon or other project, program or activity type prescribed by regulations made under this Act has been approved.

In this regard, all certificates issued will require a lease and license.

(a) Land Lease

The land tenure within the ER Accounting Area comprises of communally owned (89.9%), State land (4.3%) and privately owned land (5.8%). All communal lands are governed and administered by the TLTB under the iTaukei Land Trust Act (1940), whilst all State land are governed and administered by the Ministry of Lands under the State Land Act (1945) and Private land is governed under the Land Transfer Act (1971).

Under the communal tenure system, the land is registered to the clan and/or tribe in which case at least 55% of the clan/tribe members (over the age of 21 years) must render their consent before the TLTB issues a lease for development. By law, no communally owned land can be sold or transferred. It should be noted that TLTB, under the TLTB Act, is the legal custodian of all communal land and has the legal authority to issue leases for the benefit of the clan. For State land, the Ministry of Lands (Director of Lands) under the State Land Act has the legal authority to issue leases.

(b) License

The Conservator of Forests under Section 9 (Part IV-Utilization of Forest Resources) of the Forest Decree (1992) has the legal authority to issue a Forest License for the utilization of forest products. The revised Forest Bill has defined the stored forest carbon as a forest product. It is envisaged that the enactment of the revised Forest Act will be delayed. In the absence of this definition, the Minister of Forests under Section 38 (Part X-Regulations) part (1) make regulations to carry out the purpose of this decree, and part (2) (b) regulate the manner in which the license may be issued, including the terms and conditions of the license. These provisions allow the Conservator of Forests to issue a forest license that will facilitate the implementation of the ER-Program. Under Section 34 (1) allows the delegated forest officer to enter into a licensed area for the purpose of carrying out an inspection and the MRV functions.

6.2 Implementation and operation of Program and Projects Data Management System

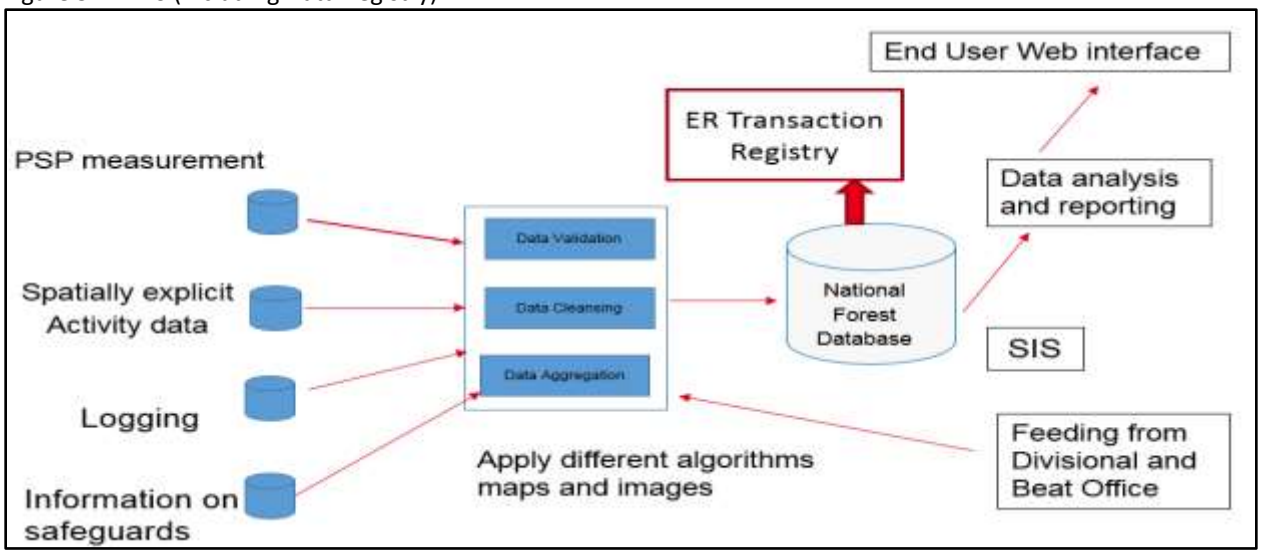
There is an existing framework of systems, processes, protocols and institutional arrangements with the TLTB, Ministry of Lands and the Ministry of Forestry regarding the development of forests and land in Fiji, which will be adopted during the implementation of the ER-Program.

All applicants or interests in the ER-Program will be required to acquire a lease, depending on the land tenure-type, from the Leasing Authority. For free-hold or privately owned land, the applicant or interest must show

evidence of having the legal ownership or right over the land. The Leasing Authority will issue a lease title (with terms and conditions) to the applicant and a copy of which is sent to the Ministry of Forestry (Conservator of Forests). The Conservator of Forests will then issue a license (Forest Management License). Both the lease and license will carry unique reference numbers that relate to a particular area of the land, which are registered in the Carbon Registry.

The National Forest Monitoring System (NFMS) was reconstructed in January 2023 along with an integration platform that allows the interfacing of existing database systems that were independently developed. The existing database are for forest harvesting (Timber Revenue System (TRS), Harvest Area Reporting (HAR) system), the Permanent Sample Plot (natural forest regrowth) measurements, the Ministry's Plantation Dashboard (30-million tree-planting program) and the Forest Management Information System (FMIS). Other databases that will be integrated are the Safeguard Information System (SIS) and the Carbon Registry. The integration work is expected to be completed by July 2023.

Figure 5: NFMS (including Data Registry)



Field Data Collection & Reporting

The Ministry of Forests has 16 field Beat offices located all over Fiji, which are responsible for data-collection work for the MRV of the ER-Program. By July 2023, all offices will be trained and issued with hand-held pre-programmed tablets, which contains designed data-collection templates. The data-collection templates will collect data on:

(a) Forest Harvesting (Logging) data, including locality, harvested area (shape-files) and log volume removed;
(b) Planting data, including locality, area (shape-files), tree-species and number of trees and growth measurements (height and diameter);
(c) Permanent Sample Plot (natural forest regrowth) measurements, including locality (GPS and shape-files) and growth measurements (height and diameter). Field samples will also be collected for analysis, which includes soils, litter and deadwood.

The first training was conducted from the 17th – 21st April 2023.

All field data is transmitted to the NFMS to, firstly, update the respective databases, secondly, support the R-Script and updating of the Forest Reference Level and thirdly, updating of the Carbon Registry in terms of the carbon value for each ER activity. This work is overseen by the Forest Resource Assessment (FRA) Division.

The ER Report for the monitoring period was conducted through semi-automated and offline approaches as the NFMS was still under reconstruction.

6.3 Implementation and operation of ER transaction registry

Fiji is expected to develop two registries to support the registration of titles issued under the ER-Program. The primary reason for having two registries is that there are two government entities, the Climate Change International Cooperation Division (CCICD or CCD) and the Ministry of Forestry that will be directly involved in the issuance, transfer and transactions surrounding the ER Titles.

National Registry – Housed by the Climate Change International Cooperation Division (CCICD)
The Fijian Registry is referenced in section 61 of the Climate Change Act 2021, for the following purpose:

(a) Emissions reduction projects, programs, and activities.
(b) Fijian Mitigation Outcome Units.
(c) Emissions reduction units issued under an approved international emissions reduction standard in relation to an emissions reduction project, program or activity in Fiji.
(d) Fiji's national registry for any incoming ITMOs from another country or outgoing Fijian Mitigation Outcome Units to another country.

At the present, the registry has not been developed however, the Capacity Building Initiative for Transparency project is well underway which has outcomes aligned to the purposes stated above. The Project outcomes include:

(1) Fiji's institutional arrangements for the Enhanced Transparency Framework (ETF) are formalized and strengthened to enable regular transparent reporting on NDC implementation and National GHG inventory.
(2) An Information Technology (IT-based) GHG inventory preparation system enables the coordinating entity CCD to efficiently co-ordinate preparation of transparent, consistent, comparable, complete, and accurate National GHG inventories.
(3) Measurement, Reporting and Verification (MRV) systems strengthened to enable Fiji in tracking and transparently reporting on Nationally Determined Contributions (NDC) implementation and resultant GHG emissions and climate finance.

While the focus is on developing an IT system for tracking and reporting on GHG emissions and the NDC, it also builds the basis for a platform for recording on the emissions reductions projects, programs and activities as well as considerations for the application of corresponding adjustment as part of this system. The output of the project is expected to be completed by the end of 2024.

Carbon Registry – Housed within the Ministry of Forestry
The Carbon Registry is the Data Management System (DMS) that will store all relevant information pertaining to the Lease and License issued for the ER-Program. The registry will be housed within the National Forest Monitoring System (NFMS) integration platform and developed by July 2023. The registry will contain:

a) The Lease information, as issued under the lease documents (including spatial information of the land and boundaries) and lease title number, which is stamped and registered by the Office of the Registrar of Titles;
b) The License information, as issued under the license documents by the Conservator of Forests and license number. The license document will also include the Lease Number as it primary reference;
c) The Forest Management Plan information, which will detail the ER-Program (REDD+) activities implemented and the equivalent forest carbon stock volume;
d) The Carbon Sequestration Property Right Certificate number – this applies only to lease/license that have been registered in the FCPF Carbon Assessment Tracking System (CATS) registry under the country's account of tradable ER Titles.

Online License Application Portal
An online license application portal for the ER-Program will be developed by July 2023. The process will include a checklist of required documents, approvals and protocols of due diligence checks that will negate the incidences of encroachment, encumbrance, 3rd party claims and double counting. A similar framework (institutional arrangements, systems, processes and checklist) is currently being used to monitor and report on all licensed harvesting operations and for imports and exports.

6.4 ERs transferred to other entities or other schemes

Fiji's Accounting Area (90% of the total landmass) is committed to the ERPA (and FCPF-Carbon Fund) and as such all ERs will be transferred to the Carbon Fund. Under the Climate Change Act (2021) and as mentioned in 6.1, all ER-Programs and interests must be registered and must acquire the consent of the Conservator of Forests. To-date, no programs and/or projects have been registered.

There are, however, Overseas Donor projects that have aligned their objectives towards the ER Program and have indicated their interest in participating in carbon trade under the ERPA and these include: -

(a) The GEF 5 STAR Ridge-to-Reef project with sites within the Tuva, Ba and Tunuloa catchments;
(b) The EU funded Ecosystem based Climate Adaptation Project (ECAP) with sites targeting 72 villages on the South-western aspects of Vanua Levu.

These projects are engaged at community level and operate on communal owned land. These organizations and communities will be revisited by July 2023 to ascertain their current status and an update will provided in the next reporting period.

7 REVERSALS

7.1 Occurrence of major events or changes in ER Program circumstances that might have led to the Reversals during the Reporting Period compared to the previous Reporting Period(s)

As this is the first monitoring period, there are no reversals.

7.2 Quantification of Reversals during the Reporting Period

As this is the first monitoring period, there are no reversals.

7.3 Reversal risk assessment

The Reversal Risk Assessment completed below (

Table) has resulted in a reduction in the reversal risk set-aside percentage from 26% presented in the ER-PD to 16% presented in this first Monitoring Report. This reduction is a result of a down grading of the risk associated with:

- Lack of broad and sustained stakeholder support
- Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination

The risk downgrades are associated with the institutionalisation of the ER Program within various levels of Government and the completion of the important programme elements related to Benefit Sharing Plans and Safeguard Information Systems.

This source of risk has reduced since the ERPD was submitted due to the Climate Bill being adopted by Government and the full socialization of the ERP combined with strong engagement across communities, businesses and government on climate change responses. As such the Broad stakeholder support and engagement is considered strong and the risk of reversal related to this Risk Factor negligible.

Table 12: Risk of Reversal Assessment for this Monitoring Period

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	*N/A*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	The ER Program interventions are designed to assist and engage directly with landowners and timber harvesting companies to protect existing forest areas, reforest degraded lands and improve sustainable harvesting practices. The full extent of the stakeholders within the Project Area have been consulted and have representation on the REDD+ Steering Committee. Several programs across the Project Area are already operational and stakeholder support and engagement is strong. The Emissions Reductions Program (ER-P) activities embrace the vision of Fiji's National Development Plan (NDP) 2017-2036 which is to encourage inclusive socio-economic development based on multi-sectoral collaboration to find solutions to climate change, environmental protection and green growth. The ERP recognises that stakeholder engagement is critical to achieving this vision along with the strong land tenure and management rights within Fiji which means that conflicts over resources are not common place. Fiji has an extensive range of existing models of benefit sharing mechanisms that are supported by existing laws and policies; ensuring equitable, transparent transactions that respects the rights of all resource owners. There are six existing models including the (i) the iTaukei Lands Trust Board Lease Payment Distribution under the iTaukei Land Trust Act; (ii) Ministry of Lands – Land Bank Lease Payment Distribution under the Land Use Decree 2010; (iii) Ministry of Lands Distribution of Mineral Royalties under the Fair Share Mineral Act 2018; (iv) Trust and Charitable Trust under the Trustee Act or Charitable Fund Act; (v) Company/ not for profit organizations under the Companies Act 2015 and (vi) co-managed cooperatives under the Cooperative Act 1996. The first three models align to existing laws that define resource owners and associated rights. While the first two models specifically deal with iTaukei or indigenous land, the third model	**10%**	10%	0%

	focuses on state owned minerals as defined in the Mining Act. The above models provide the foundation for the development of the principles, identification of benefits, beneficiaries, criteria for beneficiaries and flow of funds for the Emission Reduction Programme Benefit Sharing Plan. The Benefit Sharing Plan aims to improve the efficiency of existing models while meeting the needs of the FCPF Benefit Sharing Guidelines. All of these elements combine to ensure that the ERP has broad and sustained stakeholder support. **This source of risk has reduced since the ERPD was submitted due to the Climate Bill being adopted by Government and the full socialization of the ERP combined with strong engagement across communities, businesses and government on climate change responses. As such the Broad stakeholder support and engagement is considered strong and the risk of reversal related to this Risk Factor negligible.**			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	The ER Program's design draws on a number of recent forest projects which have strengthened institutional capacities related to data collection, stakeholder engagement and delivery of effective environmental outcomes. Fiji is a small nation with limited human resources and so Government agencies, the private sector and NGOs are very use to pooling and sharing experiences. The ER Programme has experienced a transformation since the completion of the ER Program Document and the signing of the ERPA. The various levels of central and provincial Governments involved now see this as an operational ongoing programme, opposed to a short-term time dependent project. This transformation has seen an increase in the commitment from cross sector Ministries which has increased effective participation and coordination. The ER Program and the National Forest Monitoring System for REDD+ is now embedded in the Ministry of Forestry and the Ministry of Economy as part of operational budgets. There is also broad support from the Ministries of Forestry, Agriculture and Lands and the TLTB for the development of the Fiji Land Use Plans and co-ordination on the implementation of sustainable land use options. The REDD+ Steering Committee will continue to exist and is being considered for a broader Land Use role as decisions around REDD+ become part of broader coordinated Government planning. Institutional capacity is growing and being sustained as project officers become permanent staff within the Ministry of Forestry and the tasks for REDD+ are absorbed into the budget of the Ministry of Forestry and Ministry of Economy. While there	**10%**	10%	0%

	will always be a need for more capacity building amongst staff this will continue to evolve within the strongly established co-ordination mechanisms. **This source of risk has reduced since the ERPD was submitted due the increased capacity and infrastructure now embedded in the Ministry of Forestry and the ongoing co-ordination between the Ministry of Economy and Ministry of Lands. Consideration of the NFMS is being the basis of a broader full lands monitoring system is ongoing and capacity across the Ministries is increasing. As such the risk of reversal related to this Risk Factor negligible.**			
Lack of long term effectiveness in addressing underlying drivers	**Avoiding Deforestation** There are several programs in Fiji actively working with agriculturists to improve practices, with the aim of protecting forests. One such program, funded by the Global Environment Facility (GEF) and implemented by FAO has established a partnership with the Land Resources Division of the Secretariat of the Pacific Community to reduce or reverse the forest and land degradation around Protected Forest Areas. A package of activities designed for the introduction of sustainable land and soil management practices is under implementation at the three major project sites in Fiji. The major activities are: • Training of agricultural extension workers to provide advice on suitable crops, develop farm budgets and income generating opportunities from sustainable land management practices. • Establishing on site demonstration plots for sustainable land management and to promote agroforestry. • Training of local farmers in sustainable land management practices • Development of Tikina (district) based land-use management plans for communities living adjacent to the protected areas. **Reducing Degradation** Fires are generally lit in grassland areas within Fiji to maintain open agricultural lands. Arson and random setting of fires also occurs. Typically, such fires pose most threat to plantation areas which are generally established on degraded lands. Fires pose a threat to the successful establishment of plantation areas and is considered a large contributing factor to failure in plantation establishment.	**5%**	2%	3%

	Several programs are ongoing in Fiji funded by EU and GEF grants that will lead to the development of a National Forest Fire Management Strategy as well as demonstration activities to strengthen the sustainable livelihoods of communities living in and around forest areas. Reforestation areas will be planned and established taking these initiatives into consideration to include buffer zones, fire management plans and targeted awareness programs. **Promoting sustainable forest management**: The ER program will strengthen adherence to the national code of harvesting practice. Government has already started a programme to inform and train the industry on the code of harvesting and plans are underway to develop regulations for the enforcement of the code. Fiji was one of the first countries in Asia-Pacific to develop a code of logging practice and this has been recently reviewed to strengthen reduced impact logging requirements.			
Exposure and vulnerability to natural disturbances	Fiji experiences cyclone season between January and May. The outer island regions are affected more regularly than the larger islands included in the Project Area. Storms that result in heavy damage typically occur every ten years, however with climate change the frequency of such damaging storms are anticipated to increase. Whilst this this is the case, damage from heavy storms is typically more significant in exotic plantation forests compared to secondary native forest areas and decreases further in primary forests. To mitigate potential losses, areas identified for reforestation projects will undergo a prior assessment of suitability (i.e. aspect, soil type, species composition, management regime) with the aim of minimizing losses from natural disasters. Additionally Fiji Pine Limited and Fiji Hardwood are considerate of where they establish plantations so as to protect their investment. This risk remains unchanged from the ERPD.	**5%**	2%	3%
		Total reversal risk set-aside percentage		16%
		Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)		*26%*

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

Table 13: ER Available for Transfer

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*	**1,041,961**
B.	**If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)**		320,034
C.	**Number of Emission Reductions estimated using measurement approaches (A-B)**		721,927
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	*from section 6.1*	*100%*
E.	**ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes**	*from section 6.4*	-
F.	**Total ERs (B+C)*D-E**		1,041,961
G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*	4%
H.	**Quantity of ERs to be allocated to the Uncertainty Buffer (0.15*B/A*F)+(G*C/A*F)**		76,882
I.	**Total reversal risk set-aside percentage applied to the ER program**	*from section 7.3*	16%
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**		106,159
K.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%**		48,253
L.	**Number of FCPF ERs (F- H – J – K)**		810,667

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

ANNEX 2: INFORMATION ON THE IMPLEMENTATION OF THE BENEFIT-SHARING PLAN

ANNEX 3: INFORMATION ON THE GENERATION AND/OR ENHANCEMENT OF PRIORITY NON-CARBON BENEFITS

ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

Technical corrections were made to the FRL since the submission of Fiji's ERPD as a result of:

- improvements to quality assurance/quality control procedures relating to the generation of the activity data for deforestation and reforestation and Softwood Plantations,
- inclusion of new data and methods for estimating Forest Degradation across all natural forests in Fiji.

The technical corrections are covered by the following condition as set out in paragraph 3 of the Guideline on the application of the Methodological Framework Number 2 – Technical Corrections

Table 22: Corrections to historical activity data resulting from improvements to quality assurance/quality control procedures.

Related Element of FRL	**Technical Correction item**	**Description**
Data Improvements related to Deforestation	Improvement to activity data	Corrections to activity data resulting from the use of reference data of higher accuracy and/or precision. ii. Improvements to quality assurance/quality control procedures used to collect the reference data (e.g. resampling of visual interpretations, use of an increased number of repeated interpreters, use of written SOPs and robust training procedures)
Data Improvements related to Softwood Plantations	Corrections of material errors, omissions and misstatements	Reduced to corrections of material errors, omissions and misstatements identified in assumptions, data or calculations used to estimate the historical to GHG emissions and removals reported in the reference period. Acceptable technical corrections include the correction of mistakes in calculations, transfer or transcript errors of data, or wrong application of IPCC default values.
Increased scope of Forest Degradation Emissions	Other	The methodology for estimating of Forest Degradation has been expanded to include transitions from Closed to Open forest in Natural Forest other than areas subject to time harvest. This improvement to the FRL means that Fiji is more comprehensively accounting for emissions related to Forest Degradation using what is considered direct measurement approaches.

The technical corrections have not compromised the consistency of GHG emissions and removals estimates between the Reference Period and monitoring periods as the FRL has been recalculated with the updated datasets and ER calculations conducted based upon the consistent methodology and datasets between the FRL Period and the Monitoring Period.

Technical Correction 1 - Data Improvements related to Deforestation

Improvements to the processes for developing estimates of Forest cover loss over the Reference Period we made. These improvements related to the sampling design and training of interpreters. There were no changes made to the data source (Landsat) or the algorithm applied (CPN).

These improvements specifically lead to creating a buffer stratum around areas of change, clear instruction and training to interpreters and qa/qc processes that lead to samples being checked multiple times and by different interpreters. This led to a significant reduction in the detected area of deforestation between the first FRL and this technically corrected FRL. The new area of deforestation is more aligned with other global datasets for the region and additional work carried out using the CODED algorithm in Fiji. There is much more confidence in the figures presented in this technical correction to the FRL.

Technical Correction 2 - Data Improvements related to Softwood Plantations

The methodology for estimating removals on areas of stocked pine plantations in the Reference Level relied on modelling of data to estimate of stocked area in 2006 which is adjusted through the time series based on areas harvested and areas replanted each year of the reference period. Removals during the FRL period are estimated based on this annual stocked area of growing plantations.

The stocked area applied in the Reference Period was initially modelled due to a lack of data available from Fiji Pine Limited at the time. During the first Monitoring Period, Fiji Pine Limited conducted a stocktake and data collection exercise in order to fill the data gap. Subsequently, it was realised that the modelled stocked area was an overestimation. The FRL was recalculated using the same methodology with the new data set for annual stocked area in the Reference Period.

Technical Correction 3 - Increased scope of Forest Degradation Emissions

Measurement and reporting of activities related to Forest Degradation was expanded beyond areas of harvest in natural forest to include transitions from Closed forest to Open forest in all Natural Forest within the area of Fiji covered by the FRL. Degradation from Closed to Open forest was defined as "A non-cyclone disturbance in a forest that results in a reduction of canopy cover from 40-100% to 10-40%". The activity data was generated through the combination of the CODED algorithm using the same Landsat archive and reference data set as that used to estimate deforestation. Canopy cover estimates were added by the interpreters and the area converted from Closed to Open forest estimated.

Development of a National Tier 2 emission factor for canopy cover change was not possible with the available data sets. Instead a model-based approach to estimating biomass density (for example Ståhl et al. 2010) was used based on the GEDI data set. A model was developed that relates field measurements to auxiliary data (in this case remote sensing data) as the basis for statistical estimation. The previous forest inventory was used to calibrate a GEDI-to-biomass model, then biomass was predicted at every GEDI observation in Fiji. Hybrid statistical inference was used to calculate mean biomass density and confidence intervals. The statistical framework for using GEDI and hybrid inference is described in Patterson et al. 2019. The country was divided into Open and Closed forests using the forest type classification. Then the difference between the two classes is considered the emission factor. This process led to the development of an emissions factor of 121 tCO_2e +/-22 tCO_2e resulting from the transition from Closed to Open Forest.

Summary of data applied in the technical corrections

The following datasets have been updated as a result of the technical corrections.

Table 23: Technical Correction 1 – Annual average area of deforestation and reforestation

REDD+ Activity	New Dataset	Old Dataset
Deforestation (Lowland)	1459	8332
Deforestation (Upland)	79	2681
Reforestation (Lowland + Upland)	2883	6180

Table 24: Technical Correction 2 – Stocked Area of Softwood Plantation

Year	New Dataset	Old Dataset
	ha	ha
2006	33,071	49,503
2007	33,872	47,980
2008	33,509	48,105
2009	32,336	48,166
2010	32,322	48,303
2011	31,334	48,204
2012	30,897	49,371

2013	30,601	46,555
2014	31,117	47,219
2015	29,527	48,630
2016	23,960	48,113

Technical Correction 3- Expanded scope of Forest Degradation
This technical correction lead to a new methodology (see section 8.3 below) and the following new FRL data set.

Table 25: Technical Correction 3

REDD+ Activity	Area ($ha\ yr^{-1}$)	Emission Factor ($tCO_2e\ ha^{-1}$)
Degraded (Closed to Open Forest)	875	121

As a result of these technical corrections the Forest Reference Level changed and the difference between the FRL are summarised in the two tables below.

Table 26: Summary

Forest Reference Emission Level	Technically Corrected FRL	Original FRL
	Emission / Removal ($tCO_2e\ yr^{-1}$)	Emission / Removal ($tCO_2e\ yr^{-1}$)
Deforestation	394,121	2,696,831
Forest Degradation	498,028	310,442
Enhancement of Carbon Stocks*	590,560	-1,370,469
Net FRL	**1,482,709**	**1,636,804**

***Note that positive numbers are an emission. Accounting has been completed in accordance with Legacy emissions have been assessed following FMT Note CF2020-5 dating 29 January 2021.

Start Date of the Crediting Period

As per the signed ERPA, the start date of the Crediting Period start date for Fiji's ERP is 11th July, 2019.

This date meets the definition of the Start Date of the Crediting Period provided in the FCPF Glossary of Terms as follows:

- It is not earlier than the date the first ER Program Measure(s) (including any SubProject(s)) begins generating ERs. This was confirmed by the FCPF TAP process and the World Bank due diligence process that proceeded the signing of the ERPA.
- It is not earlier than January 1st 2016.
- It does not fall within the Reference period 2006-2016.
- The ER Program complies with requirements since the start date on safeguards (see Annex I of this report), carbon accounting (section 4 of this report) and double-counting (section 6 of this report).

7. CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

Table 27: Descriptions of Sources and Sinks

Sources/ Sinks	Included?	Justification/Explanation
Emissions from deforestation	Yes	Deforestation has mainly taken place in natural forests such as conversion of forests to commercial and subsistence agricultural cultivation, infrastructure development etc. ER Programs must account for emissions from this REDD+ activity.
Emissions from forest degradation	Yes	The source 'forest degradation' is included in Fiji's FRL. Emissions from forest degradation are considered significant [ER-PIN, 2016]. Forest degradation occurs in Fiji in Natural Forests as a result of unsustainable timber extraction practices in government and privately harvest areas as well as from shifting agriculture. The Government of Fiji is planning to increase the area of natural forest under sustainable management. Forest degradation also occurs predominately in Softwood Plantations as a result of fire. Management of fire has become a national priority through the establishment of a National Fire Strategy in 2018/2019.
Removal from enhancement of forest carbon stocks	Yes	The sink 'enhancement of forest carbon stocks' is included in Fiji's FRL. The ER-PIN [2016] identifies afforestation/reforestation (AR) activities on degraded lands as key to increase greenhouse gas (GHGs) removals. The sink 'enhancement of forest carbon stocks' also includes areas belonging to the stratum Forest Plantations. In collaboration with the private sector, the MINISTRY OF FORESTRY (MINISTRY OF FORESTRY) is planning to increase the area of sustainably managed forest plantations.
Emissions from deforestation	Yes	Deforestation has mainly taken place in natural forests such as conversion of forests to commercial and subsistence agricultural cultivation, infrastructure development etc. ER Programs must account for emissions from this REDD+ activity.
Emissions from forest degradation	Yes	The source 'forest degradation' is included in Fiji's FRL. Emissions from forest degradation are considered significant [ER-PIN, 2016]. Currently unsustainable forest management practices are widespread in Fiji, causing a decline of carbon stocks in Natural Forests. The Government of Fiji is planning to increase the area of natural forest under sustainable management. Additionally, fire contributes to degradation predominately of softwood plantations and is included in the estimation of emissions. Management of fire has become a National priority through the establishment of a National Fire Strategy in 2018/2019. Additionally, fire contributes to degradation predominately of softwood plantations and is included in the estimation of emissions. Management of fire has become a National priority through the establishment of a National Fire Strategy in 2018/2019.
Removal from enhancement of forest carbon stocks	Yes	The sink 'enhancement of forest carbon stocks' is included in Fiji's FRL. The ER-PIN [2016] identifies afforestation/reforestation (AR) activities on degraded lands as key to increase greenhouse gas (GHGs) removals. The sink 'enhancement of forest carbon stocks' also includes areas belonging to the stratum Forest Plantations. In collaboration with the private sector, the Ministry of Forestry is planning to increase the area of sustainably managed forest plantations.
Emissions and/or removals from conservation of carbon stock	No	The national REDD+ activities are not clearly defined at this stage for the monitoring and reporting of conservation of carbon stock.
Emissions and/or removals from sustainable	No	There is unclear definition of this activity under national REDD+ scheme and there are no clear boundaries for forest areas under sustainable

Sources/ Sinks	Included?	Justification/Explanation
management of forests		management. Therefore, this activity is assumed to be included in the above REDD+ activities.

7.2 Description of carbon pools and greenhouse gases selected

Table 28: Carbon Pools

Carbon Pools	Selected?	Justification / Explanation
Above Ground Biomass (AGB)	Yes	This is the largest carbon pool and is impacted by the sources of deforestation and forest degradation.
Below Ground Biomass (BGB)	Yes	This is a significant carbon pool. As there is no country specific data on BGB, it is estimated using IPCC 2006 default values.
Dead wood	No	No national data is currently available for deadwood. IPCC 2006 (Vol 4, Chapter 2) notes that Tier 1: Carbon stock of DOM is assumed to be 0 for non-forestland use categories. Deadwood data has not been estimated in the Fiji national forest inventory. In the future, a stepwise approach is proposed to be applied in MMR to improve the measurement of this carbon pool.
Litter	No	No national data is currently available for litter. IPCC 2006 (Vol 4, Chapter 2) notes that Tier 1: Carbon stock of DOM is assumed to be 0 for non-forestland use categories. Litter data has not been estimated in the Fiji national forest inventory. In the future, a stepwise approach is proposed to be applied in MMR to improve the measurement of this carbon pool.
Soils	No	Soil organic carbon data has not been estimated in the Fiji national forest inventory. IPCC 2006 (Ch. 4, Section 4.2.3.1) Tier 1 method states there is no change in forest soil carbon with management or soil carbon change is zero for mineral soils. This has been assumed in Fiji as there are no Peat soils. Additionally, as per the "Tool for estimation of change in soil organic carbon in the implementation of A/R CDM activities", estimation is required for afforestation/reforestation activities in which site disturbance is more than 10 percent of the area (Clean Development Mechanism Executive Board 55, Annex 21). Site disturbance in approaches to afforestation/reforestation in Fiji will result in less than 10 percent of the area due to the forest establishment techniques. Additionally, such activities will focus on degraded lands and it is assumed that planting trees in these areas will cause a net increase in SOC. On this basis SOC is not included in the Reference Scenario. In the future, a stepwise approach is proposed to be applied to improve the estimation of this carbon pool.
Harvested Wood Products	No	Not required by the Methodological Framework and is thus excluded.

Table 29: Greenhouse Gases

Greenhouse gases	Selected?	Justification / Explanation
CO_2	Yes	The ER Program shall always account for CO_2 emissions and removals. The emissions are caused by deforestation and forest

		degradation. The removals are generated from reforestation and forest enhancement.
CH_4	Yes	Methane (CH_4) associated with forest fires are included.
N_2O	Yes	Nitrous oxide (N_2O) sources include fires and fertilizer application. N_2O emissions from forest fires only are included in the FRL. As forest management practices in Fiji do not include application of nitrogen fertilizer, N_2O emissions from fertilizer application are not covered in the FRL.

8 REFERENCE LEVEL

8.1 Reference Period

The Reference Period of Fiji's ER-Program provides an estimate of net historical forest-related emissions/removals for the period 2006 to 2016.

8.2 Forest definition used in the construction of the Reference Level

For its national REDD+ Policy (MPI, 2011), Fiji has adopted the forest definition provided in FAO (2006):

> *"Land spanning more than 0.5 hectares with trees higher than five meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agriculture or urban use. Forest is determined both by the presence of trees and the absence of other predominant land uses. Areas under reforestation that have not yet reached but are expected to reach a canopy cover of 10 percent and a tree height of five meters are included, as are temporarily unstocked areas, resulting from human intervention or natural causes, which are expected to regenerate. Includes: areas with bamboo and palms, provided that height and canopy cover criteria are met; forest roads, fire breaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of scientific, historical, cultural or spiritual interest; windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 meters; plantations primarily used for forestry or protected purposes. Excludes tree stands in agricultural production systems, for example in fruit plantations and agroforestry systems. The term also excludes trees in urban parks and gardens".*

Fiji's most recent country report to the FRA [FRA-Fiji, 2015] lists four forest classes within its forest area, namely (i) closed forest, (ii) open forest, (iii) pine plantations, and (iv) hardwood plantations.

The 'strata' closed and open forest were not retained as the methods used to map forest areas did not produce reliable estimates of closed and open forest areas or forest area changes between these forest types. Additionally, a preliminary analysis of the NFI 2006 data did not demonstrate any significant difference between classified closed and open forest carbon stocks.

The decision to distinguish between Lowland and Upland Natural Forest was based on findings by Mueller-Dombois & Fosberg [1998], who identified significant changes in structural and floristic characteristics in forests in Fiji below and above approximately 600 m above sea level (a.s.l) Mueller-Dombois & Fosberg [1998] found that above 600 m a.s.l. Fijian forests show characteristics typical for mountain forests systems, whereas forest located below 600 m a.s.l. show characteristics of either tropical rain forests or tropical moist deciduous forests. An analysis of the NFI data supported the findings of this scientific study, whereby a significant difference was found between the carbon stocks estimated on NFI plots above 600m when compared to that below 600m.

In a stepwise approach, a priority of the NFMS MRV (see Chapter 9) is to improve the NFI sample frame to capture carbon stocks and stock changes in open and closed forest within the upland and lowland strata. In parallel to NFI

data collection improvements, the semi-automated algorithms for mapping land cover change will be calibrated to enable the capturing of changes in and between open and closed forest classes. These combined improvements will facilitate a move away from a proxy approach to monitoring and reporting degradation to a direct approach using a combination of remote sensing and ground-based data.

Mangrove is not listed under forest in Fiji's FRA country report, partly because the areas of mangrove, defined here as the habitat and entire plant assemblage in which species of the plant family Rhizophoraceae dominate, is located below the high tide water mark (i.e., not considered as land). Moreover, mangrove was not included in the FRL because (i) at least three governmental agencies have regulatory jurisdiction over mangrove and, therefore, the MOF refrained from including mangrove in the FRL to avoid potential conflict between the agencies involved, (ii) mangrove may be considered under "Coastal Wetlands (Blue Carbon)" in the Low Emission Development Strategy (LEDS), and (iii) to ensure consistency with other reporting requirements (i.e., FRA reporting). Also note that coconut plantations are not considered as forest in Fiji (see FRA-Fiji [2015] and Anonymous [2005]).

Forest stratification

For Fiji's FRL, the IPCC land-use category 'Forest Land' was disaggregated into two sub-categories ('Natural Forest' and 'Forest Plantation'). Each sub-category holds two forest strata: the sub-category 'Natural Forest' contains the strata 'Lowland Forest' and 'Upland Forest' and the sub-category 'Forest Plantation' contains the strata 'Softwood plantation' and 'Hardwood plantation' (Table 8-1).

The boundary between 'Lowland Forest' and 'Upland Forest' was drawn at 600 m above sea level (a.s.l.). 'Lowland forest' is located below 600 m a.s.l. and 'Upland Forest' equal or above 600 m a.s.l. This threshold value was set based on findings of Mueller-Dombois & Fosberg (1998), who identified structural and floristic changes below and above the threshold. A preliminary analysis of the NFI 2006 data revealed significant differences in average carbon stocks [t ha^{-1}] between the two strata.

The strata 'Softwood plantations' and 'Hardwood plantations' within the sub-category 'Forest Plantations' cover the areas leased by Fiji Pine Limited (FPL) and Fiji Hardwood Corporation Limited (FHCL), respectively. The sub-category 'Forest Plantations' does not include areas outside the plantation lease areas of FPL and FHCL that are planted with e.g., pine or mahogany. These generally small areas (~1 ha) of planted forest are privately owned for personal use such as house renovations. These reforested areas are considered part of the fragmented forest land landscape and included as part of natural forest which is monitored using wall-to-wall analysis of remote sensing data. Remote sensing methods to distinguish these areas and classify them as plantations will be considered in stepwise improvements to activity data generation (see Section 8.3.2) now they are reported under the class 'Natural Forest'. Figure 8-1 displays a land-cover map of Fiji (2006), showing areas of Lowland Natural Forest, Upland Natural Forest, Hardwood Plantations, Softwood Plantations and Non-Forest.

The stratification of forests applied differs from the one given in Fiji's Country Report to FAO's Global Forest Resources Assessment (FRA) (FRA-Fiji, 2015). The stratification provided in the FRA is based on forest cover maps produced by the Geoscience Division of the Pacific Community (SPC-GSD). To differentiate between closed and open natural forest unsupervised classification techniques were used. However, no rigorous accuracy assessment has been conducted on these historical maps, and their quality remains unknown.

Therefore, a new activity data set was generated for the FRL using semi-automated classification algorithms to generate map predictions upon which an accuracy assessment was conducted using a stratified random sampling approach to generate error adjusted areas of deforestation and afforestation/reforestation (see Section 8.3.2 and Annex 8-1). This wall-to-wall annual times-series dataset has been produced from Landsat imagery and currently enables the distinction between upland and lowland forests. The NFMS improvement plan (Chapter 9) includes activities for improvement of MRV capabilities to eventually report forest degradation from remote sensing by mapping open and closed forest classes. The NFMS improvement plan also includes improvements to the ground data collection through the design and implementation of a repeatable NFI which will enable reporting of more forest classes, including open and closed, in a stepwise approach.

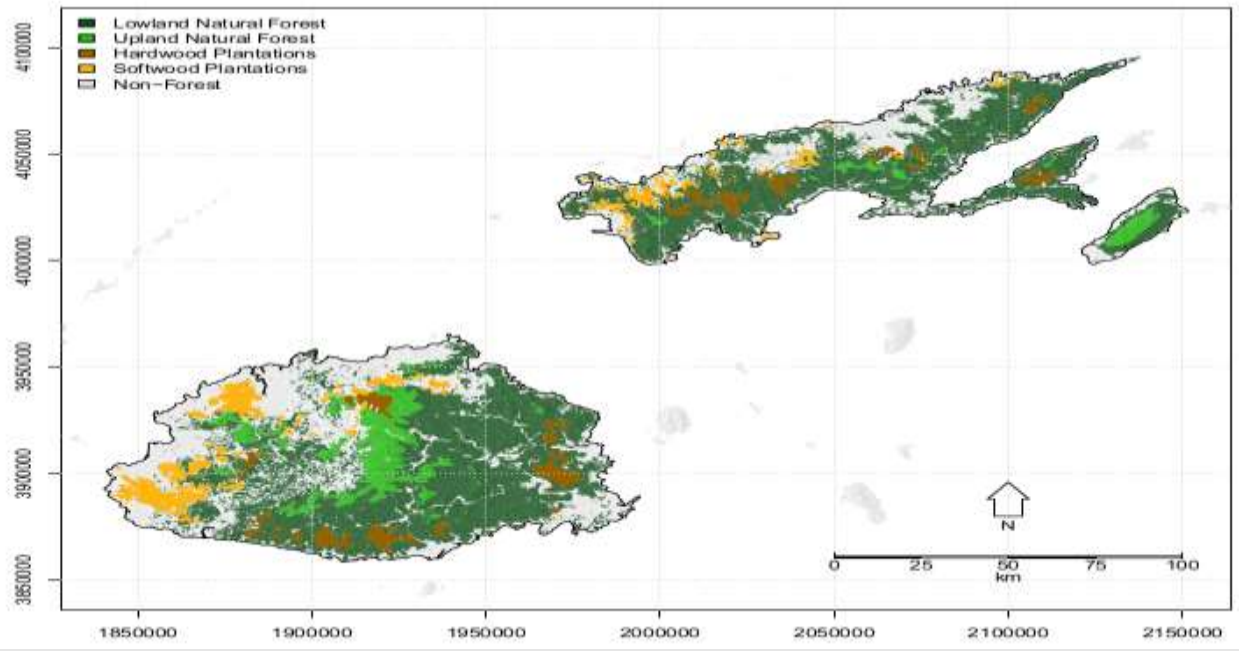


***Figure 8-1: Land-cover map of Fiji (2006)*, showing areas of Lowland Natural Forest, Upland Natural Forest, Hardwood Plantations, Softwood Plantations and Non-Forest. Coordinate Reference System: Fiji 1986 Map Grid (EPSG code: 3460).**

The stratification used for the FRL is described in Table 30.

Table 30: Stratification of land use types used in calculations for the FRL

IPCC Category	Sub-Category	Stratum	Description
Forest Land	Natural Forest	Lowland forest	The stratum 'Lowland Forest' includes all areas classified as forest that are located <600 m a.s.l. It includes primary (native) forest, human modified forests as well as small areas planted with native or introduced tree species which don't require concessions and cannot be distinguished from medium resolution imagery. It excludes forest in plantation lease areas.
		Upland forest	The stratum 'Upland Forest' includes all areas classified as forest that are located ≥600 m a.s.l. It includes primary (native) forest, human modified forests as well as small areas planted with native or introduced tree species which don't require concessions and cannot be distinguished from medium resolution imagery. It excludes forest in plantation lease areas.
	Forest Plantation	Softwood plantation	The stratum `Softwood plantation' includes all areas leased by Fiji Pine Limited (FPL). Areas not currently stocked with trees (crown cover percent is zero) but which are situated within FPL's lease area are classified as forest.
		Hardwood plantation	The stratum `Hardwood plantation' includes all areas leased by Fiji Hardwood Corporation Limited (FHCL). Areas not currently stocked with trees (crown cover percent is zero) but which are situated within FHCL's lease area are classified as forest.
Non-Forest Land		Non-forest	The land-use category `Non-Forest Land' includes all areas not classified as `Forest Land'. Note that `Non-Forest Land' is not an IPCC land-use category. For the FRL, the land-use category `Non-Forest Land' includes all IPCC land-use categories, i.e., `Grassland', `Cropland', `Wetlands', `Settlements' and `Other Land', except the category `Forest Land'.

8.3 Average annual historical emissions over the Reference Period

Description of method used for calculating the average annual historical emissions over the Reference Period

The method for calculating the average annual historical emissions over the Reference Period applies, in general, the IPCC Good Practice Guidelines generic equation:

$$Emissions = AD \times EF \qquad (8.1)$$

where the *AD* is the activity data and *EF* is the emission factor.

For each source and sink included in the FRL, average annual net emissions are reported. Net emissions are computed as the difference between gross emissions and gross removals for a source/sink. The FRL is computed as a historical average and is estimated by taking the sum of the average annual net emissions over all sources and sinks considered. An overview of the sources and sinks considered in Fiji's FRL is presented in Figure 8-2.

A brief description on the method adopted for each REDD+ activity included in the FRL is provided below. Detailed step by step calculations can be found in Fiji's FRL Methodology Documents and References which are all accessible on Fiji's Forest Information Management System.

The FRL estimates are generated by running a Monte Carlo simulation, where values are sampled at random from the input probability distributions for each variable. The outputs from Equation 1 become the inputs to the Monte Carlo simulation which runs through iterations until it lands on the most likely estimate with a confidence interval. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. The Monte Carlo simulation was run 40,000 times, and the result is a probability distribution of possible outcomes for the FRL. In this way, the Monte Carlo simulation provides a much more comprehensive view of the emissions estimate by estimating what the ERs will be with a confidence interval. As a result of the Monte Carlo simulations the 'final estimates' can be slightly different to the simple AD x EF multiplication presented in Equation 8.1. This should be noted when attempting to replicate the numbers as they could marginally vary from the simple linear multiplication of variables as the confidence interval around each individual variable influences the final result (University of Hamburg, 2018).

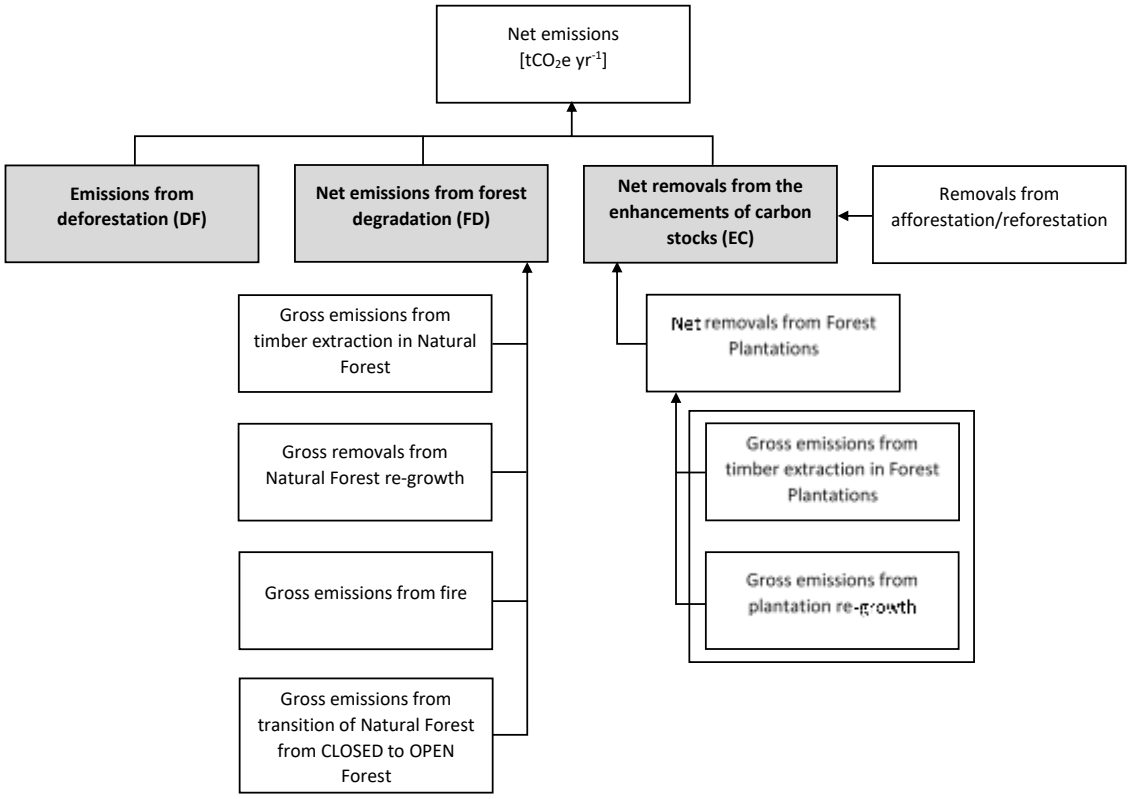


***Figure 8-2: Overview of the sources and sinks considered in Fiji's Forest Reference Level (FRL)*, including the sub-sources and sinks for forest degradation and enhancement of forest carbon stocks**

Fiji's Forest Reference Level (FRL) is estimated as the sum of gross emissions and gross removals generated over the Reference Period.

$$\widehat{\emptyset}_{FRL} = \widehat{\emptyset}_{em} + \widehat{\emptyset}_{re}$$

Where;
$\widehat{\emptyset}_{FRL}$ = Overall average annual net emissions over the Reference Period in the Accounting Area, i.e., the Forest Reference Level (FRL); $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{em}$ = Average annual gross emissions (including all sources); $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{re}$ = Average annual gross removals (including all sinks); $tCO_2e\ yr^{-1}$

The detailed calculations applied to estimate the REDD+ activities during the Reference Period follow.

Deforestation
Activity Data
The area of deforestation over the Reference Period is generated from an annual time series of forest loss. Refer to Activity Data Generation Methodology document for details of how the data is generated.

Emissions Factors
Emissions from deforestation were estimated by multiplying the average annual forest area loss by an emission factor. Emission factors for the source 'deforestation' were estimated from the difference between average C stocks in Lowland and Upland Natural Forest [$tC\ ha^{-1}$] and the average C stocks in grassland [$tC\ ha^{-1}$].

The IPCC default equation was used to compute the C stock change [IPCC;2006, Vol. 4, Chap. 2, Eq. 2.16].

$$\Delta C_{B,i} = \Delta C_G + \Delta C_{CONVERSION,i} + \Delta C_L$$

where;
$\Delta C_{B,i}$ = change in carbon stocks in biomass in Natural Forest stratum I converted to Non-Forest; tC ha^{-1}
ΔC_G = annual increase in carbon stocks in biomass due to growth in Non-Forest; tC ha^{-1} yr^{-1}
ΔC_L = annual decrease in carbon stocks in biomass due to disturbances in Non-Forest; tC ha^{-1} yr^{-1}
And

$$\Delta C_{CONVERSION,i} = C_{AFTER} - C_{BEFORE_i}$$

where;
$\Delta C_{CONVERSION,i}$ = initial change in carbon stocks in biomass in Natural Forest stratum i converted to Non-Forest; tC ha^{-1}
C_{AFTER} = carbon stocks in biomass in Non-Forest; tC ha^{-1}
C_{BEFORE_i}= carbon stocks in biomass in Natural Forest stratum i; tC ha^{-1}

ΔC_G and ΔC_L are assumed to be zero; the change in C stock in biomass due to the conversion of Natural Forest to grassland is captured in $\Delta C_{CONVERSION,i}$, hence $\Delta C_{B,i} = \Delta C_{CONVERSION,i}$.
C_{AFTER} is the peak C stock in grassland as estimated by Rounds [2013] to be 17.11 ± 10.81 tC ha^{-1}.
A description of the data and methods used to estimate C_{BEFORE_i} is provided in University of Hamburg (2018). The carbon stock change due to deforestation was computed by:

$$\Delta C_{B,Lowland} = C_{AFTER} - C_{BEFORE,Lowland}$$

$$-70.74 = 17.11 - 87.85 \quad \text{(Example)}$$

$$\Delta C_{B,Upland} = C_{AFTER} - C_{BEFORE,Upland}$$

$$-54.45 = 17.11 - 71.56 \quad \text{(Example)}$$

Where;
$\Delta C_{B,Lowland}$ = change in C stock in biomass in Lowland Natural Forest due to deforestation; tC ha^{-1}
$\Delta C_{B,Upland}$ = change in C stock in biomass in Upland Natural Forest due to deforestation; tC ha^{-1}
C_{AFTER} = average carbon stock in grasslands in Fiji (Rounds, 2013); tC ha^{-1}
$C_{BEFORE,Lowland}$ = average carbon stock in Lowland Natural Forest in Fiji; tC ha^{-1}
$C_{BEFORE,Upland}$ = average carbon stock in Upland Natural Forest in Fiji; tC ha^{-1}

Carbon losses from deforestation are converted to emission factors by:

$$\Psi_{DF,Lowland} = \Delta C_{B,Lowland} \times n_{cc}$$

$$-259.38 = -70.74 \times (\frac{44}{12}) \quad \text{(Example)}$$

Where;
$\Psi_{DF,Lowland}$ = emission factor for deforestation in Lowland Natural Forest, tCO$_2$e ha^{-1}
$\Delta C_{B,Lowland}$ = change in carbon stock in biomass in Lowland Natural Forest due to deforestation; tC ha^{-1}
n_{cc} = ratio of molecular weights of CO$_2$ and carbon; tCO$_2$e (tC^{-1})

And

$$\Psi_{DF,Upland} = \Delta C_{B,Upland} \times n_{cc}$$

$$-199.65 = -54.45 \times \left(\frac{44}{12}\right) \quad \text{(Example)}$$

Where;
$\Psi_{DF,Upland}$ = emission factor for deforestation in Upland Natural Forest, $tCO_2e\ ha^{-1}$
$\Delta C_{B,Upland}$ = change in carbon stock in biomass Upland Natural Forest due to deforestation; $tC\ ha^{-1}$
n_{cc} = ratio of molecular weights of CO_2 and carbon; $tCO_2e\ (tC^{-1})$

Average annual emissions from deforestation
Average annual emissions from deforestation are first estimated separately by strata using Monte Carlo:
$\widehat{\emptyset}_{DF,Lowland} = \underline{\hat{A}}_{DF,Lowland} \times \Psi_{DF,Lowland}$

$\widehat{\emptyset}_{DF,Lowland} = 7{,}914 \times -259.40$ (Example)‡
Where;
$\widehat{\emptyset}_{DF,Lowland}$ = average annual emissions from deforestation of Lowland Natural Forest; $tCO_2e\ yr^{-1}$
$\underline{\hat{A}}_{DF,Lowland}$ = average annual loss of Lowland Natural Forest area; $ha\ yr^{-1}$
$\Psi_{DF,Lowland}$ = emissions factor for deforestation in Lowland Natural Forest, $tCO_2e\ ha^{-1}$

And

$\widehat{\emptyset}_{DF,Upland} = \underline{\hat{A}}_{DF,Upland} \times \Psi_{DF,Upland}$
$\widehat{\emptyset}_{DF,Upland} = 2{,}112 \times -199.68$ (Example)

Where;
$\widehat{\emptyset}_{DF,Upland}$ = average annual emissions from deforestation of Upland Natural Forest; $tCO_2e\ yr^{-1}$
$\underline{\hat{A}}_{DF,Upland}$ = average annual loss of Upland Natural Forest area; $ha\ yr^{-1}$
$\Psi_{DF,Upland}$ = emissions factor for deforestation in Upland Natural Forest, $tCO_2e\ ha^{-1}$

Then total average annual emissions from deforestation (Low- and Upland Natural Forest) were estimated by:

$$\widehat{\emptyset}_{DF} = \widehat{\emptyset}_{DF,Lowland} + \widehat{\emptyset}_{DF,Upland}$$

Where;
$\widehat{\emptyset}_{DF}$ = average annual emissions from deforestation; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{DF,Upland}$ = average annual emissions from deforestation of Upland Natural Forest; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{DF,Lowland}$ = average annual emissions from deforestation of Lowland Natural Forest; $tCO_2e\ yr^{-1}$

Forest Degradation
Emissions from degradation are estimated as the combination of the net emissions/removals from logging in Natural Forests managed by the Ministry of Forestry, transitions from Closed to Open Forest in Natural Forests and emissions from fire in Pine Plantations.

Felling in Natural Forest
Emissions related to logging practices in natural forest were estimated using the approach proposed by Pearson et al. (2014) which converts volumes extracted during logging operations to total carbon loss including loss from the felled tree itself (AGB and BGB), logging residues of the felled tree, logging damages to the remaining stand (AGB

‡ Note because the emissions are estimated using a Monte Carlo approach the final annual average emissions vary (slightly) from the linear calculation presented by virtue of the iterative process undertaken to estimate the most likely value.

and BGB), and losses due to the establishment of logging infrastructure (e.g., skid trails, logging roads and log landings). Gross emissions from forest degradation were estimated using the IPCC generic equation where the volumes recorded in the Timber Revenue systems served as Activity Data and the Total Emission Factor (TEF) (multiplied by n_{cc}) served as the Emissions Factor.

Average annual gross emissions
Annual carbon loss due to logging in Natural Forest was estimated by:

$$\Delta C_{FD,L,t} = \left[V_{FD,t} \times TEF\right] \times (-1)$$

$$-83{,}454_{FD,L,2006} = \left[79{,}480_{FD,2006} \times 1.05\right] \times (-1) \qquad \text{(Example)}$$

where;
$\Delta C_{FD,L,t}$ = carbon loss in year t due to logging in Natural Forest; tC
$V_{FD,t}$ = wood volume extracted from Natural Forest in year t; m^3
TEF = total emission factor, TEF = 1.05 (Haas, 2015); tC $(m^3)^{-1}$
The multiplication of the brackets by -1 is required because carbon losses are always reported with a negative sign.

Average annual gross emissions from forest degradation were estimated by:

$$\widehat{\emptyset}_{FDem} = \mathrm{T}^{-1}\left[\sum_T \quad \Delta C_{FD,L,t} \times n_{cc}\right]$$
$$-168{,}498 = 11^{-1}\left[-502{,}494 \times \left(\frac{44}{12}\right)\right] \qquad \text{(Example)}$$

where;
$\widehat{\emptyset}_{FDem}$ = average annual gross emissions from forest degradation; $tCO_2e\ yr^{-1}$
T = length of the Reference Period $|T|$ = 11; yrs
$\Delta C_{FD,L,t}$ = carbon loss in year t due to logging in Natural Forest; tC
n_{cc}= ratio of molecular weights of CO_2 and carbon; $tCO_2e\ (tC^{-1})$

Average annual gross removals
Removals are computed based on data of areas logged and mean annual increment (MAI) in logged forests in year t is estimated by:

$$\Delta C_{FD,G,t} = \delta_t \times A_{FD,t} \times MAIC_{FD}$$

$$1{,}739_{FD,G,2006} = (0.5)_{2006} \times 3{,}513_{FD,2006} \times 0.99 \qquad \text{(Example)}$$

where;
$\Delta C_{FD,G,t}$ = carbon gains over the Reference Period on areas logged in year t; tC
δ_t = 2006 – t + 0.5, i.e. the length of time interval available for growth on areas conventionally logged in year t; yrs
$MAIC_{FD}$ = mean annual C increment after logging (above ground and belowground); $tC\ ha^{-1}\ yr^{-1}$
$A_{FD,t}$ = the area logged in Natural Forest in year t; ha

Average annual gross removals on Natural forest areas conventionally logged were estimated by:

$$\widehat{\emptyset}_{FDre} = \mathrm{T}^{-1}\left[\sum_T \quad \delta_t \times MAIC_{FD} \times A_{FD,t} \times n_{cc}\right] \times (-1)$$
$$= \mathrm{T}^{-1}\left[\sum_T \quad \Delta C_{FD,G,t} \times n_{CC}\right] \times (-1)$$

where;
$\widehat{\emptyset}_{FDre}$ = average annual gross removals on Natural Forest areas conventionally logged; $tCO_2e\ yr^{-1}$
T, T, t = length of the Reference Period. i.e. 11 years; yrs

δ_t = 2006 – t + 0.5, i.e. length of time interval available for growth on conventionally logged area in year t; yrs
$MAIC_{FD}$ = mean annual carbon increment after logging (AGC and BGC); tC ha^{-1} yr^{-1}
$A_{FD,t}$ = the area logged in Natural Forest in year t; ha
n_{cc} = ratio of molecular weights of CO_2 and carbon; tCO_2e (tC^{-1})

Transition from Closed to Open Forest Natural Forest
Emissions from the transition of Natural Forest from Closed to Open have been estimated and included as Forest Degradation. The methodology applied relies on a combination of what would be considered Tier 1 (emission factor) and Tier 2 (activity data) methods.

The calculation performed was

$$\widehat{\emptyset}_{FDco} = \mathrm{AD}_{FDco} \times EF_{OC}$$

where
$\widehat{\emptyset}_{FDco}$ = average annual gross emissions from losses from disturbance of Closed to Open Native Forest; tCO_2e yr^{-1}
AD_{FDco} = average area of natural forest transitioned from open to closed forest during the reference period; ha yr^{-1}
EF_{OC}= carbon stock difference between closed and open forest; tCO_2e ha^{-1}

Closed to Open Forest Activity Data
Degradation from Closed to Open forest was defined as "A non-cyclone disturbance in a forest that results in a reduction of canopy cover from 40-100% to 10-40%". The activity data was generated through the combination of the CODED algorithm using the same Landsat archive and reference data set as that used to estimate deforestation. Canopy cover estimates where added by the interpreters and the area converted from Closed to Open forest estimated.

Closed to Open Forest Emission Factor
Development of a National Tier 2 emission factor for canopy cover change was not possible with the available data sets. Instead a model-based approach to estimating biomass density (for example Ståhl et al. 2010) was used based on the GEDI data set. A model was developed that relates field measurements to auxiliary data (in this case remote sensing data) as the basis for statistical estimation. The previous forest inventory was used to calibrate a GEDI-to-biomass model, then biomass was predicted at every GEDI observation in Fiji. Hybrid statistical inference was used to calculate mean biomass density and confidence intervals. The statistical framework for using GEDI and hybrid inference is described in Patterson et al. 2019. The country was divided into Open and Closed forests using the forest type classification. Then the difference between the two classes is considered the emission factor. This process led to the development of an emissions factor of 121 tCO_2e +/-22 tCO_2e resulting from the transition from Closed to Open Forest.

Fire in Softwood Plantations
Data from Fiji Pine Limited (FPL) were used to estimate emissions from fire in Softwood Plantations. The dataset provided by FPL lists plantation compartments (coupes) that burned between 2015 and 2018. For each compartment the following attributes were provided: the year of burning (year), the area burnt in hectares (ha), and the age in years (yrs) of each compartment, i.e., the time elapsed since planting. Where compartments listed in the FPL dataset had an area of zero, these compartments were dropped from the dataset.
The greenhouse gases (GHGs) included in the estimation of emissions are: carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). To estimate GHG emissions, the biomass available for combustion in a compartment was estimated first. It is assumed that the entire above-ground biomass (AGB) is available for combustion. AGB in a compartment that burnt in year tb, with Tb = {2015;…..; tb;….; 2018}, was predicted as follows (note that this is the amount of AGB that is available for combustion — it is not to be confused with the AGB that actually burns during a fire).

$$AGB_{l,t_b} = \Lambda_{l,t_b} \times \frac{MAIB_{SW}}{(1 + R_{dll})}$$

where;
Λ_{l,t_b}= the age of a compartment that burnt in year tb, L = {1; 2;…..;l; ….; L}
L = the total number of compartments \
$MAIB_{SW}$= the mean annual total biomass (above-and below-ground biomass) increment [tB ha^{-1} yr^{-1}]
R_{dll} = root-to-shoot ratio in tropical moist deciduous forest < 125 tAGB ha^{-1}.

If AGB burns some amount of below-ground biomass (BGB) is also lost, e.g., if the stem and crown of a tree is lost, the BGB of the tree is, in the majority of cases, also lost.
It is assumed that only CO2 is released from the BGB (since it does not burn, or at least only a small fraction of it burns). The amount of BGB available for combustion was predicted as follows:

$$BGB_{l,t_b} = \Lambda_{l,t} \times MAIB_{SW} \times R_{dll}.$$

CO2 emissions from AGB in compartment that burnt in year tb was estimated as follows (cf. IPCC [2006, Vol. 4, Chap. 2, Eq. 2.27])

$$EACO2_{l,t_b} = A_{l,t_b} \times AGB_{l,t} \times C_f \times G_{ef,CO_2}$$

where;
A_{l,t_b}= the area burnt [ha] in compartment l at time tb,
C_f = the combustion factor, i.e., the proportion of prefire biomass consumed (the value was taken from IPCC 2006, Vol. 4, Chap. 2, Tab. 2.6, young secondary tropical forest (3-5) year])
G_{ef,CO_2}= the emission factor [g kg^{-1}] taken from IPCC [2006, Vol. 4, Chap. 2, Tab. 2.5, Tropical forest].

Carbon dioxide (CO_2) emissions from BGB were estimated by:

$$EBCO2_{l,t_b} = A_{l,t_b} \times BGB_{l,t_b} \times C_f \times \eta_{CF} \times [\eta_{CC} \times -1]$$

Where;
n_{CF}= 0:47 and n_{CC}= 44/12 are the conversion factors of biomass to carbon and carbon to carbon dioxide equivalents, respectively.

Methane (CH4) emissions were estimated as follows:

$$ECH4_{l,t_b} = A_{l,t_b} \times AGB_{l,t_b} \times C_f \times G_{ef,CH_4} \times GWP_{CH_4} \quad (24)$$

where:
G_{ef,CH_4}= the emission factor for CH_4
GWP_{CH_4} = the global warming potential of CH_4 , taken from IPCC [2014, Box 3.2, Tab. 1].

Nitrous oxide (N_2O) emissions in compartment l that burnt in year tb were estimated by

$$EN2O_{l,t_b} = A_{l,t_b} \times AGB_{l,t_b} \times C_f \times G_{ef,N_2O} \times GWP_{N_2O}.$$

where:
G_{ef,N_2O}= the emission factor for N_2O

GWP_{N_2O} = the global warming potential of N_2O , taken from IPCC [2014, Box 3.2, Tab. 1].

Total GHG emissions from compartment l were computed by:

$$E_{l,t_b} = EACO2_{l,t_b} + EBCO2_{l,t_b} + ECH4_{l,t_b} + EN2O_{l,t_b}$$

The sum of GHG emissions from individual compartments was computed for each year:

$$E_{t_b} = \sum_{L} E_{l,t_b}$$

The average of Etb was used as an estimate of the average annual GHG emissions from biomass burning in Softwood Plantations [$tCO_2e\ yr^{-1}$] over the Reference Period.

$$\hat{\theta}_{BSW} = \frac{\sum_{T_b} E_{t_b}}{|T_b|} = \frac{\sum_{T_b} E_{t_b}}{4}$$

Average annual net emissions from forest degradation
Average annual net emissions from forest degradation were estimated by:

$$\widehat{\emptyset}_{FD} = \widehat{\emptyset}_{FDem} + \widehat{\emptyset}_{BSW} + \widehat{\emptyset}_{FDre}$$

where
$\widehat{\emptyset}_{FD}$ = average annual net emissions from forest degradation; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{FDem}$ = average annual gross emissions from forest degradation; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{BSW}$ = average annual gross emissions from fire in softwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{FDre}$= average annual gross removals from forest degradation; $tCO_2e\ yr^{-1}$

Note: Gross removals are added to gross removals because gross removals always have a negative sign.

Enhancement of Forest Carbon Stocks
The sink "enhancement of forest carbon stocks" includes removals from afforestation/reforestation (AR), as well as gross emissions and removals from forest plantation management.

Afforestation/Reforestation
Afforestation/Reforestation is defined as the conversion of land in the land-use sub-category Non-Forest to land in the sub-category Natural Forest (Low- or Upland) and Plantations (Softwood and Hardwood).
Afforestation/reforestation if the crown-cover percent on a patch of land (min. 0.5 ha) reaches or exceeds the threshold value of 10%. Afforestation/reforestation cannot occur within lands defined as plantations as this land is classified as Forest Land regardless of canopy cover as it primarily land use is forest. It is assumed that afforestation/reforestation always has anthropogenic causes in Fiji.
Initial carbon stocks on land afforested/reforested is considered to be zero. Carbon gains on afforestation/reforestation land were estimated by taking the average forest area gain in each sub-period and multiply the average by the mean annual carbon increment for the forest strata.
Afterwards annual carbon gains were available for each year (t). These carbon gains for each year are subsequently multiplied by the time elapsed since conversion to estimate carbon gains over the FRL Reference Period for each year. Finally, the average annual carbon gain over the Reference Period was estimated by taking the average of the carbon gains of each year over the Reference Period.

Average annual gross removals

To compute the average annual removals from forestation, the removals over the Reference Period for each time interval were computed first. The area of reforestation over the Reference Period is generated from an annual time series of forest gain (see Annex 8.2 for detail on how this data is generated).

For the first time interval 2005-2006 it was assumed that half of the area was afforested (or reforested) during the first half of 2006.

$$A_{AR,2006} = \frac{1}{2} A_{AR,2005-2006}$$

where
AAR;2005-2006 is the total area that was afforested/reforested during the interval 2005-2006 (including Low-and Upland Natural Forest), i.e., from mid 2005 to mid 2006. It is assumed that this area is not deforested during the FRL Reference Period.

The area AAR;2006 is assumed to grow for 10.5 years. That is, from the mid of the first half of 2006 until the end of the Reference Period. For example for the interval 2005-2006 (i.e., mid 2005 to mid 2006) there is a forest area gain of 4,841 ha. Only half of this is considered (i.e., 4,841/2 = 2,420 ha), since it is assumed that half of the area was afforested/reforested in the second half of the year 2005 (which is not covered by the FRL Reference Period). Hence, there are 2,420 ha of forest area gain in the 'first half of 2006'. It is assumed that the 2,420 ha were afforested/reforested in the mid of the first half of 2006 (i.e.,April 1, 2006). If these 2,420 ha grow from April 1, 2006 to December 31, 2016, they grow for 10.5 years.

The total carbon gains on AAR;2006 over the Reference Period were calculated as follows:

$$\Delta C_{AR,2006} = A_{AR,2006} \times 10.75 \times MAIC_{AR}$$

Carbon gains for the last time interval 2016-2017 were estimated in a similar way.

$$A_{AR,2016} = \frac{1}{2} A_{AR,2016-2017}$$

However, AAR,2016 does not grow for 10.75 years but for 0.25 years (mid of the second half of 2016 until the end of the FRL Reference Period, i.e., from October 1, 2016 on).

$$\Delta C_{AR,2016} = A_{AR,2006} \times \frac{1}{4} MAIC_{AR}$$

Carbon gains for year t_1 generated over the rest of the FRL Reference Period were estimated by

$$\Delta C_{AR,tm} = \delta_{t_m} \times A_{AR,t_m} \times MAIC_{AR}$$

where;
$\Delta C_{AR,t_1}$= carbon gains for the year t_1 generated over the Reference Period; tC
δ_{t_1}= {10,9,…. δtm,…,1}, yrs
$MAIC_{AR}$= mean annual carbon increment for afforestation/reforestation (above ground and belowground); tC ha^{-1} yr^{-1}
A_{AR,t_m} = forest area gain in each interval tb, ha

Total carbon gains over the Reference Period were calculated using:

$$\Delta C_{AR} = \Delta C_{AR,2006} + \left[\sum_{T_m} \Delta C_{AR,t_m}\right] + \Delta C_{AR,2016}$$

Average annual net removals from Afforestation/Reforestation
Total carbon gains were converted to tCO_2e and annualized:

$$\hat{\theta}_{ECAR} = T^{-1}\left[\Delta C_{AR} \times \eta_{CC}\right]$$

Where;
$\widehat{\emptyset}_{ECAR}$= average annual removals from afforestation/reforestation; $tCO_2e\ yr^{-1}$
ΔC_{AR} = average annual carbon gains from afforestation / reforestation over the Reference Period; $tC\ yr^{-1}$
η_{CC} = conversion factor C to CO_2; $tCO_2\ (tC)^{-1}$

Forest Plantation Management
Fiji's forest definition lists two types of Forest Plantations, namely Hardwood Plantations and Softwood (or Pine) Plantations. By definition, deforestation and afforestation/reforestation are not possible within Forest Plantations. Forest Plantations remain in the land-use category Forest Land even if the crown-cover is completely removed following harvest, e.g., temporarily unstocked.
For the FRL it was assumed that field data, i.e., records on the current stocking, volumes and areas harvested and areas planted available at FPL and FHCL, would provide more reliable estimates of emissions and removals from Forest Plantations. As spatial data on the extent of Hard- and Softwood Plantations was available, the methods used may still be considered to follow IPCC Approach 3.
To estimate gross emissions from Forest Plantations, records on the timber volumes extracted in the years 2006 to 2016 provided by the plantation management companies were used. Timber volumes extracted were converted to total tree biomass, to total carbon and finally to CO2 emissions. The conversion from logging to emissions was calculated differently for Hardwood and Softwood Plantations as described below.
Removals from Forest Plantations were estimated based on the mean annual increment (MAI) reported for Hard- and Softwood Plantations. Removals originate from areas that were planted during the FRL Reference Period and plantations that were planted before the start year 2006 and were not harvested until the end of the Reference Period.

Softwood Plantations
Average annual gross emissions from softwood plantations
Emissions from logging in softwood plantations were estimated from data on extracted volumes provided by Fiji Pine Limited (FPL) for the years of the Reference Period.

$$AGB_{SW,L,t} = V_{SW,L,t} \times \frac{1}{\lambda_{Pine}} \times \rho_{Pine}$$

where;
$AGB_{SW,L,t}$= aboveground biomass loss in year t in softwood plantations; tAGB
$V_{SW,L,t}$ = wood volumes harvested in softwood plantations in year t; m^3
λ_{Pine} = recovery rate in softwood plantations; dimensionless
ρ_{Pine} = wood density of pine wood harvested in softwood plantations (dry weight over fresh volume); $g\ cm^{-3}$

Total biomass loss was estimated by:

$$TB_{SW,L,t} = AGB_{SW,L,t} \times (1 + R_{dlh})$$

where;
$T_{SW,L,t}$ = total biomass loss in year t in Softwood Plantations; tB

$AGB_{SW,L,t}$ = aboveground biomass loss in softwood plantations; tB
R_{dlh} = root-to-shoot ratio for tropical moist deciduous forest >125 tB ha^{-1}, taken from IPCC, 2006, Vol.4, Chap. 4, Tab. 4.4; dimensionless

Carbon loss due to harvest in softwood plantations was estimated by:

$$\Delta C_{SW,L,t} = \left[TB_{SW,L,t} \times \eta_{CF}\right] \times (-1)$$

where;
$\Delta C_{SW,L,t}$ = carbon loss in softwood plantations in year t due to logging; tC
$TB_{SW,L,t}$ = total biomass loss in year t in softwood plantation; tB
n_{CF} = conversion factor for dry matter to C; tC (tB)$^{-1}$

Average annual gross emissions from softwood plantations were estimated by:

$$\widehat{\emptyset}_{ECS_{em}} = \mathrm{T}^{-1}\left[\sum_T \quad \Delta C_{SW,L,t} \times \eta_{CC}\right]$$

where;
$\widehat{\emptyset}_{ECS_{em}}$ = average annual gross emissions from softwood plantations; tCO$_2$e yr^{-1}
T = length of the FRL Reference Period, i.e. 11 years; yrs
$\Delta C_{SW,L,t}$ = carbon loss in softwood plantations in year t due to logging; tC
η_{CC} = conversion factor C to CO$_2$e; (tCO$_2$ (C)$^{-1}$)

Average annual gross removals from softwood plantations
Average annual gross removals from softwood plantations were estimated based on the mean annual increment of above and belowground biomass, $MAIB_{SW}$(taken from Waterloo [1994]), areas planted during the Reference Period and growth on areas that were planted before 2006 and were either harvested or not harvested before the end of the Reference Period.
Spatial data on annual opened stocked area, area planted and area harvested per year were provided by Fiji Pine Limited. To estimate C accumulation on areas planted during the Reference Period and areas that have been planted before 2006 (and were not harvested until the end of the Reference Period), the MAIBSW was converted to C increment by:

$$MAIC_{SW} = \left[MAIB_{SW} \times \eta_{CF}\right]$$

where;
$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha^{-1} yr^{-1}
$MAIB_{SW}$ = mean annual biomass increment (AGB + BGB) in Softwood Plantations; tB ha^{-1} yr^{-1}
η_{CF} = conversion factor biomass to C; dimensionless

Using the same methods as for Hardwood Plantations, C gains on areas planted and areas growing during the Reference Period were estimated for each year (over the Reference Period) by:

$$\Delta C_{SW,G,t} = \delta_t \times A_{SE,t} \times MAIC_{SW}$$

where;
$\Delta C_{SW,G,t}$ = carbon gains for year t in Softwood Plantations over the Reference Period; tC
δ_t = 2016−t + 0.5; yrs
$A_{SE,t}$ = Opening stocked area, plus planted area minus harvested area in Softwood Plantations in year t; ha
$MAIC_{SW}$ = mean annual C increment in Softwood Plantations; tC ha^{-1} yr^{-1}

Total average annual C gain in softwood plantations was computed by:

$$\Delta C_{SW,G} = \left[\mathrm{T}^{-1} \sum_{T} \quad \Delta C_{SW,G,t}\right]$$

where;
$\Delta C_{SW,G}$ = carbon gains for year t in Softwood Plantations over the Reference Period; tC
T = length of the FRL Reference Period, i.e. 11 years; yrs
$\Delta C_{SW,G,t}$ = carbon gains for year t in Softwood Plantations over the Reference Period; tC

Estimated total average annual carbon gains in softwood plantations were converted to average annual removals by:

$$\widehat{\emptyset}_{ECS_{re}} = \Delta C_{SW,G} \times \eta_{CC}$$

where;
$\widehat{\emptyset}_{ECS_{re}}$ = average annual gross removals from softwood plantations; $tCO_2e\ yr^{-1}$
$\Delta C_{SW,G}$ = carbon gains for year t in Softwood Plantations over the Reference Period; tC
η_{CC} = carbon to carbon dioxide equivalents conversion factor; $(tCO_2\ (C)^{-1})$

<u>Average annual net emissions from Softwood plantations</u>
Average annual net emissions from softwood plantations were estimated by:

$$\widehat{\emptyset}_{ECS} \ = \ \widehat{\emptyset}_{ECS_{em}} + \widehat{\emptyset}_{ECS_{re}}$$

where;
$\widehat{\emptyset}_{ECS}$ = average annual net emission from softwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECS_{em}}$ = average annual gross emissions from softwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECS_{re}}$ = average annual gross removals from softwood plantations; $tCO_2e\ yr^{-1}$

Average annual removals are added to the average annual emissions because removals have a negative sign.

Hardwood Plantations
Gross emissions from hardwood plantations utilise annual logged volume data reported by Fiji Hardwood Corporation Limited (FHCL).

$$AGB_{HW,L,t} = V_{HW,L,t} \times BCEF_{HW,R}$$

where;
$AGB_{HW,L,t}$= aboveground biomass removed in hardwood plantations in year t; tAGB
$V_{HW,L,t}$ = volume of hardwood extracted in year t; m^3
$BCEF_{HW,R}$ = biomass conversion and expansion factor for logging; tAGB m^{-3}

Aboveground biomass is converted to total biomass (above- and belowground biomass) by:

$$TB_{HW,L,t} = \left(AGB_{HW,L,t} \times (1 + R_{wl})\right)$$

where;
$TB_{HW,L,t}$ = total biomass loss due to harvesting in hardwood plantations in year t; tB
$AGB_{HW,L,t}$ = aboveground biomass removed in softwood plantations in the year of harvest; tAGB yr^{-1}
R_{wl} = root-to-shoot ratio for tropical rainforests; dimensionless

Extracted total biomass was converted to carbon loss by:

$$\Delta C_{HW,L,t} = \left[TB_{HW,L,t} \times \eta_{CF}\right] \times (-1)$$

where;
$\Delta C_{HW,L,t}$ = carbon loss in hardwood plantations in year t due to logging; tC
$TB_{SW,L,t}$ = total biomass loss in year t in hardwood plantation; tB
n_{CF} = conversion factor for dry matter to C; tC (tB)$^{-1}$

Average annual gross emissions from hardwood plantations were estimated by:

$$\widehat{\emptyset}_{ECH_{em}} = \mathrm{T}^{-1}\left[\sum_T \quad \Delta C_{HW,L,t} \times \eta_{CC}\right]$$

where;
$\widehat{\emptyset}_{ECS_{em}}$ = average annual gross emissions from hardwood plantations; tCO_2e yr^{-1}
T = length of the FRL Reference Period, i.e. 11 years; yrs
$\Delta C_{SW,L,t}$ = carbon loss in hardwood plantations in year t due to logging; tC
η_{CC} = conversion factor C to CO_2e; (tCO_2 (C)$^{-1}$)

Average annual gross removals from hardwood plantations
Removals within hardwood plantations were estimated based on mean annual volume increments on areas planted during the reference period (i.e. between 2006 and 2016) and growth on areas that were planted before 2006 and were either harvested or not harvested before the end of the Reference Period.

$$MAIAGB_{HW} = \underline{MAIV}_{HW} \times BCEF_{HW,I}$$
$$6.44 = 5.85 \times 1.1 \qquad \text{(Example)}$$

where;
$MAIAGB_{HW}$ = mean annual AGB increment in Hardwood Plantations; tB ha^{-1} yr^{-1}
$\underline{MAIV}_{HW}$ = average mean annual increment in Hardwood Plantations; m^3 ha^{-1} yr^{-1}
$BCEF_{HW,I}$ = biomass conversion and expansion factor for increment taken from IPCC, 2006, Vol. 4, Chap. 4. Tab. 4.5; $BCEF_I$for humid tropical natural forest; growing stock level 21-40 m^3 ha^{-1}; tB (m^3)$^{-1}$

Total carbon increment, including both aboveground and belowground, was estimated by:

$$MAIC_{HW} = [MAIAGB_{HW} \times (1 + R_{wl})] \times \eta_{CF}$$

where;
$MAIC_{HW}$ = mean annual carbon increment in Hardwood Plantations; tB ha^{-1} yr^{-1}
$MAIAGB_{HW}$ = mean annual biomass increment; tB ha^{-1} yr^{-1}

Carbon gains over the Reference Period on areas that were planted between 2006 and 2016 in FHCL's lease area were estimated for each year by:

$$\Delta C_{HW,G,t} = \delta_t \times A_{HW,PL,t} \times MAIC_{HW}$$

where;
$\Delta C_{HW,G,t}$ = carbon gains for year t in hardwood plantations over the Reference Period; tC
δ_t = 2016 – t + 0.5; yrs
$A_{HW,PL,t}$ = area planted in hardwood plantations in year t; ha
$MAIC_{HW}$ = mean annual carbon increment in hardwood plantations; tC ha^{-1} yr^{-1}

For the year 2011, FHCL reported a stocking area of AHW,S,2011 = 56,652 ha. The stocking area is the area of the plantation lease area that was stocked with trees. No data were provided for a date prior to 2011. The area stocked at the end of 2005 was calculated by:

$$A_{HW,S,2005} = A_{HW,S,2011} + \sum_{t=2006}^{2010} A_{HW,LG,t} - \sum_{t=2006}^{2010} A_{HW,PL,t}$$

where;
$A_{HW,S,2005}$= stocking area in Hardwood Plantations in 2005; ha
$A_{HW,S,2011}$ = stocking area in Hardwood Plantations in 2011; ha
$A_{HW,LG,t}$ = area logged in Hardwood Plantations in year t; ha
$A_{HW,PL,t}$ = area planted in Hardwood Plantations in year t; ha

The total of the areas harvested between 2006 and 2016 was subtracted from the stocking area of 2005, $A_{HW,S,2005}$ to obtain the area that accumulated C during the Reference Period, i.e., the area that was neither planted nor harvested during the Reference Period,

$$A_{HW,GR} = A_{HW,S,2005} - \sum_{T} A_{HW,PL,t}$$

where;
$A_{HW,GR}$= stocking area in Hardwood Plantations that was planted before 2006 and was not harvested until the end of the Reference Period; ha
$A_{HW,S,2005}$ = stocking area in Hardwood Plantations in 2005; ha
$A_{HW,LG,t}$ = area logged in Hardwood Plantations in year t; ha

The average annual C gain on hardwood plantation was estimated by:

$$\Delta C_{HW,GR} = A_{HW,GR} \times MAIC_{HW}$$

where;
$\Delta C_{HW,GR}$ = average annual carbon gain on areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr^{-1}
$A_{HW,GR}$= stocking area in hardwood plantations that was planted before 2006 and not harvested during the Reference Period; ha
$MAIC_{HW}$ = mean annual C increment in hardwood plantations; tC ha^{-1} yr^{-1}

Carbon also accumulated on plantation compartments that were harvested during the FRL Reference Period. For example, a plantation compartment that was harvested in 2010 accumulated C in 2006, 2007, 2008, 2009 and half of 2010. When the compartment is harvested in 2010 all carbon stored in the compartment is emitted to the atmosphere. This includes the C that was sequestered during the years 2006 to mid of 2010. However, since the C was sequestered during the Reference Period, these removals have to be accounted for. Average annual removals on compartments that were harvested during the Reference Period were estimated as follows:

$$\Delta C_{HW,GRH} = \mathrm{T}^{-1}\left[\sum_{T} \delta_t \times A_{HW,LG,t} \times MAIC_{HW}\right]$$

where;
$\Delta C_{HW,GRH}$ = average annual C gain on areas that were planted before 2006 and harvested during the Reference Period; tC yr^{-1}
δ_t = the time a compartment logged in year t grew during the Reference Period, δ' t = t−2016 + 10.5, i.e., the reversal of δt; yrs
$A_{HW,LG,t}$ = area logged in Hardwood Plantations in year t; ha
$MAIC_{HW}$ = mean annual C increment in Hardwood Plantations; tC ha^{-1} yr^{-1}
T = duration of the Reference Period (i.e. 11 years); yrs

Total average annual C gain, including gains on areas planted during the Reference Period, areas harvested during the Reference Period and areas that were planted before 2006 and were not harvested until the end of the Reference Period, was computed by:

$$\Delta C_{HW,G} = \left[\mathrm{T}^{-1} \sum_{T} \quad \Delta C_{HW,G,t}\right] + \Delta C_{HW,GRH} + \Delta C_{HW,GR}$$

where;
$\Delta C_{HW,G}$ = total average annual C gains including gains from areas that were planted in Hardwood Plantations during the Reference Period, areas that were harvested during the Reference Period, and areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr^{-1}
$\Delta C_{HW,G,t}$ = carbon gains for year t in Hardwood Plantations over the Reference Period; tC
$\Delta C_{HW,GRH}$ = average annual C gain on areas that were planted before 2006 and harvested during the Reference Period; tC yr^{-1}
$\Delta C_{HW,GR}$ = average annual C gain on areas that were planted before 2006 and were not harvested until the end of the Reference Period; tC yr^{-1}

Estimated total average annual carbon gains in hardwood plantations were converted to average annual removals by:

$$\widehat{\emptyset}_{ECHre} = \Delta C_{HW.G} \times \eta_{CC}$$

where;
$\widehat{\emptyset}_{ECHre}$ = average annual gross removals from hardwood plantations; $tCO_2e\ yr^{-1}$
$\Delta C_{HW.G}$ = total average annual carbon gains including gains from areas that were planted before 2006 and were not harvested until the end of the Reference Period and areas that were planted in hardwood plantations during the Reference Period; tC yr^{-1}
η_{CC} = conversion factor C to CO_2e; $(tCO_2\ (C)^{-1})$

<u>Average annual net emissions from hardwood plantations</u>
Average annual net emissions from hardwood plantations were estimated by:

$$\widehat{\emptyset}_{ECH} = \widehat{\emptyset}_{ECH_{em}} + \widehat{\emptyset}_{ECH_{re}}$$

where;
$\widehat{\emptyset}_{ECH}$ = average annual net emission from hardwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECH_{em}}$ = average annual gross emissions from hardwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECH_{re}}$ = average annual gross removals from hardwood plantations; $tCO_2e\ yr^{-1}$

Average annual removals are added to the average annual emissions because removals have a negative sign.

<u>Average annual net emissions from plantations</u>
Average annual gross emission from forest plantations were estimated by:

$$\widehat{\emptyset}_{ECHS_{em}} = \widehat{\emptyset}_{ECH_{em}} + \widehat{\emptyset}_{ECS_{em}}$$

where;
$\widehat{\emptyset}_{ECHS_{em}}$ = average annual gross emissions from forest plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECH_{em}}$ = average annual gross emissions from hardwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECS_{em}}$ = average annual gross emissions from softwood plantations; $tCO_2e\ yr^{-1}$

Average annual gross removals from forest plantations were estimated by:

$$\widehat{\emptyset}_{ECHS_{re}} = \widehat{\emptyset}_{ECH_{re}} + \widehat{\emptyset}_{ECS_{re}}$$

where;
$\widehat{\emptyset}_{ECHS_{re}}$ = average annual gross removals from forest plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECH_{em}}$ = average annual gross removals from hardwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECS_{em}}$ = average annual gross removals from softwood plantations; $tCO_2e\ yr^{-1}$

Average annual net emissions from forest plantations were estimated by:

$$\widehat{\emptyset}_{ECHS} = \widehat{\emptyset}_{ECH} + \widehat{\emptyset}_{ECS}$$

where;
$\widehat{\emptyset}_{ECHS}$ = average annual net emissions from forest plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECH}$ = average annual net emissions from hardwood plantations; $tCO_2e\ yr^{-1}$
$\widehat{\emptyset}_{ECS}$ = average annual net emissions from softwood plantations; $tCO_2e\ yr^{-1}$

Activity data and emission factors used for calculating the average annual historical emissions over the Reference Period

Activity data
Fiji's MOF, supported by CSIRO's Remote Sensing Image Integration Group, adopted a multi-temporal wall-to-wall semi-automated approach to generate IPCC Approach 3 activity data covering the islands of Viti Levu, Vanua Levu and Taveuni for a period of at least 10 years between 2006 - 2016[§].

The technique adopted is consistent with that used by the CSIRO team in Australia, Indonesia and Kenya. Fiji selected this technique because of its operational status, demonstration of successful application in large mountainous areas where cloud cover is frequent (e.g. Indonesia) and the availability of expertise to support training and operational processing to enable the local Fijian team to replicate the process themselves for future MRV cycles.

Some features of the technique used are:

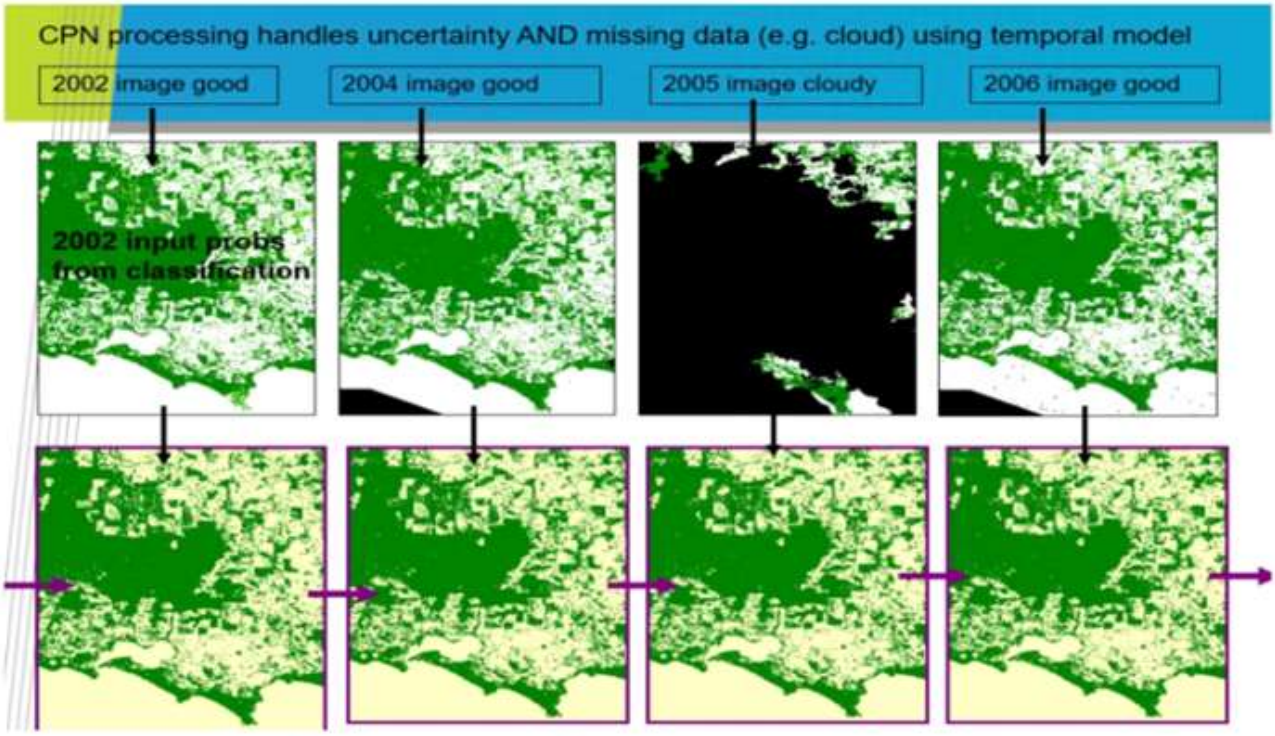
- Assembly of multi-year data series (e.g. annual time series)
- Classification of each image date using supervised classification methods
- Multi-temporal processing of the full time series of classifications in a joint temporal model; this has the effect of inferring classification for areas of missing data. The result, given appropriate inputs to the model, is to improve the accuracy and particularly to reduce error on mapped change.
- Accuracy assessment and resulting area adjustment to produce unbiased estimates of the LULC changes, and some measure of uncertainty associated with each of the estimates.

The technique overcame the major limitation identified with Fiji's previously used activity data set which relied on mapping change (i.e. deforestation, reforestation) from two or more dates of imagery using a 'hard' classification scheme (i.e. manual). When differencing 'hard classifications" 'errors add up'; that is, errors of omission or commission at any date are likely to introduce false areas of change. Since areas of change are usually a small proportion of the forest area, the result is (typically) large error rates on derived change products. This was the main reason Fiji opted to make the change to semi-automated processing. The semi-automated processing was also preferred as it can provide a more consistent interpretation of images through time when compared to manual digitization.

[§] Analysis was extended to 1 year prior (i.e. 2015) and 1 year post the reference period.

The process applied to generate the new activity data set results in processing the full times series jointly; errors are resolved progressively using quality assurance (QA) checks using inferences from the sequence of classification probabilities. As a simple example, an agricultural land pixel may appear spectrally similar to forest at one date because of its particular crop at that time and be classified (with a high probability but incorrectly) as forest on that date. If it is (correctly) classified as non-forest in the surrounding years, it is inferred from knowledge of landcover transitions that the forest label is incorrect.

The joint time series processing uses mathematical models to resolve time series forest probabilities in this way. Figure 9 illustrates the process. For a formal description see Caccetta et al (2012). For ongoing monitoring using Landsat, the approach can be immediately applied to produce updates.



Example of input and output to multi-temporal forest classification. The top row shows the individual year classifications from 4 time periods (Forest in dark green; light green colours in top row indicate uncertainty in forest classifications). The 2005 map has large areas of missing data due to cloud. The bottom row shows the output forest maps after multi-temporal processing. Source: CSIRO.

Figure 9: Process for Activity Data Remote Sensing

The Figure below shows a high-level flow chart of the steps in the approach. QA checks are conducted at all stages to ensure data and results are as accurate as possible. Failure of QA triggers a repeat of the processing step. The final stage 'attribution' is conducted in GIS to attach labels or to remove particular errors which cannot be resolved by spectral signatures.

Attribution is conducted to address potential errors from misclassification of land use, for example classifying forest loss as deforestation rather than temporary loss from harvest or loss due to natural disturbance. GIS layers and local knowledge were used to attribute change. For example, change data sets for deforestation and reforestation in Natural Forest areas were generated by masking out areas of mangroves, softwood and hardwood plantations, and areas subject to harvest in Natural Forest to ensure that there is no double counting of emissions within these areas

which adopt proxy methods to generate emissions reduction from Forest Degradation or Enhancement of Carbon Stock activities.

The remaining area was then stratified into Upland and Lowland Forest Classes using the digital elevation model to distinguish change above (Upland) and below (Lowland) 600m a.s.l. to align with available emission factors in Fiji.

The archived data for attribution consists of a set of GIS vectors and rules applied to these vectors. This set of data is a 'library' which can be improved over time and applied to new images or products as appropriate.

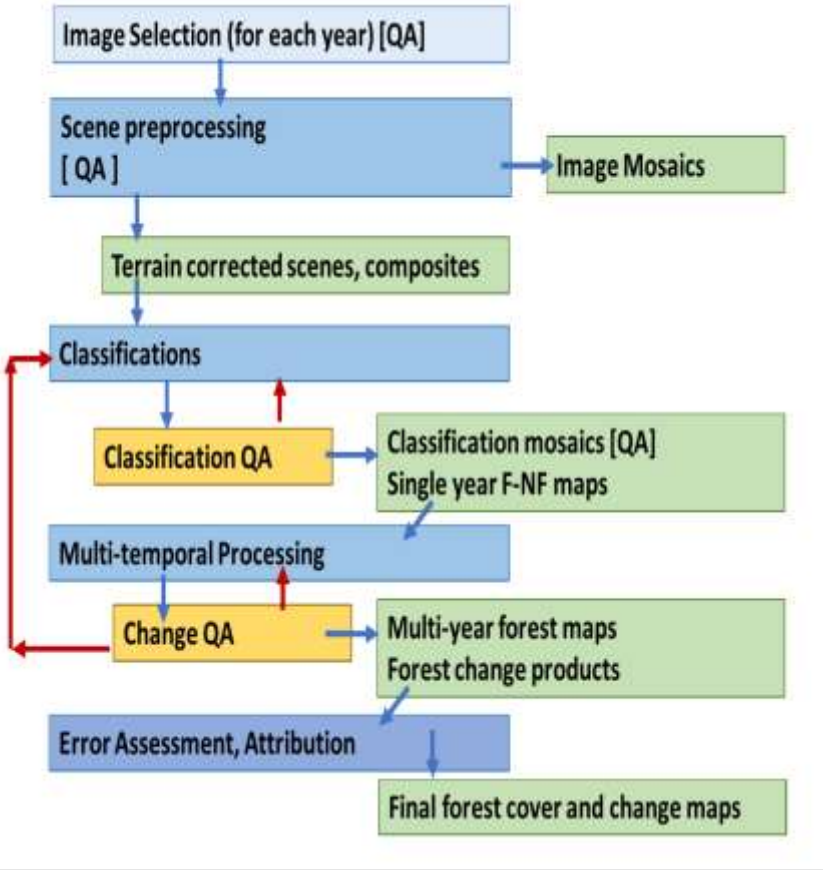


Figure 10: Schematic diagram of the multi-temporal classification workflow.
***Note: Outputs** are shown in green boxes. The **red arrows** indicate iterative refinement processes following assessment of map and change products.*

Attribution is relevant for multiple reasons. The first is to label extent and change data within specified areas differently for accounting purposes. Vector boundaries and rules need to be defined and recorded. Another reason for attribution is persistent error in classification due to spectral overlap and ground cover or bad data. The bad data are mostly caused by 'errors' in the terrain correction; (1) due to steep terrain (peaks, ridgetops) where slight mis-registration causes small bright and dark faults; and (2) areas where the SRTM DEM was missing or missing and replaced with coarse 90m data. These areas are small and in the same locations each year – the recommended approach is to build a GIS library of such areas and re-label to the known cover (e.g. in central Taveuni, these ridge effects are forest). Spectral overlap causing false change can occur in special lands – e.g. grassy wetlands where water and vegetation changes give false forest and change signals.

On completion of the classification of the remote sensing images, an accuracy assessment was conducted following methods outlined in Olosson et al. (2014). This process relied on the comparison of predictions from the image

classification and observations from a sample of reference data to assess errors of omission and commission in the predicted data set. The accuracy assessment process was fully independent of the generation of the LULC change maps being verified.

Activity Data for Forest Degradation

Measurement and reporting of activities related to Forest Degradation included both proxy (relating to commercial harvest in Natural Forest) and sample based approaches (relating to transition of Natural Forest from Closed to Open forest in non-commercial harvested areas) Degradation from Closed to Open forest was defined as "A non-cyclone disturbance in a forest that results in a reduction of canopy cover from 40-100% to 10-40%". The activity data was generated through the combination of the CODED algorithm using the same Landsat archive and reference data set as that used to estimate deforestation. Canopy cover estimates where added by the interpreters and the area converted from Closed to Open forest estimated.

Use of proxy methods for activity data in Forest Degradation

Activity data for the estimation of emissions and removals from harvested areas are from commercial logging statistics; both in natural forests and plantations. Information related to timber extraction from native forest concessions is collected by the MOF, this includes area harvested and volumes extracted. Plantation management companies Fiji Pine Limited and Fiji Hardwood Corporation also submit areas harvested, volume extracted, and areas replanted, to the Ministry in accordance with standard operating procedures. The Ministry also has field crew who regularly conduct training in the data collection methods and QA/QC checks on the submitted data.

Harvest volumes are self-reported by Fiji Pine and Fiji Hardwood Limited and natural forest logging contractors to the MOF. The volume data provided is a census of actual timber volume extracted, therefore there is no sampling error. The systematic measurement error of logs (i.e. diameters, lengths and number of logs) is likely to be small as standard operating procedures are used for these measurements. There may be random errors related to unreported logs, however QA/QC checks by MOF staff are in place and therefore the incidence of unreported logs is considered minimal.

Digital maps of harvested areas from the logging plans provided by the loggers within natural and planation forests were used to determine the area logged and the area of re-growth/replanting after logging. This approach has some inherent limitations as it does not account for failures in establishment of plantations and can therefore lead to an over estimation of carbon stock regrowth following replanting or natural regeneration in natural forest areas after harvest.

A QA/QC check of the harvested and replanted areas conducted by the MOF found that the self-reported data on area harvested and area replanted was not accurate and some corrections were made based on random sampling (both in the field and from google earth data) of a proportion of logged and replanted areas. Additionally, checks of the data against the improved dense time series of change data indicate some remaining inconsistencies/uncertainty. This source of uncertainty is considered relevant to the emissions reductions estimates related to Forest Degradation and Enhancement of Carbon Stocks (Plantations) activities. Therefore, in the Mote Carlo simulation the uncertainty related to harvested areas is categorized as medium and that related to replanted areas is classified as large (see Chapter 12, Annex 12.1 for more detail). The activity data used are listed in the Tables below.

Table 31: Area Deforested in Natural Forest

Description:	Area Deforested in Natural Forest
Data unit:	ha yr^{-1}
Source of data and description of measurement/calculation methods and procedures applied:	Data generated from sample based area assessment, using a wall-to-wall change map as a stratifyer.
Value applied	Lowland: 1459 Upland: 79
QA/QC procedures applied:	Samples were checked by multiple interpreters, multiple times.
Uncertainty for this parameter	Lowland LCI: 1094 / UCI: 1855 Upland LCI: 32 / UCI: 159
Any comments:	

Description:	Area Afforested
Data unit:	ha yr^{-1}
Source of data and description of measurement/calculation methods and procedures applied:	Data generated from sample based area assessment, using a wall-to-wall change map as a stratifyer.
Value applied	2882
QA/QC procedures applied:	Samples were checked by multiple interpreters, multiple times.
Uncertainty for this parameter	LCI: 1446 / UCI: 5138
Any comments:	

Parameter:	AD_{FDco}
Description:	average annual area of natural forest transitioned from open to closed forest during the reference period
Data unit:	ha yr^{-1}
Source of data and description of measurement/calculation methods and procedures applied:	Generated from the application of the CODED algorithm to an annual mosaic of LandSAT data.
Value applied	875
QA/QC procedures applied:	Samples were checked by multiple interpreters, multiple times.

Uncertainty associated with this parameter:	Uncertainty reported based on the sample based approach and estimated as a standard error to be:
Any comment:	

Table 32: Annual volume extracted from logging operations in natural and plantation forests

Parameter:	$V_{FD,t}$
Description:	Wood volumes harvested in natural forest in year t; m^3
Data unit:	$m^3\ yr^{-1}$
Source of data and description of measurement /calculation methods and procedures applied:	The total wood volume of logs extracted annually from Natural Forests subject to logging activities is collected by the Management Services Divisions of the Ministry of Forestry through Division of Forest Offices (DFO) staff, known as Log Scalers. On issuance of a licence to log, logging companies can proceed to extract the agreed volume. The logging contractors haul the timber to the log-landings and log-scalers from the Division Forest Offices (DFOs) assess the amount of timber extracted and enter the data into the Timber Revenue System (TRS) database. This volume is used to determine the amount of royalty fees the logger has to transfer to the Ministry of Forestry. As the accuracy of the data is linked to royalties there is confidence in these figures. The volume estimates are derived from diameter measurements at both ends of the bole in cm as well as the length of the bole in meters. The parameters measured are then used to estimate the volume.
Value applied	*The average extracted volume over the FRL period was 50,731 m^3yr^{-1}*

Year	Natural Forest Volumes Extracted (m^3)
2006	79,480
2007	45,122
2008	81,706
2009	59,614
2010	49,814
2011	36,499
2012	30,517
2013	26,947
2014	46,431
2015	51,091
2016	50,825

QA/QC procedures applied:	Standard operating procedures exist for field measurement and data by Forest Beat Staff who collect the data and staff from the Forest Divisional Offices who conduct the data collation. Staff from the Management Services Division conduct a QA/QC check at the data entry point and any issues are rectified in collaboration with Beat Staff and Divisional Officers. All staff are trained in their roles and responsibilities. These SOPs are available on the Fiji's Forest Information Management System.
Uncertainty associated with this parameter:	Data from this census of actual timber volume extracted is considered to have small uncertainty — most likely as measurement error of the logs (diameters, lengths and number of logs). The staff (i.e. log-scalers) from the Division of Forest Offices (DFOs) are trained in the collection of this information which is also linked to royalty collection. It is on the basis of these points that the uncertainty was considered small and the residual uncertainty was considered zero.
Any comment:	

Parameter:	$V_{SW,L,t}$
Description:	Wood volumes harvested in softwood plantations in year t; m^3
Data unit:	$m^3\ yr^{-1}$
Source of data and description of measurement /calculation methods and procedures applied:	Fiji Pine Limited manages the plantations of softwood. The company provides volume of softwood (Pine) and green weight of harvested wood annually to the Ministry of Forests. Harvesting details are published annually in the Ministry of Forests annual progress report and all relevant data are inputted into the TRS database system.
Value applied	*The average annual extracted volume over the FRL period was 334,463 m^3yr^{-1}*

Year	Softwood Plantation Volumes Extracted (m^3)
2006	282,102
2007	294,685
2008	265,046
2009	249,769
2010	256,040
2011	306,684
2012	158,214
2013	668,833
2014	393,519

	2015	544,902	
	2016	259,301	
QA/QC procedures applied:	Ministry of Forests staff from the Management Services Division will check samples of the measurement to assess the accuracy of the data provided. The Ministry of Forests continue to work with FPL to establish data collection protocols for this data to be supplied to the Management Services Division.		
Uncertainty associated with this parameter:	Harvested volume is census hence small source of uncertainty and no sampling error. The residual random uncertainty was considered to be zero.		
Any comment:			

Parameter:	$V_{HW,L,t}$
Description:	Wood volumes harvested in hardwood plantations in year t; m^3
Data unit:	$m^3\ yr^{-1}$
Source of data and description of measurement /calculation methods and procedures applied:	Fiji Hardwood Corporation Limited will provide wood volume harvested annually. The data on wood volume harvested also include harvested plantation area with area polygons (with spatial information).
Value applied	*The average annual extracted volume over the FRL period was 62,200 m^3yr^{-1}*

Year	Hardwood Plantation Volumes Extracted (m^3)
2006	37,216
2007	5,0092
2008	79,869
2009	63,758
2010	92,283
2011	91,025
2012	53,737
2013	63,251
2014	58,542

	2015	54,568	
	2016	39,854	
QA/QC procedures applied:	The Ministry of Forestry has supported Fiji Hardwood Corporation in training relating the data they collect and how it is used in the Emission Reduction calculations. The volume data is used for commercial purposes therefore the teams measuring the logs are well trained in this data collection. Once the data is provided to the Ministry of Forestry, data compilers conduct logic checks to ensure the data set is complete.		
Uncertainty associated with this parameter:	Small source of uncertainty; not included in the quantification of total uncertainty. Note that the data are census data (i.e., no sampling error). High confidence in the data collected by Ministry staff as systematic and random errors are considered nil due to QA/QC checks and training and strong links to Ministry revenues.		
Any comment:			

Table 33: Annual area harvested in Native Forest and Hardwood Plantations during the Reference Period

Parameter:	*AFD,t*
Description:	Natural forest area harvested
Data unit:	ha yr^{-1}
Source of data and description of measurement /calculation methods and procedures applied:	Annual data on the areas harvested are available from digital logging maps which are provided by logging companies to the Ministry of Forests as part of the process of obtaining a logging license. This data is collected from all sites issued with a logging license throughout Fiji, however only areas of natural forest logged within the Fijian islands of Viti Levu, Vanua Levu and Taveuni will be included for monitoring in the ER program.
Value applied	*The average annual a*rea harvested over *the FRL period was 1798 ha* yr^{-1}

Year	Natural Forest Area Harvested (ha)
2006	3,513
2007	2,546
2008	3,259
2009	1,165
2010	1,641
2011	905
2012	796

	2013	1,354
	2014	1,428
	2015	1,738
	2016	1,438
QA/QC procedures applied:	Maps/GIS layers are checked and if necessary, corrected by staff from the Management Service Division (MSD) where discrepancies are found. SOPs describing these checks are available on the Fiji's Forest Information Management System.	
Uncertainty associated with this parameter:	The data for the areas logged are census data (i.e., no sampling error). There may be some small errors in boundaries because of GPS instruments. The residual random uncertainty was considered to be zero.	
Any comment:		

Parameter:	$A_{HW,LG,t}$
Description:	Hardwood plantation area harvested
Data unit:	ha yr^{-1}
Source of data and description of measurement /calculation methods and procedures applied:	Fiji Hardwood Corporation Limited provide area of hardwood logged annually. Simultaneously Fiji Hardwood Corporation Limited provide polygons (with spatial information) of the plantation area logged.
Value applied	*The average annual a*rea harvested over *the FRL period was 301 ha* yr^{-1}

Year	Hardwood Plantation Area Harvested (ha)
2006	212
2007	278
2008	736
2009	165
2010	432
2011	132
2012	110
2013	310
2014	394

	2015	375
	2016	172
QA/QC procedures applied:	Ministry of Forests monitor the planted area by visiting the sample sites; and will use Landsat images to identify the area of hardwood planted. Fiji Hardwood Corporation use internal auditing process to make the area of pine planted is accurate.	
Uncertainty associated with this parameter:	Area of logged in hardwood plantations is census based hence there is no source of uncertainly due to sampling (no sampling error). Uncertainty will be mainly from the use of instruments (GPS). Key uncertainties include error in remote sensing classification due to haze, cloud cover, differences in seasonal greenness, and reflectance differences between Landsat images if Landsat images are used.	
Any comment:		

Parameter:	$A_{SW,LG,t}$
Description:	Softwood plantation area harvested
Data unit:	ha yr^{-1}
Source of data and description of measurement /calculation methods and procedures applied:	Fiji Pine Limited provide area of softwood logged annually.
Value applied	*The average annual a*rea harvested over *the FRL period was 1,282 ha* yr^{-1}

Year	Softwood Plantation Area Harvested (ha)
2006	1,082
2007	1,130
2008	1,016
2009	958
2010	982
2011	1,176

	2012	607	
	2013	2,564	
	2014	2,089	
	2015	1,509	
	2016	994	
QA/QC procedures applied:	Ministry of Forests monitor the planted area by visiting the sample sites; and will use Landsat images to identify the area of softwood planted. Fiji Pine Limited apply internal auditing process to make the area of pine planted is accurate.		
Uncertainty associated with this parameter:	Area of logged in softwood plantations is census data based hence there is no source of uncertainly due to sampling (no sampling error). Uncertainty will be mainly from the use of instruments (GPS). Key uncertainties include error in remote sensing classification due to haze, cloud cover, differences in seasonal greenness, and reflectance differences between Landsat images if Landsat images are used.		
Any comment:			

Parameter:	$A_{SW,Pt}$
Description:	Softwood plantation area planted
Data unit:	ha yr^{-1}
Source of data and description of measurement /calculation methods and procedures applied:	Fiji Pine Limited manages the plantations of softwood. The company provides the annual areas planted to the Ministry of Forests.
Value applied	*The average annual a*rea harvested over *the FRL period was 371 ha* yr^{-1}

Year	Softwood Plantation Area Planted (ha)
2006	1,478
2007	3
2008	14
2009	17
2010	177
2011	273

		2012	871	
		2013	13	
		2014	202	
		2015	1,032	
		2016	0	
QA/QC procedures applied:	Ministry of Forests staff from the Management Services Division check areas in the remote sensing to assess the accuracy of the data provided.			
Uncertainty associated with this parameter:	Area planted is census data hence small source of uncertainty and no sampling error. The residual random uncertainty was considered to be zero.			
Any comment:				

In a step-wise continuous improvement approach, the Ministry of Forestry is working on multiple ways to improve the data quality of the area harvested and area of regrowth, including improvements to the data collection methods for self-reported data and ways to integrate the use of the wall-to-wall data in tracking harvest and regrowth activities. A stepwise improvement plan for the National Forest Monitoring System can be found in Chapter 9.

Emission factors

Emissions factors have been developed using national data collected from national inventories in combination with some sub-national and project level studies. Carbon stocks of above- and below ground biomass of natural forests were generated using two primary datasets - the National Forest Inventory and the Permanent Sample Plot Inventory. Data from these sources enabled the generation of carbon stock estimates for Upland and Lowland Forest classes with the application of allometric equation of Chave et al. [2014] parameterized with Fiji data to generate Fiji specific allometric equations.

Post deforestation and pre-afforestation carbon stocks as well as growth rates were taken from multiple project level studies and expert judgement. The limitations of these data sources are acknowledged by attributing high level of uncertainty to the data in the Monte Carlo simulation.

All factors, their source and uncertainty that are used in the National Forest Monitoring System are summarised in the Tables below.

Table 35: Carbon Stock due to conversion of natural forest to grassland

Parameter:	C_{AFTER}
Description:	Carbon stock in biomass due to the conversion of Natural Forest to grassland
Data unit:	tC ha^{-1}
Source of data or description of the method for	Rounds, I., 2013. Baseline carbon assessment of talasiga grassland vegetation of REDD+ pilot site, Emalu. Draubuta, Navosa.

developing the data including the spatial level of the data (local, regional, national, international):	
Value applied:	17.11
QA/QC procedures applied	This value was sourced from published literature and therefore unclear of QA/QC procedures applied
Uncertainty associated with this parameter:	The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated. Lower Confidence Interval [8.31] Upper Confidence Interval [25.96]
Any comment:	

Parameter:	$C_{BEFORE,Lowland}$
Description:	Estimated carbon stocks stored in AGB and BGB in Lowland Natural Forest
Data unit:	tC ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Philip Mundhenk, Prem Raj Neupane & Michael Köhl 2016 - Fiji's Forest Reference Level. Reference Period 2006 — 2016 World Forestry — University of Hamburg. September 2019 - Appendix A2 - Fiji FRL Report, 2018
Value applied:	87.86

QA/QC procedures applied	Some QA/QC procedures were applied in the field data collection for the NFI and Permanent sample plots including hot and cold field checks. Additionally the calculations values were checks independently by a third party from FAO.
Uncertainty associated with this parameter:	The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated. Lower Confidence Interval [84.25] Upper Confidence Interval [93.21]
Any comment:	

Parameter:	$C_{BEFORE,Upland}$
Description:	Estimated carbon stocks stored in AGB and BGB in Upland Natural Forest
Data unit:	tC ha^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Philip Mundhenk, Prem Raj Neupane & Michael Köhl 2016 - Fiji's Forest Reference Level. Reference Period 2006 — 2016 World Forestry — University of Hamburg. September 2019 - Appendix A2 - Fiji FRL Report, 2018
Value applied:	71.57
QA/QC procedures applied	Some QA/QC procedures were applied in the field data collection for the NFI and Permanent sample plots including hot and cold field checks. Additionally the calculations values were checks independently by a third party from FAO.
Uncertainty associated with this parameter:	The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated. Lower Confidence Interval [66.45] Upper Confidence Interval [78.58]
Any comment:	

Parameter:	EF_{OC}

Description:	Emission factor for the conversion of Closed Forest to Open Forest;
Data unit:	$tCO_2e\ ha^{-1}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The methodology applied to generate the emission factor for native forest degradation outside of harvested areas would be considered a Tier 1 Emission Factor. Development of a National Tier 2 emission factor for canopy cover change was not possible with the available data sets. Instead a model-based approach to estimating biomass density (for example Ståhl et al. 2010) was used based on the GEDI data set. A model was developed that relates field measurements to auxiliary data (in this case remote sensing data) as the basis for statistical estimation. The previous forest inventory was used to calibrate a GEDI-to-biomass model, then biomass was predicted at every GEDI observation in Fiji. Hybrid statistical inference was used to calculate mean biomass density and confidence intervals. The statistical framework for using GEDI and hybrid inference is described in Patterson et al. 2019. The country was divided into Open and Closed forests using the forest type classification. Then the difference between the two classes is considered the emission factor. This process led to the development of an emissions factor of 121 tCO_2e +/-22 tCO_2e resulting from the transition from Closed to Open Forest.
Value applied:	121
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Lower Confidence Interval [99] Upper Confidence Interval [143] The upper and lower confidence intervals represent the uncertainty associated with this value. The interval is based on the distribution of the sample taken. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated.
Any comment:	Equation 2

Parameter:	$\boldsymbol{MAIV_{AR}}$
Description:	Mean annual volume increment for afforestation/reforestation
Data unit:	$m^3\ ha^{-1}\ yr^{-1}$
Source of data or description of the method for developing the data	Derived from data provided from Fiji Hardwood Corporation Limited

including the spatial level of the data (local, regional, national, international):	
Value applied:	3.71
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Assumed to have a high uncertainty due to a lack of QA/QC procedures applied. 50% uncertainty estimated to include systematic and random error. Sampled from a Triangular distribution with lower bound $a = \mathrm{MAIV}_{\mathrm{AR}} - \mathrm{MAIV}_{\mathrm{AR}} \times 0.5$ upper bound $b = \mathrm{MAIV}_{\mathrm{AR}} + \mathrm{MAIV}_{\mathrm{AR}} \times 0.5$ and mode $c = \mathrm{MAIV}_{\mathrm{AR}}]$
Any comment:	

Parameter:	$\boldsymbol{\lambda_{Pine}}$
Description:	Softwood plantation recovery rate following harvest
Data unit:	Ratio - dimensionless
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Waterloo, M., 1994. Water and Nutrient Dynamics of Pinus caribaea plantation forests on former grassland soils in Southwest Viti Levu, Fiji. Ph.D. thesis, Vrije Universiteit Amsterdam.
Value applied:	0.76
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Drawn from a Normal distribution with $\mu = \lambda_{\mathrm{Pine}}$ and $\sigma^2 = [\lambda_{\mathrm{Pine}} \times 0.1]^2$ The distribution is based on the sample taken as published in the reference. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated.

Any comment:	

Parameter:	$\boldsymbol{\rho_{Pine}}$
Description:	Pine tree wood density (dry weight over fresh volume)
Data unit:	g cm^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Cown, D., 1981. Wood density of Pinus caribaea var. hondurensis grown in Fiji. New Zealand Journal of Forestry Science, 11(3):244–253.
Value applied:	0.47
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Drawn from a Normal distribution with $\mu = \rho_{\mathrm{Pine}}$ and $\sigma^2 = 0.0031$ The distribution is based on the sample taken as published in the reference. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated.
Any comment:	

Parameter:	$\boldsymbol{MAIB_{SW}}$
Description:	Mean annual increment of above and belowground biomass in softwood plantations
Data unit:	tB ha^{-1} yr^{-1}
Source of data or description of the method for developing the data including the spatial level of the data (local, regional,	Waterloo, M., 1994. Water and Nutrient Dynamics of Pinus caribaea plantation forests on former grassland soils in Southwest Viti Levu, Fiji. Ph.D. thesis, Vrije Universiteit Amsterdam.

national, international):	
Value applied:	10
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Triangular distribution with lower bound $a = \mathrm{MAIB_{SW}} - \mathrm{MAIB_{SW}} \times 0.25$ upper bound $a = \mathrm{MAIB_{SW}} + \mathrm{MAIB_{SW}} \times 0.25$, mode $c = \mathrm{MAIB_{SW}}$. The distribution is based on the sample taken as published in the reference. It is unlikely that measurement and random error have been considered. This residual uncertainty has not been estimated.
Any comment:	

Parameter:	$\boldsymbol{CC_{SW}}$
Description:	Length of the harvest cycle in softwood plantations
Data unit:	Yrs.
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Personal communication Fiji Pine Limited (FPL) indicated that most pine plantations are harvested around 20 years ranging between 15 to 25 years.
Value applied:	20
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Assumed to have a high uncertainty due to a lack of QA/QC procedures applied. 50% uncertainty estimated to include systematic and random error. Sampled from a Triangular distribution with lower bound $a = CC_{SW} - 5$, upper bound $a = CC_{SW} + 5$, mode $c = CC_{SW}$
Any comment:	

Parameter:	$\boldsymbol{\overline{MAIV}_{HW}}$
Description:	Average mean annual increment in Fiji hardwood plantations
Data unit:	$m^3\ ha^{-1}\ yr^{-1}$

Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Derived from data provided from Fiji Hardwood Corporation Limited.
Value applied:	5.85
QA/QC procedures applied	None
Uncertainty associated with this parameter:	Assumed to have a medium uncertainty due to a lack of QA/QC procedures applied. 50% uncertainty estimated to include systematic and random error. Sampled from a Triangular distribution with lower bound $a = \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$, upper bound $= \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$, mode $c = \overline{\mathrm{MAIV}}_{\mathrm{HW}}$.
Any comment:	

Parameter:	TEF
Description:	Conversion factor for timber volumes extracted to total carbon loss
Data unit:	tC $(m^3)^{-1}$
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	Haas, M., 2015. Carbon Emissions from Forest Degradation caused by Selective Logging in Fiji. Regional project Climate Protection through Forest Conservation in Pacific Island Countries, GIZ, SPC.
Value applied:	1.05
QA/QC procedures applied	This value was sourced from published literature and therefore unclear of QA/QC procedures applied.

Uncertainty associated with this parameter:	Large source of uncertainty, highly relevant; included in the quantification of uncertainty. Sampled from a triangular distribution with lower bound a = TEF - TEF x 0.25, upper bound b = TEF + TEF x 0.25, and mode c = TEF The mode of TEF was determined from a small-scale study within the ER Program area (Haas, 2015), however the upper and lower bounds were estimated from expert judgement.
Any comment:	

The MOF has identified a number of priority improvement areas related to improving Nationally relevant emissions factors. This includes improvements to the NFI design with the aim of determining Open and Closed Forest carbon stocks within the upland and lowland forest classifications to be conducted in conjunction with the step-wise approach to incorporating direct measurement and estimation of forest degradation in Fiji's National Forest Monitoring System (see improvement plan outlined in Section 9). Should this be completed, utilising this forest classification to improve the proxy methods applied to estimate emissions related to forest degradation will be investigated as part of the continuous improvement process.

8.4 Estimated Reference Level

Table 37: ER Program Reference level

Crediting Period year t	Average annual historical emissions from deforestation over the Reference Period (tCO_2-e/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_2-e/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_2-e/yr)	Adjustment, if applicable (tCO_2-e/yr)	Reference level (tCO_2-e/yr)
2019	394,121	495,654	577,001		1,466,776
2020	394,121	489,126	538,613		1,421,859
2021	394,121	482,596	500,225		1,376,943
2022	394,121	476,069	461,837		1,332,027
2023	394,121	469,541	423,449		1,287,111

Calculation of the average annual historical emissions over the Reference Period

The methodology applied to generate the Forest Reference Emission Level is described in full in the REDD+ Estimation Methodology document. This methodology is implemented in R scripting language and applied in the Forest Information Management System Integration tool. The R script tool has been provided as additional supporting resources to this Monitoring Report and can be reviewed in R studio.

8.5 Upward or downward adjustments to the average annual historical emissions over the Reference Period (if applicable)

There has been a downward adjustment to the removals in the Enhancement of Carbon Stocks activity which has resulted in an upward adjustment to the Net FRL.

8.6 Relation between the Reference Level, the development of a FREL/FRL for the UNFCCC and the country's existing or emerging greenhouse gas inventory

The FRL has been developed using a new National data set for activity data as well as more refined National Specific emissions factors for above-ground biomass. The national Reference Level is proposed to be developed following the methods and procedures used for ER program Forest Reference Level. Activity data covering the other major islands will be generated and used to develop a national FREL that will be submitted to the UNFCCC.

Consistencies include the design characteristics of the FRL such as forest definition, carbon pools, gases. Any variations relating to stratification and reporting of REDD+ activities in the Forest Remaining Forest category of the GHGI will be transparently explained.

Consistency in the methodology and data sources applied to generate the ER-Programme FRL will be prioritised for any reports provided to the UNFCCC, specifically the FRL, National Greenhouse Gas Inventory (GHGI) estimates and National Communications for the forestry sector.

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

9.1 Measurement, monitoring and reporting approach for estimating emissions occurring under the ER Program within the Accounting Area

Line diagrams

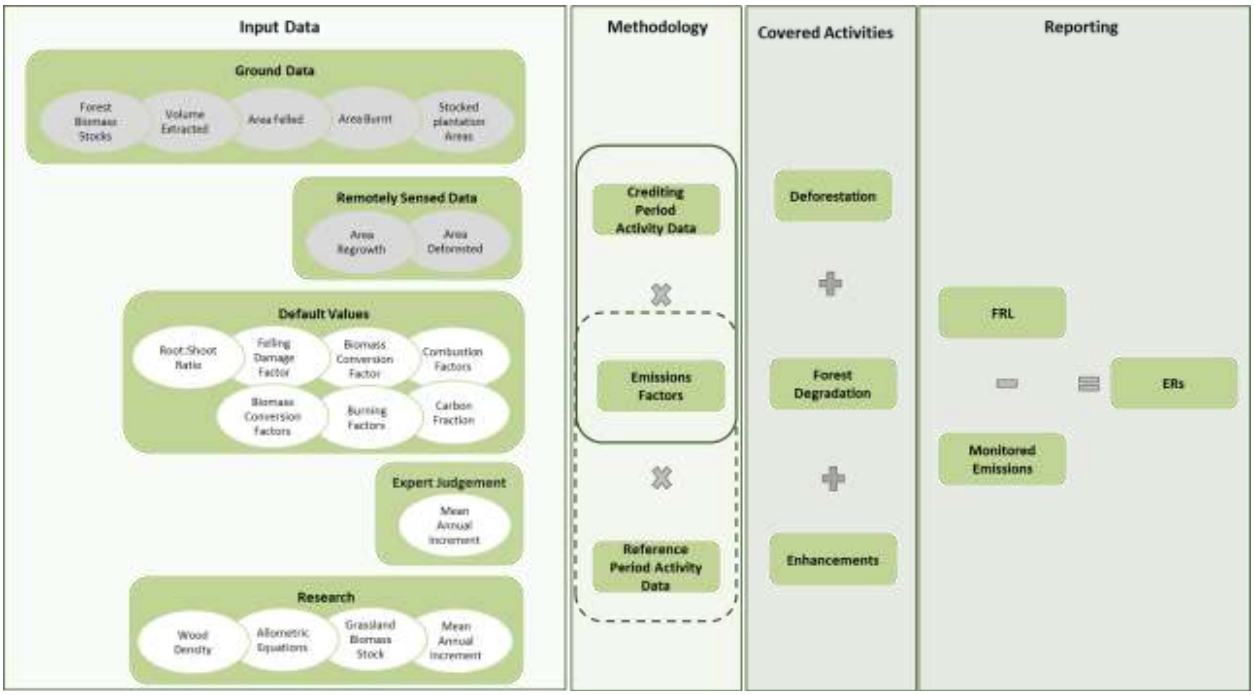


Figure 11: Line diagram to explain the calculation framework

Greyed input data represents data collected for each Monitoring Period. All other input data remain the same between the FRL and the Monitoring Period. Standard Operating Procedures are available outlining the processes for all the collected Input Data, implementation of the methodology through the Integration Tool and Generation of Reports from the Forest Information Management System.

Calculation steps

Emission reduction calculation

The methodology for estimating emissions and removals during the Monitoring Period (July 2019 – December 2020) is the same as that used for estimating annual emissions and removals in the Reference Period (2006-2016). A combination of direct and proxy methods is applied to generate emissions and removals from the following REDD+ Activities: i) Deforestation; ii) Forest Degradation; and iii) Enhancements of Carbon Stocks (see Figure below).

The estimates are generated by running a Monte Carlo simulation, where values are sampled at random from the input probability distributions for each variable.

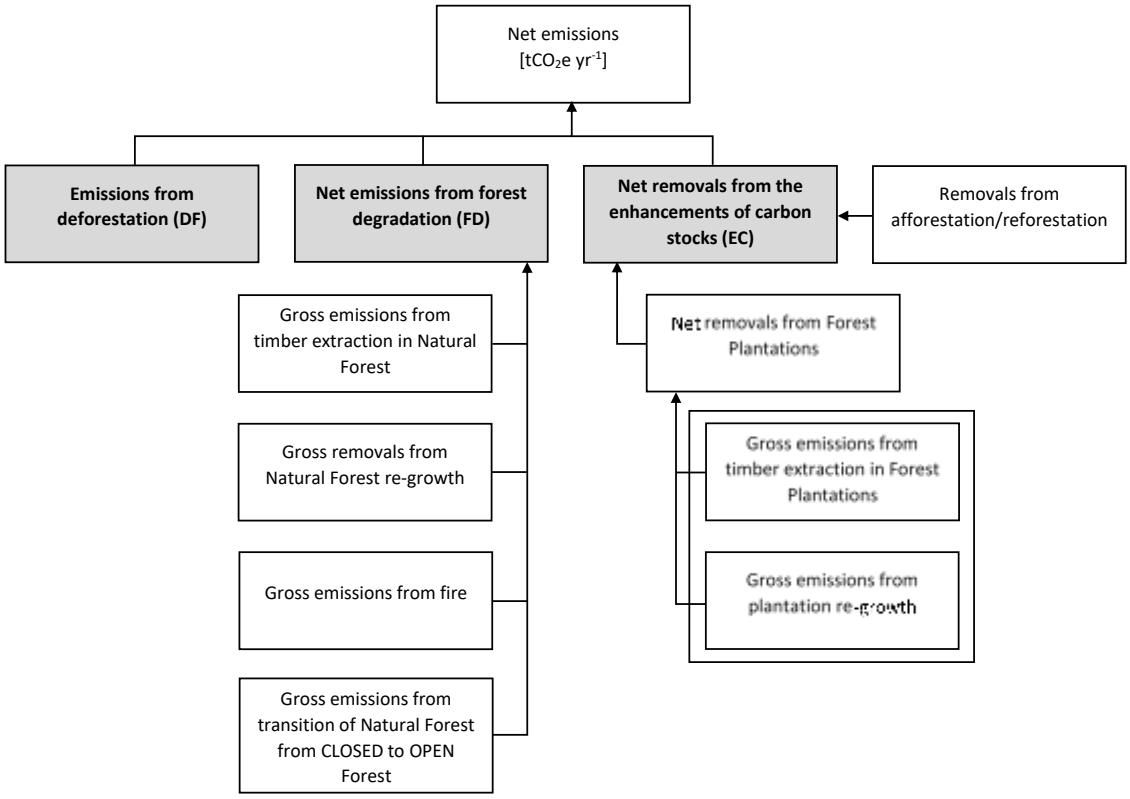


Figure 12: Overview of the sources and sinks considered *in Fiji's Forest Reference Level (FRL), including the sub-sources and sinks for forest degradation and enhancement of forest carbon stocks*

The calculation of emissions reductions is conducted by subtracting the actual emissions/removals over the Reporting Period from the predicted emissions/removals from the estimation of the Forest Reference Level (FRL) for each activity and then adding the ERs from each activity together to arrive at the total ER number.

Accounting for Emissions and Removals in the Monitoring Period

Emissions and removals[**] as a result of REDD+ Activities are estimated based on the following principles:

- calculation of the emission reductions are based on comparing the emission associated with the land use changes, extractive and regrowth activities in the reference period and the monitoring period;
- As such it is assumed that the average annual rates of area change and extractive or regrowth activities during the Reference Period would have applied during the Crediting Period; and
- therefore the emission reductions are calculated as the difference between the expected emissions and removals under the Reference Level and the actual emissions and removals.

Deforestation

Emission Removals from deforestation were estimated as:

$$ER_{Def} = \left[(\mathrm{AD}_{FRLDef,i} \times \mathrm{EF}_{CS,i}) - (\mathrm{AD}_{MPDef,i} \times \mathrm{EF}_{CS,i})\ \right] \times \frac{44}{12} \qquad (2)$$

Where:

ER_{Def} = Emission reductions from deforestation during the monitoring period; tCO_2e

[**] Legacy emissions have been assessed following FMT Note CF2020-5 dating 29 January 2021

AD_{FRLDef}	=	Average area of deforestation in strata i in the FRL period; ha
AD_{MPDef}	=	Area of deforestation in strata i in the monitoring period; ha
EF_{CS}	=	Deforestation emission factor for strata i; tC ha^{-1}

Forest Degradation

$$ER_{FD} = \{[[(\mathrm{AD}_{FRLNFHvol} \times \mathrm{EF}_{NFH}) - ((\mathrm{AD}_{FRLNFH} \times \mathrm{EF}_{NFHrem})) + (\mathrm{AD}_{FRLNFF} \times \mathrm{EF}_{NFF}) + (AD_{FRLFSW} \times EF_{FSW})] - [((\mathrm{AD}_{MPNFHvol} \times \mathrm{EF}_{NFH}) - (\mathrm{AD}_{MPNFH} \times \mathrm{EF}_{NFHrem})) + (\mathrm{AD}_{MPNFF} \times \mathrm{EF}_{NFF}) + (AD_{MPFSW} \times EF_{FSW})]\} \times \frac{44}{12} \quad \textbf{(2)}$$

Where:

ER_{Def}	=	Emission reductions from forest degradation during the monitoring period; tCO_2e
$AD_{FRLNFHvol}$	=	Average Volume of timber harvested in Natural Forest during the FRL period; m^3 ha^{-1}
AD_{FRLNFH}	=	Average area harvested in Natural Forest during the FRL period; ha
AD_{FRLNFF}	=	Average area of Natural Forest converted from Closed to Open forest during the FRL period; ha
AD_{FRLFSW}	=	Average area a of fire in Softwood Plantations during the FRL period; ha
$AD_{MPNFHvol}$	=	Volume of timber harvested in Natural Forest during the monitoring period; m^3 ha^{-1}
AD_{MPNFH}	=	Area of timber harvest in Natural Forest during the monitoring period; ha
AD_{MPNFF}	=	Area of Natural Forest converted from Closed to Open forest during the monitoring period; ha
AD_{MPFSW}	=	Area of fire in Softwood Plantations during the monitoring period; ha
EF_{NFH}	=	Forest degradation emission factor resulting from timber extraction from natural forest; tC m^{-3} ha^{-1}
EF_{NFH}	=	Forest degradation removal factor resulting from regrowth following timber extraction from natural forest; tC m^{-3} ha^{-1}
EF_{NFF}	=	Emission factor for the conversion of Closed Forest to Open Forest; tC ha^{-1}
EF_{FSW}	=	Emission factor for fire in softwood plantations; tC ha^{-1}

Enhancement of Carbon Stocks

$$ER_{EN} = \{[(\mathrm{AD}_{FRLAR} \times \mathrm{EF}_{NF}) + ((\mathrm{AD}_{FRLHWPharvest} \times \mathrm{EF}_{HWPharvest}) - (\mathrm{AD}_{FRLHWPreplant} \times \mathrm{EF}_{HWPreplant})) + (\mathrm{AD}_{FRLSWPharvest} \times \mathrm{EF}_{SWPharvest}) - (\mathrm{AD}_{FRLSWPreplant} \times \mathrm{EF}_{SWPreplant})] - [(\mathrm{AD}_{MPAR} \times \mathrm{EF}_{NF}) + ((\mathrm{AD}_{MPHWPharvest} \times \mathrm{EF}_{HWPharvest}) - (\mathrm{AD}_{MPHWPreplant} \times \mathrm{EF}_{HWPreplant})) + (\mathrm{AD}_{MPSWPharvest} \times \mathrm{EF}_{SWPharvest}) - (\mathrm{AD}_{MPSWPreplant} \times \mathrm{EF}_{SWPreplant})]\} \times \frac{44}{12} \quad \textbf{(3)}$$

Where:

ER_{EN}	=	Emission reductions from forest removals during the monitoring period; tCO_2e
AD_{FRLAR}	=	Average area of afforestation/reforestation during the FRL period; ha
$AD_{FRLHWPharvest}$	=	Average volume extracted from hardwood plantation during the FRL period; m^3
$AD_{FRLHWPreplant}$	=	Average area of replanted hardwood plantation during the FRL period; ha
$AD_{FRLSWPhavest}$	=	Average volume extracted from softwood plantation during the FRL period; m^3
$AD_{FRLSWPreplant}$	=	Average area of replanted softwood plantation during the FRL period; ha
AD_{MPAR}	=	Area of afforestation/reforestation during the monitoring period; ha

$AD_{MPHWPharvest}$	=	Volume extracted from hardwood plantation during the monitoring period; ha
$AD_{MPHWPreplant}$	=	Area of replanted hardwood plantation during the monitoring period; ha
$AD_{MPSWPharvest}$	=	Volume extracted from softwood plantation during the monitoring period; ha
$AD_{MPSWPreplant}$	=	Area of replanted softwood plantation during the monitoring period; ha
EF_{NF}	=	Removal factor for replanted natural forest; tC ha^{-1}
$EF_{HWPharvest}$	=	Removal factor for replanted hardwood forest; tC m^{-3}
$EF_{HWPreplant}$	=	Removal factor for replanted hardwood forest; tC ha^{-1}
$EF_{SWPharvest}$	=	Removal factor for replanted softwood forest; tC m^{-3}
$EF_{HWPreplant}$	=	Removal factor for replanted hardwood forest; tC ha^{-1}

Emission reductions

$$\widehat{\emptyset}_{ER,MP} = \mathrm{ER}_{Def} + \mathrm{ER}_{FD} + \mathrm{ER}_{EN} \quad (4)$$

Where:

$\widehat{\emptyset}_{ER,MP}$	=	Emission Reductions under the ER Program in the Monitoring Period; tCO_2e.
ER_{Def}	=	Emission reductions from deforestation during the monitoring period; tCO_2e
ER_{FD}	=	Emission reductions from forest degradation during the monitoring period; tCO_2e
ER_{EN}	=	Emission reductions from enhancement of carbon stocks during the monitoring period; tCO_2e

Emission Reductions calculated for this Reporting Period are based on a pro-rata basis over a longer Monitoring Period.

- The Reporting Period is 11 July 2019 until the 31 December 2020 (i.e. 540 days).
- The Monitoring Period is two years from 1 January 2019 - 31 December 2020 (i.e. 730 days).

As such, the ERs are estimated for the Monitoring Period by multiplying the net ERs during the monitoring period by the ratio of the length of the Reporting Period and the length of the Monitoring Period.

$$\widehat{\emptyset}_{ER,RP} = \widehat{\emptyset}_{ER,MP} \times \frac{RP}{MP} \quad (5)$$

Where:

$\widehat{\emptyset}_{ER,RP}$	=	Emission Reductions under the ER Program in the Reporting Period; tCO_2e.
$\widehat{\emptyset}_{ER,MP}$	=	Emission Reductions under the ER Program in the Monitoring Period; tCO_2e.
RP	=	Days in the Reporting Period; days
MP	=	Days in the Monitoring Period; days

Parameters to be monitored

Table 38: Monitored Data and Parameters for Deforestation

Parameter:	$A_{DF,Lowland,t\ i}$
Description:	Area of deforestation in Natural Forest, Lowland stratum in year t;
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	**2019:** 253 **2020:** 253
Source of data and description of measurement/calculation methods and procedures applied:	This data is generated using a sample based approach using a wall-to-wall map as a stratifyer. The wall-to wall maps were constructed from Landsat imagery and a machine learning algorithm.
Quality Assurance/Quality Control procedures to be applied:	QA/QC will be accomplished in a two-step process: i) A set of SOPs for land use change classification have been developed and all interpreters trained in the classification process. These SOPs are available on the Fijis Forest Information Management System. ii) Remote sensing analysis is verified using ground data and/or other independent remote sensing data that is available.
Uncertainty for this parameter:	**2019** Lower Confidence Interval – 183 ha Upper Confidence Interval – 327 ha **2020** Lower Confidence Interval – 183 ha Upper Confidence Interval – 327 ha
Any comments:	

Parameter:	$A_{DF,Upland,t\ i}$
Description:	Area of deforestation in Natural Forest Upland stratum in year t;
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019: 4 2020: 4
Source of data and description of measurement/calculation methods and procedures applied:	This data is generated using a sample based approach using a wall-to-wall map as a stratifyer. The wall-to wall maps were constructed from Landsat imagery and a machine learning algorithm
Quality Assurance/Quality Control procedures to be applied:	QA/QC will be accomplished in a two-step process— i) A set of SOPs for land use change classification has been developed and all interpreters trained in the classification process. These SOPs are available on the Fijis Forest Information Management System. ii) Remote sensing analysis is verified using ground data and/or other independent remote sensing data that is available.
Uncertainty for this parameter	**2019:** Lower Confidence Interval – 2 ha Upper Confidence Interval – 6 ha **2020:** Lower Confidence Interval – 2 ha Upper Confidence Interval – 6 ha
Any comments:	

Table 39: Monitored Data and Parameters for Forest Degradation

Parameter:	$V_{FD,t}$
Description:	wood volume extracted from Natural Forest in year t;
Data unit:	m^3
Value monitored during this Monitoring / Reporting Period	2019 – 27,583 2020 – 22,088
Source of data and description of measurement/calculation methods and procedures applied:	The total wood volume of logs extracted annually from Natural Forests subject to logging activities is collected by the Management Services Divisions of the Ministry of Forestry through Division of Forest Offices (DFO) staff, known as Log Scalers. On issuance of a licence to log, logging companies can proceed to extract the agreed volume. The logging contractors haul the timber to the log-landings and log-scalers from the Division Forest Offices (DFOs) assess the amount of timber extracted and enter the data into the Timber Revenue System (TRS) database. This volume is used to determine the amount of royalty fees the logger has to transfer to the Ministry of Forestry. As the accuracy of the data is linked to royalties there is confidence in these figures. The volume estimates are derived from diameter measurements at both ends of the bole in cm as well as the length of the bole in meters. The parameters measured are then used to estimate the volume.
Quality Assurance/Quality Control procedures to be applied:	Standard operating procedures exist for field measurement and data by Forest Beat Staff who collect the data and staff from the Forest Divisional Offices who conduct the data collation. Staff from the Management Services Division conduct a QA/QC check at the data entry point and any issues are rectified in collaboration with Beat Staff and Divisional Officers. All staff are trained in their roles and responsibilities. These SOPs are available on the Fiji's Forest Information Management System.
Uncertainty for this parameter	Data from this census of actual timber volume extracted is considered to have small uncertainty — most likely as measurement error of the logs (diameters, lengths and number of logs). The staff (i.e. log-scalers) from the Division of Forest Offices (DFOs) are trained in the collection of this information which is also linked to royalty collection. It is on the basis of these points that the uncertainty was considered small and the residual uncertainty was considered zero.
Any comments:	

Parameter:	$A_{FD,t}$
Description:	Area of Natural Forest logged in year t
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019 – 1,350 2020 – 1,083
Source of data and description of measurement/calculation methods and procedures applied:	Annual data on the areas harvested are available from digital logging maps which are provided by logging companies to the Ministry of Forests as part of the process of obtaining a logging licence. This data is collected from all sites issued with a logging licence throughout Fiji, however only areas of natural forest logged within the Fijian islands of

	Viti Levu, Vanua Levu and Taveuni will be included for monitoring in the ER program.
Quality Assurance/Quality Control procedures to be applied:	Maps/GIS layers are checked and if necessary, corrected by staff from the Management Service Division (MSD) where discrepancies are found. SOPs describing these checks are available on the Fiji's Forest Information Management System.
Uncertainty for this parameter	The data for the areas logged are census data (i.e., no sampling error). There may be some small errors in boundaries because of GPS instruments. The residual random uncertainty was considered to be zero.
Any comments:	

Parameter:	$A_{l,tb}$
Description:	Area burnt in softwood plantations at time t.
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019

Year	Age	Area
2019	2	10
2019	3	3
2019	4	3
2019	2	2
2019	2	49
2019	2	0.6
2019	5	11.3
2019	2	57.639
2019	2	17.31
2019	2	4.71
2019	3	20.42

2020

Year	Age	Area
2020	3	8.25
2020	3	39.2
2020	3	12.1
2020	3	25.9
2020	4	33.4
2020	2	4
2020	2	9.86
2020	2	4.56
2020	2	10.77
2020	3	13

Source of data and description of measurement/calculation methods and procedures applied:	Annual areas of burnt plantations have been historically collected by Fiji Pine Limited. The information collected includes the spatial location (forest coup), the year of planting, the year of burn and the total hectares burnt.
Quality Assurance/Quality Control procedures to be applied:	The Ministry of Forests continue to work with FPL to establish data collection protocols for this data to be supplied to the Management Services Division.
Uncertainty for this parameter	The main sources of uncertainty relate to the measurement of areas burnt using the field GPS and random and systematic errors in data entry. However these were considered small and assumed to be zero.
Any comments:	

Parameter:	AD_{FRLNFF}
Description:	Area of natural forest transition from Closed to Open forest
Data unit:	ha
Value monitored during this Monitoring / Reporting Period	Total for Monitoring period 428
Source of data and description of measurement/calculation methods and procedures applied:	This data is generated using a sample based approach using a wall-to-wall map as a stratifyer. The wall-to wall maps were constructed from Landsat imagery and a machine learning algorithm.
Quality Assurance/Quality Control procedures to be applied:	QA/QC will be accomplished in a two-step process— i) A set of SOPs for land use change classification has been developed and all interpreters trained in the classification process. These SOPs are available on the Fijis Forest Information Management System. ii) Remote sensing analysis is verified using ground data and/or other independent remote sensing data that is available.
Uncertainty for this parameter	Standard error 88.5
Any comments:	

Table 40: Monitored Data and Parameters for Enhancement of Carbon Stocks - Afforestation/Reforestation

Parameter::	$A_{AR,T1}$
Description:	area of afforestation/reforestation in Natural Forest year t;
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019 – 615.8 2020 – 666.6
Source of data and description of measurement/calculation methods and procedures applied:	Areas planted are recorded by the Ministry of Forestry
Quality Assurance/Quality Control procedures to be applied:	GIS layers are checked and if necessary, corrected by staff from the Management Service Division (MSD) where discrepancies are found. SOPs describing these checks are available on the Fiji's Forest Information Management System.
Uncertainty for this parameter	The data for the areas logged are census data (i.e., no sampling error). There may be some small errors in boundaries because of GPS instruments. The residual random uncertainty was considered to be zero.
Any Comments:	

Table 41: Monitored Data and Parameters for Enhanced Carbon Stocks - Forest Plantation

Parameter:	$V_{SW,L,t}$
Description:	wood volumes harvested in softwood plantations in year t
Data unit:	m^3
Value monitored during this Monitoring / Reporting Period	2019 – 386,985 2020 – 479,959
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Pine Limited manages the plantations of softwood. The company provides volume of softwood (Pine) and green weight of harvested wood annually to the Ministry of Forests. Harvesting details are published annually in the Ministry of Forests annual progress report and all relevant data are inputted into the TRS database system.
Quality Assurance/Quality Control procedures to be applied:	Ministry of Forests staff from the Management Services Division will check samples of the measurement to assess the accuracy of the data provided. The Ministry of Forests continue to work with FPL to establish data collection protocols for this data to be supplied to the Management Services Division.
Identification of sources of uncertainty for this parameter	Harvested volume is census hence small source of uncertainty and no sampling error. The residual random uncertainty was considered to be zero.
Any comments:	

Parameter:	$A_{SW,PL,t}$
Description:	area planted in softwood plantations in year t
Data unit:	ha
Value monitored during this Monitoring / Reporting Period	2019 – 2,008 2020 – 1,910
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Pine Limited manages the plantations of softwood. The company provides area of softwood (Pine) planted annually to the Ministry of Forests. Simultaneously, Fiji Pine Limited provides polygons for the area planted annually.
Quality Assurance/Quality Control procedures to be applied:	Fiji Pine Limited uses an internal monitoring system to report the area of pine planted. Ministry of Forests staff visit a sample of sites to check the quality of the data reported by Fiji Pine. The residual random uncertainty was considered to be zero.
Identification of sources of uncertainty for this parameter	Areas of forest harvested are census data (no sampling error) therefore only source of uncertainty is instrumental error (GPS).
Any comments:	

Parameter:	$V_{HW,L}$
Description:	wood volumes harvested in hardwood plantations in year t;
Data unit:	m^3
Value monitored during this Monitoring / Reporting Period	2019 – 19,802 2020 – 21,441
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Hardwood Corporation Limited will provide wood volume harvested annually. The data on wood volume harvested also include harvested plantation area with area polygons (with spatial information).
Quality Assurance/Quality Control procedures to be applied:	Fiji Hardwood Corporation Limited will monitor volume harvested internally and Ministry of Forests staff will monitor the volume of wood harvested taking samples. The processes applied are outlined in SOP – Collection and review of activity data from Fiji Hardwood Corporation.

Identification of sources of uncertainty for this parameter	Harvested volume will be census based hence small source of uncertainty and no sampling error. Uncertainty in weighing machine.
Any comments:	

Parameter:	$A_{HW,PL,t}$
Description:	area planted in hardwood plantations in year t
Data unit:	Ha
Value monitored during this Monitoring / Reporting Period	2019 – 4,008 2020 – 0
Source of data and description of measurement/calculation methods and procedures applied:	Fiji Hardwood Corporation Limited provides hardwood area planted with area polygons (with spatial details) annually to the Ministry of Forests.
Quality Assurance/Quality Control procedures to be applied:	Fiji Hardwood Corporation Limited will monitor the area of hardwood harvested internally. The processes applied are outlined in SOP – Collection and review of activity data from Fiji Hardwood Corporation. Management Service Division of Ministry of Forests will also identify the area of hardwood harvested using satellite images.
Identification of sources of uncertainty for this parameter	The area of hardwood is census data hence there is no sampling error. However main source of uncertainty is GPS equipment. GPS is used to calculate the hardwood harvested area.
Any comments:	

9.2 Organizational structure for measurement, monitoring and reporting

In Fiji's institutional hierarchy related to National Forest Monitoring the **authority** lies with the Ministry of Economy Climate Change and International Cooperation Division is the UNFCCC National Focal Point and Designated National Authority for the National Communication (NC) and the biennial update reports (BUR). The MOF is **responsible** for overall management of Fiji's National Forest Management System which enables reporting on information relating to greenhouse gas emissions and removals from forests as well as safeguards and biodiversity. These two Ministries **inform and consult** a range of stakeholders, including the REDD+ Steering Committee, which represents a cross section of civil society and business interests, as well as other government Ministries.

The MOF is mandated to sustainably manage Fiji's forest resources and as such performs the following functions:

- Coordinate and facilitate the implementation of Forest strategies and policies in partnership with Government entities and the industry;
- Monitor and evaluate the current strategies, policies and deliverables;
- Maintain coordination with other ministries;
- Allocate responsibilities of all divisions ensuring that each division has clear leading role for different components of carbon emission and removal reports;
- Develop and monitor a time frame and schedule for the preparation of the reports and Deliverables;
- Identifying constraints and gaps and related financial and technical and capacity needs;
- Developing and overseeing the implementation of a quality assurance and quality control strategy for all reports related to emissions and removals;
- Developing and maintaining systems and archiving data to ensure institutional memory;
- Managing budget for entire activities of monitoring and measurement, reporting and reporting system;
- Documenting systematically all the assumptions, data and method used;
- Conducting evaluations to identify key lesson learned and areas for improvement.

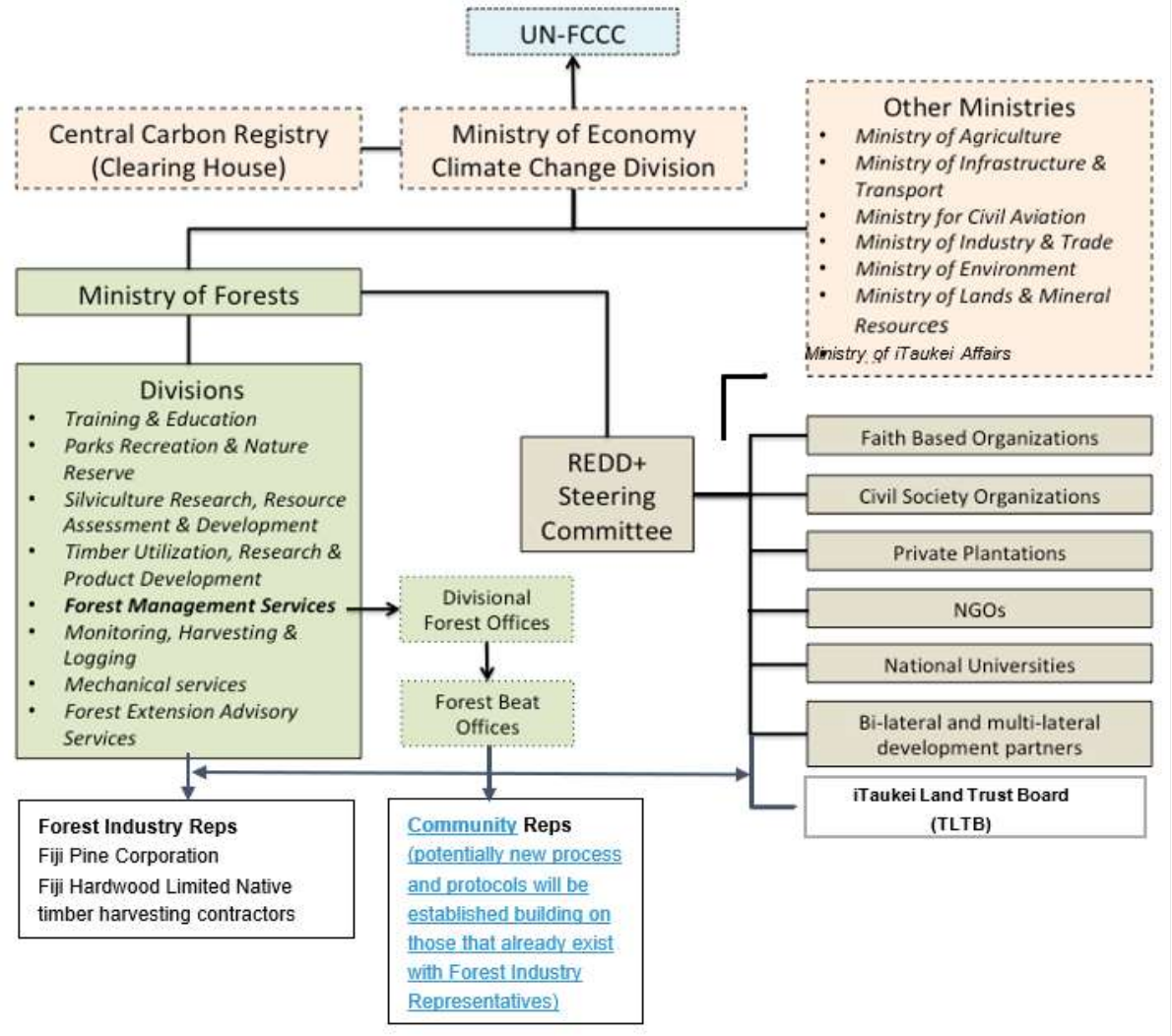


Figure 12: Institutional coordination related to National Forest Monitoring System

The competencies and experiences within the MOF required to carry out regular tasks ensure the staff of the Ministry have the relevant requirements to meet the NFMS needs and responsibility for REDD+ implementation. To meet these obligations the Ministry also collaborates with a range of other stakeholders whose role and responsibilities are outlined in the Table below.

Table 42: Responsibilities of institutions involved with REDD+ implementation

Institutions	New Responsibilities under REDD+	Report to
MOF	• Monitor and Report of GHG emissions and removals by sinks to National Designated Authority (Ministry of Economy)	Ministry of Economy Climate Change and International Cooperation Division

Institutions	New Responsibilities under REDD+	Report to
Silviculture Research, Resource Assessment & Development Division	• Undertaking applied research to develop knowledge and skill to improve the ways in which forest owners manage and use forest resource to meet current and future demand of the expanding population. • Undertake research on silviculture to generate knowledge and technology for sustainable management of forests • Develop guidelines for sustainable forest management • Building capacity of government and community members on sustainable forest management • Develop allometric equations for the major tree species, including Mangrove • Develop yield and growth models for the major forest types and species	Permanent Secretary, MOF
Timber Utilization, Research & Product Development Division	• Carry out research on harvesting and utilization of timber, value added products from timber • Timber seasoning and preservation • Conduct research on utilization of lesser-known species for timber and other uses	Permanent Secretary, MOF
Management Services Division	• Provide Forest Management Information needs and services to the Ministry Forestry (forest areas, standing forest stocking, logged areas & volume**)** • Provide technical support and services to members of the public relating to natural forest management (volume estimate, logging plan maps, forest inventory) • Management of Forest Information System and Database (forest cover change analysis of satellite image & updating information into our database) • Measurement of permanent sample plots • Mapping & surveying of forest boundaries, forest functions & services • Coordination & facilitation of International, regional conventions & agreements on forests • Regulate Quality control and quality assurance of forest monitoring and measurement • Carry out National Forestry Inventory	Permanent Secretary, MOF
Forestry Training Centre	• Carry out capacity building activities related to forest inventory, yield and growth, remote sensing and GIS, land use classification, accuracy and uncertainty assessment	Permanent Secretary, MOF
Divisional Forest Offices	• Carry out pre-harvesting inventory and assessment of logging operation • Monitoring and surveillance of harvesting activities • Participate in community awareness and outreach to NGO and communities in rural areas associated with NGOs • Reporting on forest management activities including logging operation to Forestry Department • Maintaining divisional level database system	Conservator of Forests

Institutions	New Responsibilities under REDD+	Report to
Ministry of Forest		
Divisional Forest Offices	• Carry out pre-harvest inventory and assessment of logging operations • Monitoring and surveillance of harvesting activities • Participate in awareness and outreach to NGOs and communities in rural areas • Report on development activities including, logging operations to Forestry Department • Maintaining division level database system	Conservator of Forests
Communities and Landowner Groups/ Programmes		
Communities	• Provide land for Programme activities • Adopt new land and forest resource management practices • Attend capacity building activities related to REDD+ socialisation and forest monitoring • Collect and report ground data related to monitoring of forest resources and safeguard indicators	Communities (Village/District/ Provincial Council Meeting)
International Development Partners		
SPC Geoscience, Energy & Maritime Division	• Provide technical support particularly on Remote Sensing and GIS to MOF and its sub-ordinate organizations • Provide technical support to estimate activity data using remote sensing techniques • Provide technical support on forest inventory • Carry out capacity building activities related to forest assessment and RS and GIS application	Government of Fiji as a member of the Pacific Community
GIZ	• Provide technical support for forest assessment. • Carry out capacity building activities. • Provide financial support to carry out research and development activities.	Government of Fiji
Conservation International	• Provide technical and financial support to community for afforestation and reforestation • Support to develop livelihood options	Permanent Secretary of Forest

The **Management Services Division (MSD)** under the MOF is responsible for measurement, monitoring and reporting activities including data collection and management and verifying outputs from the National Forest Monitoring System. The structure of MSD is presented in the Figure below, including proposed new units to facilitate the measurement, monitoring and reporting including a new Forest Biometrics section which is responsible for ground data and safeguards and an expanded Remote Sensing and GIS section responsible for mapping and database management. The database unit will also be responsible to support implementation and analysis of data collected using the National Forest Monitoring System.

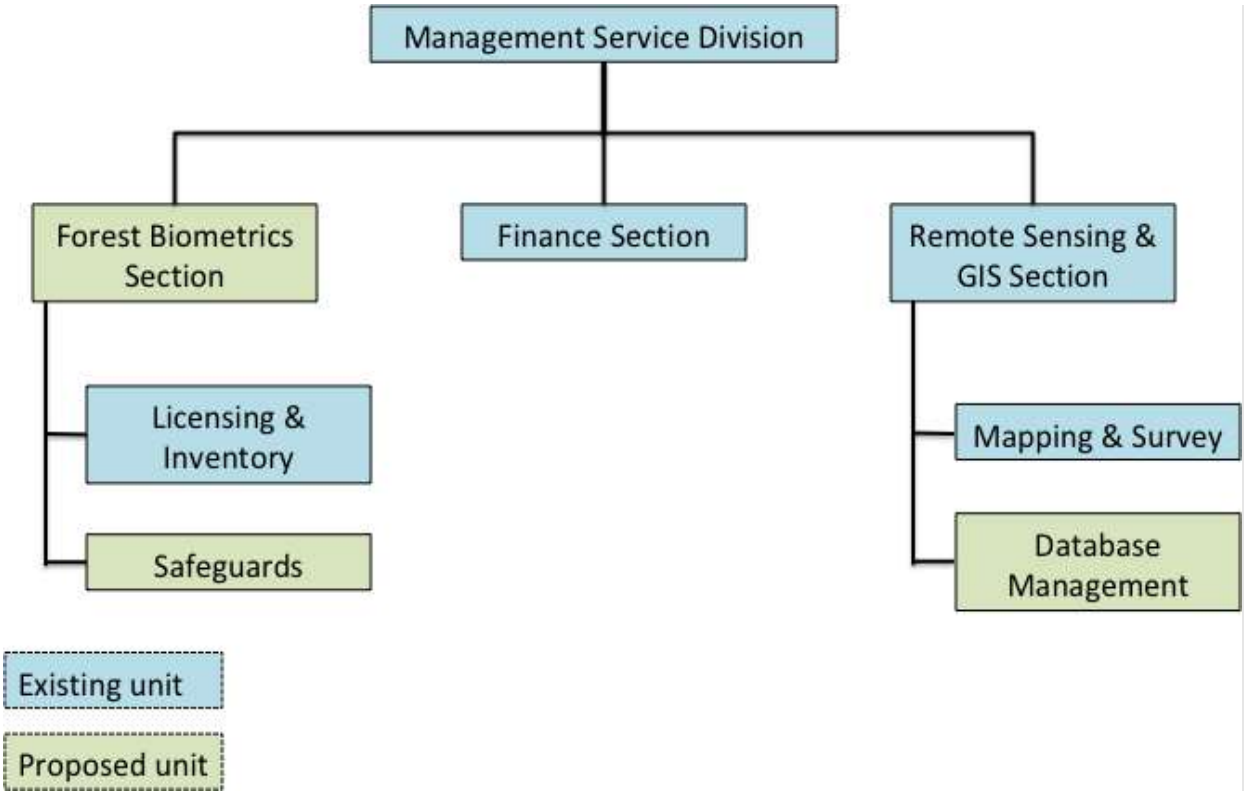


Figure 13: MSD Existing and proposed institutional arrangements

The MOF issue maps of areas to be harvested to native forest and plantation logging companies. The logging companies must log within these areas and are permitted only to extract the volume outlined in the MOF harvest plan. The plantation and native forest extracted volume data is collected from the field by Beat Officers who submit it to their Divisional offices located in the Central/Eastern/Western and Northern Districts. Staff at the Divisional officers are positioned to check the data for completeness before it is submitted to the Management Services Division.

The Ministry of Forestry issues timber harvest permits to logging companies who extract logs. The Ministry monitors if these operations are in accordance with the permit and collect census data on the logs extracted and areas harvested. There is a template for data collection and the data is stored in the Timber Revenue System database. The harvest areas are captured in maps using GPS from the Forest Beat Offices which have historically been submitted to the MSD office every 6 months to determine the total harvested areas. The process has been revised to require 3 monthly submissions of the information. The data collected on timber volumes is subject to QA/QC procedures which the Ministry enforce. More frequent data collection will enable QA/QC checks to be completed more regularly to improve data quality. The process for capturing the harvest area records is represented in the Figure below. The QA/QC process involves MSD staff conducting both desk-based and field-based data checks and staff interviews. Responses to data quality issues, such as additional training requirements are noted and followed up under adaptive management.

It has been identified that the data collection protocols and processes require review and augmentation to accommodate the expanded data needs for REDD+. This will include incorporation of new data suppliers (e.g. communities involved in afforestation/reforestation activities and reporting of fire impact), data completeness, quality requirements and timely delivery of data to meet the reporting requirements. This need has been identified as a high priority in Fiji's REDD+ Improvement Plan which is detailed in Section 9.4 below.

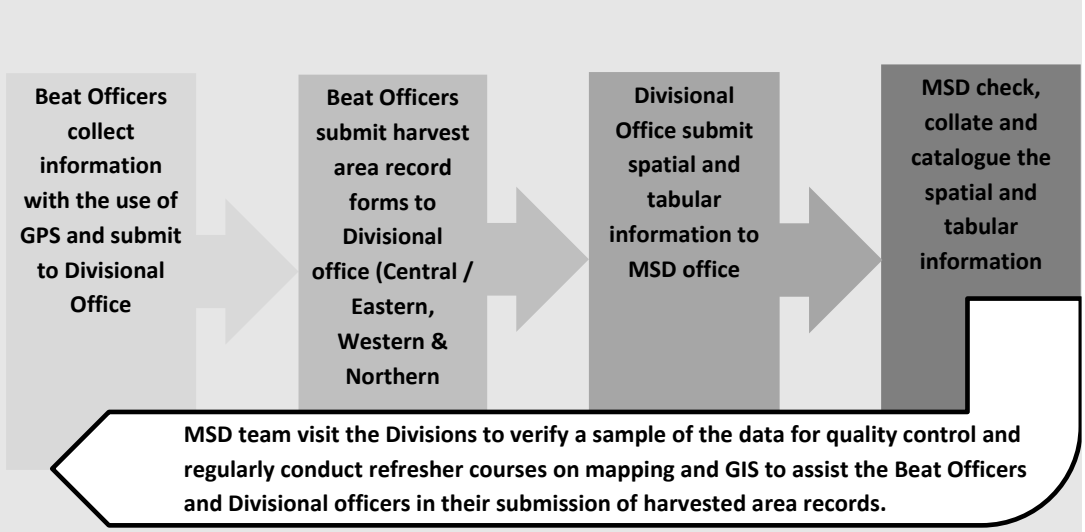


Figure 14: Harvest Area Record Data Collection Process

9.3 Relation and consistency with the National Forest Monitoring System

Fiji aims to develop a multi-purpose National Forest Monitoring System through planning and design that ultimately achieves the following:

- Data generated by the NFMS meets information needs of policymakers and local communities and forest entrepreneurs;
- The NFMS integrates multiple thematic fields such as carbon, biodiversity, policy and measures and non-carbon benefits
- The NFMS supports both national and international reporting commitments

Additionally, Fiji is adopting an open data accessibility and transparency policy that will be achieved through following activities:

- National data generated is made freely made available to those complying with national laws and regulations;
- Data sharing between different institutions and user groups is encouraged and facilitated;
- The NFMS builds on existing (local, national, regional, global) systems and is embedded in (existing) national institutions;
- The NFMS provides data needed to support national policies, policy design and enforcement.

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

12.1 Identification and assessment of sources of uncertainty

Table 43: Identification & Assessments of Sources of Uncertainties

Sources of Uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty
Measurement	Y	Y	The sources of uncertainty associated with the use of satellite imagery include: 1) the quality and suitability of the satellite data in terms of spatial and temporal resolutions, 2) the consistency and quality of radiometric and geometric pre-processing of annual images, 3) the thematic and cartographic standards such as the land cover type and the minimum mapping unit, and 4) the interpretation procedure from either automatic classification of the imagery or the visual

			interpretation, 5) the error for visual interpretation of sampling in the accuracy assessment. This error is reduced by extensive QA/QC procedures by trained staff working together and discussing any classification issues with each other. Additionally, the methodology and processes are documented in a series of standard operating procedures to ensure consistency in the interpretations which are available on Fiji's Forest Information Management System.
Representativeness	Y	N	Annual deforestation maps are used as the basis for stratification, to ensure the sample used to estimate the areas is representative of the area of interest. A probabilistic-based sampling design is applied, where all areas have an inclusion probability larger than zero.
Sampling	N	Y	SRS (Stratified random sampling) method was applied for AD sampling design.
Extrapolation	NA	NA	Estimates of deforestation and reforestation per forest type, based on reference data.
Approach 3	Y	N	IPCC Approach 3 was used to develop spatially disaggregated activity data using annual forest cover maps generated from Landsat imagery.
DBH Measurement	Y	Y	Measurement of DBH and plot delineation are subject to errors. Errors may be caused by multiple factors such as poor training, poor measurement protocols, etc. While measurement errors are significant at the tree level, they usually average out at plot level and inventory level (Chave et al. 2014). Picard et al. (2015) also found the measurement error to be small when compared to the other errors. Indications are that the data used from the 2005 inventory have a high level uncertainty. This is being addressed in the current phase of NFI data collection and associated QA/QC procedures (refer to SOPs on the Fiji's Forest Information System). The high levels of uncertainty in the 2005 data set which was used for this FRL and Monitoring Period are currently propagated using Monte Carlo methods through the estimates. Fiji expect that this source of uncertainty will reduce in the future but the new NFI data will not be available for updating the emission factors generated from NFI field data in this ERPA period.
H Measurement	Y	Y	H parameter is used in the estimation of aboveground biomass stock. This parameter has been shown to be highly uncertainty in the current NFI dataset and is being addressed with training and improved collection methods in the new NFI collection phase ongoing now. The high levels of uncertainty in the 2005 data set which was used for this FRL and Monitoring Period are currently propagated using Monte Carlo methods through the estimates. The residual uncertainty associated with H measurements form the 2005 NFI cannot be addressed in this ERPA period.
Plot delineation	Y	Y	See analysis in column "DBH measurement" above.
Wood density estimation	Y	Y	Wood density is used in the estimation of aboveground biomass stock. Wood density is collected from a range of National and Internationally published data sets. The recording of species information from the NFI pots is considered of low uncertainty as trained local personal record this information. The High uncertainty is associated with the application of published datasets to the Fiji situation. The residual uncertainty associated with wood density values cannot be addressed in this ERPA period.
Allometric model	Y	N	Global allometric equations published by Chave et al 2014 were applied in Fiji. The selection of the equations was discussed with experts from the University of Hamburg who conducted a study into the most appropriate equation to apply. Associated uncertainty is expected to be low, as emission factors remain constant from reference to monitoring period. The Chave allometric equation has not been validated with data from Fiji, which presents a potential a source of bias. The residual uncertainty associated with applying a global allometric model cannot be addressed in this ERPA period.
Sampling	Y	Y	Sampling error relating to emissions factors is the statistical variance of the estimate . This source of error is random and is considered to be high. The estimation of mean and their respective uncertainties (standard error, sampling error, and confidence interval) for the variables of aboveground biomass were estimated form the 2005 forest inventory data. The residual uncertainty associated with the 2005 Inventory data cannot be addressed in this ERPA period.

Other	Y	Y	Other parameters used to estimate emission factors include aboveground biomass in non-forest land, carbon fraction and root-to-shoot ratios. Some of these are sourced from the 2006 IPCC Guidelines and others collected from National research studies or expert judgement. This can lead to both random and systematic errors. The random error of each individual parameter might be low but the aggregated effect might be high. Confidence intervals of all default values are included and propagated in Fiji's Monte Carlo simulations. These confidence intervals have been taken from the IPCC Guidelines for default values and published research papers used for National values. Expert judgement from local sources was used in the absence of peer reviewed publications.
Modelling	Y	Y	The simple linear modelling approach applied leads to the combination of AD & EF. This method is considered to be IPCC Tier 2 given there are national specific emissions factors and activity data applied. In this case the modelling approach itself would be considered appropriate to model the changes in the forest landscape and the uncertainty with the models ability to estimate change is considered low.
Integration	Random / Systematic		This source of uncertainty is related to the lack of comparability between the transition classes of the Activity Data and those of the Emission Factors. In Fiji, Activity Data is estimated from remotely sensed data, whereas Emission Factors for a specific forest type are based on ground-based observations. Fiji has stratified the landscape to maintain consistency with its National forest classes and its National Forest Inventory program. These transition classes and emission factors are considered comparable and as such uncertainty related to integration is considered Low.

12.2 Quantification of uncertainty in Reference Level Setting

Table 44: Parameters and assumptions used in the Monte Carlo method

Parameter included in the model	**Parameter values**	**Range or standard deviations**		**Error sources quantified in the model (e.g. measurement error, model error, etc.)**	**Probability distribution function**	**Source of assumptions made**
		Lower	**Upper**			
$\boldsymbol{R_{wl}}$ dimensionless Root-to-shoot ratio for tropical rainforest	0.37 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	$a = R_{wl} - R_{wl} \times 0.25$	$b = R_{wl} + R_{wl} \times 0.25$	sampling	Triangular	
$\boldsymbol{R_{dll}}$ dimensionless Root-to-shoot ratio for tropical moist deciduous forest < 125 tB ha^{-1}	0.20 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	a = 0.09	b = 0.25	sampling	Triangular	mode c = 0.20; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].
$\boldsymbol{R_{dlh}}$ dimensionless Root-to-shoot ratio for tropical moist deciduous forest > 125	0.24 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	a = 0.22	b = 0.33	sampling	Triangular	mode c = 0.24; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4,

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
tB ha^{-1}						Tab. 4.4].
$\boldsymbol{R_u}$ dimensionless shoot ratio for tropical mountain systems	0.27 Source: IPCC, 2006, Vol. 4; Chap. 4; Tab. 4.4	a = 0.269	b = 0.0.28	sampling	Triangular	c = 0.27; a, b and c were taken from IPCC [2006, Vol. 4, Chap. 4, Tab. 4.4].
$\boldsymbol{BCEF_{AR,I}}$ tB $(m^3)^{-1}$ biomass conversion and expansion factor for volume increments in humid tropical natural forests	1.1 Source: IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level 21-40 m^3 ha^{-1})	$a = BCEF_{AR,} - BCEF_{AR,} \times 0.25$	$b = BCEF_{AR,} + BCEF_{AR,} \times 0.25$	sampling	Triangular	$c = BCEF_{AR,I}$
$\boldsymbol{BCEF_{HW,R}}$ tB $(m^3)^{-1}$ biomass conversion and expansion factor for logging	1.05 Source: IPCC [2006, Vol. 4, Chap.4, Tab. 4.5]; (growing stock level >200 m^3 ha^{-1})	$a = BCEF_{HW} - BCEF_{HW} \times 0.25$	b= $BCEF_{HW,R}$ $BCEF_{HW,R}$ 0.25	sampling	Triangular	$c = BCEF_{HW,R}$
$\boldsymbol{BCEF_{HW,I}}$ tB. $(m^3)^{-1}$ biomass conversion and expansion factor for logging	1.1 Source: IPCC, 2006, Vol.4, Chap. 4, Tab. 4.5; growing stock level 21-40 m^3 ha^{-1})	$a = BCEF_{HW} - BCEF_{HW} \times 0.25$	$b = BCEF_{HW} + BCEF_{HW} \times 0.25$	sampling	Triangular	$c = BCEF_{HW,I}$
$COMF_i$ Dimensionless Combustion factor – proportion of pre-fire fuel biomass consumed)	0.46 Source: (IPCC 2006 Vol. 2, Table 2.6)	a = 50% of mode c	b = 150% of mode c	sampling	Triangular a	
$G_{g,CO2}$ g CO_2 kg^{-1} Dry matter burnt	1580 Source: IPCC 2006 Vol. 4, chapter 2, Table			sampling	Normal	N(μ= $G_{g,CO2;}$ σ^2=902; see Table 2.5 in IPCC, 2006, Vol 4, Chap.

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
	2.5)					2, Tropical Forest).
$G_{g,N2O}$ g N_2O kg^{-1} Dry matter burnt	0.2 Source: (IPCC 2006 Vol. 4, chapter 2, Table 2.5)	a = 50% of mode c	b = 150% of mode c	sampling	Triangular	
$G_{g,CH4}$ g CH_4 kg^{-1} Dry matter burnt	6.8 Source: IPCC 2006 Vol. 4, chapter 2, Table 2.5)	a = 50% of mode c	b = 150% of mode c	sampling	Triangular	
C_{AFTER} tC ha^{-1} C stock in biomass due to the conversion of Natural Forest to grassland	17.11 Source: Rounds [2013]	CI [8.31]	CI[25.96]	measurement and sampling error	Normal	
$C_{BEFORE,Lowland}$ tC ha^{-1} Estimated C stocks stored in AGB and BGB in Lowland Natural Forest	87.86 Source: Appendix A2 - Fiji FRL Report, 2018	CI[84.25]	CI[93.21]	measurement and sampling error	Normal	
$C_{BEFORE,Upland}$ tC ha^{-1} Estimated C stocks stored in AGB and BGB in Upland Natural Forest	71.57 Source: Appendix A2 - Fiji FRL Report, 2018	CI[66.45]	CI[78.58]	measurement and sampling error	Normal	
EM_{FELL} tC $(m^3)^{-1}$ carbon loss from the extracted logs, including logging residues	0.69 Source: Haas [2015]	a = TEF - TEF x 0.25	upper bound b = TEF + TEF x 0.25	measurement and sampling error	Triangular	mode c = TEF
EM_{DAM}	0.15	a = TEF -	upper	measurement	Triangular	mode c =

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
tC $(m^3)^{-1}$ damage to the remaining stand (all killed [snapped and up-rooted] trees 10 cm DBH), crown damage	Source: Haas [2015]	TEF x 0.25	bound b = TEF + TEF x 0.25	and sampling error		TEF
$\boldsymbol{EM_{INFR}}$ tC $(m^3)^{-1}$ infrastructure development (all trees _ 10 cm DBH on logging roads, skid trails and log landings	0.21 Source: Haas [2015]	a = TEF - TEF x 0.25	upper bound b = TEF + TEF x 0.25	measurement and sampling error	Triangular	mode c = TEF
$\boldsymbol{MAIV_{AR}}$ m^3 ha^{-1} yr^{-1} mean annual volume increment for afforestation/reforestation	3.71 Source: Derived from data provided from Fiji Hardwood Corporation Limited	$a = \mathrm{MAIV_{AR}} - \mathrm{MAIV_{AR}} \times 0.5$	$= \mathrm{MAIV_{AR}} + \mathrm{MAIV_{AR}} \times 0.5$	measurement and sampling error	Triangular	mode $c = \mathrm{MAIV_{AR}}$
$\boldsymbol{MAIC_{FD}}$ tC ha^{-1} yr^{-1} mean annual C increment after logging (above ground and belowground)	0.99 Source: Personal Communication Based on measurements from projects within Fiji	$a = \mathrm{MAIC_{FD}} - \mathrm{MAIC_{FD}} \times 0.5$	$b = \mathrm{MAIC_{FD}} + \mathrm{MAIB_{SW}} \times 0.5$	measurement and sampling error	Triangular	mode $c = \mathrm{MAIC_{FD}}$.
$\boldsymbol{\lambda_{Pine}}$ Dimensionless Softwood plantation recovery rate following harvest	0.76 Source: Waterloo [1994]			measurement and sampling error	Normal	$\mu = \lambda_{\mathrm{Pine}}$ and $\sigma^2 = [\lambda_{\mathrm{Pine}} \times 0.1]^2$
$\boldsymbol{\rho_{Pine}}$ g cm^{-1} Pine tree	0.47 Source: Crown			measurement and sampling error	Normal	$\mu = \rho_{\mathrm{Pine}}$ and $\sigma^2 =$

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
wood density	[1981]					0.0031
mean annual increment of above and belowground biomass in softwood plantations	10 Source: Waterloo [1994]	$a = \mathrm{MAIB_{SW}} - \mathrm{MAIB_{SW}} \times 0.25$	b= $\mathrm{MAIB_{SW}} + \mathrm{MAIB_{SW}} \times 0.25$	measurement and sampling error	Triangular	mode $c = \mathrm{MAIB_{SW}}$.
$\boldsymbol{CC_{SW}}$ Yrs. length of the harvest cycle in softwood plantations	20 Source: Personal communication Fiji Pine Limited (FPL) indicated that most pine plantations are harvested around 20 years ranging between 15 to 25 years.	$a = CC_{SW} - 5,$	$b = CC_{SW} + 5$	measurement	Triangular	mode $c = CC_{SW}$
$\overline{\boldsymbol{MAIV}}_{\boldsymbol{HW}}$ m^3 ha^{-1} yr^{-1} Average mean annual increment in Fiji hardwood plantations	5.85 Source: derived from data provided from Fiji Hardwood Corporation Limited	$a = \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$	$b = \overline{\mathrm{MAIV}}_{\mathrm{HW}} - \overline{\mathrm{MAIV}}_{\mathrm{HW}} \times 0.25$	measurement	Triangular	mode $c = \overline{\mathrm{MAIV}}_{\mathrm{HW}}$
$\boldsymbol{EF_{CO}}$	33 Source: USFS research	27	39	Modelling	Normal	
$\widehat{\boldsymbol{A}}_{\boldsymbol{AR,t}}$ hectares Forest area gain	2883 Source: Accuracy assessment conducted following the stratified random sampling methods outlined in	1450	2880	sampling	Sampled using bootstrapping technique	

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
	Olofsson et al (2014)					
$\hat{A}_{DF,Lowland}$ hectares Forest area loss in the strata Lowland Natural Forest	1459 Source: Accuracy assessment conducted following the stratified random sampling methods outlined in Olofsson et al (2014)	1093	1855	sampling	Sampled using bootstrapping technique	
$\widehat{\boldsymbol{A}}_{\boldsymbol{DF,Upland}}$ Hectares Forest area loss in the strata Upland Natural Forest	79 Source: Accuracy assessment conducted following the stratified random sampling methods outlined in Olofsson et al (2014)	32	159	sampling	Sampled using bootstrapping technique	
$\boldsymbol{AD}_{\boldsymbol{FRLNFF}}$	875 Source: Accuracy assessment conducted following the stratified random sampling methods outlined in Olofsson et al (2014)	393	1357	sampling	Normal	

Table 45: Quantification of the uncertainty of the estimate of the Reference level

		Deforestation	Forest degradation	Enhancement of carbon stocks
A	**Median**	394,121	456,557	958,151
B	**Upper bound 90% CI** (Percentile 0.95)	501,547	544,840	1,236,016
C	**Lower bound 90% CI** (Percentile 0.05)	277,648	370,540	682,542
D	**Half Width Confidence Interval at 90% (B – C / 2)**	111,950	87,150	276,737
E	**Relative margin (D / A)**	0.28	0.19	0.29
F	**Uncertainty discount**	4%	4%	4%