Malawi's Second National REDD+ Forest Reference Level

August 2024

REPUBLIC OF MALAWI

The Ministry of Natural Resources and Climate Change

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EQUATIONS

LIST OF ACRONYMS

Acronym	Full Name
A/R	Afforestation / Reforestation
AD	Activity Data
AFOLU	Agriculture, Forestry, and Other Land Use
AGB	Aboveground Biomass
AT	Assessment Team
BGB	Belowground Biomass
CDM	Clean Development Mechanism
CI	Confidence Interval
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CoP	Conference of Parties
CSA	Climate-Smart Agriculture
DBH	Diameter at Breast Height
DoF	Department of Forestry
DW	Dead Wood
EAD	Environmental Affairs Department
EF	Emission Factor
FOPA	Forests Outside of Protected Areas
f_{NRB}	Fraction of Non-Renewable Biomass
FRL	Forest Reference Level
GHG	Greenhouse Gas
GHG-IS	Greenhouse Gas Inventory System
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land-use change, and forestry
MCHF	Modern Cooking for Healthy Forests
MRV	Monitoring, Reporting, and Verification
NCCMP	National Climate Change Management Policy
NDC	Nationally Determined Contribution
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NGO	Nongovernmental Organization
PERFORM	Protecting Ecosystems and Restoring Forests in Malawi
PES	Payment for Ecosystem Services
PPP	Public-Private Partnership
QA/QC	Quality Assurance and Quality Control
REDD+	Reducing emissions from deforestation and forest degradation, and the role of conservation of forest carbon stocks, sustainable management of forests and enhancement of carbon stocks
REL	Reference Emissions Level
RL	Reference Level
SE	Standard Error
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
tCO_2e	Tons of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WISDOM	Wood fuels Integrated Supply/Demand Overview Mapping

1. INTRODUCTION

In recognition of Decision 1/CP.16 adopted at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) in 2010, identifying national Reference Emissions Levels (REL)/Reference Levels (RL) is an essential prerequisite for Parties aiming to undertake activities under the Reducing Emissions for Deforestation and Forest Degradation (REDD+) program. This document serves as a second Malawi National Forest Reference Level (FRL) submission to the UNFCCC. Carefully adhering to existing guidance set forth by the UNFCCC and recognizing established precedents, the report explains in full detail Malawi's proposed FRL, including the historical time period it represents, the activities included, the methodologies applied for deriving the estimates, and key assumptions and rationalizations that underpin decisions made in the development of Malawi's FRL.

The Department of Forestry (DoF) and academic partners developed the initial Malawi FRL in 2018-2019 and the Environmental Affairs Department (EAD) submitted the FRL to the UNFCCC in 2019. The UNFCCC conducted a Technical Assessment between 2020-2021, resulting in a series of recommendations to strengthen Malawi's FRL**.** As a result of the facilitative process during the technical assessment, the DoF has modified the submission. Major improvements include a refined approach to account for degradation and replacing the Wood fuels Integrated Supply/Demand Overview Mapping (WISDOM) model with a more simple and transparent method designed for long-term sustainability (Drigo 2019). The scope of the FRL also broadened from a subnational to a national scale; extended forest inventory beyond forested areas; and incorporated improved sampling techniques, including stratification. To bolster assessment of activity data generation and enhance visual interpretation accuracy, Malawi adopted Collect Earth based on recommendations from the technical assistance team.

For this submission, the DoF developed a national FRL that adopts a stepwise approach and is the sum of the expected emissions and removal associated with deforestation, forest degradation, and enhancements. For deforestation, estimates of historical emissions were 1,008,600 tons of carbon dioxide equivalent (tCO2e) of greenhouse gas emissions (GHG) annually on average for the 2010-2020 reference period. For degradation, estimated historical emissions were 543,511 tCO2e annually on average for the same reference period (2010-2020). For enhancements driven by plantation management, estimated removals were 61,070 tCO2e annually on average for the reference period. The combined RL for these three REDD+ activities is 1,491,041 tCO2e y-1. Regarding GHGs, the submission includes only CO_2. The FRL does not include non-CO_2 emissions (e.g., those resulting from fires).

For constructing its FRL, the DoF used the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines as the basis for estimated carbon stock changes and emissions. The DoF used a visual interpretation of satellite imagery available on Collect Earth to estimate deforestation and degradation extent nationally. Using a simple random sampling approach, 6,000 sample plots covering an area of 24,590 km^2 or 1 plot per 5 km^2 ha were randomly generated. The DoF assessed deforestation by examining the proportion of plots exhibiting forest loss between 2010 and 2020.

The DoF estimated the emissions factor by calculating the difference in carbon stocks before and after conversion. For the carbon stocks before conversion, the average forest carbon stock for the above-ground biomass pool was based on a combination of sample plot measurements from five National Forest Inventory (NFI) campaigns undertaken since 2018 throughout the country. This FRL includes all carbon pools (i.e., above-ground and below-ground biomass, deadwood, litter, and soil organic carbon [SOC]) from the activity reducing emissions from deforestation.

The DoF defines forest degradation as a reduction in biomass or disturbance within a naturally occurring forest that remains a forest after the disturbance and measures it as a change in canopy closure between four canopy closure classes. Similar to the deforestation method, the DoF calculated activity data following the same Collect Earth sampling-based technique and estimated the emissions factor by calculating the difference in carbon stocks before and after degradation (change in canopy closure). Under the degradation activity, measurements include only the aboveground and below ground carbon pools, as deadwood and litter pools would be insignificant due to anthropogenic pressures.

The DoF estimated carbon removals from timber plantations and tobacco plantations for 2010–2020 based on growth factors of the specific tree species planted, and not measured growth values. This FRL uses the number of hectares planted with specific species provided by plantation managers. The FRL derives removal factors from the global removals database and the growth curves for the three groups of species planted. For the enhancement of carbon stocks, the FRL includes only the above ground and below ground biomass pools, other biomass pools such as deadwood and litter are not significant due to the management procedures of the plantations.

This document also explains the role of Malawi's National Forest Monitoring System (NFMS), a system tasked with the responsibility of tracking and regularly reporting GHG emissions and removals from REDD+ activities, ensuring that accounting methods and procedures are compliant with IPCC principles of transparency, consistency, comparability, completeness, and accuracy. As a party to the UNFCCC and signatory to the Kyoto protocol, Malawi committed to monitoring levels of national GHG emissions and carbon sinking capacity, as well as implementing various climate change-related activities.

Malawi has submitted three national communications and its first Biennial Transparency Report, and is currently working toward its fourth national communication. Starting in 2015, Malawi submitted its first Intended Nationally Determined Contribution (INDC) to the UNFCCC, outlining planned efforts for redirecting the country's emissions trajectory in support of the UNFCCC Paris Agreement to keep global surface temperature from rising more than 1.5°C. Malawi's updated Nationally Determined Contributions NDCs for 2021 articulate areas of priority for both mitigation and adaptation in sectors such as agriculture, energy, industrial processes, and waste management. The estimated indicative emission reduction for Malawi in these updated 2021 NDCs is at 59.8 million tCO2e of reductions by 2040, through a range of AFOLU interventions covering an area of up to two million hectares.

Malawi established the Malawi REDD+ Program in 2012 and has made tremendous progress, including the development and endorsement of the Government of Malawi REDD+ Action Plan 2014

-2019. The REDD+ Action Plan defined a stepwise approach to achieving the REDD+ readiness phase. Malawi has made progress on all four REDD+ pillars: the NFMS, the FRL, the Safeguard Information System, and the National REDD+ Strategy developed in 2020 (GoM 2020a). The REDD+ Strategy identifies agriculture, forestry, and land use (AFOLU) and energy sectors as the country's largest sources of GHG emissions. Also cited as major drivers of these emissions were unsustainable fuelwood and charcoal use, along with poor agricultural practices leading to high deforestation and degradation rates. Consequently, the country plans to implement mitigation measures that directly target these activities. Efforts include the promotion and introduction of alternative renewable energy sources, more efficient cookstoves, promotion of sustainable forest management practices, and afforestation and reforestation (including woodlots). Malawi's NDCs and the REDD+ Strategy point toward the establishment of a Malawi REDD+ Program as the principal mechanism for lowering emissions in the forestry and other land use sector, in accordance with the Government of Malawi's REDD+ Action Plan.

The organization of this second FRL document offers a comprehensive overview. Section 2 reviews the revised approach, technical improvements made since the first FRL submission, and current national circumstances. Section 3 covers the scope of activities, forest definitions, scale, pools and gases, and historical time periods, establishing the groundwork for understanding the calculations. Section 4 provides an overview of the NFMS, detailing the methodologies and technologies used for accurate data collection. Sections 5 through 7 focus on emissions estimation, a summary of FRL, and uncertainties of the FRL calculations.

1.1 THE MALAWI CONTEXT

Malawi is a landlocked country located in Southern Africa that shares borders with Zambia, Tanzania, and Mozambique and covers 94,080 square kilometers of land area. Approximately 25% of the total area of Malawi is forested land, defined as 0.5 hectares area of trees that are greater than 5m in height with 10% canopy coverage (Malawi Department of Forestry 2017). The forest resources of Malawi are classified into (i) natural woodland, (ii) forestry plantations, and (iii) woodlots. The natural woodland comprises forest reserves (8,076 km^2), national parks and game reserves (9,680 km^2), and customary forests (8,843 km^2), totaling 26,428 km^2 of forest land (GoM 2011). Malawi's natural woodland boasts 88 forest reserves, 5 national parks, 4 wildlife reserves, and 3 nature sanctuaries, with natural forests also interspersed within private and community lands.

Malawi has a tropical climate, with temperatures ranging from 18-19°C in June, July, August, and rising to 22-27°C between September and January. Rainfall is mostly prevalent from November to February but can extend through April (GoM 2020a). Malawi primarily has four major soil categories: latosols (Chromic Luvisols), calcimorphic soils, hydromorphic soils (Haplic Lixisols), and lithosols (Eutric Leptosols) (Malunga 2022).

Rain-fed agriculture forms the foundation of Malawi's economy, making the country highly susceptible to risks associated with climate change. The increased intensity and frequency of drought events has devastated much of the country's economy, including the forestry sector, reducing biomass productivity in plantations, as well as increasing the incidences of forest fires (GoM

2011). In addition, forest resources in Malawi have been dwindling in quality and quantity for decades as more than 97% of households in Malawi rely on illegally and unsustainably sourced biomass (charcoal and firewood) for domestic cooking and heating energy (GoM 2017).

By 2030, the population of Malawi is expected to be 30 million, which will further strain the already limited capacity of agricultural land, water availability, hydropower-generating capacity, and biodiversity (Thiruvengadam 2019). The population's vulnerability to climate change will continue to increase as fuelwood and other natural resource demand increases.

2. APPLICATION OF UNFCCC MODALITIES TO MALAWI'S REFERENCE LEVEL

Malawi welcomes the opportunity to submit a modified proposed FRL to the UNFCCC in response to Decision 1/CP.16 that requests developing country Parties intending to undertake REDD+ activities develop a national FRL.

Guided by decisions made at the UNFCCC COP, particularly decision 12/CP.17 and its Annex, Malawi outlines the establishment of FRLs as benchmarks for performance evaluation herein. These guidelines emphasize transparency in their creation, considering historical data and adapting to national circumstances as per COP decisions. Recognizing that many nations may lack the capacity or comprehensive data to quantify emissions and carbon removals from all potential REDD+ activities, the UNFCCC guidance allows for a "stepwise approach." This approach permits Parties to progressively refine FRLs by integrating improved data, methodologies, and additional carbon pools over time. This revised submission incorporates such enhancements over the initial FRL. Proposal FRLs are expressed in units of tons of CO_2 equivalent (CO_2e) per year, representing emissions over the historical time period selected. Parties must maintain consistency with a country's GHG inventory (according to 12/CP.17, Paragraph 8[1]). In response to the guidelines for submissions of information on FRLs provided in UNFCCC Decision 12/CP.17, a summary of Malawi's decisions on these modalities is given in Table 1.

Table 1. Malawi's proposed approach on components of UNFCCC Decision 12/CP.17

Reference to Guidelines	Description	Malawi's Proposal
Text Decision 12/CP.17 Paragraph 10	Allows for a stepwise approach	Emissions from forest degradation caused by fire and logging have not been included in Malawi's RL as they do not present an opportunity for emission reductions in Malawi at this time. Malawi's forests are naturally fire-adapted ecosystems. Nevertheless, as new technologies and approaches emerge, Malawi will continue to seek opportunities to make its RL more complete by including this activity.
Decision 12/CP.17 Annex, paragraph (c)	Pools and gases included	**Pools:** Deforestation: • Aboveground biomass is the most significant pool for forests in Malawi. • Belowground biomass is significant. • Litter included for completeness. • Deadwood included for completeness. • Soil is a significant pool. Degradation • Aboveground biomass is the most significant pool for forests in Malawi.

[1] https://unfccc.int/resource/docs/2011/cop17/eng/09a02.pdf

Reference to Guidelines	Description	Malawi's Proposal
		• Belowground biomass is significant. Enhancements • Aboveground biomass is the most significant pool for forests in Malawi. • Belowground biomass is significant. • Other carbon pools not significant in plantations for the first 30-60 years. **Gases:** • CO_2 always accounted for emissions and removals.
Decision 12/CP.17 Annex, paragraph (c)	Activities included	• Deforestation • Forest degradation as observed in change in forest canopy over time. • Carbon stock enhancements from planted forests are included (timber and fuelwood plantations on customary lands managed by both the public and the private sector, including the tobacco and tea estates).
Decision 12/CP.17 Annex, paragraph (d)	Definition of forest used is same as that used in national GHG inventory	• 10% canopy cover • Minimum height of 5 meters • Minimum area of 0.5 hectares
Decision 12/CP.17 Annex	The information should be guided by the most recent IPCC guidance and guidelines.	GHG estimates were developed integrating 2006 IPCC Guidelines, Vol. 4 (AFOLU).
Decision 12/CP. 17 II. Paragraph 9	To submit information and rationale on the development of forest FRLs/FRELs, including details of national circumstances and on how the national circumstances were considered.	Forest degradation and deforestation pose a significant threat to Malawi because forests provide a wide range of products and services that are central to Malawi's development and the well-being of our people. Deforestation has been a major contributor to climate change through CO_2 emissions in Malawi. Therefore, Malawi will be a net emitter of CO_2 if it fails to halt deforestation and forest degradation, particularly by addressing the energy challenges which contribute to these issues. Additionally, recent significant extraction from Malawi's plantations has worsened the shrinkage of the country's carbon sink, making forest enhancement an essential strategy to prevent Malawi from becoming a net CO_2 emitter. As a result, Malawi has embraced REDD+ as a key component of its national development strategy. Once effectively implemented, its REDD+ program will serve as an important pathway for the country to maintain the ecological integrity of its forest cover, while contributing to national efforts aimed at mitigating climate change. This FRL for Malawi will therefore provide the baseline that will enable a robust assessment of Malawi's efforts toward addressing emissions from the forestry sector.

2.1 Technical Improvement Beyond the First FRL Submission

Malawi's updated FRL submission features several technical improvements compared to the original reference level submitted in 2018. These include an updated reference period from 2010-2020, an expanded scale of the FRL, and a more transparent approach for degradation monitoring, which complements the image interpretation approach applied for deforestation monitoring. Based on recommendations from the technical assessment team, Malawi expanded the scale of national monitoring for deforestation and degradation, as well as forest inventory, to include forests outside of the protected areas excluded in the previous FRL submission. Additionally, the DoF used Collect Earth software to facilitate image interpretation rather than Google Earth. Collect Earth software offers a streamlined approach to interpreting images with an easy to fill in form and built-in quality assurance and quality control (QA/QC) safeguards. Table 2 summarizes the technical specifications in each FRL submission. The details of each technical assessment response can be found in Annex 2. The DoF has committed to continually updating the FRL estimates employing the stepwise approach to improvements based on feedback from the UNFCCC.

Table 2. Technical specifications of Malawi's FRLs

	First FRL Submission	**Second FRL Submission**
Reference Period†	2006-2016	2010-2020
Scale†	Sub-national[2]	National
Scope of pools	AGB, BGB, DW, L, SOC	AGB, BGB, DW, L, SOC
Scope of gases	CO_2	CO_2
Scope of REDD+ activities	Deforestation, Degradation, and Enhancement	Deforestation, Degradation, and Enhancement
Forest definition	Crown cover > 10%; area > 0.5 ha; tree height >5m	Crown cover > 10%; area > 0.5 ha; tree height >5m
Key source of activity data †	Image interpretation of point sampling for deforestation assessment, WISDOM analysis for forest degradation, and reporting from plantation managers for forest enhancement assessment.	Image interpretation of point sampling for both deforestation and forest degradation assessment. Reporting from plantation managers for forest enhancement assessment.
Key source of emission factors†	NFI data from multiple inventories from 2011 to 2018, IPCC guidelines	NFI data from 2016- 2023, IPCC guidelines
Uncertainly analysis	Covers activity data and emission estimates	Covers activity data and emission estimates

† Technical parameters which were updated in the second FRL submission

[2] The intention of the first submission was to produce a national FRL. However, based on review from the Technical Assessment team the scale of the FRL was found to be sub-national. See paragraph 39 of the Technical Assessment Report 2020.

The first FRL submission in 2019 estimated a total of 1,236,631 tons of carbon dioxide equivalent (tCO2e) of greenhouse gas emissions per year using the earth observation method described below. Forest degradation modelled for 2016 and 2021 using the WISDOM model estimated 2,991,058 tCO2e in 2016 rising to 4,645,844 tCO2e by 2021. Enhancements driven by plantation management resulted in annual removals of 57,964 tCO2e according to the estimates in the first submission.

2.2 National Circumstances:

Malawi has adopted several policy instruments to manage climate change and abate climate shocks. While success cannot be attributed to specific policies, some of the key policy instruments that Malawi has developed are the Malawi Vision 2063 (2020), the National Climate Change Policy (2016), the National REDD+ Strategy (2020a), Malawi NDCs (2021), National Forestry Policy (2016), National Charcoal Strategy (2017) and the National Forest Landscape Restoration Strategy (2017). Each of these key policy strategies is described in Table 3.

Table 3. Malawi Policies in Relation to Climate Change Management

Policy Instrument/ Strategy	Description
Malawi 2063 (2020b)	Vision and development goals for Malawi by 2063. Enabler 7 of the Malawi 2063 Implementation Plan focuses on environmental sustainability, with the specific objective of promoting sustainable development within a clean, secure environment. This Enabler focuses on the following areas: • **Ecosystem conservation and environmental management:** Ecosystem-based approaches in managing the environment with harmonized legislation. • **Waste management and green economy:** Adequate waste disposal, treatment and recycling, air and water pollution management, and prudent water resource management. • **Climate change management:** Mitigation of GHG emissions and adaptation to the impacts of climate change. • **Environment and climate change financing:** Coordinated and innovative financing mechanisms toward climate change, conservation, adaptation, and mitigation measures. • **Natural disasters and climate adversities preparedness:** Disaster preparedness, response, and recovery.
National Climate Change Management Policy (NCCMP) (2016)	• The major areas of interventions encapsulated in the NCCMP include climate change adaptation and mitigation focal areas, as well as waste management. • Priorities of **adaptation** include Payment for Ecosystem Services (PES); REDD+; Clean Development Mechanisms (CDM); biodiversity improvement; climate-smart agriculture (CSA); reduced dependence on wood fuel and biomass. • Priorities of **mitigation** include afforestation; reduced dependence on biomass; sustainable extraction; promotion of renewable energy; REDD+; CSA; energy-saving technology; carbon emission trading schemes; PES. • Priorities of **waste management** include promoting: i) development of policy and infrastructure; ii) adoption of practices and technologies for waste reduction, reuse, recycle, and retrieve; iii) public-private partnerships (PPP) in waste management and disposal, as well as enhancing data collection, analysis, and monitoring of emissions arising from domestic waste to reduces GHGs and improve health.

Policy Instrument/ Strategy	Description
Malawi's NDCs (2021)	Malawi's NDCs outline aspirations to attain a low-carbon resilient development pathway, prioritizing energy, agriculture, forestry, and waste sectors. Malawi's adaptation contribution prioritizes three main objectives: • Promote an enabling environment to facilitate Climate Change Adaptation mainstreaming. • Improve capacity for data and information management and sharing, and access to technology and financing for adaptation. • Plan and implement adaptation actions toward an increased resilience of the most vulnerable Malawians.
National REDD+ Strategy (2020)	Under its REDD+ program, the Government of Malawi is seeking to maximize potential emission reductions by implementing targeted measures and activities that will lower net emissions by: 1. lowering rates of deforestation, 2. lowering rates of forest degradation from unsustainable fuelwood harvesting, and 3. enhancing carbon stocks through afforestation and reforestation. To better evaluate and curb emissions from these activities and maximize potential emission reductions, an activity-based monitoring, reporting and verification (MRV) system has been established whereby each REDD+ activity is tracked and measured separately.
National Forestry Policy (2016)	The goal of the National Forest Policy is to improve provision of forest goods and services to contribute toward sustainable development of Malawi through protection and conservation of forest resources. The policy aspires to control deforestation and forest degradation. The policy promotes strategies that will contribute to increased forest cover and sustainable management of existing forest resources. The National Forest Policy takes a holistic approach to sustainable forest management. It adequately addresses issues of forests and water, climate change, food security, HIV and AIDS, gender and equity, wealth creation, biodiversity and PES, REDD+, and CDM. The National Forest Policy recognizes among others the importance of creating an enabling environment for participation of all stakeholders including public, private, civil society, nongovernmental organizations (NGOs), communities, and academia in collaboration with international community in the management of forest resources.
National Charcoal Strategy (NCS) (2017)	The NCS provides a guided framework to address problems of increased deforestation and increased demand of household cooking fuel. The strategy is aimed at setting Malawi on a path toward a diversified, sustainable and regulated household energy sector; while reducing deforestation and the associated impacts on rural livelihoods and the national economy. The NCS is organized around seven inter-related pillars: • Pillar 1: Promote Alternative Household Cooking Fuels; • Pillar 2: Promote Adoption of Fuel-Efficient Cookstove Technologies; • Pillar 3: Promote Sustainable Wood Production; • Pillar 4: Strengthen Law Enforcement; • Pillar 5: Regulate Sustainable Charcoal Production; • Pillar 6: Enhance Livelihoods; and • Pillar 7: Promote Information, Awareness and Behavior Change Communications.
National Forest Landscape Restoration Strategy (2017)	The National Forest Landscape Restoration Strategy outlines a series of activities designed to restore ecological functionality, and the attendant benefits to livelihoods, health, and water supply, to 4.5 million hectares of land. The Strategy outlines five "specific restoration objectives:"

Policy Instrument/ Strategy	Description
	• Sustainable agriculture and increasing tree cover on marginal agricultural lands, • Community forestry, • Improved management of natural and plantation forests, • Soil and water conservation, and • River and stream bank restoration.
National Resilience Strategy 2018-2030 (2017)	The National Resilience Strategy has four pillars that focus on resilience in agriculture, communities, and ecosystems, as well as cross-cutting disaster risk mitigation and response. The resilient ecosystem pillar employs the theme of *Catchment Protection and Management* to target five strategic priorities: • Integrated Watershed Management; • Land and Forest Management, Restoration, and Conservation; • Payment for Ecosystem Services; • Forest-Based Enterprises; and • Sustainable Energy.

3. RATIONALE AND JUSTIFICATION OF MALAWI'S DECISIONS FOR THE FOREST REFERENCE LEVEL

3.1 Scope of Activities

The most significant drivers of deforestation and forest degradation in Malawi are the expansion of agriculture and settlements and unsustainable fuelwood extraction (GoM, 2016). Under its REDD+ program (2012-2019), the Government of Malawi agreed to maximize potential emission reductions by implementing targeted measures and activities that will lower net emissions by (1) lowering rates of **deforestation**, (2) lowering rates of **forest degradation** from unsustainable fuelwood harvesting, and (3) **enhancing carbon stocks** through afforestation and reforestation. Each REDD+ activity and its justification of inclusion or exclusion is described below.

Activities included:

- **Reducing Emissions from Deforestation:** Deforestation is defined as the conversion of forest to non-forest land uses across all management systems, both protected and non-protected. Deforestation does not include plantation forests and their associated carbon emissions.
- **Reducing Emissions from Forest Degradation**: Degradation accounting has been modified in this FRL submission and is considered an improvement on the previous submission in terms of transparency. The definition of degradation is a reduction in canopy class to another of lower canopy coverage while maintaining a minimum canopy cover of 10%, as per the definition of forests.
- **Forest Enhancements:** This is defined as the activities on plantation forest areas that increase carbon stocks within both public and private plantations.

Activities excluded:

- **Sustainable Management of Forests**: The conversion of non-planted forest areas to planted forest area is not included as a separate activity within this FRL. The carbon enhancements from sustainable forest management and associated removals from plantations forests are considered under the forest enhancements activity. Additionally, this is beyond the operational capacity of the DoF. In the event that non-planted forest areas are expanded throughout the country, this activity can be included in future monitoring.
- **Conservation of Carbon Stocks**: This refers to conservation activities that reduce emissions from deforestation and degradation in naturally occurring forests. This activity is not included because it not fully defined or distinguished within the forestry sector of Malawi. As conservation activities in natural forests expand, this activity can be included in the future.

To better evaluate the impact measures to curb emissions from the included activities and maximize potential emission reductions, an activity-based MRV system has been established. This system tracks and measures each REDD+ activity separately.

While unsustainable extraction of fuelwood is not the only driver of human-induced forest degradation in Malawi, the Malawi REDD+ program considers it to be the most significant driver and the greatest opportunity to lower emissions. Fire is also likely a driver of forest degradation in some contexts, as it is sometimes used to clear land in customary landscape management activities, including hunting, pasture management, and land preparation for agriculture. At present, there is no approach available to reliably differentiate between fires driven by anthropogenic activities and those that occur naturally in Malawi. Fire is integral to Malawi’s natural forests and woodlands and is utilized in traditional landscape management practices. While opportunities to mitigate emissions from fire are limited, image interpretation of point sampling can help map forest degradation, enabling accurate assessments of carbon stock losses resulting from chronic forest fire degradation, if present.

Similarly, forest degradation from commercial timber extraction has been omitted, as it is not considered a significant cause of degradation based on the commercial timber extraction practices in Malawi. Degradation resulting from the illegal selective logging on plantations is not currently monitored but will be an area of future improvement when the DoF has the increased capacity to monitor such activities. The overwhelming majority of biomass extracted from natural forests in Malawi is used for heating and energy (Kerr 2005, Mauambeta 2010).

3.2 Forest Definition

Forests are defined as land with woody vegetation (i.e., trees defined as a woody perennial plant with a single well-defined stem, a more or less defined crown, and includes palms, shrubs, bamboos, saplings and re-shoots of all ages and of all kinds and any part thereof) (Malawi Department of Forestry 2017). For national mapping, woody vegetation should be the dominant class in a minimum mapping area of 0.5 hectare. For all mapping purposes, woody vegetation must have a minimum crown closure of 10% and a potential height of 5 meters at maturity. For multiple time series data, an area of land that has the potential for woody vegetation in situ to exceed the minimum height of 5m at maturity should be considered as forest.

The Malawi forest definition excludes all trees, whether timber and non-timber, grown on cropland, where the tree cover does not meet the forest criteria, as well as windbreaks, shelter belts, and roadside plantings less than 30 m in width.

The definition of forest in Malawi was adapted from international guidelines, including the FAO (Global Land Cover Network land cover classification system), the IPCC (2003), and the UNFCCC (2006). The definition also reflects the National Land Use and Land Cover Classification System. The definition was intended for natural resource management and biodiversity related applications, as well as a practical definition for all forest users and managers.

Malawi also adopts the IPCC definition of forestland which *“includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category."* According to this definition, Malawi considers agroforestry systems (where the shade trees meet the forest definition criteria) and early-stage forest plantations (such as 1–3-year-old teak plantations that have not yet reached the forest definition thresholds) as forests (Malawi Department of Forestry 2017).

3.3 Scale

Malawi's REDD+ program is being developed at the national scale. The first proposed FRL submitted in 2019 was intended to be national but found to be subnational. The scale differed for each activity. The deforestation activity was measured over a limited sampling frame covering 20% of the country. The degradation activity was modeled nationally and removals from the enhancement activity was quantified in GoM plantations. As an improvement to the first FRL submission, forests outside of protected areas (FOPA)—predominantly less dense forests—have been included, ensuring a representative national scale assessment for the deforestation and degradation activities. Collection of enhancement data was done on both public and private lands including tobacco and tea estates. A national REDD+ program is appropriate for Malawi due to its largely centralized government structure and the country's relatively small size.

3.4 Pools and Gases

3.4.1 Pools

All significant[3] pools and sinks for all REDD+ activities under Malawi's REDD+ program have been incorporated in the RL. For deforestation, the only omitted carbon pool was harvested wood products because, as noted above, extracted timber remaining as harvested wood products is primarily sourced from plantations in Malawi, rather than natural forests. For emissions from forest degradation, aboveground biomass and below ground biomass pools are included. It is assumed that deadwood and litter pools would be insignificant due to anthropogenic pressures. For carbon stock enhancement, only above ground and below ground biomass pools are included as the other pools are not considered a significant source of additional removals (Pearson et al. 2005).

Table 4. List of carbon pools included in each activity of Malawi's Forest Reference Level

Activity	Aboveground Biomass (AGB)	Belowground Biomass (BGB)	Dead Wood (DW)	Litter (L)	Soil Organic Carbon (SOC)
Deforestation	✓	✓	✓	✓	✓
Degradation	✓	✓			
Carbon stock enhancements	✓	✓			

3.4.2 Gases

This FRL focuses on CO_2. Emissions from nitrous oxide (N_2O) and methane (CH_4) were excluded, as these gases are only significant when fire is a significant driver of deforestation and degradation.

3 Defined as >10% of total forest-related emissions in the accounting area.

Since fire has been omitted from Malawi's RL, these gases are not included (see Scope of Activities section above for justification).

3.5 HISTORICAL TIME PERIOD

The time period selected for evaluating historical emissions should be representative of what future emissions are expected in the absence of a REDD+ program, although data availability can be a limiting factor in some cases. The historical period for Malawi's national REDD+ RL is the 10-year period starting in 2010 and ending in 2020. This historical period was selected as the most recent period for which remote sensing imagery and inventory data was readily available.

4. MALAWI’S FOREST MONITORING SYSTEM

Malawi is currently in the process of developing its National Forest Monitoring System (NFMS). Since 2016, the country has made noteworthy progress in completing a ground-based biomass survey, trialing a satellite-based land monitoring system and developing a national GHG accounting system. The monitoring components have only been applied in a historical observation context, but they form the basis for formalizing a more regularized NFMS.

The DoF has launched a National Forest Monitoring Unit which has the specific charter to continually monitor the natural and plantation forests within Malawi. Regarding the ground-based carbon inventory, the DoF has led several forest inventories since 2010 (2011, 2012, 2016, 2018, 2020-2023). These past inventories have been site-based and used a variety of approaches driven by the department imperatives at the time of design. As a crucial step to NFMS, the DoF aggregated and harmonized these past inventories, and incorporated new measurements taken in 2018, to fill gaps and produce the first truly national forest inventory (Malawi Department of Forestry 2019). This national forest inventory effort lays the foundation for a future continuation of a regularized NFI program.

Malawi has also taken steps to ensure consistency and efficiency in emissions accounting between its REDD+ program and national efforts to regularly report GHG emissions from all economic sectors to the UNFCCC. Through a formal and integrated process, results from Malawi’s annual forest monitoring efforts conducted by the DoF, with support from the United States Agency for International Development (USAID) and United Kingdom Aid (UKAid)-funded project Modern Cooking for Healthy Forests (MCHF), will be reported to Malawi’s Environmental Affairs Department (EAD) in the Ministry of Natural Resources, Energy and Mining, who manage the Greenhouse Gas Inventory System (GHG-IS) in the country. This system, launched in 2019, has been designed to estimate emissions and removals consistently and comprehensively across all economic sectors defined by the IPCC. Under the GHG-IS, EAD follows explicit and formal processes to gather and analyze necessary data from sectoral focal points to conduct the GHG accounting analyses. These formal processes and procedures are articulated through standard operating procedures that include quality assurance and quality control measures to control systematic or random errors, as well as automated custom calculation tools that estimate emissions and removals in accordance with IPCC guidelines.

Since the first submission in 2019, a satellite land monitoring system (SLMS) for tracking deforestation has been formalized by the DoF in Malawi. This approach, used to generate historical activity data for deforestation and degradation, relies on the SLMS and a sampling-based approach using the Collect Earth software, which is outlined in further detail below. This is a low-cost approach that the DoF and Malawi’s academic community has shown capable of leading from within, allowing these methods to be sustained into the future by trained experts. As technology advances and automated land cover mapping improves, new opportunities may arise for reevaluating SLMS.

However, in the near term, a high-resolution, visual sampling-based approach will remain an important component of the NFMS.

Enhancements of forest carbon stocks are primarily monitored through management records from large government and private timber plantations. Although the DoF is involved in forest restoration and planting activities outside of timber plantations—either directly or as a coordinator of NGO and community-based organizations—there is currently no systemized approach for monitoring the non-plantation-related enhancement of forest carbon stocks activities. Consequently, non-plantation restoration efforts have been omitted from the FRL.

The remainder of this section presents a more detailed description of the analytical approaches used to generate both activity data and emission factors for each of the three REDD+ activities.

4.1 DEFORESTATION

4.1.1 Activity Data

Activity data for deforestation and forest degradation was estimated in hectares per year from 2010-2020 using a sample-based approach and with respect to a national forest definition of 10% canopy cover over 0.5 hectares. In the sample-based approach, deforestation was estimated for an entire landscape based on the proportion of the visually interpreted plots showing forest loss between the nominal years 2010-2020.

Six thousand plots were randomly generated and numbered within a forest mask, which informed the sampling frame that included all protected areas in Malawi as well as forests outside of protected areas. The forest mask was created using a United States Geological Survey land cover map of Malawi with a 100m resolution. It included all forest landcovers, such as Dense Forest, Gallery Forest/Riparian Forest, Open (degraded), Gallery Forest/Riparian Forest, Moderate (open) Forest (or open Woodland), Open Mopane Woodland, Sparse Forest (or Sparse Woodland), Grassland with Trees, Dense Montane Evergreen Forest and Dense Lowland Evergreen Forest. To ensure that the forest mask did not introduce bias into the sampling, the grassland with trees land use class was included. The sampling frame covered 24,590km^2, or 20% of the land area of Malawi, and it included protected areas, and forests outside of protected areas, while excluding government and private timber or fuelwood plantations (Figure 1).

Since a uniform national forest area is not currently accepted by the DoF, these methods use the proportion of points which are forest in time one within the sampling frame to calculate the initial forest area. The initial forest area in 2010 is estimated to be 17,397 km^2 throughout all of Malawi. The sampling frame area is smaller than the previous sampling frame of 26,128 km^2 used for the first submission and the assessment of the 2006-2016 deforestation rate, even though it is distributed within more of the country. The first sampling frame was confined to protected areas, which includes bare land and grasslands and some high forest customary land in the north of Malawi. This number of plots translates to a sampling density of one plot per 5 km^2, 2.6 times higher than the previous sampling density of one plot per 13 km^2. This sampling is more representative of the forest resources in Malawi because it uses a forest mask to inform the sampling frame instead of an administrative boundary. In addition, it includes less dense forests outside of protected areas. Such forested areas still meet the national forest definition and are mosaiced within the agricultural landscape.

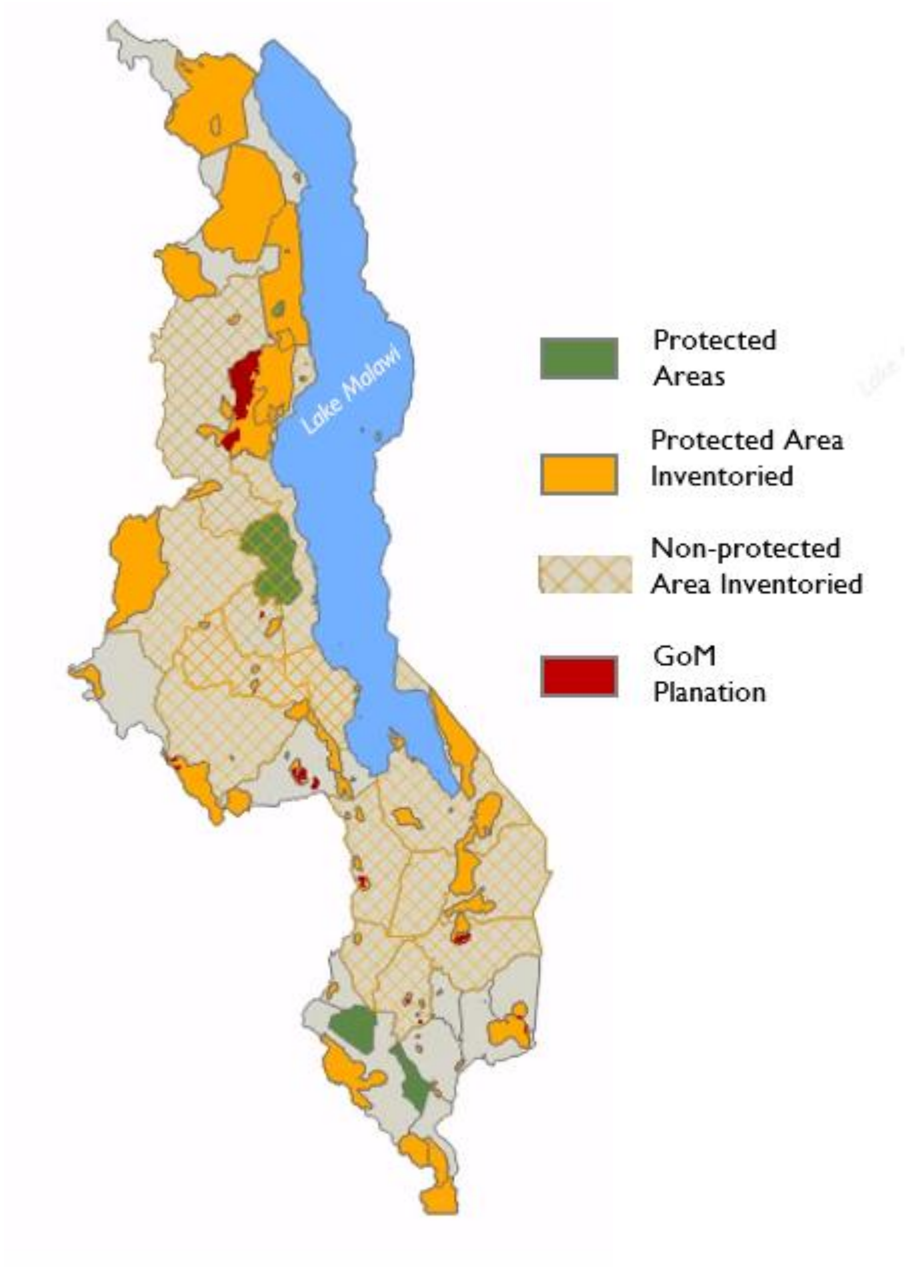


Figure 1. Location of inventoried areas used to determine the emission factors for deforestation

The mapping of deforestation and forest degradation were done by visual interpretation of high-resolution images (Google Earth) accessed through Collect Earth, and with a 0.5 ha plot gridded into a 3x3 sub-grid configuration (Figure 1). Other image repositories such as Bing maps and Planet imagery were considered. However, Google Earth offered the best temporal and spatial resolution suited for this assessment. Google Earth images are derived from a number of sensors including, GeoEye, DigitalGlobe, Spot Image, ASTER, BlackBridge, ImageSAT International and Meteosat, different sensors provided different images through visual assessment. Analysts recorded canopy coverage within each plot for the following canopy coverage thresholds: sparse canopy closure (10%-15%), low canopy closure (15%-30%), moderate canopy closure (30%- 60%), and dense canopy closure (>60%). These canopy closure classes were derived from a fractional tree cover study in Malawi and complement the natural ecology and natural breaks in canopy.

Records were made for the start and end of the reference period 2010 and 2020. The observed transitions were annualized over the 10-year period, because images were not available for all years. One limitation of freely available Google Earth imagery is that it is not necessarily available annually over a given site, though in more recent years there has been more consistent coverage throughout Malawi. Analysts were given the flexibility to use images with dates up to two years either before or after the nominal years, meaning that 2010 could include 2008-2012 and 2020 could include 2017-2022. The deviation in time period is considered in the calculations to normalize the observation period (see equation 2). Analysts were instructed to choose the image with a date closest to the nominal target whenever multiple alternatives were available. If there are two images available at the same interval from the target date, the more recent image was selected. For the target date of 2010, 77% of observations were taken from 2012 and 2013 due to the limited images available in 2010. However, for the images with a target date of 2020, 81% were from 2020, due to higher image availability within the last 10 years. Figure 2 shows the frequency of observations by year from 2010-2020. As more images become available on image repositories such as Google Earth, there should be a greater selection for the target year, allowing for the use of smaller time windows.

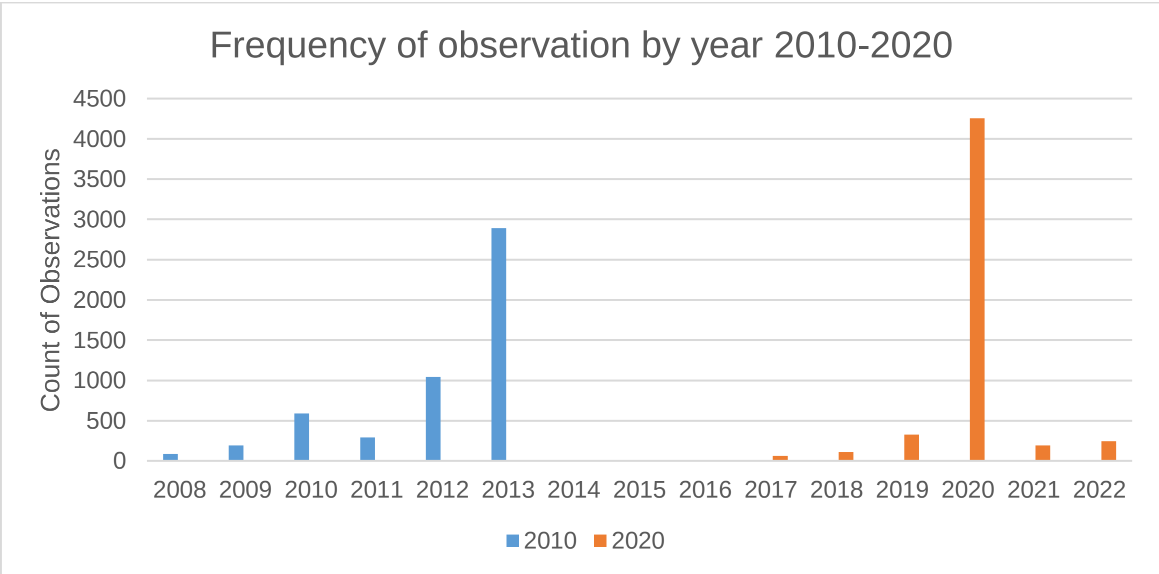


Figure 2. Frequency of observations by actual year of source imagery, for nominal 2010 and 2020

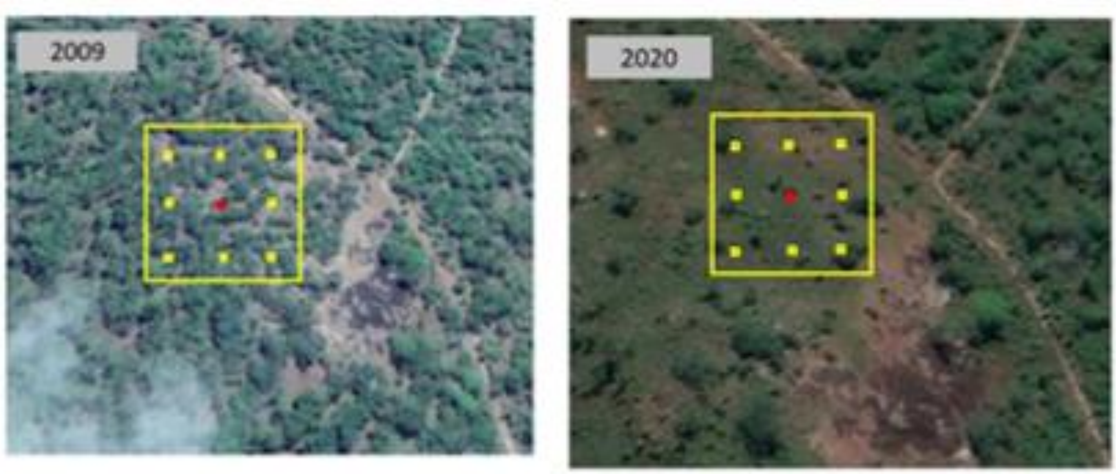


Figure 3. Visual comparison of a single plot over two time periods in Google Earth, showing a deforestation event over the 10-year period

For 2010 and 2020, the land cover interpreted at each plot was compared, and a single determination was made for each plot as to whether it exhibited deforestation over the period. Building on the methods from the previous FRL submission, analysts were trained to identify and distinguish between grassland and cropland, which are the primary land covers to which forests transition. Furthermore, grassland and cropland are visually harder to distinguish compared to settlements or bare lands, therefore further guidance is necessary. The major differentiation between agriculture and grassland are the lines or linear features within the landscape from crop cultivation. Analysts were instructed to toggle through time to ensure that no agriculture activity was present before determining the final land use class. The majority of the plots (77%) transitioned from forest land to grassland and 13% shifted from forest land to cropland. The remaining 10% of plots transitioned to other land uses or settlements. The proportion of each transition within the forest reserve and forests outside of protected areas were applied in the calculations to accurately represent the emissions from deforestation. This is considered an improvement on the previous submission which assumed all forests transitioned to grasslands.

Table 5. Determination of deforestation by land cover observations for 2010 and 2020

2010	2020	Transition
Forest	Forest	Not deforestation
Forest	Non-forest	Deforestation
Non-forest	Non-forest	Not deforestation
Non-forest	Forest	Not deforestation

Out of the 6,000 randomly generate plots, 5,087 were evaluated to reach the precision threshold of at least 3,000 complete plots that had usable imagery available for both 2010 and 2020. Plots with incomplete image coverage were discarded. The proportion of the sample experiencing deforestation was therefore estimated from the retained 5,087 plots (Equation 1)

Equation 1. Proportion of deforestation in the sample

$$\hat{p}_{deforestation} = \frac{N_{adjusted-deforestation}}{N_{adjusted-total}}$$

Where:

$\hat{p}_{deforestation}$	Proportion of the sample that exhibits deforestation from 2010-2020
$N_{adjusted\text{-}deforestation}$	Count of deforestation observations adjusted to account for differences in dates of source imagery (Equation)
$N_{adjusted\text{-}total}$	Count of all observations (Equation)

Because of the differences in time periods covered by each paired observation, it was necessary to normalize the results to reflect the 10-year reference (Equation 2).

Equation 2. Normalization of results to a 10-year period

$$N_{adjusted} = \sum_{i}^{N} \frac{10}{Y_{2020,i} - Y_{2010,i}}$$

Where:

$N_{adjusted}$	Count of complete observations adjusted to accounted for differences in time periods of each paired plot observation
N	Count of complete observations
$Y_{2010,i}$	Actual year of record for nominal 2010-era observation i
$Y_{2020,i}$	Actual year of record for nominal 2020-era observation i

Activity data in units of hectares per year were estimated by multiplying the period-adjusted proportion of deforestation in the sample by the total area of the sample frame (2,459,000 ha in this study), as shown in Equation 3.

Equation 3. Annual rate of deforestation in hectares

$$AD = \frac{\hat{p}_{deforestation} \times A}{10}$$

Where:

AD	Activity data for deforestation (ha y^{-1})
A	Area of the sampling frame (ha)
$\hat{p}_{deforestation}$	Count of deforestation observations adjusted to account for differences in dates of source imagery (Equation 1)

Quality control was conducted on observations by incorporating repeat measurement for a subset of plots and using a tiebreaking procedure for instances where the first and second records did not match. After all initial 5,087 complete observations were recorded, all plots exhibiting deforestation, and an equal number of plots randomly taken from the set not showing deforestation, were given blind review by an analyst not responsible for the initial records. Following this exercise, any plots that did not agree between the first and second viewings were given a third blind review by a designated tie-breaker analyst. The corrected observations following quality control were ultimately used in estimation of change statistics. Most (94%) of the points assessed were in agreement during multiple rounds of analysis. This is an improvement on the previous assessment which had a 60% agreement during multiple rounds of analysis.

The reference level requires area of change estimation as activity data, which includes the determination of the final land use type following a deforestation event. However, even though estimating the percentage of forest loss was not a primary goal of this analysis, it was calculated nevertheless due to a strong interest in this percent loss figure from the Malawi's government.

Percent deforestation was estimated by comparing the hectares of forest loss to the circa-2010 forest extent observed in the sample (Equation 4).

Equation 4. Forest loss expressed as a percent of 2010 forest area

$$deforestation\% = \frac{AD}{A \times \frac{N_{forest-2010}}{N_{total}}}$$

Where:

deforestation%	Percent of circa-2010 forest loss annually (% y^{-1})
AD	Activity Data for deforestation (ha y^{-1}), from Equation
A	Area of the sampling frame (ha)
$N_{forest-2010}$	Count of observations showing forest land cover in 2010
N_{total}	Total count of observations

4.1.2 Emission Factors

Over the past 10 years, the DoF has conducted several NFIs with the support of different international donors and actors. These efforts have been primarily to support the country's path toward REDD+ Readiness and to promote broader sustainable natural resource management goals. While many of these inventories were implemented and executed, their scope has been limited to specific geographies, typically in protected areas, which includes forest reserves, national parks, and wildlife reserves.

Since 2018, nearly annual inventories have been conducted in Malawi with assistance from USAID supported projects, Protecting Ecosystems and Restoring Forests in Malawi (PERFORM) and MCHF. The project staff worked with the Malawi REDD+ Technical Working Group and the DoF to expand on existing NFI efforts to date and produce updated estimates of forest biomass stocks in the country. This work resulted in data collected from 583 plots throughout the country from 2018-2023. Mosaiced within the broader forest landscape, 426 plots were within protected areas and 157 plots outside of protected areas. Results from the national NFI synthesis were presented for forests as two single strata: one for protected areas and one for areas outside of protected areas. These strata predominantly represent dense and less dense forests, respectively, and reported carbon stock for above and below-ground biomass.

This estimated forest biomass stock, calculated using the Kachamba et al. 2016 allometric equation specific to Malawi's forests, was applied to calculate live tree carbon stocks for Malawi's deforestation emissions factor (EF) including aboveground and below ground biomass (Equation 5).

Equation 5. Belowground biomass (BGB) equation, from Kachamba et al. 2016

$$AGB_t = 0.21691 * (AGB_t)^{2.31831}$$

$$BGB_t = 0.284615 * (AGB_t)^{1.992658}$$

Where:

BGBt	Belowground biomass of the tree *t*; kg dry mass (d.m.)
AGB_t	Aboveground biomass of the tree *t*; kg dry mass (d.m.)

The total live tree biomass was then converted to tons of carbon (C) multiplying by 0.47 t C t^{-1} dry biomass matter, which was then multiplied by the molecular weight ratio of CO_2 to C (i.e., 44/12) to convert to CO_2e, following IPCC 2006 Guidelines.

Forest carbon stocks in the deadwood pool (standing and lying) were estimated by assuming dead biomass was equivalent to 1% of the total live biomass and litter biomass was equivalent to 1% of total live biomass[4] following CDM look up tables for tropical forests which receive an annual precipitation of 1,000mm –1,600mm per year. Forest soil carbon stocks were obtained from Henry et al. 2008.

The sum of all pools (aboveground, belowground, deadwood, litter, and soil) result in the total forest carbon stock (following Equation 2.3 in UNFCCC 2006). The final forest carbon stocks used in Malawi's deforestation reference level are presented in Table 6, along with values and sources of all carbon pools.

Table 6. Stocks in forest carbon pools applied to develop Malawi's forest EF

	Total Live Tree Carbon Stocks (AGB & BGB) Forest Reserves (t C/ha)	Dead Wood Carbon Stocks (t C/ha)	Litter Carbon Stocks (t C/ha)	SOC (t C/ha)	Total Forest Carbon Stocks (t C/ha)
Forest Reserve	57.26	0.57	0.57	47.00	105.40
Forests outside of protected Areas	45.03	0.45	0.45	47.00	92.93
Source	NFI Data Collection t	CDM AR-TOOL12	CDM AR-TOOL12	Henry et al. 2008	IPCC 2006 method

[4] https://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-12-v3.0.pdf

Deforestation emission factors were developed following the IPCC stock-difference approach (Equation 2.25 in the IPCC 2006 Guidelines, Volume 4), which estimates the difference between the pre-deforestation and post-deforestation carbon stocks for each stratum (Equation 6). The carbon stock in biomass prior to deforestation is subtracted from the carbon stock post deforestation, plus the change in soil carbon stock following deforestation (see Equation 6), the conversion factor of C to CO_2 e should be applied to give a final result in units of tones of CO_2 e per ha as shown in Table 7. The post deforestation carbon stock in biomass was derived from the IPCC guidelines lookup tables based on the end land use. The tropical dry ecosystem type was applied because Malawi is generally dry for 5-8 months of the year in the winter. The post deforestation carbon stock for forests converted to grasslands is 8.7 t C/ha and the carbon stock for forests converted to croplands is 1.8 t C/ha (UNFCCC 2006, chapter 6, table 6.4 and Chapter 5, Table 5.9 respectively). The final values are presented in Table 7.

Equation 6. Deforestation EF

$$EFdef = (Cbio.pre - Cbio.post + \Delta SOC) * 44/12$$

Where:

EFdef	Emission factor for deforestation, t CO_2e ha^{-1}
Cbio.pre	Carbon stock in biomass, prior to deforestation (see Equation 8), t C ha^{-1}
Cbio.post	Carbon stock in biomass, post-deforestation, t C ha^{-1}
ΔSOC	Change in soil carbon stock following deforestation (see Equation 7), t C ha^{-1}
44/12	Conversion factor from carbon to CO_2

Table 7. Emission factors (t CO2e ha-1) for deforestation used in Malawi's RL, indicating the land use forest is converted to after the deforestation event

Strata	Forest land converted to other land use	Deforestation EFs (t CO_2e ha^{-1})
Forest Reserve	Cropland	133.92
FOPA	Cropland	112.42
Forest Reserve	Grassland	88.09
FOPA	Grassland	66.59

The forest soil carbon stock (SOC.f) was obtained from Henry et al. (2008). At the recommendation of the technical assessment team of the initial FRL submission, a national average provided for Malawi was a used rather than an average of an ecoregion. The management coefficients listed in Table 8 (FLU, FMG, and FI) used in the development of Malawi's deforestation EF development assume that cropland is a long-term, full-tillage, and low to medium inputs (see UNFCCC 2006, Tables 5.5 and 5.9), while grassland assumes a moderately degraded management (see UNFCCC 2006, Table 6.2).

Equation 7. Change in soil carbon stock following deforestation

$$\Delta SOC = SOC.f * (1 - (FLU * FMG * FI))$$

Where:

ΔSOC	Change in soil carbon stock following deforestation, t C ha^{-1}
SOC.f	Forest soil carbon stock prior to deforestation, t C ha^{-1}
FLU	Stock change factor for land use, dimensionless
FMG	Stock change factor for management regime, dimensionless
FI	Stock change factor for input of organic matter, dimensionless

Table 8. Soil management factors used in Malawi's deforestation EF

Forest land converted to other land use	FLU	FMG	FI
Cropland	0.58	1	0.96
Grassland	1	0.97	1

The deforestation emission factor is based on biomass carbon stock difference for above and below ground biomass, (Equation 8), with the addition of soil emissions which are calculated separately (Equation 7). The carbon stock in aboveground biomass (*C.AGB*) and belowground biomass (*C.BGB*) were calculated as the area-based aggregate from the NFI reports from 2018- 2023. The rest of the carbon stocks (i.e. deadwood and litter) were obtained following the IPCC guidelines.

Equation 8. Carbon stock in total forest biomass, prior to deforestation, used in Malawi's deforestation EF

$$Cbio.pre = C.AGB + C.BGB + C.DW + C.LIT$$

Where:

Cbio.pre	Carbon stock in forest biomass, prior to deforestation, t C ha^{-1}
C.AGB	Carbon stock in aboveground live tree biomass, t Cha^{-1}
C.BGB	Carbon stock in belowground live tree biomass, t C ha^{-1}
C.DW	Carbon stock in standing and lying deadwood pool, t C ha^{-1}
C.LIT	Carbon stock in litter, t C ha^{-1}

The deforestation EFs developed for Malawi are given in Table 6 above. The final emissions for forest deforestation, annually, were 1,008,600 tCO_2e with 671,590 tCO_2e on forest reserves and 337,010 tCO_2e in forests outside of protected areas.

4.2 DEGRADATION

4.2.1 Activity Data

The quantification of degradation activity data was collected in tandem with the deforestation data described in detail above. Analysts used a Collect Earth survey to assess the landcover in freely available high resolution Google Earth images from time one (2010) and time two (2020). Points were generated within a sampling frame of 24,590km^2, including protected areas, and forests outside of protected areas, while a mask excluding government and private timber, or fuelwood plantations was applied. Degradation on government or private timber plantations was not accounted for with this method, however, could be considered in the future under the quantification of the enhancement's activity.

Literature suggests that degradation has 50 working definitions due to complexities in the causes, different forms and intensity of forest degradation (FAO 2011, Wheeler et al. 2021). Forest degradation encompasses a wide range of processes and drivers, including selective logging, fire, and fragmentation, each of which can affect carbon stocks differently. These processes often occur over large spatial scales, making it challenging to capture their full extent and impact accurately. Additionally, the rate and intensity of degradation can vary significantly across different forest types and regions, further complicating estimation efforts. The complex interactions between various factors such as vegetation type, topography, and human activities further contribute to the uncertainty in emission factor estimation. Currently, degradation is defined within the DoF as a reduction in biomass or disturbance within a naturally occurring forest which remains a forest after the disturbance. In this assessment, the degradation was defined as the loss of canopy from one canopy closure class to another.

Figure 4. Visual comparison of a single plot over two time periods in Google Earth, showing a degradation event over the 10-year period

Of the approximately 3,301 plots analyzed of forest remaining forest, 277 points exhibited signs of degradation resulting from a change in canopy closure. This method of degradation is sensitive only to large scale degradation events that result in a change in canopy closure classes and does not take into account sub canopy degradation. This is a known limitation of this method and is considered an area of future improvement as monitoring methods are refined. Table 9 below illustrates the number of point observations within each degradation class transition.

Table 9. Transition matrix of degradation observed in all forests of Malawi

		Canopy closure at time two (point count)			
		Moderate	Low	Sparse	Count of Degradation Observations
Canopy closure at time one (point count)	Dense	86	36	23	145
	Moderate		36	23	59
	Low			23	23
Total Points					**227**

The area of each degradation transition was quantified, applying equations 1-4 to calculate the proportion of deforestation in the sample using the count normalized for the period of observation to calculate the annual rate of degradation nationally. The national rate of degradation was 0.77% ± 0.04% which translates to an annual degradation of 14,192 ha ± 1,323 ha within all forests of Malawi. Further the annual hectares of deforestation were calculated for each canopy closure class transition (see Table 10). Representative sampling was not completed for the individual canopy closure classes, because it was not reliably mapped throughout the country. For this reason, the proportion of the calculated area of degradation for each canopy closure transition to the total degradation in the strata was used to correct the area estimate and ensure accurate reporting of the total activity data of degradation.

Table 10. Activity data for each transition

Activity Data	Area Degradation Forest Reserve (ha)	Area Degradation FOPA (ha)
Dense- Moderate	1,938	2,886
Dense-Low	962	800
Dense- Sparse	719	440
Moderate-Low	1,925	652
Moderate-Sparse	1,168	745
Low-Sparse	1,049	908
Total	**7,761**	**6,431**

4.2.2 Emission Factors

Estimating emission factors from forest degradation poses a significant challenge due to various factors inherent in the dynamic nature of forests and the complexities involved in measuring and quantifying changes accurately.

In Malawi, estimating emission factors for forest degradation is particularly challenging due to the prevalence of anthropogenic activities such as illegal charcoal production, unsustainable firewood collection, forest fires, logging, and agricultural expansion. To address this challenge, emission factors have been calculated based on the national inventory data collected from 2018-2023. The NFI, explained in further detail above, constituted 583 plots. In forests mosaiced within the broader landscape, 426 plots were within protected areas and 157 plots were outside of protected areas.

The inventory captured all canopy closure classes which teams assessed and recorded in the field. This value was used to assign each plot to a canopy closure class, from which the area weighted average of each canopy closure class was calculated (Table 11). The canopy closure class was not used to stratify the sampling prior to the field inventory and therefore the carbon stock values were not further stratified between the forest reserve area and the forests outside of protected areas. The emission calculations apply the change in initial forest canopy class to final canopy closure class and multiply it by the area of each transition see Equation 9.

Table 11. Carbon stock averages per canopy closure class

Canopy Closure class	Dense	Moderate	Low	Sparse
	tDM/ha	tDM/ha	tDM/ha	tDM/ha
AGB & BGB (t C/ha)	86.44	64.42	46.12	44.28
Area Weighted Average t DM/ha	183.91	137.06	98.13	94.21

Equation 9. Change in carbon stock EF for degradation

$$\Delta Cstock = Cstock_{time1} - Cstock_{time2}$$

Where:

$\Delta Cstock$	Change in carbon stock between canopy closure classes, t C ha^{-1}
$Cstock_{2010}$	Carbon stock in AGB and BGB at canopy closure class in 2010, t C ha^{-1}
$Cstock_{2020}$	Carbon stock in AGB and BGB at canopy closure class in 2020, t C ha^{-1}

The final emissions for forest degradation, annually, were 543,511tCO_2e with 297,176 tCO_2e on forest reserves and 246,335 tCO_2e in forests outside of protected areas.

4.3 ENHANCEMENTS

Malawi includes in their GHG emissions calculations the enhancement in carbon stocks resulting from commercial forest plantations. The enhancement of carbon stocks in the country results from timber and fuelwood plantations managed by both the public and private sector. These planted forests remove (i.e., sequester) and store carbon dioxide from the atmosphere in their biomass, thereby increasing national carbon stocks. The lack of permanence or replenishment of these plantations can have a significant bearing on Malawi's carbon sink, which is an area for improvement in the future. Currently, these dynamics are not incorporated in the current methods. Accounting for carbon removals from these activities relies on data provided (in hectares) by plantation managers on the area of tree plantations established each year, as well as the composition of tree species planted and their rotation period. The following section describes the activity data and carbon removal factors applied to estimate the carbon dioxide impact of carbon stock enhancement activities under Malawi's REDD+ program.

4.3.1 Activity Data

The data on the number of hectares of plantation forest established each year were collected by contacting plantation managers in both public and private plantations that also included agricultural estates and institutions with such plantations. Based on the best possible data available, the survey template was developed to collect information on the years of plantation, species planted, number of trees, the areas planted in hectares, the planting spacing, and the survival rate.

As shown in Table 12, eucalyptus and pine species account for approximately 99% of the plantations in the country. Therefore, the plantation data was grouped into three major categories: pine, eucalyptus, and other conifer species. Within the reference period (2010-2020), the average annual plantation establishment is 1,552 hectares per year. Table 12 below presents the annual average plantation activities data from the years 2010 to 2020.

Table 12. Total area of areas during the reference period

Year	New Area of Forest Plantations Activity Data (AD; ha)		
	Eucalyptus species	Pine species	Other conifer species
2010	543.4	647.5	0
2011	555.1	627.6	0
2012	188.6	1478.7	55.5
2013	228.6	1322.3	0
2014	662.2	781.2	0
2015	560.0	669.7	0
2016	1080.3	1254.2	0.3
2017	793.7	1021.3	0
2018	746.3	527.9	0
2019	547.5	294.5	5
2020	1122.1	1341.2	21.9

4.3.2 Removal Factors

The removal factors applied represent the carbon accumulation of planted tree species in the timber and fuelwood plantations for Malawi. The species, as indicated through plantation records, are comprised of *Eucalyptus* species, pine species and, to a lesser extent, other conifer species. Table 13 describes their national composition as well as typical harvest cycles, as reported by plantation managers in Malawi.

Table 13. Planted species in Malawi and rotation cycles.

Species	Average % of national plantation area	Rotation cycle (years)
Eucalyptus spp.	41.15 %	14
Pinus spp.	58.36 %	30
Other sp.	0.48 %	36

Removal factors were derived from the Global CO_2 Removals Database (Bernal et al. 2018), which provide tropical dry climate values specific to the species listed in Table 13. The Global Removals Database was chosen over the IPCC defaults (2006 Guidelines and 2019 Refinement, Volume 4) due to its comprehensive and scientifically validated data on all three species of interest in Malawi. Notably, the IPCC (2019) does not provide removal rates for coniferous Eucalyptus species in tropical dry climates. In contrast, the Global CO_2 Removals Database, developed through a review of 335 scientific peer-reviewed manuscripts and published reports, offers a robust dataset with 1197 independent data points. Specifically, the database provides 32 data points for Eucalyptus and 28 data points for Pine species, ensuring a reliable basis for our removal factor calculations. Pursuant to a conservative approach, only accumulation in above and belowground live tree biomass carbon pools were included under this activity. The growth curves used to derive removals factors for the three species groups included under this activity are shown in Figure , Figure , and Figure .

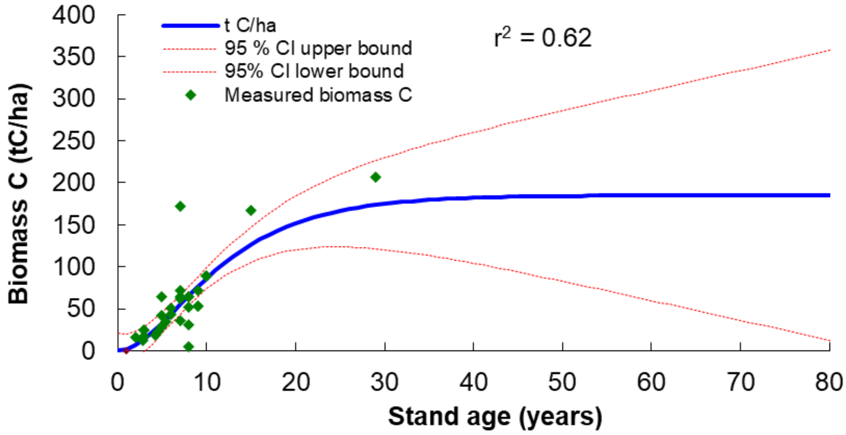


Figure 5. Eucalyptus spp. growth curve used in Malawi's enhancements reference level

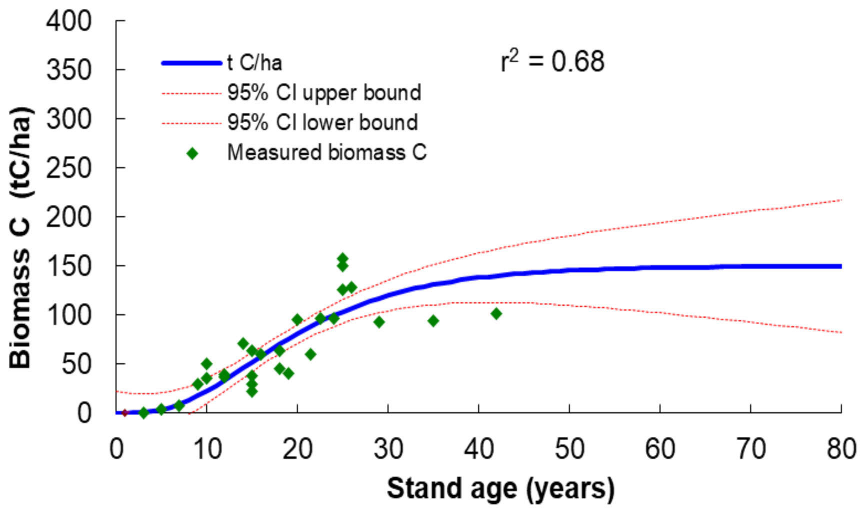


Figure 6. Pinus spp. growth curve used in Malawi's enhancements reference level

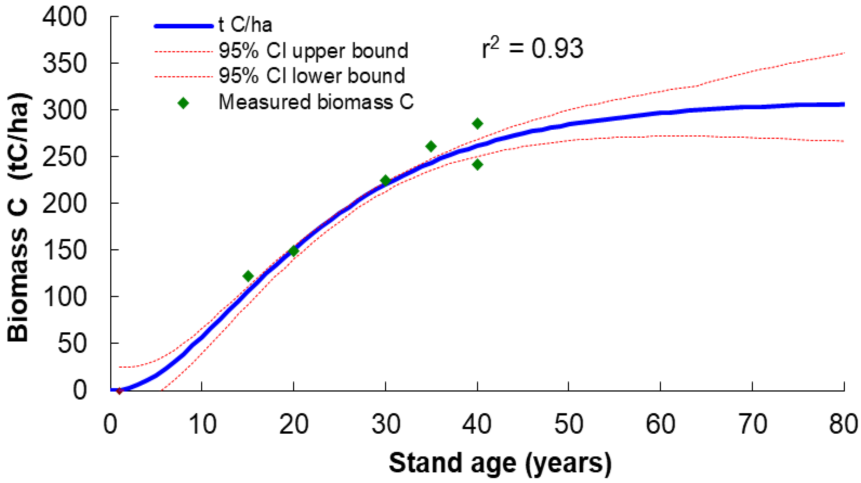


Figure 7. Conifer (non-pinus spp.) growth curve used in Malawi's enhancements reference level

To derive an average annual removal rate (in Table 14), the total aboveground biomass carbon stocks for each of these species were divided by half of their rotation age (listed in Table 13). Asymptote values (maximum yield in tC/ha) for each species, derived from growth curves based on Bernal et al. (2018), were used to estimate average total biomass. Aboveground biomass was used to calculate total belowground biomass, following the method of Mokany et al. 2006. To calculate the removal factor (total tons of biomass per hectare per year), the above and below ground biomass rates were summed and then averaged, as the maximum yield was used to estimate aboveground biomass. Total biomass C was converted to CO_2e by applying the molecular weight ratio of CO_2 to C (i.e., 44/12). The final removal factors applied for each species planted in forest plantations included in Malawi's REDD+ program assume that each year the committed sequestration for an entire rotation length (listed in Table 14) is accounted for each year a new plantation area is planted. This entails taking the middle point of the maximum peak biomass at felling age and applying it as a removal factor for a plantation. These removal factors are shown in Table.

Table 14. Removal factors (t C ha^{-1} yr^{-1} and t CO_2e ha^{-1} yr^{-1}) applied to estimate the enhancements reference level in Malawi

Plantation Species	Tons total biomass (C ha-1 yr-1)	Tons total biomass (CO2e ha-1 yr-1)
Eucalyptus spp.	16.9 ± 1.4	61.8 ± 5.0
Pinus spp.	6.4 ± 0.5	23.5 ± 1.9
Conifer spp.	10.9 ± 0.1	39.8 ± 0.5

5. UNCERTAINTIES OF THE FOREST REFERENCE LEVEL

Potential sources of uncertainty of each of the REDD+ activities included in the FRL (deforestation, degradation, and enhancements) are divided between the activity data and the emission factors used to estimate the reference level of each of the activities. The uncertainty of these REDD+ activities, in turn, determines the overall uncertainty of the proposed FRL. The sections below describe the methodology followed to estimate the uncertainty of the three REDD+ activities and that of the final Forest Reference Level, with the uncertainty results reported at the end (Section 5.3).

5.1 Deforestation and Degradation

The activity data was calculated from a visual assessment and QA/QC process of forest transitioning to non-forest land from 2010 to 2020 using Google Earth imagery, as described in Section 4.1. Emission factors were calculated using national forest inventory data, also detailed in Section 4.1. These activity data and emission factors were then used to calculate emissions resulting from deforestation and forest degradation The confidence interval (CI) for emissions from deforestation and forest degradation was calculated from the distribution of outcomes generated by running Monte Carlo simulations using SimVoi tools. After simulations were completed, the analyst collected the outcomes of each iteration, calculated the mean and standard deviation, and used these values to determine the CI. This was done using z-score value corresponding to a 90% CI, using the equation below.

Equation 10. Equation used to estimate the confidence interval used in estimating uncertainty percentage

$$\bar{x} \pm z * \frac{\sigma}{\sqrt{n}}$$

Where:

$\bar{x}$ = the sample mean of the distribution

z = z-value for a given confidence level (1.96 for confidence level of 95%)

σ = standard deviation of the mean

n = number of simulations

Monte Carlo simulations were run 10,000 times for the activity data and the emission factors of each land use transition (deforestation and degradation) respectively and applied to the equation used to identify the final distributions of deforestation emissions using the SimVoi statistical software for excel. The following assumptions were made about each value:

1) that they had a normal (i.e., Gaussian) distribution, and
2) the estimated values are the means of the normal distributions.

The simulated distributions were truncated to prevent unrealistic values from being generated, i.e. distributions of parameters which the value could not be negative were truncated to a minimum value of 0 (zero). Based on the Monte Carlo simulations produced for emissions, the 90% CI of the final distribution is identified (using equation 10). Once the confidence interval has been identified, % uncertainty was calculated using the propagation of error method, using the following equation 12

Equation 11. Calculation of % uncertainty of the estimate

$$\% \, uncertainty = \frac{\frac{1}{2} \times Confidence\ interval\ width}{Removals\ estimate} * 100$$

5.2 Enhancements

The activity data were available as a single datapoint per year, equivalent to all new planted hectares during that year. The removal factors, on the other hand, were developed from the growth curves presented in Section 4.3.2, which used multiple datapoints and presented confidence intervals of the RFs.

Monte Carlo simulations for uncertainty analyses as recommended by the IPCC were employed, with the uncertainty quantified using confidence intervals, leading to low uncertainties. We employed 10,000 simulation iterations, which is a commonly used number of simulations. CI to estimate uncertainty percentage was calculated using equation 10:

Where:

$\bar{x}$ = the sample mean of the distribution

z = z-value for a given confidence level (1.645 for confidence level of 90%)

σ = standard deviation of the mean

n = number of simulations

Applying equations to estimate confidence interval in above questions with following values.

	Symbol	Values
The sample mean of the distribution	$\bar{x}$	134,976
z-value for a given confidence level	z	1.645
Standard deviation of the mean	σ	71,054
Number of simulations	n	10,000
Confidence interval	CI	134976 ± 1168

Once the CI has been identified, % uncertainty was calculated using the propagation of error method, using the following equation 11 listed above.

5.3 Reference Level Total Uncertainty

To combine the uncertainties of deforestation, degradation and enhancement reference levels, a straightforward approach is employed by adding the individual uncertainties together. These individual uncertainties were calculated using Monte Carlo analysis with bootstrapping, based on 10,000 simulated emissions and removals. This method is easy to calculate and works well when the individual uncertainties are relatively low and largely independent of each other. This approach provides a conservative estimate of the total uncertainty, as it assumes that the individual uncertainties are additive and do not account for potential correlations between them. However, when the individual uncertainties are small and independent, this method provides a reasonable and simple way to estimate the total uncertainty. The uncertainty of the net emissions is listed in Table 15.

Table 45. Uncertainty (%) of the REDD+ activities included in Malawi's Forest Reference Level, and uncertainty of total (net) Forest Reference Level

Deforestation RL	Degradation RL	Enhancements RL	Total (net) RL
3.37%	1.9 %	1.91%	7.18%

6. HISTORICAL EMISSIONS

6.1 DEFORESTATION

The sampling-based land cover change analysis revealed that 115,650 ha were deforested in Malawi from 2010-2020, which equates to a rate of 11,565 ha ± 1,067 ha y^{-1}, equivalent to a 0.66% ± 0.03% annual rate of deforestation within forests nationally.

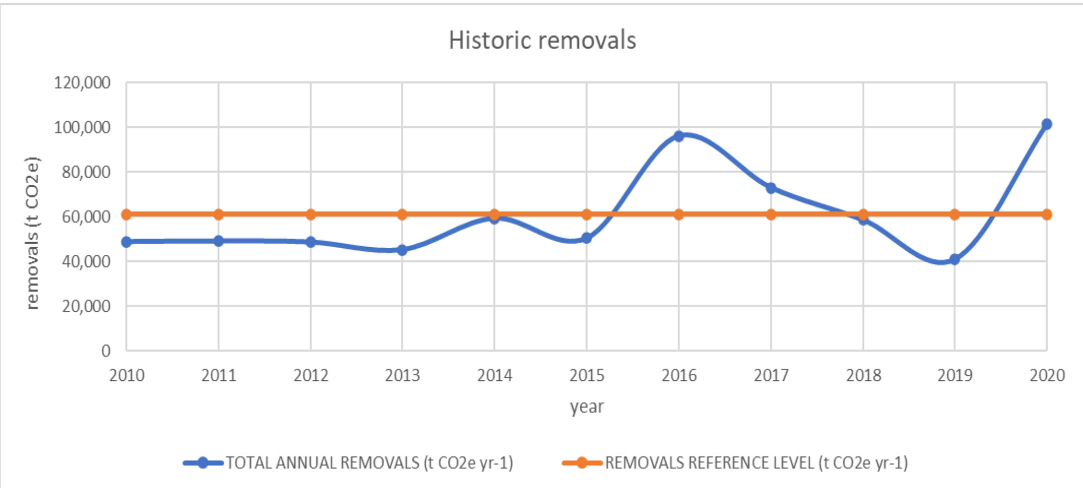
The methodology followed to obtain deforestation AD for Malawi for the 2010-2020 reference period incorporated a consistent assessment of post-deforestation land use. Considering that most of the deforestation resulted in either grasslands or croplands, specific EFs were used proportionally to each final land use. Based on the percent of total land use conversion, 15% of the deforestation was attributed to for the converted landcover majority of the deforestation points converted to grassland (85%) and the remaining deforestation was attributed to cropland (15%). The emission factors of these two types of conversion are detailed in Table 7. This calculation resulted in a historical rate of emission from deforestation of 1,008,600 tCO_2e yr^{-1}.

6.2 DEGRADATION

The sampling-based land cover change analysis revelated that 14,192 ha ± 1,323 ha were degraded annually in Malawi from 2010-2020 for a total of 141,920 ha over the reference period. In reference to the 2010 forest cover, this per hectare rate of change is equivalent to 0.77% ± 0.04% annual rate of degradation. The calculation resulted in a historical rate of emissions from degradation of 543,511 tCO_2e yr^{-1}.

6.3 ENHANCEMENTS

The **average annual removals** from Malawi's timber and fuelwood plantations during the reference period of 2010-2020 were 61,070 t CO_2e ha^{-1} yr^{-1} (



). This average is therefore the enhancements reference level that Malawi would use from 2020 onwards. Over the reference period removals fluctuated from 45,202 tCO2e to 101,726 t CO2e for a total removals of 671,773 t CO2e.

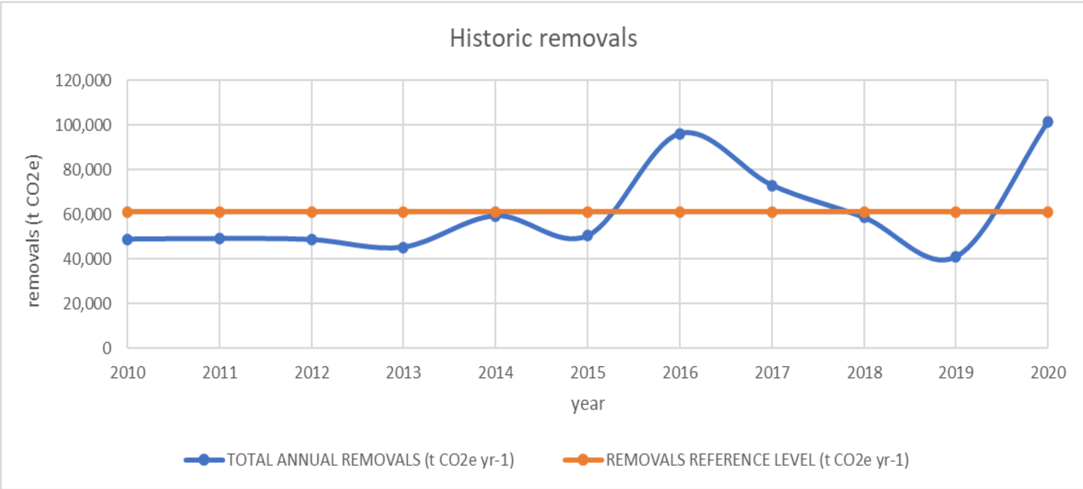


Figure 8. Historic removals (t CO_2e yr^{-1}) during the reference period (2010-2020) in blue, and the removals reference level (t CO_2e yr^{-1}) in orange.

7. MALAWI'S PROPOSAL FOR THE REFERENCE LEVEL FOR REDD+

The net emissions of Malawi's forest reference level during the 2010-2020 reference period is the sum of all emissions from deforestation, forest degradation, and emission removals from enhancements (plantations) each year (Table 16).

Table 165. Forest emissions in Malawi for Deforestation, Enhancements, and Total (net) during the reference period 2010-2020.

Year	Deforestation emissions, tons CO2e	Degradation emissions, tons CO2e	Enhancements (emission removals), tons CO2e
2010			-48,794
2011			-49,053
2012			-48,612
2013			-45,202
2014			-59,279
2015	10,085,999	5,435,108	-50,343
2016			-96,241
2017			-73,044
2018			-58,524
2019			-40,954
2020			-101,726
Annual average	1,008,600	543,511	-61,070

For all activities, the emissions and removals from the historical reference period are assumed to continue into the monitoring period. The reference level is therefore different every year of the monitoring period. The final reference level is the sum of the three assessed activities and is presented in Table 17 as 1,491,041$_e$ y^{-1} annually from 2021 to 2026.

Table 17. Malawi's proposed forest reference level for the period 2021-2025.

Year	Projected degradation emissions, tons CO2e yr-1	Projected deforestation emissions, tons CO2e yr-1	Projected enhancements removals, tons CO2e yr-1	Total (net) forest emissions, tons CO2e yr-1
2021	543,511	1,008,600	-61,070	1,491,041
2022	543,511	1,008,600	-61,070	1,491,041
2023	543,511	1,008,600	-61,070	1,491,041
2024	543,511	1,008,600	-61,070	1,491,041
2025	543,511	1,008,600	-61,070	1,491,041

REFERENCES

Bernal, B., L.T. Murray, T.R.H. Pearson. 2018. Global carbon dioxide removal rates from forest landscape restoration activities. Carbon Balance and Management 13: 22.

Drigo, Rudi. 2019. WISDOM Malawi – Analysis of woodfuel demand, supply, and harvesting sustainability. Prepared for United States Agency for International Development (USAID).

Henry, M., Valentini, R., Bernoux, M. 2008. Soil carbon stocks in ecoregions of Africa. Biogeosciences Discuss. 6:797-823.

FAO. 2011. Assessing forest degradation: Towards the development of globally applicable guidelines. Forest Resources Assessment Working Paper 177. https://www.fao.org/4/i2479e/i2479e00.pdf.

Government of Malawi. 2011. Second National Communication of the Republic of Malawi to the Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC). https://unfccc.int/sites/default/files/resource/mwinc2.pdf.

Government of Malawi. 2016. National Forest Policy. https://faolex.fao.org/docs/pdf/mlw190487.pdf.

Government of Malawi. 2017. National Charcoal Strategy 2017-2027. Ministry of Natural Resources, Energy and Mining. https://faolex.fao.org/docs/pdf/mal215462.pdf.

Government of Malawi. 2020a. National REDD+ Strategy.

Government of Malawi. 2020b. Malawi 2063: Malawi's Vision An Inclusively Wealthy and Self-reliant Nation. National Planning Commission. https://faolex.fao.org/docs/pdf/mlw208480.pdf.

IPCC. 2003. Good Practice Guidance for Land Use, Land Use Change, and Forestry. https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf.

Kachamba, D.J., T. Eid, T. Gobakken. 2016. Above- and Belowground Biomass Models for Trees in the Miombo Woodlands of Malawi. Forests 7, 38.

Kerr, A. 2005. Disappearing forests in Malawi: Causes and solutions. EEP 153 Research Project, 31 pp.

Malawi Department of Forestry. 2019. Malawi National Forest Inventory Assessment

Malawi Department of Forestry. 2017. Technical Order – Definition of "Forest" in Malawi

Malunga, G. 2022. Soil Fertility in Malawi. https://www.researchgate.net/publication/359256738_Soil_fertility_in_Malawi_SOIL_FERTILITY_IN_MALAWI.

Mauambeta, D. 2010. STATUS OF FORESTS AND TREE MANAGEMENT IN MALAWI: A Position Paper Prepared for the Coordination Union for Rehabilitation of the Environment (CURE). 10.13140/2.1.3497.7926.

Mokany, K., R.J. Raison, A.S. Prokushkin. 2006. Critical analysis of root: shoot ratios in terrestrial biomes. Global Change Biology 11:1-3.

Pearson, T., Walker, S., Brown, S. 2005. Sourcebook for Land Use, Land-Use Change, and Forestry Projects. BioCarbon Fund and Winrock International, 64 pp.

Republic of Malawi. 2017. Intended Nationally Determined Contribution. Submission to the UNFCCC. 13 pp. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Malawi%20First/MALAWI%20INDC%20SUBMITTED%20TO%20UNFCCC%20REV.pdf

Thiruvengadam, V. 2019. Technology Development of Charcoal Briquetting from Mangochi, Malawi, Central Africa. ACTA Scientific Nutritional health. 3:12.,058

UNFCCC, 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use; Chapter 2: Generic Methodologies Applicable to Multiple Land-Use Categories; Chapter 4: Forest Land.

Wheeler, C., Mitchard, E., Nalasco Reyes, H. E., Iñiguez Harrera, G., Marques Rubio, J. I., Carstairs, H., & Williams, M. 2021. A New Field Protocol for Monitoring Forest Degradation. Frontiers in Forests and Global Change. https://doi.org/10.3389/ffgc.2021.655280

ANNEX 1: ADDITIONAL DATA

Table 18. Enhancements Activity Data

Timber Plantation Name	Year	Final Hectares	Species Planted Category
Chitakala Tea Estate	2010	15	Eucalyptus Species
Chitakala Tea Estate	2011	50	Eucalyptus Species
Chitakala Tea Estate	2012	40	Eucalyptus Species
Chitakala Tea Estate	2017	7.6	Eucalyptus Species
Chitakala Tea Estate	2018	4.4	Eucalyptus Species
Chitakala Tea Estate	2019	58	Eucalyptus Species
Chitakala Tea Estate	2020	26	Eucalyptus Species
Nauko plantation	2018	1.5	Eucalyptus Species
Nauko plantation	2019	6.02	Eucalyptus Species
Nauko plantation	2020	3.01	Eucalyptus Species
Dzimbiri	2017	4.92	Pinus Species
Dzimbiri	2018	7.1	Pinus Species
Dzimbiri	2019	9.9	Pinus Species
Dzimbiri	2020	2.73	Pinus Species
Ngala	2013	12	Eucalyptus Species
Ngala	2014	12	Eucalyptus Species
Ngala	2015	12	Eucalyptus Species
Ngala	2016	12	Eucalyptus Species
Ngala	2017	4	Eucalyptus Species
Ngala	2018	4	Eucalyptus Species
Ngala	2019	12	Eucalyptus Species
Ngala	2020	12	Eucalyptus Species
Nchima Estate	2014	12	Eucalyptus Species
Nchima Estate	2015	2	Eucalyptus Species
Nchima Estate	2017	30	Eucalyptus Species
Nchima Estate	2018	6	Eucalyptus Species
Ntchisi	2016	24.33	Eucalyptus Species
Ntchisi	2017	6.18	Eucalyptus Species
Ntchisi	2018	17.34	Eucalyptus Species
Ntchisi	2019	2.08	Eucalyptus Species
Ntchisi	2020	2.28	Eucalyptus Species

Timber Plantation Name	Year	Final Hectares	Species Planted Category
Chigumula	2012	24.01	Pinus Species
Chigumula	2014	22.51	Eucalyptus Species
Chigumula	2016	13.93	Pinus Species
Chigumula	2017	19.24	Eucalyptus Species
Chigumula	2018	115.13	Pinus Species
Chigumula	2019	116.39	Pinus Species
Chigumula	2020	22.37	Eucalyptus Species
Kawalazi	2013	63.19	Eucalyptus Species
Kawalazi	2014	117.34	Eucalyptus Species
Kawalazi	2015	80.91	Eucalyptus Species
Kawalazi	2016	94	Eucalyptus Species
Kawalazi	2017	60	Eucalyptus Species
Kawalazi	2018	46	Eucalyptus Species
Kawalazi	2019	47.54	Eucalyptus Species
Kawalazi	2020	112.18	Eucalyptus Species
Fort Lister	2010	5	Pinus Species
Fort Lister	2019	23.46	Pinus Species
Fort Lister	2020	2.71	Eucalyptus Species
Ndirande	2017	1	Pinus Species
Chongoni Timber	2010	124.85	Pinus Species
Chongoni Timber	2011	82.72	Pinus Species
Chongoni Timber	2012	148.45	Pinus Species
Chongoni Timber	2013	93.11	Pinus Species
Chongoni Timber	2014	157.19	Pinus Species
Chongoni Timber	2015	126.44	Pinus Species
Chongoni Timber	2016	92.51	Pinus Species
Chongoni Timber	2017	69.7	Pinus Species
Chongoni Timber	2018	110.34	Pinus Species
Chongoni Timber	2019	44.75	Pinus Species
Chongoni Timber	2020	64.14	Pinus Species
DEDZA Mountain	2010	32.93	Pinus Species
DEDZA Mountain	2012	22.47	Pinus Species
DEDZA Mountain	2013	88.8	Pinus Species
DEDZA Mountain	2014	105.21	Pinus Species
DEDZA Mountain	2015	3.2	Pinus Species

Timber Plantation Name	Year	Final Hectares	Species Planted Category
DEDZA Mountain	2016	55.35	Pinus Species
DEDZA Mountain	2017	43.39	Pinus Species
DEDZA Mountain	2018	21.89	Pinus Species
DEDZA Mountain	2019	84.44	Pinus Species
DEDZA Mountain	2020	14.4	Pinus Species
Greenwing Agricultural Resources Limited	2016	25	Pinus Species
Kaombe	2016	24.33	Eucalyptus Species
Kaombe	2017	6.18	Eucalyptus Species
Kaombe	2018	17.34	Eucalyptus Species
Kaombe	2019	2.08	Eucalyptus Species
Kaombe	2020	2.28	Eucalyptus Species
Katete	2017	3	Eucalyptus Species
Katete	2019	4	Eucalyptus Species
Katete	2020	3	Eucalyptus Species
Kayola	2019	4	Pinus Species
Likhubula	2010	4	Pinus Species
Likhubula	2011	4	Pinus Species
Likhubula	2012	5	Others
Likhubula	2013	53	Pinus Species
Likhubula	2014	12.2	Pinus Species
Likhubula	2018	107.5	Pinus Species
Total Land Care	2012	388.4	Pinus Species
Total Land Care	2013	470.4	Pinus Species
Total Land Care	2014	23.2	Eucalyptus Species
Total Land Care	2015	17.4	Pinus Species
Total Land Care	2016	177	Eucalyptus Species
Total Land Care	2017	80.9	Pinus Species
Total Land Care	2018	117.2	Pinus Species
Total Land Care	2019	5	Others
Total Land Care	2020	30	Eucalyptus Species
Zomba Timber Plantation (ZTP) and Outer Slope	2014	16.83	Pinus Species
Zomba Timber Plantation (ZTP) and Outer Slope	2017	20.42	Pinus Species

Timber Plantation Name	Year	Final Hectares	Species Planted Category
Zomba Timber Plantation (ZTP) and Outer Slope	2018	25.74	Pinus Species
Viphya(Champhoyo) Pine	2016	273.5	Pinus Species
Viphya(Champhoyo) Pine	2020	125.8	Pinus Species
Viphya(Champhoyo) Pine	2022	460	Pinus Species
Viphya(Champhoyo) Eucalyptus	2016	9.3	Eucalyptus Species
Viphya(Champhoyo) Eucalyptus	2020	28.3	Eucalyptus Species
Viphya(Champhoyo) Eucalyptus	2022	37.9	Eucalyptus Species
Viphya (Chikangawa) Pine	2016	262	Pinus Species
Viphya (Chikangawa) Pine	2020	280.2	Pinus Species
Viphya (Chikangawa) Pine	2022	403.37	Pinus Species
Viphya (Chikangawa) Eucalyptus	2016	106	Eucalyptus Species
Viphya (Chikangawa) Eucalyptus	2020	149	Eucalyptus Species
Viphya (Chikangawa) Eucalyptus	2022	103.69	Eucalyptus Species
Viphya (Chikangawa) Other	2016	0	Others
Viphya (Chikangawa) Other	2020	20.2	Others
Viphya (Chikangawa) Other	2022	1.56	Others
Viphya(Kalungulu) pine	2011	10.7	Pinus Species
Viphya(Kalungulu) pine	2012	32	Pinus Species
Viphya(Kalungulu) pine	2016	131.1	Pinus Species
Viphya(Kalungulu) pine	2020	285.5	Pinus Species
Viphya(Kalungulu) pine	2022	807	Pinus Species
Viphya(Kalungulu) Eucalyptus	2016	41.6	Eucalyptus Species
Viphya(Kalungulu) Eucalyptus	2020	245.8	Eucalyptus Species
Viphya(Kalungulu) Eucalyptus	2022	39.6	Eucalyptus Species
Viphya (Lusangazi) Pine	2011	18.2	Pinus Species
Viphya (Lusangazi) Pine	2012	191.5	Pinus Species
Viphya (Lusangazi) Pine	2016	29.8	Pinus Species
Viphya (Lusangazi) Pine	2020	34.5	Pinus Species
Viphya (Lusangazi) Pine	2022	2.7	Pinus Species
Viphya (Lusangazi) Eucalyptus	2016	42.9	Eucalyptus Species
Viphya (Lusangazi) Eucalyptus	2022	129.7	Eucalyptus Species
Viphya (Lusangazi) Other	2012	12.9	Others
Viphya (Lusangazi) Other	2016	0.26	Others
Viphya (Luwawa) pine	2010	126.6	Pinus Species
Viphya (Luwawa) pine	2011	7.5	Pinus Species
Viphya (Luwawa) pine	2012	240.1	Pinus Species

Timber Plantation Name	Year	Final Hectares	Species Planted Category
Viphya (Luwawa) pine	2016	9	Pinus Species
Viphya (Luwawa) pine	2020	147.9	Pinus Species
Viphya (Luwawa) pine	2022	132	Pinus Species
Viphya (Luwawa) Eucalyptus	2016	76.29	Eucalyptus Species
Viphya (Luwawa) Eucalyptus	2020	169.8	Eucalyptus Species
Viphya (Luwawa) Other	2012	23.2	Others
Viphya (Mazamba) Pine	2010	28	Pinus Species
Viphya (Mazamba) Pine	2011	16.1	Pinus Species
Viphya (Mazamba) Pine	2012	7.2	Pinus Species
Viphya (Mazamba) Pine	2016	10.5	Pinus Species
Viphya (Mazamba) Pine	2020	129.3	Pinus Species
Viphya (Mazamba) Pine	2022	50	Pinus Species
Viphya (Mazamba) Eucalyptues	2020	20.1	Eucalyptus Species
Viphya (Mazamba) Eucalyptues	2022	7	Eucalyptus Species
Viphya (Nthungwa) Pine	2011	14.9	Pinus Species
Viphya (Nthungwa) Pine	2012	77.7	Pinus Species
Viphya (Nthungwa) Pine	2020	231.9	Pinus Species
Viphya (Nthungwa) Pine	2022	298.4	Pinus Species
Viphya (Nthungwa) Eucalyptus	2016	55.43	Eucalyptus Species
Viphya (Nthungwa) Other	2012	14.4	Others
Viphya (Nthungwa) Other	2020	1.7	Others
Kawandama Hills Plantation	2010	155.1	Eucalyptus Species
Kawandama Hills Plantation	2011	245.7	Eucalyptus Species
Kawandama Hills Plantation	2012	79.3	Eucalyptus Species
Kawandama Hills Plantation	2013	47.44	Eucalyptus Species
Kawandama Hills Plantation	2014	306.42	Eucalyptus Species
Kawandama Hills Plantation	2015	179.68	Eucalyptus Species
Kawandama Hills Plantation	2016	165.32	Eucalyptus Species
Kawandama Hills Plantation	2017	239.35	Eucalyptus Species
Kawandama Hills Plantation	2018	90.71	Eucalyptus Species
Kawandama Hills Plantation	2019	139.73	Eucalyptus Species
Kawandama Hills Plantation	2020	41.5	Eucalyptus Species
Dzonzi Mvai	2012	15	Pinus Species
Dzonzi Mvai	2013	132.89	Pinus Species
Dzonzi Mvai	2014	45.7	Pinus Species
Dzonzi Mvai	2015	53.44	Pinus Species

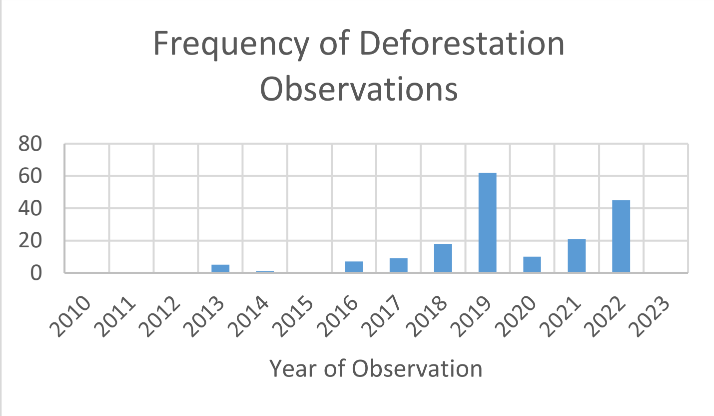
Timber Plantation Name	Year	Final Hectares	Species Planted Category
Dzonzi Mvai	2016	6.69	Pinus Species
Dzonzi Mvai	2017	24.15	Pinus Species
Dzonzi Mvai	2018	23	Pinus Species
Dzonzi Mvai	2019	11.6	Pinus Species
Dzonzi Mvai	2020	13.8	Pinus Species
Thuchila Plantation	2016	5.3	Eucalyptus Species
Thuchila Plantation	2017	2.3	Eucalyptus Species
Thuchila Plantation	2018	2.6	Eucalyptus Species
Thuchila Plantation	2019	3.1	Eucalyptus Species
Thuchila Plantation	2020	7.8	Eucalyptus Species
Reformed Millers Timbers Union	2020	11	Pinus Species
Satemwa Tea Estate	2010	42.83	Eucalyptus Species
Satemwa Tea Estate	2011	20.98	Eucalyptus Species
Satemwa Tea Estate	2012	21.8	Eucalyptus Species
Satemwa Tea Estate	2013	22.6	Eucalyptus Species
Satemwa Tea Estate	2014	23.01	Eucalyptus Species
Satemwa Tea Estate	2015	11.32	Eucalyptus Species
Satemwa Tea Estate	2016	21.2	Eucalyptus Species
Satemwa Tea Estate	2017	24.23	Eucalyptus Species
Satemwa Tea Estate	2018	29.53	Eucalyptus Species
Satemwa Tea Estate	2019	51.55	Eucalyptus Species
Satemwa Tea Estate	2020	61.96	Eucalyptus Species
Raiply (Champhoyo) Pine	2010	45.7	Pinus Species
Raiply (Champhoyo) Pine	2011	205.7	Pinus Species
Raiply (Champhoyo) Pine	2012	154.3	Pinus Species
Raiply (Champhoyo) Pine	2013	14.2	Pinus Species
Raiply (Champhoyo) Pine	2014	210.1	Pinus Species
Raiply (Champhoyo) Pine	2015	299.4	Pinus Species
Raiply (Champhoyo) Pine	2016	58.4	Pinus Species
Raiply (Champhoyo) Pine	2017	112.6	Pinus Species
Raiply (Champhoyo) Eucalyptus	2010	39.6	Eucalyptus Species
Raiply (Champhoyo) Eucalyptus	2011	96.4	Eucalyptus Species
Raiply (Champhoyo) Eucalyptus	2012	33.8	Eucalyptus Species
Raiply (Champhoyo) Eucalyptus	2013	10.8	Eucalyptus Species
Raiply (Champhoyo) Eucalyptus	2014	2.9	Eucalyptus Species
Raiply (Champhoyo) Eucalyptus	2015	68.7	Eucalyptus Species

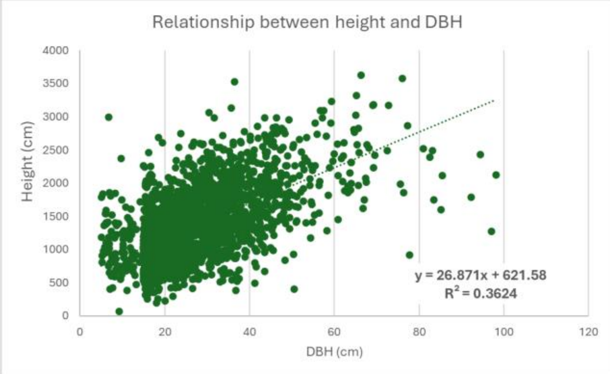
Timber Plantation Name	Year	Final Hectares	Species Planted Category
Raiply (Champhoyo) Eucalyptus	2016	99.4	Eucalyptus Species
Raiply (Champhoyo) Eucalyptus	2017	96.2	Eucalyptus Species
Raiply (Chikangawa) Pine	2010	123.2	Pinus Species
Raiply (Chikangawa) Pine	2011	93.8	Pinus Species
Raiply (Chikangawa) Pine	2012	39.1	Pinus Species
Raiply (Chikangawa) Pine	2013	381.8	Pinus Species
Raiply (Chikangawa) Pine	2014	105.8	Pinus Species
Raiply (Chikangawa) Pine	2015	0	Pinus Species
Raiply (Chikangawa) Pine	2016	245.5	Pinus Species
Raiply (Chikangawa) Pine	2017	516	Pinus Species
Raiply (Chikangawa) Eucalyptus	2010	54.9	Eucalyptus Species
Raiply (Chikangawa) Eucalyptus	2011	62.2	Eucalyptus Species
Raiply (Chikangawa) Eucalyptus	2012	0	Eucalyptus Species
Raiply (Chikangawa) Eucalyptus	2013	72.6	Eucalyptus Species
Raiply (Kalungulu) Pine	2010	157.2	Pinus Species
Raiply (Kalungulu) Pine	2011	174	Pinus Species
Raiply (Kalungulu) Pine	2012	138.5	Pinus Species
Raiply (Kalungulu) Pine	2013	88.1	Pinus Species
Raiply (Kalungulu) Pine	2014	128.2	Pinus Species
Raiply (Kalungulu) Pine	2015	169.8	Pinus Species
Raiply (Kalungulu) Pine	2016	40.9	Pinus Species
Raiply (Kalungulu) Pine	2017	148.2	Pinus Species
Raiply (Kalungulu) Eucalyptus	2011	30.6	Eucalyptus Species
Raiply (Kalungulu) Eucalyptus	2012	13.7	Eucalyptus Species

ANNEX 2: OVERVIEW OF RESPONSES TO TECHNICAL ASSESSMENT TEAM RECOMMENDATIONS

Table 19. Summary Table of TAR recommendations in response to the first Malawi FRL submission

Paragraph Number	Recommendation	Status
15	Malawi deviated from the IPCC guidance for SOC pool and land use change category by not considering a multi-year time frame (preferably 20 years). Removals in land converted to forest land should be estimated as annual removals resulting from tree growth and not as 'committed removals' in the first year of the plantation cycle. The Assessment Team (AT) notes that moving toward a carbon quantification approach that is fully in line with the 2006 IPCC Guidelines is an area for future technical improvement.	Resolved
	The calculations were updated to adhere to the IPPC guidelines for the SOC pool and the LULC category.	
16	The AT, while commending Malawi on its efforts, considers the establishment of a GHG inventory system that generates consistent estimates to be both included in NCs and BURs and used for constructing FRLs as an area for future technical improvement.	Pending
	In support of inspiring unified national reporting the FRL-WG recommends that the DOF engage with the EAD, and other key GHG and LULC mapping sectors as Agriculture and Surveys Department to decide on a simple straightforward approach for consistent LULC data reporting within the forestry sector and all other sectors. Initial stakeholder engagement with the DNA (EAD) is underway prior to engagement of all other stakeholders to ensure Malawi generates unified, consistent LULC data for such reporting purposes	
17	The AT considers that introducing more efficient sampling approaches, including, potentially, post stratification, which would contribute to reducing uncertainties, is an area for future technical improvement.	Resolved
	The AD was post stratified into protected and non-protected areas however there was not a significant difference in the uncertainty. The uncertainty for the image interpretation was improved by enhancing the training for the analysts.	
18	The AT considers that assessing the full time series of the reference period and recording the years of land-use change instead of assessing only the start and end years of the 10-year reference period, which could enhance the accuracy of the estimates, is an area for future technical improvement.	Resolved
	A full time series analysis was not possible with the freely available high-resolution imagery from Google Earth. To adhere to this recommendation, the analysts were instructed to identify the last year with forest for those points which transitioned from forest to non-forest. No deforestation and regrowth was observed as hypothesized during the TAR. Further improvements are possible with the expansion of the Google Earth repository.	

Paragraph Number	Recommendation	Status
		
19	The AT, while commending Malawi on its efforts to reduce uncertainty in the interpretation of satellite imagery, notes that accessing a wide range of high-quality data to ensure accurate identification of forest-cover change is an area for future technical improvement.	Justified
	The Collect Earth Tool was used to visually interpret satellite imagery. While multiple sources of high quality images were available via Collect Earth, the Google Earth images were found to have the most robust dataset with the highest quality and were used for initial assessments. The other image repositories were used to provide context when and if the Google images were unclear.	
20	the Party clarified that the data set does not adequately represent all of the country's forests because the data collection focused on only the 22 per cent of the country with forest landscapes that are intact and dense, including those in forest reserves and specific areas of land held in customary lands.	Resolved
	The modified FRL submission expanded data collection to all Malawi forests – both dense and less dense forests.	
21	The AT considers that providing more details on estimating post-deforestation carbon stocks, which could enhance the accuracy of the estimates, is an area for future technical improvement.	Resolved
	During the deforestation assessment the post transition land use was determined and there was a differentiation between grassland and cropland. The majority of the points (77%) transitioned from forest to grassland. This FRL assessment defaulted to the right tropical dry climate zone, and subsequently the default biomass stocks for the grasslands of this climatic zone.	
22	The AT notes the further analysis of plot-level data to maximize the use of all information from all plots is an area for future technical improvement.	Justified
	The inclusion of the height parameter was explored however it was not feasible to change the allometric equation because the height parameter is not collected within all plots or subplots. The relationship between tree height and the diameter at breast height (DBH) was nonlinear so it was not possible to extrapolate tree height for trees which were not measured (See Figure 9 below). Due to this limitation the more simplified allometric equation, that utilizes DBH only, not DBH and height is applied as developed by Kachamba et al. (2016).	

Paragraph Number	Recommendation	Status
	 *Figure 9.5 Relationship between tree height and DBH for all trees sampled from 2018-2023* The degradation accounting utilises canopy closure information which has been collected since 2018 to further optimise the parameters measured in the filed.	
23	The AT notes that identifying the most appropriate equations for relating root biomass to shoot biomass, which could enhance the transparency of the below-ground biomass estimates, is an area for future technical improvement.	Resolved
	Country-specific below ground biomass equation from Kachamba et al (2016) was applied rather than the Mokany et al. (2006) regional equation which was not properly justified in the first submission.	
24	Malawi used WISDOM for estimating emissions from forest degradation.	Resolved
	This recommendation was resolved by applying a more transparent degradation mapping approach using Collect Earth with the assessment concurrently running with deforestation assessment for all points generated	
25	During the TA, Malawi indicated that it would consider discarding the application of WISDOM for future FREL/FRL submissions, and instead apply more transparent and robust approaches, as proposed by the AT.	Resolved
	This recommendation was resolved by applying a more transparent degradation mapping approach using Collect Earth with the assessment concurrently running with deforestation assessment for all points generated	
26	The AT views moving toward an approach that quantifies increases in carbon stocks in line with guidance provided by the 2006 IPCC Guidelines and estimates removals on a year-by-year basis as an area for future technical improvement.	Resolved
	The Global Removals Database was chosen over the IPCC defaults (2006 Guidelines and 2019 Refinement, Volume 4) due to its comprehensive and scientifically validated data on all three species of interest in Malawi. Notably, the IPCC (2019) does not provide removal rates for coniferous Eucalyptus species in tropical dry climates. In contrast, the Global CO2 Removals Database, developed through a review of 335 scientific peer-reviewed manuscripts and published reports, offers a robust dataset with 1197 independent data points. Specifically, the database provides 32 data points for Eucalyptus and 28 data points for Pine species, ensuring a reliable basis for our removal factor calculations	

Paragraph Number	Recommendation	Status
	To estimate year-by-year removals, species-specific growth rates data and annual biomass increment data are essential. However, this information is currently unavailable for the country	
27	The AT noted the following issues regarding the analysis of uncertainties in the FRL submission:	Resolved
	The uncertainty analysis was updated in line with the recommendations. Within the Forest Reference Level (FRL), an uncertainty analysis for forest degradation was also presented, employing a Monte Carlo simulation approach. For this FRL, Malawi utilised SimVOI, a user-friendly, spreadsheet-based simulation tool, similar to the approaches adopted by countries such as Guyana, Peru, and Costa Rica. This tool offers an accessible interface, facilitating its use by individuals without extensive technical expertise. The reported uncertainty percentage in this FREL is 7.18% at a 90% confidence interval, which exceeds the 1.06% reported in the previous FREL. As noted in the Technical Assessment Report (TAR), the uncertainties reported pertain to the simulation results themselves. These uncertainties were calculated using consolidated data at the strata level, which may potentially lower the uncertainty due to averaging effects. The use of strata-level data was necessitated by data availability constraints. As recommended, area-weighted emission factors from the yearly National Forest Inventory (NFI) campaigns were used to analyze the uncertainties.	
30	Hence, the AT notes that collecting more information on the relative contribution of all the pools to emissions and removals, working toward a more complete coverage of carbon pools and justifying transparently any exclusions are areas for future technical improvement.	Justified
	Belowground biomass was included for the degradation activity. Based on expert knowledge of the Forest Reference Level Working Group members, there was consensus that the deadwood and litter pools were not significant in the forest plantations and are not included in the forest enhancement activity.	
31	The Party may wish to improve its estimation by choosing values for deadwood and litter biomass stocks that are more representative of the country's biophysical conditions. The AT notes this is an area for future technical improvement.	Resolved
	Malawi has improved the values applied for deadwood and litter biomass that are more representative of the country's biophysical conditions from the CDM look up tables. The Malawi has approximately 1,000mm –1,600mm per year annual precipitation. The deadwood and litter biomass factor of 1% was used.	
32	The AT considers that providing adequate quantitative information to render the Party's selection of the most appropriate ecoregion and forest SOC stocks transparent is an area for future technical improvement.	Resolved
	Rather than apply the ecoregion level Soil C stock factor, the National Malawi C Content value was applied. The National Malawi C content value was available in Henry et al. (2009) paper.	
34	The AT notes that developing definitions for each of the REDD+ activities could facilitate the justification of their exclusion or inclusion and broaden the scope of the FRL, which in turn could enhance the transparency, comprehensiveness and accuracy of future FRL	Justified

Paragraph Number	Recommendation	Status
	submissions, and considers this as an area for future technical improvement.	
	A definition of each of the REDD+ activities has been added to section 3.1 which includes a justification of the exclusion of the following activities; Sustainable management of Forests and Conservation of Carbon Stocks. • **Sustainable Management of Forests**: The conversion of non-planted forest areas to planted forest area is not included as a separate activity within this FRL. The carbon enhancements from sustainable forest management and associated removals from plantations forests are considered under the forest enhancements activity. Additionally, this is beyond the operational capacity of the DoF. In the event that non planted forest areas are expanded throughout the country, this activity can be included in future monitoring. • Conservation of Carbon Stocks: This refers to conservation activities that reduce emissions from deforestation and degradation in naturally occurring forests. This activity is not included because it not fully defined or distinguished within the forestry sector of Malawi. As conservation activities in natural forests expand, this activity can be included in the future.	
37	The AT noted inconsistencies in the use of the forest definition in estimating both AD for deforestation and emissions from forest degradation.	Resolved
	Within this FRL the AD collection was extended to forests outside of protected areas for the deforestation and degradation activities. And the emission factors were calculated from inventories that covered the majority of the country including protected and non-protected areas	
38	The AT notes that moving toward a methodological approach that allows the forest definition to be applied to the quantification of emissions from deforestation and forest degradation is an area for future technical improvement.	Resolved
	The inconsistencies in the use of the forest definition in estimating both AD for deforestation and emissions from forest degradation were avoided in the second submission by applying a joint method to quantify deforestation and degradation.	
39	The AT notes that collecting AD on deforestation for the whole country to allow a national scale estimation of emissions from deforestation is an area for future technical improvement.	Resolved
	Within this FRL the AD collection was extended to forests outside of protected areas for the deforestation and degradation activities. And the emission factors were calculated from inventories that covered the majority of the country including protected and non-protected areas	
40	The AT considers that as long as the FRL remains subnational, analyzing drivers of deforestation and assessing the risk of emission displacement to areas not covered by the FRL is an area for future technical improvement.	Resolved
	Within this FRL the AD collection was extended to forests outside of protected areas for the deforestation and degradation activities. And the emission factors were calculated from inventories that covered the majority of the country including protected and non-protected areas