Forest Carbon Partnership Facility (FCPF) Carbon Fund **ER Monitoring Report (ER-MR)**	
ER Program Name and Country:	People and Forests- A Sustainable Forest Management -Based Emission Reduction Program in the Terai Arc Landscape, Nepal. NEPAL
Reporting Period covered in this report:	22-06-2018 to 31-12-2021
Number of FCPF ERs:	**2,310,319**
Quantity of ERs allocated to the Uncertainty Buffer:	485,361
Quantity of ERs to allocated to the Reversal Buffer:	302,542
Quantity of ERs to allocated to the Reversal Pooled Reversal buffer:	137,519
Date of Submission:	14-09-2023

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Table of Contents

List of Figures

List of Tables

ACRONYMS

AEPC	Alternative Energy Promotion Center
AGB	Above-ground biomass
BGB	Below-ground biomass
BSM	Benefit sharing mechanism
CBFM	Community based forest management
CF	Carbon Fund
CFUG	Community forest user group
CI	Confidence interval
CSO	Civil Society Organization
DFMP	District forest management plan
DFO	Divisional Forest Office
EIA	Environmental impact assessment
ER	Emission reduction
ERPA	Emission reduction payment agreement
ERMR	Emission reduction monitoring report
ERPD	Emission reduction program document
ESMF	Environmental and social management framework
ESMP	Environmental and social management plan
FCPF	Forest Carbon Partnership Facility
FDF	Forest Development Fund
FECOFUN	Federation of Community Forest Users, Nepal
FPIC	Free, prior and informed consent
FSCMD	Forest Survey and Carbon Monitoring Division
GRM	Grievance redressal mechanism
IEE	Initial environmental examination
IPLC	Indigenous peoples and local community
IPP	Indigenous people plan
LHF	Leasehold forestry
MoFE	Ministry of Forests and Environment
MoITFE	Ministry of Industry, Tourism, Forests and Environment (Province level)
NEFUG	Nepalese Federation of Forest User Groups
NFMIS	National Forest Monitoring and Information System
NRC	National REDD+ Center
NRCC	National REDD+ Coordination Committee
NRSC	National REDD+ Steering Committee
PPE	Personal protective equipment
ScFM	Scientific forest management
SESA	Strategic environmental and social assessment
SFM	Sustainable forest management
SIS	Safeguards information system
SoI	Summary of information (on safeguards)

TAL	Terai Arc Landscape
WB	The World Bank

1 IMPLEMENTATION AND OPERATION OF THE EMISSION REDUCTION (ER) PROGRAM DURING THE REPORTING PERIOD

1.1 Implementation status of the Emission Reduction (ER) Program and changes compared to the Emission Reduction Program Document (ER-PD)

The Government of Nepal (GoN) has been implementing the Emissions Reduction (ER) program "People and Forests - A Sustainable Forest Management-Based Emission Reduction Program in the Terai Arc Landscape, Nepal" since 22 June 2018. This ER program is based on the Emission Reduction Program Document (ERPD) finalized and submitted to the Forest Carbon Partnership Facility (FCPF) on May 23, 2018.[1] Nepal's ERPD was accepted into the Carbon Fund Portfolio during the Carbon Fund meeting held from June 20–22, 2018 in Paris. Subsequently, on February 24, 2021, the GoN and the World Bank entered into Emission Reductions Payment Agreement (ERPA),[2] which establishes the two reporting periods for performance-based payment (Table 1):

Table 1: Reporting Periods and Contract Emission Reductions (ERs)

SN	Period	Minimum Contract ERs	Cumulative Contract ERs
1	June 22, 2018, to December 31, 2021	4,000,000	4,000,000
2	January 1, 2022, to December 31, 2024	5,000,000	9,000,000

The ERPA establishes the contract for the ER program to transfer 9,000,000 ER units to FCPF over the entire duration at the rate of USD 5.00 per transferred ER unit. This Emission Reduction Monitoring Report (ER-MR) covers performance of the ER program for the first reporting period (June 22, 2018 to Dec 31, 2021), **consisting the time period of 3.53 years**. This ER-MR follows the FCPF ER monitoring report template, version 2.4 issued in May 2022.[3]

The ER Program covers a geographic area of approximately 2.4 million hectares of Nepal's lowlands (called "Terai") and some of the adjoining Chure hills spread over jurisdictionally delineated 13 districts[4] that together comprises the Terai Arc Landscape (TAL). These districts are spread across five of Nepal's seven provinces – Madhesh, Bagmati, Gandaki, Lumbini, and Sudurpaschim. Uniquely rich in culture and natural resources, the TAL represents approximately 15% of Nepal's total area, 20% of its forests, 25% of its total population. This area is the country's most productive agricultural region. The ER program is expected to be a model for the implementation of performance-based activities to address drivers of deforestation and degradation, as it is aligned with the National REDD+ strategy.

Nepal viewed the ER program as an opportunity for aligning the priorities laid out in the country's policies with the opportunities in the land sector in the Terai region. The region supports the most productive forests, rich biodiversity and most significant protected areas (PAs) in the country. But the region also has the highest population growth and urbanization in the country, and offers greater economic development opportunities than elsewhere. Similarly, the livelihood and well-being of many communities in the region are linked to the health and productivity of the forests. Forestry, agroforestry, fuelwood and fodder collection and non-timber forest products directly support the livelihoods and customary practices of people in the region. As a consequence, the natural resources in the region face significant threats, which were identified in the ERPD as drivers of deforestation and forest degradation.

[1] People and Forests – A Sustainable Forest Management-Based Emission Reduction Program in the Terai Arc Landscape, Nepal. Date of Revision – 23 May 2018. Available at https://www.forestcarbonpartnership.org/system/files/documents/Nepal%20ERPD%2024May2018final_CLEAN_0.pdf.

[2] ERPA texts, Tranche A: https://www.forestcarbonpartnership.org/system/files/documents/FCPF%20Carbon%20Fund%20ERPA-Nepal%20Tranche%20A.pdf and Tranche B: https://www.forestcarbonpartnership.org/system/files/documents/FCPF%20Carbon%20Fund%20ERPA-Nepal%20Tranche%20B.pdf

[3] This version is available at https://www.forestcarbonpartnership.org/resources.

[4] While ERPD mentions 12 districts for the ER program area, presently it has 13 districts, as one of the districts (Nawalparasi) was divided into two.

The ERPD states that **deforestation** accounted for approximately two-thirds of land-based emissions in the Terai. It was driven by **immigration and unplanned settlement, encroachment of government-managed forests, illegal and unsustainable logging (mostly in government-managed forests) and expanding infrastructure development**.

The ERPD further states that **forest degradation** accounts for approximately one-third of land-based emissions and is driven by an **overall supply-demand gap for forest products, in particular for fuelwood and fodder, and illegal and unsustainable logging in government-managed forests.** Unmanaged grazing, particularly outside community forests, exacerbates these drivers and likely plays a role in inhibiting forest regeneration and enhancement in many areas. High fire frequency also plays a significant role in Terai. While fire is part of a natural disturbance regime in many of Nepal's forests and grasslands, most fires also occur intentionally, either as part of a prescribed burning regimen in protected areas (e.g. to enhance wildlife habitat) or to enhance grazing conditions in unmanaged areas. ERPD suggested that fires were not a significant source of emission.
ERPD also notes that regeneration appeared significant in the ER program area, with roughly 60,000 ha of regrowth (non-forest to forest) during the Reference Period (2004-2014). It may represent benefits already generated by community-based forest management.

1.1.1 Progress on the actions and interventions under the ER program

The ER program envisioned a total of seven interventions to achieve emission reductions.[5] They include (1) improving forest management; (2) localizing forest governance through hand-over of forest to local user groups; (3) expanding private sector forestry; (4) expanding access to alternative energy with biogas and improved cookstoves; (5) scaling up pro-poor leasehold forestry; (6) improving integrated land-use planning to reduce forest conversion; and (7) strengthening the management of protected areas. Some of them, especially interventions 1 and 2 were already being implemented since July 2018 before the approval of ERPD was approved. Hence Nepal intends to claim retroactive results-based payments for the ER credit generated from the interventions 1 and 2.

The central theme of interventions under the ER program was to expand community-based forest management regimes (community forestry and collaborative forestry), reducing the land area in less-managed government forests and enhancing the benefits of localized forest management with increased knowledge and application of sustainable forest management principles. These activities were implemented under the Ministry of Forest and Environment (MoFE) by supporting the actual "handover" process – by transferring the management rights of the forests to local forest user groups, and by working with forest user groups to upgrade management plans to reflect SFM guidelines.

Table 2 shows the progress made, mostly as of 2021, against the targets set for the seven interventions for the duration of the ER program. Subsequent paragraphs provide description of these interventions.

Table 2: Intervention Targets (2018-2028) and Progress as of 2021

SN	Intervention	Target	Progress 2018-2021[6]	Description / remarks
1	Improve management practices on existing community and collaborative forests building on traditional and customary practices	336,069 ha	154,766 ha (total) Community Forests: 94,236 ha; Collaborative Forests Management: 52,515 ha; Block Forest: 8015 ha	Data up to 2020
2	Localize forest governance through transfer of National Forests to	200,937 ha	12,107 ha of forest handed over to communities.	

[5] People and Forests – A Sustainable Forest Management-Based Emission Reduction Program in the Terai Arc Landscape, Nepal. Date of Revision – 23 May 2018. Available at https://www.forestcarbonpartnership.org/system/files/documents/Nepal%20ERPD%2024May2018final_CLEAN_0.pdf.

[6] Progress data drawn from two sources: a) REDD IC (2021, March). Implementation Status of Emission Reduction Program Intervention in Terai Landscape Nepal (From June 2018 to July 2020); and b) REDD IC (2022, May). Nepal Emissions Reduction Program: Environmental and Social Safeguards Consistency and Gap Assessment Report of Program Interventions for Retroactive GHG Emissions Reduction Crediting.

SN	Intervention	Target	Progress 2018-2021[6]	Description / remarks
	Community and Collaborative Forest User Groups		(9454 ha of CF; 2653 ha of collaborative forest)	
3	Expand private sector forestry operations through improved access to extension services and finance	30,141 ha	2127 ha new plantation	190 new private forests (114 ha) registered.
4	4a. Expand access to alternative energy with biogas	60,000 units	2382 units (July 2018 to June 2021)	
	4b. Expand access to alternative energy with improved cookstoves	60,000 units	3728 units (July 2018 to June 2021)	
5	Scale up pro-poor leasehold forestry	12,056 ha	3030 ha (Chitwan and Nawalpur divisions)	
6	Improve integrated land use planning to reduce forest conversion associated with infrastructure development	9,000 ha	Land use planning in 44 (out of 144) local government jurisdictions in ER program area	
7	Improve management of existing Protected Areas (PAs)	6 PAs	The PAs being managed under PA legislation and institutional arrangement	

Intervention 1. Improve management practices on existing community and collaborative forests building on traditional and customary practices. This is the one of the two main interventions of the ER program, for which a target was set to improve management practices in 336,069 hectares in the 13 districts of the ER program. This intervention consists mainly of the adoption of Sustainable Forest Management (SFM), aiming to increase the production of timber and fuelwood as well as biomass, by integrating local needs as well as the traditional and customary practices. Under the intervention, silviculture system-based forest management is being undertaken in community forests, collaborative forests, and government-managed "block forests". Accordingly, not only in community forest and collaborative forests, the block forests in Rautahat, Nawalparasi, Dang and Banke districts of the ER program area are implementing SFM as the regular government-led activity. REDD Implementation Center (REDD IC) supported the preparation of SFM plans, while Divisional Forest Offices (DFOs) are responsible to implement these plans.

By 2020, a total of 154,766 ha of forest has been brought under improved management practice in the 13 districts of the ER program. This area consists of community forest (94,236 ha); collaborative forest (52,515 ha) and Block Forest: 8015 ha. The activities under this intervention included sustainable forest management; silvicultural system; silvicultural treatments; forest protection activities including the control of illegal cutting of trees and ban on grazing, such as through strict law enforcement as well as community-level anti-encroachment teams monitoring the SFM sites. They also included forest plantation in open space and public land and adoption of more effective harvesting and utilization of forest produce.

Intervention 2. Localize forest governance through transfer of National Forests to Community and Collaborative Forest User Groups. This intervention targeted the hand-over of approximately 200,937 ha of government managed forests (equivalent to 40 percent of the remaining government forests in the Terai) to community or collaborative forest management user groups. Since 2018, a total of 12,107 ha of forest has been handed over to communities under community forest or collaborative forest models. Of this, 9454 ha of forest was handed over as community forests within seven districts of the ER program area. This handover involved the transfer of forest management responsibility, custodianship and tenurial rights to 60 community forest user groups (CFUGs), consisting of a total of 13,793 households. Similarly, 2653 ha of forest was handed over to communities as a collaborative forest in Kailali. This intervention is closely linked to the first intervention - the forest management operational plans approved as a requirement of the hand-over were drawn up following the principles of scientific/sustainable forest management.

Intervention 3. Expand private sector forestry operations through improved access to extension services and finance. The ERPD set the target of supporting 30,141 ha of private forest in the ER program area during 2018-2024. This is additional to the private forests that existed earlier. At the beginning of the ER program, there were a total of 639 registered private forests in the TAL area covering 550 ha of forests. Since 2018, a total of 190 new private forests which include an area of 114 ha, have been registered in eight districts. At the same time, many private forest owners operate without registering their forest – and a substantial number of private forests is expected to have developed during this period. Records show that a total of 8.5 million tree seedlings were distributed during this period. With the assumption of 1,600 seedlings planted per ha and with 40% survival, this amounts to the raising of 2,127 ha of new private forests in the ER program area. Because of low land-holding size in the ER program area – and in Nepal more generally – these plantations are assumed to be scattered in small areas in and around the settlements.

Intervention 4. Expand access to alternative energy with (4a) biogas and (4b) improved cookstoves. This intervention targeted the installation of 60,000 biogas plants and 60,000 improved cookstove (ICS) units over the duration of the ER program. The installation of biogas plants and ICS units is carried out by Alternative Energy Promotion Center (AEPC), which sells ER credits of alternative energy installations in the international market. Accordingly, ER credits from biogas plants and ICS are not included in this ER program. Over the first three years of the ER program, biogas plant installation was carried out in 11 districts of ER program area and 2,382 units were installed. Similarly, a total of 3,728 ICS units were installed in 11 districts. The adoption of biogas plants as a source of household energy and energy saving from improved cookstoves contribute to emission reductions from the land use sources.

Intervention 5. Scale up pro-poor leasehold forestry. Nepal's pro-poor leasehold forestry (LHF) program has been acknowledged to increase the livelihoods and employment opportunities of the rural poor. ERPD set the target of scaling up pro-poor LHF in 12,056 ha in 12 districts, excluding Bardia district. The intervention was implemented in only two (Chitwan and Nawalpur) of the 13 ER program districts. By 2020, 584 LHF groups with 4,567 households were managing 3,030 ha of forest in these two districts.[7]

Intervention 6. Improve integrated land use planning to reduce forest conversion associated with infrastructure development. Main objective of this intervention was to reduce deforestation of 11,736 ha of forest area through integrated land use planning and implementation in infrastructure development in the ER program districts. REDD Implementation Centre supported the land use plan preparation in 31% of the local governments (municipalities or rural municipalities in the ER program area. The REDD IC accomplished major background works and prepared the plans of 44 local governments in 10 of the 13 districts (Table 3). Of the 44 plans, nine were prepared in Fiscal Year 2018/19 and 35 in FY 2019/20. Further, the integrated land use plans require review and minor updates to ensure consistency and alignment with the recently endorsed Land Use Regulation 2022 before the local governments can proceed with the plans' implementation.

Table 3. Local governments in ER Program Area Supported with Integrated Land Use Planning

District	Municipality/Rural Municipality	Fiscal Year
Rautahat	Chandrapur	2018/19
	Kataharia, Phatuwa Bijayapur, Dewahni Gonahi, Molapur, Bodhimai, Gujara, Ghadimai, Brindaban	2019/20
Bara	Jitpur Simara, Nijgadh	2018/19

[7] MoFE, 2020. Current Status of Community Based Forest Management Models in Nepal. Ministry of Forests and Environment, Singhadurbar, Kathmandu. https://mofe.gov.np/uploads/documents/current-status-of-cbfm-in-nepal20201629351493pdf-3355-366-1658827849.pdf, p.101-02

	Pheta, Parawanipur, Kohabi, Kalaiya, Kataiyamai, Debatal	2019/20
Parsa	Parsagadhi	2018/19
	Bahuharmai, Pokhariya, Birgunj, Thori, Satuwaparsoni, Parera Sugauli	2019/20
Parasi	Bardaghat, Sunwal, Sarawal	2019/20
Rupandehi	Devdaha, Kanchan, Lumbini Sanskritik, Gaidahawa, Tilottama, Sainamaina, Butwal	2019/20
Kapilvastu	Banganga, Kapilvastu, Buddhabhumi, Shivaraj, Bijayanagar	2019/20
Dang	Tulasipur	2018/19
Banke	Kohalpur	
Bardia	Barhbardia	
Kailali	Dhangadhi, Lamkichuha	

Intervention 7. Strengthen the management of protected areas (PAs). The ER program area contains six PAs, that include five National Parks and a Conservation Area. These six PAs cover a total area of 341,997 hectares (Table 4). The five National Parks have buffer zones in their peripheries that cover a total area of 210,617 ha spread over 39 local government jurisdictions. As carbon stocks in the PAs are generally much higher than that under other management regimes (National forests, community forest, collaborative forests, leasehold forests, religious forests), strengthening the PA management to conserve and enhance the forest carbon stocks is important. Once established as PAs, various conservation measures are adopted in these jurisdictions. All of these PAs are managed under the Department of National Parks and Wildlife Conservation (DNPWC). Owing to stricter protection, these areas are not subject to historical deforestation and forest degradation. These areas are included in the ER Program for the significant non-carbon benefits that they provide and to safeguard against any social and environmental impacts (e.g. human wildlife conflict) that could arise due to the implementation of REDD+ program. Accordingly, no direct activities were proposed under this intervention.

Table 4. Protected Areas in Nepal ER Program Area

SN	National Parks (NPs) and Conservation Area (CA)			Buffer zone	
	NP or CA	Area sq.km.	Districts	Area sq.km.	No of Local Governments
1	Parsa NP	627.39	Bara, Parsa, Makwanpur	285.3	4
2	Chitwan NP	952.63	Chitwan, Nawalpur, Parsa, Makwanpur	729.37	12
3	Banke NP	550	Banke	343	6
4	Krishnasar CA	16.95	Bardia	-	-
5	Bardia NP	968	Bardia	505	10
6	Shuklaphanta NP	305	Kanchanpur	243.5	7
Total		**3,419.97**		**2,106.17**	**39**

Source: REDD IC. 2021, March. Implementation Status of Emission Reduction Program Intervention in Terai Landscape Nepal, p.25.

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

The Nepal ER Program carried out efforts to mitigate or minimize displacement of emissions to areas outside the Program boundaries. The program's main thrust in achieving this was through improving forest management in existing community forestry and collaborative forest areas and government-managed block forests, and the handover of government forest to local communities – along with other interventions and policy/regulatory efforts to mitigate and/or minimize displacements. Key measures for displacement mitigation included the following.

- Handover of community forest
- Handover collaborative forest management
- Improve sustainable forest management, including scientific forest management
- Revise forest operational plans
- Community custodianship and control over local forest under community and collaborative forestry regimes

Table 5 shows specific risk levels and the strategies adopted for addressing the drivers of deforestation and forest degradation.

Table 5: Update on Strategies to Mitigate and/or Minimize Potential Displacement

Drivers of deforestation and degradation	Risk of displacement	Strategies for mitigating / minimizing displacement
A. DEFORESTATION		
1. Encroachment	Low	Encroachment to forest fringes occurred mostly in the context of open access to government owned land. The clear demarcation of forest land as collaborative and community forestry establishes both statutory basis and community custodianship to reduce and avoid encroachment.
2. Infrastructure Development	Low	Infrastructure development – such as road, hydropower, school construction – are typically designed to serve a given area and do not pose significant risk of displacement outside the ER program area. For new infrastructure projects, the developers have to follow Nepal's laws and technical procedures on environmental impact assessment and associated mitigation measures. These include initial environmental examination (IEE) and environmental impact assessment (EIA) that are conducted for all Community or Collaborative Forests for implementing SFM

Drivers of deforestation and degradation	Risk of displacement	Strategies for mitigating / minimizing displacement
		as required by the Environment Protection Act 2019[8] and Environment Protection Rules 2020.[9] Therefore, the risk of displacement due to this driver is low. The Government of Nepal was in the process of preparing Eco-friendly Linear Infrastructure Directive and conducted series of consultations with the stakeholders. In 2022, the government has endorsed wildlife-friendly Linear Infrastructure Directives which is currently under implementation. The Directive also addresses and mitigates the risks and threats to forests and ecosystems to a certain extent.
3. Resettlement	Low	Planned resettlement has not occurred in the ER program area during 2018-2021, and the risk of displacement due to this remains low. Whenever resettlements are considered, they are expected to be within the ER program area and, also subject to social and environmental management / safeguard frameworks.
B. FOREST DEGRADATION		
1. Unsustainable / illegal timber extraction	Medium	The demand of timber in the ER program area, and Nepal, exceeds the sustainable supply. Trade involves both intra- and inter-district, going into and out of the ER program area. Major approach in this ER program to address this driver is to establish clearer community rights and custodianship over forest, so that local community have the incentive to manage and utilize forests more sustainably within the local areas. Improvement in forest management in community forests, collaborative forests, and block forest also help optimize timber production and extraction.
2. Fuelwood extraction	Low	Fuelwood is extracted locally only. Improved forest management is expected to improve the supply of fuelwood locally. Similarly, the establishment of new biogas and ICS plants further reduces the demand for fuelwood, and hence forestalls potential displacement.
3. Overgrazing	Low	Grazing is typically limited within the vicinity of villages – and increasingly stall feeding is bring practiced in the ER program area. Accordingly, the risk of displacement from overgrazing remains low. While some displacement may exist around the boundaries of the ER program area, the presence of community forests immediately outside the area reduces this risk.
4. Forest fire	Low	Forest management plans for community forestry, collaborative forestry and block forests mostly include measures to control and mitigate forest fires. In many plans, the provision of fire lines and training to local people for fire control and support on simple equipment are provided. Different capacity building activities from the divisional forest offices and awareness raising and information and communication materials help people to manage and control the forest fire.

[8] Available at https://www.lawcommission.gov.np/en/wp-content/uploads/2021/03/The-Environment-Protection-Act-2019-2076.pdf

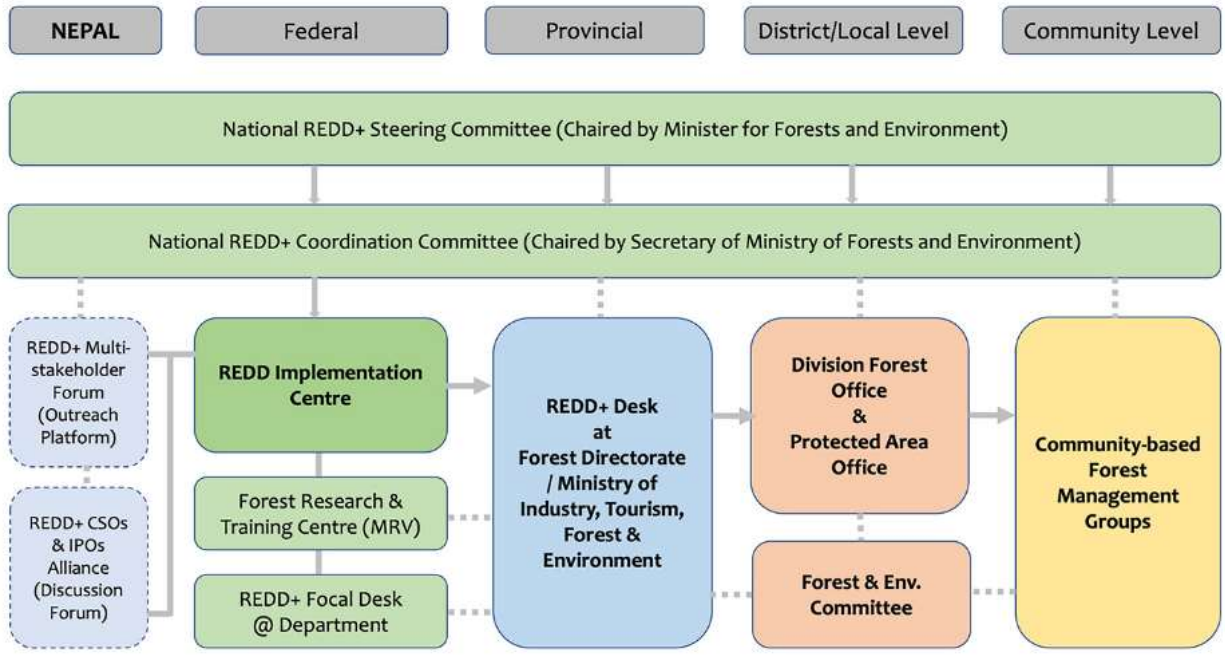
[9] Available at https://mofe.gov.np/uploads/documents/envregulation2077pdf-6209-686-1660735429.pdf

1.1.3 Effectiveness of the organizational arrangements and involvement of partner agencies

The Nepal ER Program and its effective implementation depend on the effective engagement of stakeholders. The program was initiated while Nepal was transitioning from a centralized, unitary state into a federal one. The new structure has three tiers of government, consisting of federal, provincial and local levels, constituting the federation. The organizations involved in the ER program are not only the federal institutions, including the Ministry of Forest and Environment (MoFE), but also provincial and local governments. Current institutional mechanisms have evolved from those that existed during the REDD readiness phase until 2018. The readiness phase was governed through a three-tier institutional mechanism – consisting of REDD Multi-sectoral, Multi-stakeholder Coordinating and Monitoring Committee as the apex body; the REDD Working Group (RWG) as the decision-making body; and REDD implementation Center as the implementing entity.[10] Two peripheral mechanisms, including a Stakeholder Forum and a REDD+ CSO Alliance and IPOs Alliance, were established to develop a common understanding on REDD+ among stakeholders including women, Indigenous People's organizations, Madhesis, Dalits and civil society organizations. All four departments under the MoFE have varied roles in REDD+ implementation.

During the implementation of the ER program, the previous institutional mechanism was restructured with the adoption of National REDD+ Strategy in 2018. In the ER program implementation period, institutional mechanism has been adapted to the federal set up of the country- specifying the three governance tiers – federal, provincial and local levels – and at the same time asserting the prominent role of local of communities. Existing structure shown in Figure 1, followed by a brief description in subsequent paragraphs.

Figure 1. Institutional Mechanism for REDD+ in Nepal



Source: REDD IC website, https://redd.gov.np/page/institutional-mechanism-for-redd-nepal, downloaded Dec 24, 2022.

[10] MoFE, 2018. Nepal National REDD+ Strategy. Kathmandu, Ministry of Forest and Environment. Available at https://www.forestcarbonpartnership.org/system/files/documents/Nepal%20National%20REDD%2B%20Strategy.pdf, p.12-13.

- REDD+ Implementation Center is re-envisioned as National REDD+ Center (NRC) to function as the primary operational body to provide national program leadership, coordinate ER program planning, and bridge province and district-level planning and priorities under the National REDD+ Strategy. It is expected to serve as REDD+ programs management entity. It is expected to fulfill the basic fiduciary standards of financing institutions, generate its own fund and compete to access international REDD+ related funds by maintaining an effective fund administration. For this, it will establish independent internal and external audit systems.
- The National REDD+ Steering Committee (NRSC), which is chaired by the Minister of Forests and Environment, has been established. It consists of secretaries of five federal Ministries, the National Planning Commission, National Natural Resources and Fiscal Commission, three representatives from the networks of local governments, seven provincial secretaries (Ministry of Industry, Tourism, Forests and Environment) as well as up to six representatives (at least two women) from civil society organizations drawn up from amongst IPs and other communities engaged in forest resource management. The Head of NRC serves as its Member Secretary.
- National REDD+ Coordination Committee (NRCC), which is chaired by the Secretary of the MoFE, is another structure established as per the National REDD+ strategy. It is mandated to make decisions on technical matters such as endorsing research documents, implementation and monitoring of REDD+ programs and recommending the agenda for NRCC meetings. It consists of Joint Secretaries and Directors General of the MoFE's departments, Chief of Forests Research and Training Center as well as up to nine representatives (at least three women) from civil society organizations drawn up from amongst IPs and other communities engaged in forest resource management. The Head of NRC serves as its Member Secretary.
  On June 5, 2021, a meeting of NRCC was held, with the participation of six women and 19 men members. The meeting discussed the internal procedure for the working of the NRCC.

- REDD+ Multistakeholder Forum is another structure, consisting of representatives from the private sector, civil society, media, government organizations, community-based organizations, IP organizations, local and international NGOs, donors, academic and research institutions.
- REDD+ CSOs and IPOs Alliance is expected to discuss and develop a common understanding on REDD+ on behalf of women, IP organizations, Madhesis, Dalits and CSOs.
- REDD+ Focal Desks have been established in each of the four departments under the MoFE; the focal desks are required to liaise with NRC, and sub-national level REDD+ Focal Desks.
- The provincial Ministry of Industry, Tourism, Forests and Environment (MoITC) in each of Nepal's seven provinces have established provincial level REDD+ Desks.
- Forest and environment-related sections in local governments are tasked with coordinating the REDD+ programs in the relevant local government jurisdictions.
- At the community level, community-based forest management (CBFM) – such as those management community forest or collaborative forest are required to implement REDD+ as outlined in their respective forest management plans.

In addition to the above structures, the REDD+ implementation requires the participation of different government agencies and departments as well as other stakeholders. There is a need for cooperation from other federal ministries, such as the Ministry of Agriculture and Livestock Develoment (MoALD), Ministry of Land Management, Cooperatives and Poverty Alleviation (MoLCPA), Presidential Terai-Chure - Madhesh Conservation Development Board, Alternative Energy Promotion Center (AEPC), UN agencies, and other national and international organizations.

The following are the key milestones to be achieved for more effective institutionalization of REDD+

- Consolidate REDD Implementation Centre as National REDD+ Center with its expanded capacity and mandate, envisioned in the REDD+ strategy 2018.
- Regular convening of the meetings of the structures envisioned through the REDD+ strategy – including the NRSC and NRCC.
- More engagement and coordination with other federal ministries as well as the provincial and local governments.

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

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1.2 Update on major drivers and lessons learned

The three drivers of deforestation identified in the ERPD – encroachment, infrastructure development and resettlement – pose low levels of risks to deforestation. Encroachment of forestlands by squatters and the expansion of informal settlement (called *sukumbasi basti*) were encouraged in the past in times of political turmoil. Recent years have seen a more smooth, peaceful transition of power and consequently a more effective rule of law means reduced risks for encroachment.

On the other hand, greater political stability and social order achieved in the recent past is likely to contribute to greater infrastructure development. The successful elections for three tiers of the federation and peaceful transfers of power as well as the consolidation of the new governance / administrative structures in Nepal in the recent past have fostered political stability and encouraged infrastructure development. Infrastructure development is also politically and socially desirable, given the huge infrastructure gap that currently exists in the country . In addressing emission risks emerging from new infrastructure, enough safeguards exist in Nepal, especially on environmental legislation, which is enforced by the MoFE.
Similarly, planned resettlement is only likely in mega-projects, such from new hydropower projects' dam constructions or unforeseen disasters. These risks are not imminent in the ER program area.

Th four drivers of forest degradation identified in the ERPD – unsustainable/illegal timber extraction, fuelwood extraction, overgrazing and forest fire – pose low to medium level of risks to forest degradation. The risks associated with overgrazing and forest fire continue to be low and no apparent change to these drivers have been noted.

However, some broad patterns of change have helped to mitigate two other drivers—unsustainable timber extraction and fuelwood extraction. Firstly, Nepal has seen a steady and continuous increase in the production of hydroelectricity and Nepal Electricity Authority is encouraging the use of electricity for domestic use. This is expected to reduce demand for LPG and fuelwood. Similarly, the adoption of the use of biogas and improved cookstoves reduce the per capita demand for fuelwood. Thus, the pressures from the demand for fuelwood on forest degradation has been gradually reducing.

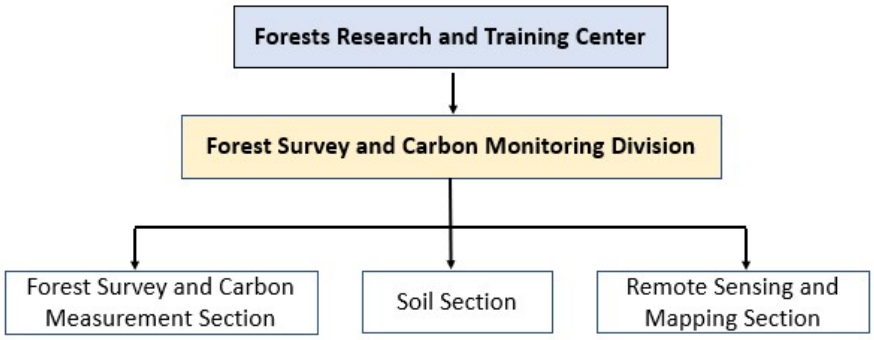
Similarly, greater political stability and law enforcement situation as well as improved community control and custodianship under participatory forest management regimes reduce illegal timber extraction. The availability of alternative building materials (including aluminum) is also expected to have alleviated some pressure on timber extraction.

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

2.1 Forest Monitoring System

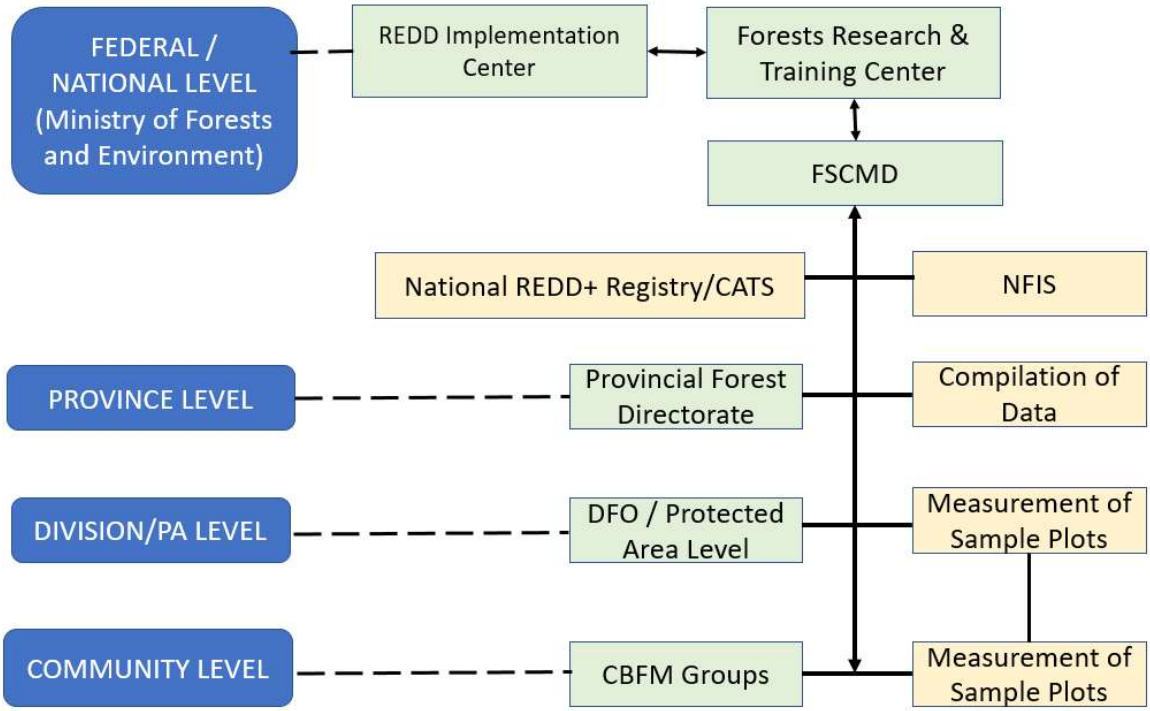
Nepal has established a comprehensive and systematic forest monitoring system. Forest cover monitoring and periodic national forest inventory have been functioning well under the Forest Research and Training Center (FRTC), Ministry of Forests and Environment. Permanent sample plots for national forest inventory have been established and measured at an interval of five years. Under the broader theme of National Land Cover Monitoring System (NLCMS), forest cover monitoring and mapping using satellite images are carried out on an annual basis. Furthermore, for precise estimation of volume and biomass, a program to develop allometric equations of 16 major tree species of the country has been initiated in 2022. The Forest Survey and Carbon Monitoring Division (FSCMD) of FRTC is the focal institution for forest monitoring systems. The organizational structure of the Division is presented in Figure 2.

Figure 2: Organizational Structure of Forest Survey and Carbon Monitoring Division in FRTC



On the national scale, forest survey and monitoring require engagement of federal, provincial (state), and local (divisional) and community level actors and agencies. The relationship of these organizations is illustrated in Figure 3. Until REDD + Registry is fully established/operationalized, it has been agreed that the Government of Nepal deploys the World Bank's Carbon Assets Tracking System (CATS).

Figure 3. Multi-Level Structure for Forest Inventory and Carbon Monitoring



2.1.1 The selection and management of GHG related data and information

The periodic Forest Resource Assessment (FRA) / National Forest Inventory (NFI) of Nepal produces the estimates on Emission Factors and generates information on tons of biomass (and carbon) stored per hectare of forest. Nepal has conducted three national forest inventories: NFI (1987-1998), FRA (2010-2014), and FRA (2016-2021). The FRA (2010-2014) produced the Emission Factors used for the FREL submitted to the UNFCCC in 2017 (Reference level mentioned in section 8 (page 120) of ERPD.[11]

FRA (2010–2014) was designed to carry out national level forest resource assessment for providing comprehensive and up-to-date national-level forest resource information to support forest policy formulation, national-level forestry sector decision-making and international reporting. FRA Nepal implemented multi-source forest resources inventory by using high-resolution satellite imagery, field inventory as well as other existing data sources such as digital elevation model and national topographic maps. Categorization of land cover followed in FRA Nepal is based on current international practices of FAO which is also adopted by Intergovernmental Panel on Climate Chang (IPCC) for greenhouse gases (GHG) emission estimation and reporting. The inventory design was largely based on the principle adopted for NFI (1999) developed by Kleinn (1994). Two-phase systematic cluster sampling was adopted for field measurement.

In order to have more accurate estimates for the Terai Arc Landscape (TAL) area, the plots located in this area were used to generate TAL-specific Emission Factors.

[11] Available at https://www.forestcarbonpartnership.org/system/files/documents/Nepal%20ERPD%2024May2018final_CLEAN_0.pdf

The Inventory design (ID) for national forest inventory has been created. The ID is based on two-phase sampling with stratification and, in case of TAL area with LiDAR Working Areas, the three-phase sampling with stratification has also been done. Different sampling intensity and design has been applied for each stratum depending on a priori information and results from the visual interpretation of satellite imageries per stratum. However, the strata for calculation of results are five physiographic zones. Both High Resolution (HR) and Very High Resolution (VHR) satellite images are used for the first phase of the sampling to classify clusters and sample points of forest coverage and to assess the accessibility of sample plots. Based on this, sample plots for the second phase of the sampling (field inventory work) are defined. The second phase of the sampling refers to the actual clusters and permanent sample plots that were measured in the field.[12]

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

National Forest Inventory (Forest Resource Assessment) data has been collected as per the FRA Field Manual, 2022 approved by FRTC.[13] The field manual contains detailed methodology of the Inventory Design and field measurement procedures.

The Forest Survey and Carbon Measurement section of FRTC validates the field data. In doing so, it deploys a validated method, stipulated in the Manual on Data Analysis and Results Generation (2021), which is available at the FRTC website.[14]

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

The overall National Forest Inventory (NFI) Forest Resource Assessment (FRA) data collection procedure has always been accompanied by various levels of Quality Assurance and Quality Control (QA/QC) to ensure that the recorded data and followed procedures are reliable and meet minimum measurement standards. A refresher's training on NFI before field data collection, hot checks by FRTC officers during the field measurement, re-measurement of 10 % forest plots to assure that collected data has error less than 5 %, QA/QC for lab measurements and data entry & archiving, etc. are some of the tools under overall system and process that ensure the accuracy of the data and information.[15]

Accordingly, the forest inventory system is well established. Periodic forest cover monitoring system using remotely sensed data (satellite images) has been put in place.

Systems and processes that support the Forest Monitoring System, including Standard Operating Procedures and QA/QC procedures. A well-established National Land Cover Monitoring System is functioning in Nepal under Google Earth Engine (GEE) platform[16]. Forest Resource Assessment manual is in operation for conducting Forest Resource Assessment (FRA) [17]. There is a standard operating procedure for QA/QC process[18].

[12] The details can be accessed at: https://drive.google.com/file/d/142FYFebXTCruimqe1wKbDoi-oBdwfERh/view?usp=drive_link

[13] Field Manual, 2022 is available at: https://drive.google.com/file/d/1EvrStTmfNAZVW7ewAqEXuKiUm-OzqUVB/view?usp=drive_link
[14] Go to: https://drive.google.com/file/d/1Z1h0Q2JiXlEXCHW1qDNcBrj1B38GEhi7/view?usp=drive_link
[15] Refer to Forest Resource Assessment in Nepal [Re-Measurement of Permanent Sample Plots] Field Manual, 2022: page 58, Chapter 5. QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC). Available at https://drive.google.com/file/d/1EvrStTmfNAZVW7ewAqEXuKiUm-OzqUVB/view?usp=drive_link
[16] Available at https://drive.google.com/file/d/1nCsDoqgsAZw79IL23gdRQqIP_pq4ZGnd/view?usp=drive_link
[17] Available at https://drive.google.com/file/d/1EvrStTmfNAZVW7ewAqEXuKiUm-OzqUVB/view?usp=sharing
[18] Go to https://drive.google.com/file/d/1YmbHZSOIxfsnfotBbb3elCBSemh4cA8h/view?usp=drive_link

Role of communities in the forest monitoring system. The communities are directly involved in forest resource assessment directly and indirectly contribute to the national forest monitoring system. Forest resource assessment (periodic NFI) is an important part of the national forest monitoring system in Nepal. During inventory of each sample plot, concerned forest communities were informed prior to the field measurement and were encouraged to participate during forest resource assessment. Their role is significant in terms of getting access to plot location, species identification, characteristics of deforestation and forest degradation including driver, causes and impacts as well. Furthermore, all community based forest management (CBFM) committees prepare and submit the annual monitoring reports to respective Division Forest Offices (DFO).

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

Nepal has developed a system for continuous monitoring of land cover using consistent methodology, following "National Land Cover Monitoring System (NLCMS) of Nepal" (2022), which is available at FRTC website.[19] Forest cover from NLCMS is the one of the input variables for generation of Activity Data. The Activity Data were prepared using ensemble methods. This method include four algorithms (please refer to Nepal Forest Change Area Estimation Tool), that include CODED (Continuous Degradation Detection), CCDC-SMA (Continuous Change Detection and Classification- Spectral Mixture Analysis), LandTrendr, and MTDD (Multivariate Time-series Disturbance Detection).

[19] Go to: https://frtc.gov.np/uploads/files/Study%20Report%20Inner-final.pdf

2.2 Measurement, monitoring and reporting approach

Table 6 provides a systematic and step-by-step description of the measurement and monitoring approach applied for the establishment of the Reference Level and estimating Emissions and Emissions Reductions during the Monitoring and Reporting Period for estimating the emissions and removals from the Sources/Sinks, Carbon Pools, and greenhouse gases selected in the ER-PD.

Table 6: Step-by-step description of the monitoring parameter and data integration tools to establish the Reference Level and estimate Emissions and Emissions Reductions during the Monitoring Period for the Carbon Pools and greenhouse gases (GHGs) selected in the ER-PD.

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
1	**Activity Data estimate and associated uncertainty.**	**CCDC-SMA**[20]: 1_CCDC_SMA_UI_C2 2_ViewExportDegDefMapp 3_LTMakeLossGainPostprocessed 4_AssembleMap **CODED**[21] Forest Disturbance Mapping GUI **LandTrendr**[22] 1_UI-ImageScreener (optional) 2_LT-Data-Visualization-NepalTool **MTDD**[23] 1MTDD_app_trainingpoints 2MTDD_app_changemap **Forest change maps**	**Nepal Forest change area estimation tool**: Documentation on how to use this tool and a compiled set of links to user interfaces of all the tools needed to complete the forest change area estimation for Nepal can be accessed at the following link: https://training.sig-gis.com/NEPALworkshopAE/ 1. **Forest change mapping**: To estimate the area, Nepal employs a sample-based approach. For the sample design, a forest change map spanning from 1983 to 2021 was prepared. The following four mapping algorithms that utilize remote sensing imagery, training data points, land cover maps, and time series data analysis were used to map areas experiencing forest loss, degradation, and/or regrowth. i. **CCDC-SMA**: Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) monitors abrupt and gradual forest degradation. ii. **CODED**: Continuous Degradation Detection (CODED) algorithm detects forest canopy disturbances and classifies them as degradation or deforestation based on land cover. CODED uses linear spectral unmixing to generate subpixel fractions of spectral endmembers, which are used to calculate a time series of the Normalized Degradation Fraction Index (NDFI). iii. **LandTrendr**: The LandTrendr algorithms use simple statistical techniques to simplify a time-series of spectral values into a sequence of connected straight-line segments that capture the overall shape of that pixel's trajectory while omitting year-to-year noise. The resultant segments can then be examined to select periods where the trajectory displays behaviors of interest such as disturbance or growth. iv. **MTDD**: Multi-variate Time-series Disturbance Detection (MTDD) classifies initially forested areas into stable forest, degraded, and deforested by training a random forest classifier with 66 metrics. These metrics are derived from six annual time-series (i.e., NDVI, two SWIR spectral regions, two NDWI indices, and SAVI) which are used to calculate eleven descriptive statistics (i.e., minimum, maximum, range, mean, standard deviation, coefficient of variation, kurtosis, skewness, slope, maximum 5-year slope, and most recent value). Overall MTDD's process includes five main steps: (1) making annual time series, (2) calculating 11 descriptive statistics for the time series, (3) generating training/validation points, (4) training a random forest classifier, and (5) validating the classification.
		Map Visualization tool **1_VisualizationApp_Nepal** (in Visualization App folder of GEE repository)	2. **Map visualization and comparison**: Each of the mapping algorithms is useful for detecting changes in a slightly different manner. However, all maps are susceptible to bias, which is why the area of map classes from the resulting maps should not be directly used for Activity Data reporting. Each map is visually assessed so any concerning results can be addressed with parameter adjustment as needed.

[20] Procedure document of CCDCSMA can be accessed at the following link https://github.com/shijuanchen/forest_degradation_georgia

[21] Tools CODED of the GEE repository can be accessed at the following link https://code.earthengine.google.com/?accept_repo=users/bullocke/coded

[22] Procedure document of LandTrendr can be accessed at the following link https://docs.google.com/document/d/1GfdMSSaU4tiDv1Sf2L8S4k2144ptpU9seB1UkPURDCA/edit

[23] Procedure document of MTDD can be accessed at the following link https://docs.google.com/document/d/1TukNQOuEqw9OoeZgcHWUrv-ER-87TkhU9HVuV_x6HZA/edit

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
		Agreement map preparation 1_MakeAgreementMap_Nepal[24] (Agreement Map in Google Drive folder) **Forest Change Agreement Map**[25] **Area available in each stratum**[26] **Spreadsheet for Sample Size/Distribution Design**[27]	3. **Sample design**: A sample-based approach is used to complete area estimation. This approach is preferred over pixel-counting methods because all maps have errors. Sample based approaches create unbiased estimates of area and allows calculation of the uncertainty of each estimate. An agreement map generated from the results of all four methods is used for sample design. The goal is to ensure that no strata is under-sampled. The 1_MakeAgreementMap_Nepal tool (in Map Agreement App folder of GEE repository) is used to combine the maps of the four forest change detection algorithms. Final strata values for the agreement map and their human-readable labels are 1: DEG, 2: LOSS, 3: GAIN, 4: Non-forest, and 5: Forest. When combining the results of the four algorithms into one map, the following logic rules are applied for each pixel: ● A GAIN supersedes all other labels. ● If an equal number of DEG and LOSS labels occur across the four algorithms, LOSS supersedes. ● If the number of DEG labels is more than the number of LOSS labels or DEG is the only type of change detected, a DEG label is given. ● If the number of LOSS labels is more than the number of DEG labels or LOSS is the only type of change detected, a LOSS label is given. ● A Non-forest label is given only if all four algorithms label it as Non-forest. ● A Forest label is given only if all four algorithms label it as Forest. Final strata definitions: DEG (1) = more algorithms detected degradation than loss, and GAIN is not detected LOSS (2) = more algorithms detected LOSS than DEG or an equal number of algorithms detected LOSS and DEG, and GAIN is not detected GAIN (3) = one or two algorithms labeled the pixel as GAIN, even if others detected LOSS or DEG Non-forest (4) = all algorithms labeled pixel as stable Non-forest Forest (5) = all algorithms labeled pixel as stable Forest 4. The number of points randomly selected depends on the relative area available in each stratum, the human resources available to do interpretations, and a target standard error. The linked spreadsheet in tools columns contains equations needed to calculate the ideal sample size to hopefully achieve the target standard error. A total of **1,522** points were selected via stratified random sampling to be used for sample-based area estimation. For the smaller strata a minimum of 110 points was required.
		Nepal's CEO institution Interpretation key	**5. Reference data collection (completed in CEO):** To estimate emissions from deforestation, carbon enhancement removals, and forest degradation emissions, reference data were collected through visual imagery interpretation and **time series analysis** of 1,522 sampling plots in CEO[28]. The sampling points were visually interpreted for the same period that the forest change map was created (2004 to 2021). However, to identify the age of forests in order to differentiate between secondary and permanent forests, an additional pre-period was examined. The time period of examination was divided into four subperiods with distinct sets of survey questions: 1984-2003, 2004-2014, 2015-2017 and 2018-2021 (see Figure 4). The canopy cover was visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

[24] https://drive.google.com/drive/folders/1SJq6ZGzVTM4g1IB5ALSq6z2JHJdyFX7d?usp=sharing
[25] https://drive.google.com/file/d/1VtYM-xCunuRpjfOgeAO9aLDMMGwj_H71/view?usp=drive_link
[26] https://docs.google.com/spreadsheets/d/1Wp0lxDpqKMFlro7OdeTuaLwAQSVb2VqJ/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true
[27] https://docs.google.com/spreadsheets/d/1AfZTmd-KQHMy_amBkz03ZepFhrUIcqCG/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true
[28] https://drive.google.com/file/d/1PI95tEihWMqXNE9QORqgjdg8d9B5oEN6/view?usp=sharing

<table>
<tr><th>Step</th><th>Monitoring parameters and Data Integration tools</th><th>Tools and datasets</th><th>Description of the measurement and monitoring approach</th></tr>
<tr><td></td><td></td><td></td><td>i. <u>Generating a CEO project from a template:</u> FRTC created a template to collect land-use change and degradation reference data in Collect Earth Online (CEO[29]) for the following periods: Pre-reference period (t0) - 1983-2003, Reference Period (t1) – 2004-2014, First monitoring period (t2) – 2015-2017 and Second monitoring period (t3) – 2018-2021.
ii. <u>Sampling unit</u>: The Sampling Unit (SU) is a 70 x 70 meter plot. Inside the SU, a 3x3 points sub-grid (9 points) was created to estimate forest canopy cover percentage within each sampling unit. Negative changes in this value were used to indicate whether a degradation event had occurred.
iii. <u>Number of Sampling Units</u>: A total of 1,522 sampling points, selected via stratified random sampling, were visually assessed.
iv. <u>Interpretation key[30]</u>: Nepal produced an interpretation key that should be reused and updated as needed. The key was used to increase consistency across the team of interpreters. The land use categories considered are the following:
<table><tr><th>Forest lands:</th><th>Non-forest lands</th></tr><tr><td>1 Intact Forest
2 Degraded Forest
3 Very Degraded Forest
4 Secondary natural forest
5 Plantation Forest
6 Shaded croplands</td><td>7 Grasslands
8 Other lands
9 Settlements
10 Unshaded croplands (tree canopy cover 10% or less)</td></tr></table>● Note, the first three types of forest land (intact, degraded, and very degraded) were indirectly labeled in post-processing using the number of tree-covered points out of a 9-point grid over each plot.
v. <u>Performing QA/QC with reference data collection</u></td></tr>
<tr><td></td><td></td><td><u>Reference data compilation R-script CompiledData_CEO</u></td><td>6. Reference data compilation: The data collected in the CEO was compiled in R for each period (t0, t1, t2, and t3) to obtain necessary information that was then used to estimate the Activity Data:
i. Deforestation Activity Data
● tx_disturbance_type_subcat: type of forest loss and gain, stable forest, and stable non-forest.
● Non.forest.land.use.type.in.[year of interest] Non forest land use type in the period.
● Number.of.tree.covered.samples.[year of interest]: Number from 9-point grid of sample points within the plot that are covered by tree canopies.
● GEEcombo_strata_readable: Agreement map strata.
● tx_type_final: Land use / land cover type
● tx_yr_secondaryforest_establ: year of secondary forest establishment
ii. Forest gain Activity Data
● tx_disturbance_type_subcat: type of forest loss and gain, stable forest, and stable non-forest.
● GEEcombo_strata_readable: Agreement map strata.
iii. Degradation Activity Data
● tx_type_final: Land use / land cover type
● tx_numbretrees: canopy cover
● GEEcombo_strata_readable: Agreement map strata</td></tr>
<tr><td></td><td></td><td><u>Activity Data Tool</u>
(Please read this file “<u>READ</u>” before accessing it)</td><td>7. Area and uncertainty estimation: Nepal employs a sample-based approach to estimate the Activity Data for Deforestation, Forest gain and Degradation. All 1,522 samples were used as the basis for calculating area estimates and their uncertainty. The estimation of Activity Data was done using the stratified random estimator based</td></tr>
</table>

[29] CEO is a custom built, open-source, satellite image viewing and interpretation system. Collect Earth Online promotes consistency in locating, interpreting, and labeling reference data plots for use in classifying and monitoring land cover / land use change (see https://app.collect.earth).

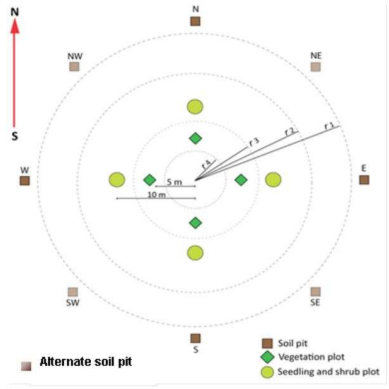
[30] https://docs.google.com/document/d/1z-jMtUqBjFt9z7atHKv2kr9nt6r57eS7/edit?usp=drive_link&ouid=101304895378504185754&rtpof=true&sd=true

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
			on the formulas described by Cochran (1977)[31]. Estimates are made for each of the land use categories considered (10 classes) and in terms of changes from one period to another representing a total of more than 26 effective combinations (Deforestation 14, Forest Gain 3, and Degradation 9). Estimates and associated uncertainties are produced in the Activity Data Tool (**Nepal_TAL_AD_tool.xlsx**) for each combination considering the stratification applied. The Activity Data tool comprises various spreadsheets that estimate different types of Activity Data. These include the Dataset that is used to estimate sample-based Activity Data (CompiledData_CEO_GEE(7) sheet), as well as spreadsheets for estimating Activity Data for deforestation (Deforestation sheet), forest restoration (Forest_gain sheet), and area of change in canopy cover (loss and gain) in permanent forest lands (Degradation sheet). To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheets. This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok".
2	**Forest regrowth removal rates and forest carbon densities calculation, including the uncertainty estimate.**	**NFI dataset**	1. **National Forest Inventory**: The biomass estimates used for the ER monitoring report are Tier 2 (country specific data) and has been derived from the National Forest Inventory-Forest Resource Assessment (NFI-FRA). The NFI-FRA involved remeasurement of the permanent sample plots established by the FRA Nepal Project (2010-2014) in addition to an additional number of plots established and measured using the same methodology. The Inventory Design adopted was based largely on methods developed by Kleinn (1994) [32]and finalized by the DFRS/FRA 2010-2014. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. One of the important characteristics of NFI in Nepal is hidden permanent sample plots leaving "no marks" above ground. Instead, the plots are georeferenced and plot centers consist of metal pegs inserted a few inches below the ground level. The reason behind hidden plots in NFI is to maintain consistency in anthropogenic activities and forest products used by local people both inside and outside the plots. These characteristics of NFI plots of Nepal might even aid to control leakage of GHG emission. The detailed methodology adopted for sample selection is presented in DFRS, 2014[33]. NFI data from 591 permanent sample plots located within the Emission Reduction Program area were derived. **i. Inventory / Sample plot design and data collection**: The Concentric Circular Sample Plot (CCSP) design was adopted as used by the FRA Nepal Project (2010-2014). Each sample plot had four concentric circles of different radii (Figure), which were used to measure trees with different DBH as follows: ▪ trees having 30 cm DBH or more enumerated within a 20 m radius plot (area: 1256.6 m2) ▪ trees having 20-29.9 cm DBH enumerated within a 15 m radius plot (area:706.9 m2) ▪ trees having 10-19.9 cm DBH enumerated within an 8 m radius plot (area:201.0 m2) ▪ trees having 5-9.9 cm DBH enumerated within a 4 m radius plot (area: 50.3 m2)

[31] Cochran, W.G. (1977) Sampling Techniques. 3rd Edition, John Wiley & Sons, New York.

[32] Kleinn, C. 1994. Forest Resources Inventories in Nepal: Status Quo, Needs, Recommendations. FRISP. His Majesty's Government of Nepal, Kathmandu, Nepal. https://drive.google.com/file/d/1yD2AuvJjAtptFTzorisLAfJWAEzY0W-D/view?usp=drive_link

[33] https://drive.google.com/file/d/1EFpJXYa7GZRiGfP0WJIWwu-zljs9C65v/view?usp=drive_link

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
			 Layout of the concentric circular plot with other sub-plots Other subplots were established to assess forest attributes other than trees, such as dead woods and disturbances, seedlings, saplings, shrubs, and herbs, etc. **ii. Volume and Biomass estimation**: Tree stem volumes and biomass were estimated using standard methodology with national allometric equations adopted since NFI / FRA 2010-2014. Details provided in the manual[34] . **iii. Quality assurance of forest inventory data:** Use of periodically revised field manual, training to field crews and regular monitoring and feedback were some of the measures applied to maintain the quality of the inventory results. For the statistical analysis to check for the quality of the results, over 10% of the total PSPs measured were systematically selected (with a random start) and re-measured. Details can be referred to: https://frtc.gov.np/uploads/files/1_%20QAQC_manual.pdf [35] Furthermore, standard protocols and manuals on modeling of required parameters e.g. diameter-height modeling & taper function curve, calculation of volume and biomass using the allometric models, and error estimation were developed under supervision of the experts from Finnish Forest Research Institute (METLA, now LUKE Finland) during the FRA 2010-2014.
		Nepal's CEO institution **NFI CEO Survey Questions**	2. **Land use change analysis of the NFI permanent plots stratification for carbon densities, and removal rate estimate**. To ensure consistency, the Emission Factors (EF) have been aligned with the estimates of land-use transitions area (AD). To achieve this, the same time series analysis and data collection methods that were used in CEO were replicated for the NFI permanent plot's locations. The NFI plots have been classified as Non-forest land use (grassland, other land, unshaded cropland), Permanent Forest, or Secondary Forests. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points).
		CarbonDensitiesTools.xlsx (Please read this file "READ" before accessing it)	3. **Carbon densities and removal rates calculation**: Nepal developed a calculation tool (CarbonDensitiesTools.xlsx), to estimate carbon densities for both forest and non-forest areas based on the NFI plots dataset. This tool also facilitates the determination of forest regrowth removal rates. Confidence intervals and errors are computed based on the number of sampling plots and standard deviation within each respective land use type or removal rate:

[34] https://drive.google.com/file/d/1Z1h0Q2JiXlEXCHW1qDNcBrj1B38GEhi7/view?usp=drive_link

[35] https://drive.google.com/file/d/1YmbHZSOIxfsnfotBbb3elCBSemh4cA8h/view?usp=drive_link

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
			i. *Natural Forest carbon densities calculation*: The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots (pl_total_bio_mrv)[36]. ii. *Non-Forest carbon densities calculation*: The determination of average carbon densities for non-forest lands was based on fourteen NFI plots[37], which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI (pl_total_bio_mspa). iii. *Forest regrowth removal rates estimate*: The forest regrowth removal rate calculation is based on a sample of sixteen NFI plots[38] established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements (pl_yr) was used to estimate the average removal rate.
3	**Emission and removals calculation**	**Nepal_TAL_Integration_tool.xlsx** (Please read this file "READ" before accessing it)	To calculate the Emission Reductions of the Nepal Emission Reduction Program, an Excel tool named Nepal_TAL_Integration_tool.xlsx is used. This tool generates estimates for emissions and removals, along with their associated uncertainties, for both the reference and reporting periods. The estimates are generated for Deforestation, Carbon Enhancement, and Degradation - the three REDD+ activities involved in the carbon accounting of the program. i. *Calculation of emissions and removals*: **The Parameters and Model sheet** generate estimates for Emissions and Removals. These estimates are calculated using Activity Data and Carbon Density tools. ii. *Emission Reductions calculation*: **Results sheet** generates estimates of Emission Reductions for the Reporting Period (June 22, 2020 – December 31, 2021). These estimates are calculated using the Parameters and Model sheet calculations. iii. *Emission Reductions available for transfer to the Carbon Fund*: The **Table-8-ER-MR sheet** computes the available ER for transfer in accordance with Section 8 of the ER monitoring report.
4	**Emission reduction uncertainty estimate and sensitivity analysis.**	**NEPAL_TAL_Integration_tool_MC.xlsx** **NEPAL_TAL_Integration_tool_SensitivityAnalysis.xlsx** (Please read this file "READ" before accessing it)	Nepal has developed two distinct Excel tools utilizing the ER calculation tool (NEPAL_TAL_Integration_tool.xlsx). The first one, NEPAL_TAL_Integration_tool_MC.xlsx, is designed to carry out Monte Carlo simulations and estimate the uncertainty of the ER calculation. The second tool, NEPAL_TAL_Integration_tool_SensitivityAnalysis.xlsx, is utilized for sensitivity analysis purposes.

36 https://docs.google.com/spreadsheets/d/1QwjOKtfdNE4To4G4iAshgfdbaGI4NLX5/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true

37 https://docs.google.com/spreadsheets/d/1FMv1JAN7wekSt7cASCiloyVpPpgmCbRx/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true

38 https://docs.google.com/spreadsheets/d/1tzInYz_RXXJyFe7zX1CD9_7ad6NPG4vm/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true

Figure 4. Activity Data Estimate (A), Data Requirements (B) and Degradation (C)

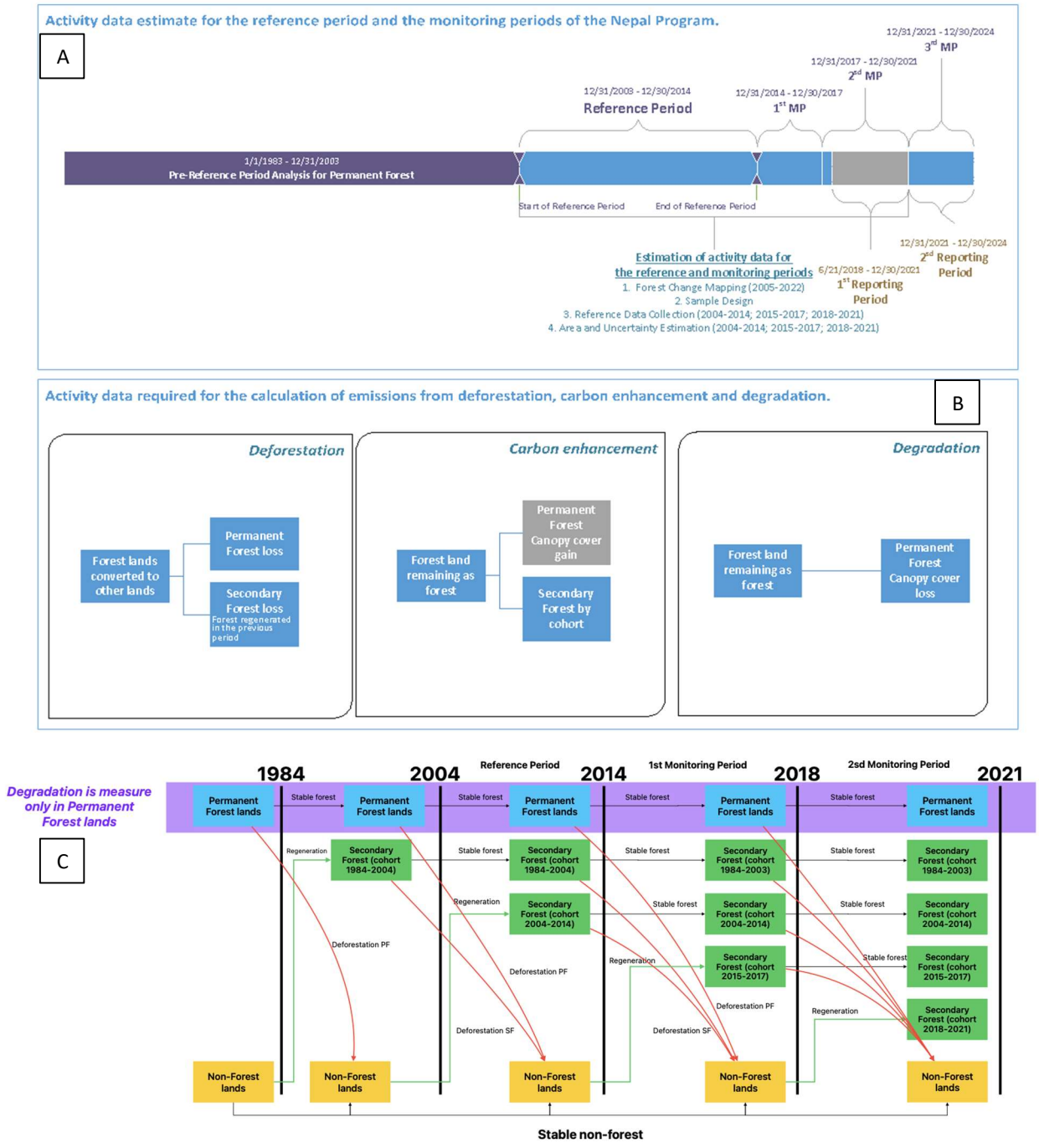
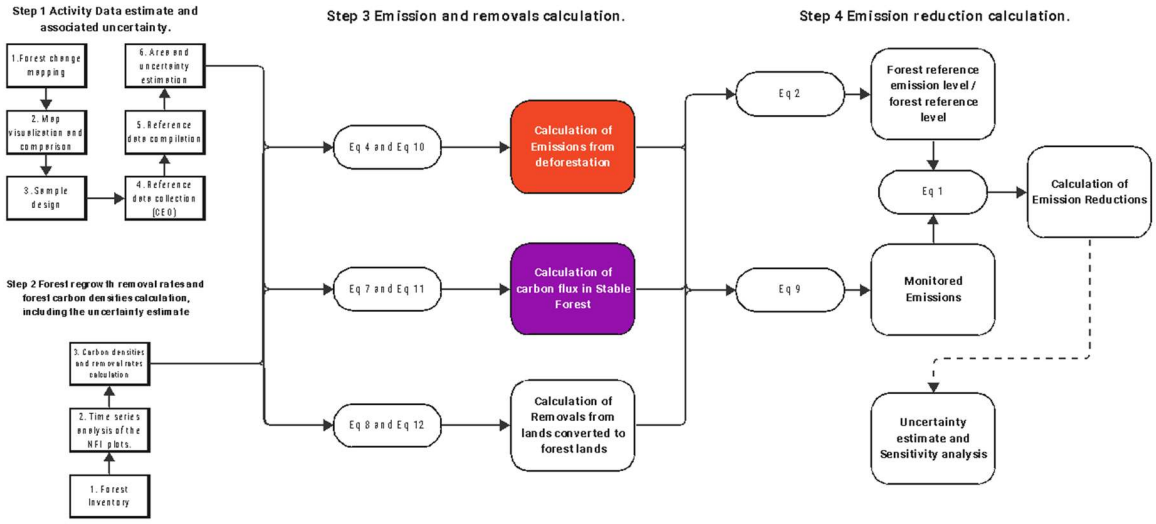


Figure 4: A. Reference Period and monitoring periods considered in collecting reference data for AD estimate. **B.** Activity Data that is required for the estimate of emissions from deforestation, carbon enhancement removals, and emissions from degradation. **C.** Forest cover type definition (permanent and secondary) based on time-series analysis.

2.2.1 Line Diagram

Figure 5 presents the emissions reductions calculation workflow during the monitoring period. Activities listed under steps 1 to 4 are all performed by the Forest Research and Training Centre (FRTC).

Figure 5. Line Diagram- Emissions reduction calculation workflow



2.2.2 Calculation

Emission reduction calculation $(ER_{ERP,t})$**:**

To determine GHG emission reductions, the IPCC methods and equations described in Annex 4 Section 8.3 were used over the monitoring period.

$$ER_{ERP,t} = RL_t - GHG_t \qquad \textbf{Equation 1}$$

Where:

ER_{ERP} = Emission Reductions under the ER Program in the Reporting Period; tCO_2.

RL_{RP} = Net emissions of the Reference Level over the Reference Period; tCO_2e. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.

GHG_t = Monitored gross emissions from deforestation during the Reporting Period; tCO_2e;

T = Number of years during the reporting period; dimensionless.

Reference Level (RL_{RP}**)**

The RL estimation may be found in Annex 4, yet a description of the equations is provided below. Net emissions of over Reference Period (RL_{RP}) are estimated as the sum of annual change in total biomass carbon stocks (deforestation and degradation), and annual removals (ΔC_{B_t}).

$$RL_{RP} = \frac{\sum_t^{RP} \Delta C_{LU_{RP,i,t}}}{RP} \qquad \textbf{Equation 2}$$

Where:

$\Delta C_{LU_{RP,i,t}}$ = Balance of emissions during the Reference Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each REDD+ activity *i* at year t; tCO_2*year^{-1}.

RP = Reference period; years.

Technical corrections:
Reference Period: There is an error in the ER-PD's Reference Period (RP) , the number of years was mistakenly defined as 10 years which should have been 11 years, considering the start and end of the RP (Start 1/1/2004, End 31/12/2014). Therefore, the Forest Reference Emission Level was calculated considering a Reference Period of 11 years.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)

Emissions from deforestation were estimated based on the Deforestation Sheet of Activity Data tool following the 2006 IPCC Guidelines, the annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta C_{B_{defo,t}}$) would be estimated through the following equation:

$$\Delta C_{B_{defo,t}} = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$ **Equation 3** (Equation 2.15, 2006 IPCC GL)

Where:

$\Delta C_{B_{defo,t}}$	Annual change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1};
ΔC_G	Annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tones C yr^{-1};
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1}; and
ΔC_L	Annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use categories, in tones C yr^{-1}.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document[39] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified and it will be assumed that: a) the annual change in carbon stocks in biomass (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$); b) it is assumed that the biomass stocks immediately after conversion are the biomass stocks of the resulting land-use. Therefore, the annual change in carbon stocks would be estimated as follows:

$$\Delta C_{Bt} = \Delta C_{CONVERSION}$$

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) x\, CF\, x \frac{44}{12} \times A(j,i)_{RP}$$

Equation 4 (Equation 2.16, 2006 IPCC GL)

Where:

$A(j,i)_{RP}$	Area converted/transited from forest type j to non-forest type i during the Reference Period, in hectares per year. In this case, sixteen forest land conversions are possible: 1 Intact Forest to Grasslands 2 Intact Forest to Other Land 3 Intact Forest to Settlements 4 Intact Forest to Unshaded Cropland (TCC 10% or less)

[39]Page 44, GFOI (2013) Integrating remote-sensing and ground-based observations to estimate emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

5 Degraded Forest to Grasslands
6 Degraded Forest to Other Land
7 Degraded Forest to Settlements
8 Degraded Forest to Unshaded Cropland (TCC 10% or less)
9 Very Degraded Forest to Grasslands
10 Very Degraded Forest to Other Land
11 Very Degraded Forest to Settlements
12 Very Degraded Forest to Unshaded Cropland (TCC 10% or less)
13 Secondary natural forest to Grasslands
14 Secondary natural forest to Other Land
15 Secondary natural forest to Settlements
16 Secondary natural forest to Unshaded Cropland (TCC 10% or less)

Technical corrections.
Activity Data: The ER-PD Activity Data assessment is a yearly analysis of tree canopy cover estimations, done in collaboration with the University of Maryland and supported by the USGS SilvaCarbon program. The assessment involves removing bias and making area estimates based on stratified random sampling. This method is used to establish changes observed between 2004 and 2014 and to determine the extent of deforestation and forest degradation. The emissions estimates for deforestation and forest degradation are based on the changes observed in the tree canopy cover.

For the current monitoring report, Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. The forest change map spanning from 1983 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO.

To differentiate between secondary and permanent forests and identify the age of forest gain cohorts, the sampling points are visually interpreted for the same period that the forest change map was created. This period is divided into four subperiods: 1984-2003, 2004-2014. 2015-2017, and 2018-2021. The canopy cover is visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest Land Use categories.

Technical corrections.
Forest carbon densities: In the ERPD, the NFI provided average estimates for each independent physiographic region by combining all sampled forest types based on the stratification used. For the ERPD, a single average was proposed for CORE and EDGE classes based on MSPA analysis results. The existing total

biomass stocks calculated for each NFI plot were reclassified into an overall CORE and EDGE class using the MSPA analysis. The mean biomass and variance were calculated following Birigazzi et al (2018) [40].

To ensure consistency between the Emission Factors and land-use transitions area, the NFI plots were evaluated and categorized according to their land use type, such as non-Forest land use, Permanent Forest, or Secondary Forests, for the current monitoring report. The same time series analysis and data collection methods used in CEO were replicated for the NFI permanent plot locations. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points). The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from 591 NFI plots. The determination of average carbon densities for non-forest lands was based on 14 NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI. The forest regrowth removal rate calculation is based on a sample of 16 NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.

CF	Carbon fraction of dry matter in tC per ton dry matter. The value used is: ● **0.47** is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.
$44/12$	Conversion of C to CO_2
R: S	Root-to-shoot ratio (0.44).

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$)

Following the 2006 IPCC Guidelines, the annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{DEG}}$) could be estimated through the Gain-Loss Method or the Stock-Difference Method as described in Chapter 2.3.1.1 of Volume 4 of the 2006 IPCC Guidelines.

$$\Delta C_B = \Delta C_G - \Delta C_L$$ **Equation 5** (Equation 2.7, 2006 IPCC GL)

$$\Delta C_B = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$ **Equation 6** (Equation 2.8 (a), 2006 IPCC GL)

ΔC_B	Annual change in carbon stocks in biomass for each land sub-category, in tones C yr^{-1}
ΔC_G	annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tones C yr-
ΔC_L	annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tones C yr-1
C_{t_2}	total carbon in biomass for each land sub-category at time t_2, tonnes C
C_{t_1}	total carbon in biomass for each land sub-category at time t_1, tonnes C

[40] Birigazzi, L, JGP Gamarra, TG Gregoire. 2018. Unbiased emission factor estimators for large-area forest inventories: domain assessment techniques. Environmental and Ecological Statistics. https://doi.org/10.1007/s10651-018-0397-3

Following the recommendations set in chapter 2.2.2 of the GFOI Methods Guidance Document[41] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified, and it will be assumed that: a) the annual change in carbon stocks in biomass (ΔC_B) due to degradation is equal to the annual decrease in carbon stocks; (b) the decrease in carbon stocks occurs the year of conversion. The long-term decrease in carbon stocks indicated in equation (1) of the GFOI MGD is assumed here to be zero. Therefore, considering the GFOI MGD the IPCC equation for forest degradation could be expressed as an Emission Factor time Activity Data as follows:

$$\Delta C_{B_{DEG}} = \sum_j \left\{ EF_j \times A(a,b)_{RP} \right\} \qquad \textbf{Equation 7}$$

Where:

EF_j Emission Factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.

$A(a,b)_{RP}$ Area of forest type a converted to forest type b (transition denoted by a,b) during the Reference Period, ha yr^{-1}.

Technical corrections. Nepal initially did not include increased forest biomass observed in forests remaining as forests. For this monitoring report a net emission from forest degradation was calculated, including biomass recovery.

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta C_{B_{reg}}$)

For non-forestland converted to forestland, CO_2 removals has been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). Since the FCPF Methodological Framework requires IPCC Tier 2 or higher method, the net annual CO_2 removals are calculated using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. These equations were simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in forests. A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground and belowground biomass. Using the outcome of equation 2.15 and 2.16, it was determined the changes in the total carbon stocks in biomass (removals) during the Reference Period as the sum of the total carbon stocks in biomass of all land units. From the point of view of notations, the Emission Factors in equation EQ7 above would be replaced by **RF**$_{SREG}$ in enhancement of carbon stocks in new forests.

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \left\{ RF_{reg} \times A(i,j)_{RP} \right\} \qquad \textbf{Equation 8}$$

Where:

RF_{reg} Above and belowground biomass removal rate in new forests [tCO2*ha*year^{-1}].

$A(j,i)_{RP}$ Area of non-forestland i converted to forestland j (transition denoted by i,j) in the Reference Period, ha yr^{-1}.

LU Land unit.

Technical corrections: The ERPD biomass removal factors were estimated using LiDAR data. Average removal factors were estimated based on areas reported as gain under the reference level submitted to the UNFCCC, which used LiDAR to estimate biomass and compared it with IPCC default values. To produce reference level estimates, a Monte Carlo analysis was applied to all biomass and Activity Data estimates, resulting in 10,000 randomized iterations.

[41]Page 48, GFOI (2013) Integrating remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

For this monitoring report, NFI plots were evaluated and categorized based on their land use type, including non-forestland use, Permanent Forest, or Secondary Forests. This ensures consistency between the Emission Factors and land-use transition areas. To replicate CEO's data collection methods, the same time series analysis was used for NFI permanent plot locations.

The forest regrowth removal rate calculation is based on 16 NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years was used to estimate the average removal rate.

Monitored emissions (GHG_t)

Annual gross GHG emissions over the monitoring period in the Accounting Area (GHG_t) are estimated as the sum of annual change in total biomass carbon stocks (ΔC_{B_t}).

$$GHG_t = \frac{\sum_t^T \Delta C_{LU_{MP,i,t}}}{T}$$ **Equation 9**

Where:

$\Delta C_{LU_{MP,i,t}}$ = Balance of emissions during the Monitoring Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each of i REDD+ activities at year t; tCO_2*year^{-1}.

T = Number of years during the monitoring period; dimensionless.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)

The annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta C_{B_{defo,t}}$) would be estimated through **Equation 4** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) x\ CF\ x \frac{44}{12} \times A(j,i)_{MP}$$ ***Equation 10*** **(Equation 2.16, 2006 IPCC GL)**

Where:

$A(j,i)_{RP}$ Area converted/transited from forest type j to non-forest type *i* during the Monitoring Period, in hectares per year. In this case, sixteen forest land conversions are possible:

1 Intact Forest to Grasslands
2 Intact Forest to Other Land
3 Intact Forest to Settlements
4 Intact Forest to Unshaded Cropland (TCC 10% or less)
5 Degraded Forest to Grasslands
6 Degraded Forest to Other Land
7 Degraded Forest to Settlements
8 Degraded Forest to Unshaded Cropland (TCC 10% or less)
9 Very Degraded Forest to Grasslands
10 Very Degraded Forest to Other Land
11 Very Degraded Forest to Settlements
12 Very Degraded Forest to Unshaded Cropland (TCC 10% or less)
13 Secondary natural forest to Grasslands
14 Secondary natural forest to Other Land
15 Secondary natural forest to Settlements

16 Secondary natural forest to Unshaded Cropland (TCC 10% or less)

$B_{Before,j}$	Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.
$B_{After,i}$	Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest IPCC Land Use categories.
CF	Carbon fraction of dry matter in tC per ton dry matter. The value used is: ● **0.47** is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.
$44/12$	Conversion of C to CO_2
R: :S	Root-to-shoot ratio (0.44).

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$)

The Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$) would be estimated through **Equation 7** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_{DEG}} = \sum_{j} \left\{ EF_j \times A(a,b)_{MP} \right\}$$ **Equation 11**

Where:

EF_j	Emission Factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.
$A(a,b)_{MP}$	Area of forest type a converted to forest type b (transition denoted by a, b) during the Monitoring Period, ha yr^{-1}.

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta C_{B_{reg}}$)

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{reg}}$) would be estimated through **Equation 8** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \left\{ RF_{reg} \times A(i,j)_{MP} \right\}$$ **Equation 12**

Where:

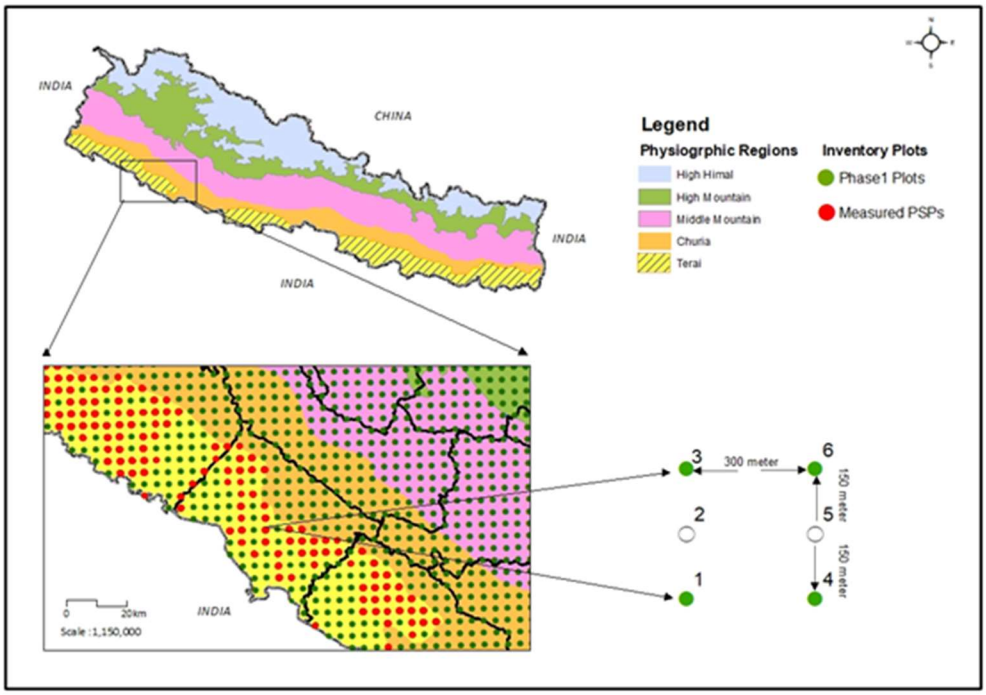
RF_{reg}	Above and belowground biomass removal rate in new forests [tCO2*ha*$year^{-1}$].
$A(j,i)_{MP}$	Area of non-forestland *i* converted to forestland *j* (transition denoted by *i,j*) in the Monitoring Period, ha yr^{-1}.
LU	Land unit.

3 DATA AND PARAMETERS

3.1 Fixed Data and Parameters

Parameter:	$B_{Before,j}$ **Equation 4;** $B_{After,i}$ **Equation 4**
Description:	**B Before**: Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground (AGB_(Before,j)) and belowground biomass (BGB_(Before,j)) and it is defined for each forest type. **B after**: Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest Land Use categories.
Data unit:	Tonne/ha (dry matter),
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The carbon densities used for the ER monitoring report are Tier 2 (country specific data) and has been derived from the latest NFI (FRA) except the removal rates for forest plantation and shaded crops. The NFI (FRA) involved remeasurement in 2022 of the permanent sample plots established by the FRA Nepal Project (2010-2014) including an additional number of plots established and measured using the same methodology. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. **NFI (FRA) Inventory Design**: The Inventory Design adopted was based largely on methods developed by Kleinn (1994)[42] and finalized by the DFRS/FRA 2010-2014 (see Figure below). The detailed methodology adopted for sample selection is presented in DFRS, 2014, link: https://frtc.gov.np/downloadfile/The-TeraiForestsofNepal_1579845265.pdf. NFI data from 622 permanent sample plots located within the ER accounting area were derived (see NFI_dataset sheet in Carbon density calculation tool – **CarbonDensitiesTools.xlsx**).

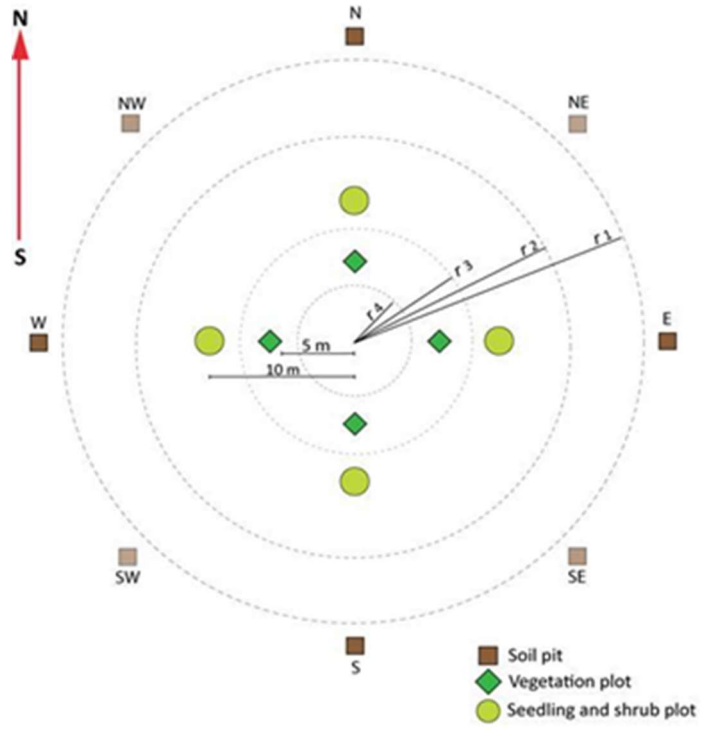
[42] Kleinn, C. 1994. Forest Resources Inventories in Nepal Status, Qou, Needs, Recommendations. FRISP, HMGN/FINNIDA



Inventory Sample plot design and data collection: The Concentric Circular Sample Plot (CCSP) design was adopted as used by the FRA Nepal Project (2010-2014). Each sample plot had four concentric circles of different radii (see Figure below), which were used to measure trees with different DBH as follows:

- trees having 30 cm DBH or more enumerated within a 20 m radius plot (area: 1256.6 m^2)
- trees having 20-29.9 cm DBH enumerated within a 15 m radius plot (area:706.9 m^2)
- trees having 10-19.9 cm DBH enumerated within an 8 m radius plot (area:201.0 m^2)
- trees having 5-9.9 cm DBH enumerated within a 4 m radius plot (area: 50.3 m^2)

Other subplots were established to assess forest attributes other than trees, such as dead woods and disturbances, seedlings, saplings, shrubs, and herbs, etc.



Layout of the concentric circular plot with other sub-plots

The plots were used for data collection of standing trees (diameter at breast height (dbh) ≥5 cm), which were used in the estimation of the biomass and carbon stocks. Data collected included tree information (bearing, distance from plot center, species code, local name, scientific name, DBH, quality class, crown class and total and crown heights. In addition, data on other important variables like dead woods, disturbances, shrub and small trees, soil characteristics and soil samples, leaf litter and debris, non-wood forest products, epiphytes, parasites, herbaceous plants, bamboo, invasive and alien plant species, forest diseases and pests, etc. have been collected in regular NFI/FRA. One of the important characteristics of NFI in Nepal is hidden permanent sample plots leaving "no marks" above ground. Instead, the plots are georeferenced and plot centers consist of metal pegs inserted a few inches below the ground level. The reason behind hidden plots in NFI is to maintain consistency in anthropogenic activities and forest products use by local people both inside and outside the plots. This characteristics of NFI plots of Nepal might even aid to control leakage of GHG emission.

Volume and Biomass estimation: Tree stem volumes and biomass were estimated using standard methodology with national allometric equations adopted since NFI / FRA 2010-2014[43]. To ensure consistency between the Emission Factors and land-use transitions area, the NFI plots were evaluated and categorized according to their land use type, such as non-Forest land use, Permanent Forest, or Secondary Forests, for the current monitoring report. The same time series analysis and data collection methods used in CEO were replicated for the NFI permanent plot locations. Additionally, the canopy cover of Permanent Forest plots was evaluated to

[43] https://drive.google.com/file/d/1Z1h0Q2JiXlEXCHW1qDNcBrj1B38GEhi7/view?usp=drive_link

<table>
<tr><td></td><td>determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points). The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands was based on 14 NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI. The forest regrowth removal rate calculation is based on a sample of 16 NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.</td></tr>
<tr><td>Value applied:</td><td>Due to the homogeneity of the forest in the Emission Reduction Program accounting area, the whole forest was considered as the same unit for the calculation.
<table>
<tr><th>Forest type</th><th>Average</th><th>CI</th><th>Unit</th></tr>
<tr><td>Natural intact forest</td><td>217.34</td><td>7.49</td><td>tdm/ha</td></tr>
<tr><td>Natural degraded forest</td><td>181.09</td><td>42.69</td><td>tdm/ha</td></tr>
<tr><td>Natural very degraded forest</td><td>96.51</td><td>66.11</td><td>tdm/ha</td></tr>
</table>
<table>
<tr><th>Non- Forest Lands</th><th>Average</th><th>CI</th><th>Unit</th></tr>
<tr><td>Grassland</td><td>3.97</td><td>5.88</td><td>tdm/ha</td></tr>
<tr><td>Other land</td><td>39.95</td><td>53.09</td><td>tdm/ha</td></tr>
<tr><td>Unshaded cropland</td><td>48.31</td><td>36.53</td><td>tdm/ha</td></tr>
</table>
Note: It was assumed the carbon density of grasslands for Settlements.</td></tr>
<tr><td>QA/QC procedures applied</td><td>Quality assurance of forest inventory data: Use of periodically revised field manual, training to field members and regular monitoring and feedback were some of the measures applied to maintain the quality of the inventory results. For the statistical analysis to check the quality of the results, over 10% of the total Permanent Sampling Plots measured were systematically selected (with a random start) and re-measured (QAQC manual[44]). Furthermore, standard protocols and manuals on modeling of required parameters e.g., diameter-height modeling & taper function curve, calculation of volume and biomass using the allometric models, and error estimation were developed under supervision of the experts from Finnish Forest Research Institute (METLA, now LUKE Finland) during the FRA 2010-2014. Also, documentation on the assemble of the QAQC protocol and QAQC report of 2022[45] are available in the QAQC manual.</td></tr>
<tr><td>Uncertainty associated with this parameter:</td><td>To determine the uncertainty in carbon density, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. This calculation only takes sampling errors into account and does not consider model or allometric errors.</td></tr>
</table>

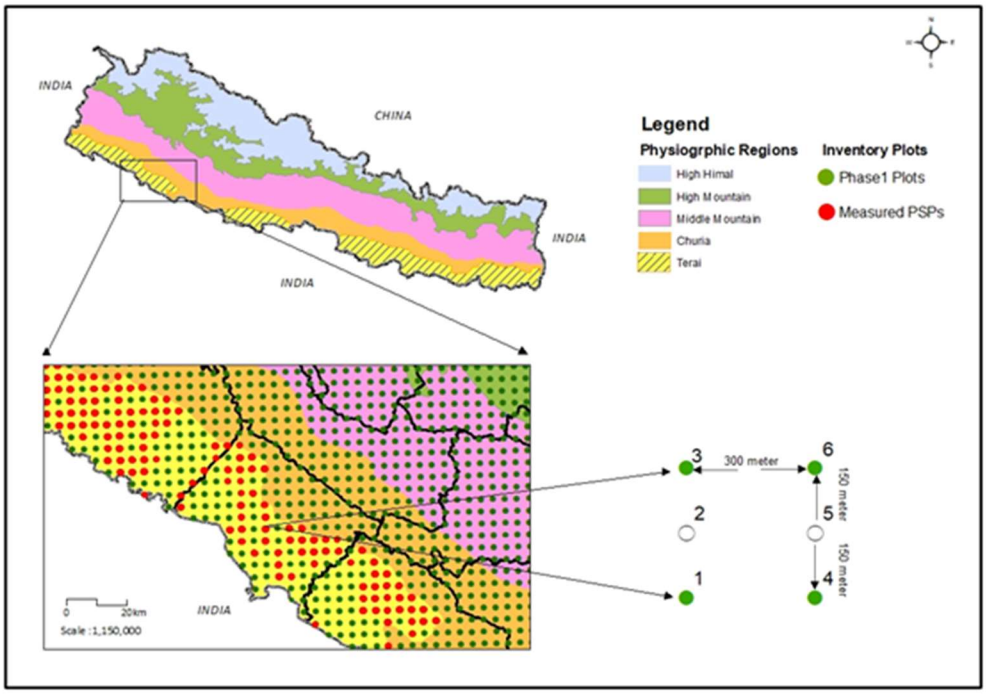
[44] https://drive.google.com/file/d/1YmbHZSOIxfsnfotBbb3elCBSemh4cA8h/view?usp=drive_link

[45] https://drive.google.com/file/d/1Xhboag3rtykW2p0oiIYuz9Rj0H6VQsg8/view?usp=drive_link

Forest type	Average	CI	% Error	n	Std Dev	Unit
Natural intact forest	217.34	7.49	3%	558	107.37	tdm/ha
Natural degraded forest	181.09	42.69	24%	23	119.22	tdm/ha
Natural very degraded forest	96.51	66.11	68%	10	114.04	tdm/ha

Non- Forest Lands	Average	CI	% Error	n	StdDev	Unit
Grassland	3.97	5.88	148%	5	6.17	tdm/ha
Other land	39.95	53.09	133%	4	45.12	tdm/ha
Unshaded cropland	48.31	36.53	76%	5	38.32	tdm/ha

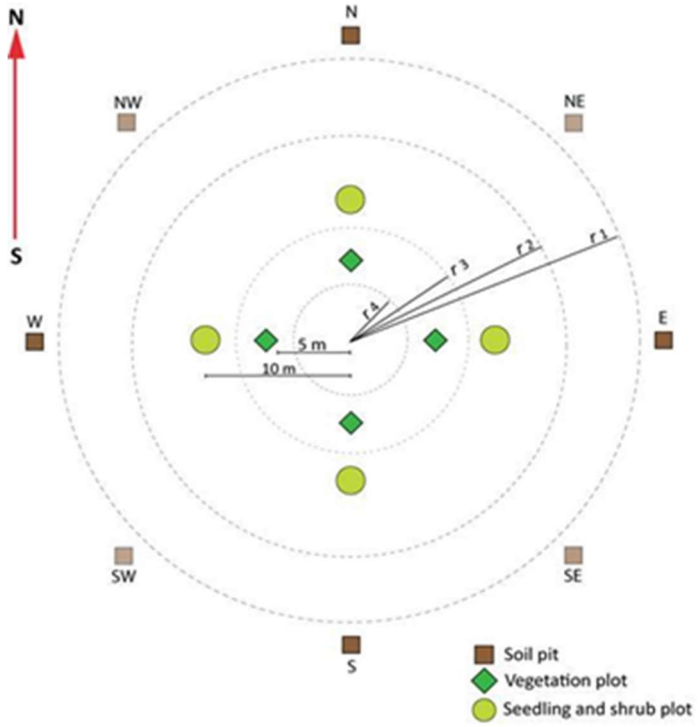
Any comment:	

Parameter:	RF_{reg} **Equation 8**
Description:	RF_{reg} : Above and belowground biomass removal rate in new forests [tCO2*ha*year^{-1}].
Data unit:	Tonne/ha (dry matter),
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The removal rates used for the ER monitoring report are Tier 2 (country specific data) and has been derived from the latest NFI (FRA) except the removal rates for forest plantation and shaded crops. The NFI (FRA) involved remeasurement in 2022 of the permanent sample plots established by the FRA Nepal Project (2010-2014) including an additional number of plots established and measured using the same methodology. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. **NFI (FRA) Inventory Design**: The Inventory Design adopted was based largely on methods developed by Kleinn (1994)[46] and finalized by the DFRS/FRA 2010-2014 (see Figure below). The detailed methodology adopted for sample selection is presented in DFRS, 2014, link: https://frtc.gov.np/downloadfile/The-TeraiForestsofNepal_1579845265.pdf. NFI data from 622 permanent sample plots located within the ER accounting area were derived (see NFI_dataset sheet in Carbon density calculation tool – **CarbonDensitiesTools.xlsx**).  **Inventory Sample plot design and data collection**: The Concentric Circular Sample Plot (CCSP) design was adopted as used by the FRA Nepal Project (2010-2014). Each sample plot had four concentric circles of different radii (see Figure below), which were used to measure trees with different DBH as follows:

[46] Kleinn, C. 1994. Forest Resources Inventories in Nepal Status, Qou, Needs, Recommendations. FRISP, HMGN/FINNIDA

- trees having 30 cm DBH or more enumerated within a 20 m radius plot (area: 1256.6 m^2)
- trees having 20-29.9 cm DBH enumerated within a 15 m radius plot (area:706.9 m^2)
- trees having 10-19.9 cm DBH enumerated within an 8 m radius plot (area:201.0 m^2)
- trees having 5-9.9 cm DBH enumerated within a 4 m radius plot (area: 50.3 m^2)

Other subplots were established to assess forest attributes other than trees, such as dead woods and disturbances, seedlings, saplings, shrubs, and herbs, etc.



Layout of the concentric circular plot with other sub-plots

The plots were used for data collection of standing trees (diameter at breast height (dbh) ≥5 cm), which were used in the estimation of the biomass and carbon stocks. Data collected included tree information (bearing, distance from plot center, species code, local name, scientific name, DBH, quality class, crown class and total and crown heights. In addition, data on other important variables like dead woods, disturbances, shrub and small trees, soil characteristics and soil samples, leaf litter and debris, non-wood forest products, epiphytes, parasites, herbaceous plants, bamboo, invasive and alien plant species, forest diseases and pests, etc. have been collected in regular NFI/FRA. One of the important characteristics of NFI in Nepal is hidden permanent sample plots leaving “no marks” above ground. Instead, the plots are georeferenced and plot centers consist of metal pegs inserted a few inches below the ground level. The reason behind hidden plots in NFI is to maintain consistency in anthropogenic activities and forest products use by local people both inside and outside the plots. This characteristics of NFI plots of Nepal might even aid to control leakage of GHG emission.

<table>
<tr><td></td><td>Volume and Biomass estimation: Tree stem volumes and biomass were estimated using standard methodology with national allometric equations adopted since NFI / FRA 2010-2014[47]. To ensure consistency between the Emission Factors and land-use transitions area, the NFI plots were evaluated and categorized according to their land use type, such as non-Forest land use, Permanent Forest, or Secondary Forests, for the current monitoring report. The same time series analysis and data collection methods used in CEO were replicated for the NFI permanent plot locations. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points). The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands was based on 14 NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI. The forest regrowth removal rate calculation is based on a sample of 16 NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.</td></tr>
<tr><td>Value applied:</td><td>In order to calculate the Emission Reductions, the entire forest was treated as a single unit due to its uniformity. The removal rate in new forests is country specific data and has been derived from the NFI (FRA). For Plantation forests and Shaded croplands, removal factors established by the IPCC were utilized.
<table>
<tr><th>Forest type</th><th>Average</th><th>CI</th><th>Unit</th></tr>
<tr><td>Natural secondary forest gain</td><td>-12.52</td><td>4.40</td><td>tCO_2/ha/yr</td></tr>
<tr><td>Plantation forest gain [1]</td><td>-13.79</td><td>4.40</td><td>tCO_2/ha/yr</td></tr>
<tr><td>Shaded cropland gain [2]</td><td>-10.23</td><td>2.46</td><td>tCO_2/ha/yr</td></tr>
</table>
[1] Table 4.10 (Updated) ABOVE-GROUND NET BIOMASS GROWTH IN TROPICAL AND SUB-TROPICAL PLANTATION FORESTS (TONNES D.M. HA-1 YR-1). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 4: Forest Land.
[2] Table 5.2 (Updated) DEFAULT COEFFICIENTS FOR ABOVE- AND BELOW-GROUND BIOMASS IN AGROFORESTRY SYSTEMS CONTAINING PERENNIAL SPECIES. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 5: Cropland.</td></tr>
<tr><td>QA/QC procedures applied</td><td>Quality assurance of forest inventory data: Use of periodically revised field manual, training to field members and regular monitoring and feedback were some of the measures applied to maintain the quality of the inventory results. For the statistical analysis to check the quality of the results, over 10% of the total Permanent Sampling Plots measured were systematically selected (with a random start) and re-measured (QAQC manual[48]). Furthermore, standard protocols and manuals on modeling of required parameters e.g., diameter-height modeling & taper function curve, calculation of volume and biomass using the allometric models, and error estimation were developed under supervision of the experts from Finnish Forest Research</td></tr>
</table>

[47] https://drive.google.com/file/d/1Z1h0Q2JiXlEXCHW1qDNcBrj1B38GEhi7/view?usp=drive_link
[48] https://drive.google.com/file/d/1YmbHZSOIxfsnfotBbb3elCBSemh4cA8h/view?usp=drive_link

	Institute (METLA, now LUKE Finland) during the FRA 2010-2014. Also, documentation on the assemble of the QAQC protocol and QAQC report of 2022[49] are available in the QAQC manual.
Uncertainty associated with this parameter:	To determine the uncertainty in removal rates, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. However, for Natural Secondary Forest gain, this calculation only considers sampling errors and does not consider model or allometric errors. In the case of forest plantations, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4 - Forest Land, Table 4.10 does not provide any reference to uncertainty. Therefore, it was assumed that the uncertainty of Natural Secondary Forests gain applies to Plantation Forests as well. When it comes to shaded cropland gain, we used the 2006 IPCC reference to uncertainty in Table 5.2.

Forest type	Average	CI	% Error	n	DevStd	Unit
Natural secondary forest gain	-12.52	4.40	35%	16	5.82	$tCO_2/ha/yr$
Plantation forest gain	-13.79	4.40[1]	32%	-	-	$tCO_2/ha/yr$
Shaded cropland gain	-10.23	2.46[2]	24%	-	-	$tCO_2/ha/yr$

[1] In the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4 – Forest Land, the Table 4.10 does not have any reference to uncertainty. As a result, it was assumed that the uncertainty of Natural secondary forest for Plantation Forest.

[2] Uncertainty indicated in Table 5.2 (Updated) of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 5: Cropland.

Any comment:	

Parameter:	Activity Data: $A(j,i)_{RP}$ Equation 4; $A(a,b)_{RP}$ Equation 7; $A(j,i)_{RP}$ Equation 8.
Description:	• Deforestation: Area converted/transited from forest type j to non-forest type I during the Reference Period • Degradation: Area of forest type a converted to forest type b (transition denoted by a,b) during the Reference Period, ha yr^{-1} • Forest gain: Area of non-forestland i converted to forestland j (transition denoted by i,j) in the Reference Period, ha yr^{-1}.
Data unit:	hectare
Source of data and description of measurement /calculation methods and	Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. A forest change map[50] spanning from 2004 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO.

[49] https://drive.google.com/file/d/1Xhboag3rtykW2p0oiIYuz9Rj0H6VQsg8/view?usp=drive_link

[50] https://drive.google.com/file/d/1VtYM-xCunuRpjfOgeAO9aLDMMGwj_H71/view?usp=drive_link

procedures applied:	**Forest change mapping**: The following four mapping algorithms that utilize remote sensing imagery, training data points, land cover maps, and time series data analysis were used to map areas experiencing forest loss, degradation, and/or regrowth. i. **CCDC-SMA**: Continuous Change Detection and Classification – Spectral Mixture Analysis (CCDC-SMA) monitors abrupt and gradual forest degradation. ii. **CODE**D: Continuous Degradation Detection (CODED) algorithm detects forest canopy disturbances and classifies them as degradation or deforestation based on land cover. CODED uses linear spectral unmixing to generate subpixel fractions of spectral endmembers, which are used to calculate a time series of the Normalized Degradation Fraction Index (NDFI). iii. **LandTrend**r: The LandTrendr algorithms use simple statistical techniques to simplify a time-series of spectral values into a sequence of connected straight-line segments that capture the overall shape of that pixel's trajectory while omitting year-to-year noise. The resultant segments can then be examined to select periods where the trajectory displays behaviors of interest such as disturbance or growth. iv. **MTD**D: Multi-variate Time-series Disturbance Detection (MTDD) classifies initially forested areas into stable forest, degraded, and deforested by training a random forest classifier with 66 metrics. These metrics are derived from six annual time-series (i.e., NDVI, two SWIR spectral regions, two NDWI indices, and SAVI) which are used to calculate eleven descriptive statistics (i.e., minimum, maximum, range, mean, standard deviation, coefficient of variation, kurtosis, skewness, slope, maximum 5-year slope, and most recent value). Overall MTDD's process includes five main steps: (1) making annual time series, (2) calculating 11 descriptive statistics for the time series, (3) generating training/validation points, (4) training a random forest classifier, and (5) validating the classification. **Sample desig**n: A sample-based approach is used to complete area estimation. This approach is preferred over pixel-counting methods because all maps have errors. Sample based approaches create unbiased estimates of area and the error associated with map. An agreement map generated from the results of all four methods is used for sample design. The goal is to ensure that no strata is under-sampled. The resulting strata is anywhere where 1-4 algorithms agreed there was a certain kind of change event or forest/non-forest remained stable, anywhere the different algorithms labeled different types of change events, anywhere all 4 algorithms labeled non-forest, and anywhere all 4 algorithms labeled forest. Final strata values for the agreement map and their human-readable labels are 1: DEG, 2: LOSS, 3: GAIN, 4: Non-forest, and 5: Forest. The number of points randomly selected depend on the relative area available in each stratum, the human resources available to do interpretations, and a target standard error. A total of **1,522** points were selected via stratified random sampling to be used for sample-based area estimation. **Reference data collection (completed in CEO):** To estimate emissions from deforestation, carbon enhancement removals, and forest degradation emissions, reference data were collected through a time series analysis of 1,522 sampling plots in CEO. To identify the age of forest gain cohorts and differentiate between secondary and permanent forests, the sampling points were visually interpreted for the same period that the forest change map was created (1983 to 2021). This period was divided into four subperiods: 1984-2003, 2004-2014, 2015-2017, and 2018-2021 (see Figure 4). The canopy cover was visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021. i. *Generating a CEO project from a template:* Nepal created a template to collect land-use change and degradation reference data in Collect Earth Online (CEO[51]) for the following periods: Pre-reference period (t0) – 1983-2003, Reference

[51] CEO is a custom built, open-source, satellite image viewing and interpretation system. Collect Earth Online promotes consistency in locating, interpreting, and labeling reference data plots for use in classifying and monitoring land cover / land use change (see https://app.collect.earth).

period (t1) – 2004-2014, First monitoring period (t2) – 2015-2017 and Second monitoring period (t3) – 2018-2021.

ii. *Sampling unit*: The Sampling Unit (SU) is a 70 x 70 meter plot. Inside SU, a 3x3 points sub-grid (9 points) was created to estimate forest canopy cover percentage within each sampling unit.

iii. *Number of Sampling Unit*s: A total of 1,522 sampling points, selected via stratified random sampling, were visually assessed.

iv. *Interpretation ke*y: Nepal produced an interpretation key that should be reused and updated as needed. The land use categories considered are the following:

Forest lands:	**Non-forest lands**
1 Intact Forest 2 Degraded Forest Very 3 Degraded Forest 4 Secondary natural forest 5 Plantation Forest 6 Shaded croplands	7 Grasslands 8 Other lands 9 Settlements 10 Unshaded croplands (tree canopy cover 10% or less)

Area and uncertainty estimation: Nepal employs a sample-based approach to estimate the Activity Data for Deforestation, Forest gain and Degradation. All 1,522 samples were used as the basis for calculating area estimates and their uncertainty. The estimation of Activity Data was done using the stratified random estimator based on the formulas described by Cochran (1977)[52]. Estimates are made for each of the land use categories considered (10 classes) and in terms of changes from one period to another representing a total of more than 26 effective combinations (Deforestation 14, Forest Gain 3, and Degradation 9).

Value applied

Deforestation

Initial	Final	2004-2014	
		Area (ha)	±90% CI
Intact Forest	Grasslands	-	-
Intact Forest	Other Land	445	727
Intact Forest	Settlements	445	727
Intact Forest	Unshaded Cropland (TCC 10% or less)	5,319	4353
Degraded Forest	Grasslands	-	-
Degraded Forest	Other Land	445	727
Degraded Forest	Settlements	445	727
Degraded Forest	Unshaded Cropland (TCC 10% or less)	3,696	4290
Very Degraded Forest	Grasslands	-	-
Very Degraded Forest	Other Land	1,848	3036
Very Degraded Forest	Settlements	-	-
Very Degraded Forest	Unshaded Cropland (TCC 10% or less)	445	727
Secondary Natural Forest	Other Land	-	-

Forest gain

Forest Type	2004-2014	
	Area (ha)	±90% CI
natural secondary forest gain	48,423	15,069
plantation forest gain	5,543	5,250
shaded cropland gain	4,200	3,999

[52] Cochran, W.G. (1977) Sampling Techniques. 3rd Edition, John Wiley & Sons, New York.

Degradation

Initial	Final	2004-2014 Area (ha)	2004-2014 ±90% CI
Intact forest	Intact forest	1,255,942	26,692
Degraded forest	Degraded forest	59,597	16,315
Very degraded forest	Very degraded forest	22,603	10,297
Intact forest	Degraded forest	22,596	9,391
Intact forest	Very degraded forest	889	1,024
Degraded forest	Very degraded forest	4,591	4,416
Degraded forest	Intact forest	20,512	9,495
Very degraded forest	Intact forest	3,698	4,297
Very degraded forest	Degraded forest	5,546	5,258

QA/QC procedures applied:

Reference data collection:

Reference data compilation: To ensure accuracy, the data collected from the CEO was compiled in R for each period of the time series analysis (t0, t1, t2, and t3). The compilation process identifies land-use interpreted points with impossible transitions, and these points are sent back to the interpreted for review, until the compilation process detects no inconsistencies.

Area estimate: To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheet[53]. This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok".

Uncertainty for this parameter:

To determine the uncertainty for Activity Data, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. This calculation only takes sampling errors into account and does not consider interpreter error.

Deforestation

Initial	Final	2004-2014 Area (ha)	2004-2014 ±90% CI	2004-2014 %E
Intact Forest	Grasslands	-	-	0%
Intact Forest	Other Land	445	727	163%
Intact Forest	Settlements	445	727	163%
Intact Forest	Unshaded Cropland (TCC 10% or less)	5,319	4353	82%
Degraded Forest	Grasslands	-	-	0%
Degraded Forest	Other Land	445	727	163%
Degraded Forest	Settlements	445	727	163%
Degraded Forest	Unshaded Cropland (TCC 10% or less)	3,696	4290	116%
Very Degraded Forest	Grasslands	-	-	0%
Very Degraded Forest	Other Land	1,848	3036	164%
Very Degraded Forest	Settlements	-	-	0%
Very Degraded Forest	Unshaded Cropland (TCC 10% or less)	445	727	163%
secondary natural forest	other land	-	-	0%
secondary natural forest	other land	-	-	0%

[53] https://docs.google.com/spreadsheets/d/1iKcoKAHrOTz0uQmL8_lCaZf-Bm57WUAs/edit?usp=sharing&ouid=105157325593840136113&rtpof=true&sd=true
(Please read this file "READ" before accessing it)

Forest gain

Forest Type	2004-2014		
	Area (ha)	±90% CI	%E
natural secondary forest gain	48,423	15,069	31%
plantation forest gain	5,543	5,250	95%
shaded cropland gain	4,200	3,999	95%

Degradation

Initial	Final	2004-2014		
		Area (ha)	±90% CI	%E
Intact forest	Intact forest	1,255,942	26,692	2%
Degraded forest	Degraded forest	59,597	16,315	27%
Very degraded forest	Very degraded forest	22,603	10,297	46%
Intact forest	Degraded forest	22,596	9,391	42%
Intact forest	Very degraded forest	889	1,024	115%
Degraded forest	Very degraded forest	4,591	4,416	96%
Degraded forest	Intact forest	20,512	9,495	46%
Very degraded forest	Intact forest	3,698	4,297	116%
Very degraded forest	Degraded forest	5,546	5,258	95%

Any comment:

3.2 Monitored Data and Parameters

Parameter:	Activity Data: $A(j,i)_{MP}$ Equation 10; $A(a,b)_{MP}$ Equation 11; $A(j,i)_{MP}$ Equation 12.
Description:	● Deforestation: Area converted/transited from forest type j to non-forest type i during the Monitoring Period ● Degradation: Area of forest type a converted to forest type b (transition denoted by a,b) during the Monitoring Period, ha yr^{-1} ● Forest gain: Area of non-forestland i converted to forestland j (transition denoted by i,j) in the Monitoring Period, ha yr^{-1}.
Data unit:	hectare
Value monitored during this Monitoring / Reporting Period:	**Deforestation**

Initial	Final	2018-2021	
		Area (ha)	±90% CI
Intact Forest	Grasslands	-	-
Intact Forest	Other Land	3,698	4,297
Intact Forest	Settlements	-	-
Intact Forest	Unshaded Cropland (TCC 10% or less)	1,462	2,394
Degraded Forest	Grasslands	-	-
Degraded Forest	Other Land	-	-
Degraded Forest	Settlements	-	-
Degraded Forest	Unshaded Cropland (TCC 10% or less)	-	-
Very Degraded Forest	Grasslands	-	-
Very Degraded Forest	Other Land	1,848	3,036
Very Degraded Forest	Settlements	-	-
Very Degraded Forest	Unshaded Cropland (TCC 10% or less)	445	727
secondary natural forest	other land	1,848	3,036

Forest gain

Forest Type	2018-2021	
	Area (ha)	±90% CI
natural secondary forest gain	11,087	7,408
plantation forest gain	3,696	4,290
shaded cropland gain	9,084	6,661

Degradation

Initial	Final	2018-2021	
		Area (ha)	±90% CI
Intact forest	Intact forest	1,283,775	26,011
Degraded forest	Degraded forest	61,890	16,365
Very degraded forest	Very degraded forest	18,701	9,131
Intact forest	Degraded forest	4,877	4,299
Intact forest	Very degraded forest	445	727
Degraded forest	Very degraded forest	1,334	1,248
Degraded forest	Intact forest	12,178	7,116
Very degraded forest	Intact forest	-	-
Very degraded forest	Degraded forest	3,988	4,177

Source of data and description of measurement /calculation methods and procedures applied:

Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. A forest change map spanning from 1983 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO.

Forest change mapping: The following four mapping algorithms that utilize remote sensing imagery, training data points, land cover maps, and time series data analysis were used to map areas experiencing forest loss, degradation, and/or regrowth.

v. **CCDC-SMA**: Continuous Change Detection and Classification–- Spectral Mixture Analysis (CCDC-SMA) monitors abrupt and gradual forest degradation.
vi. **CODE**D: Continuous Degradation Detection (CODED) algorithm detects forest canopy disturbances and classifies them as degradation or deforestation based on land cover. CODED uses linear spectral unmixing to generate subpixel fractions of spectral endmembers, which are used to calculate a time series of the Normalized Degradation Fraction Index (NDFI).
vii. **LandTrend**r: The LandTrendr algorithms use simple statistical techniques to simplify a time-series of spectral values into a sequence of connected straight-line segments that capture the overall shape of that pixel's trajectory while omitting year-to-year noise. The resultant segments can then be examined to select periods where the trajectory displays behaviors of interest such as disturbance or growth.
viii. **MTD**D: Multi-variate Time-series Disturbance Detection (MTDD) classifies initially forested areas into stable forest, degraded, and deforested by training a random forest classifier with 66 metrics. These metrics are derived from six annual time-series (i.e., NDVI, two SWIR spectral regions, two NDWI indices, and SAVI) which are used to calculate eleven descriptive statistics (i.e., minimum, maximum, range, mean, standard deviation, coefficient of variation, kurtosis, skewness, slope, maximum 5-year slope, and most recent value). Overall MTDD's process includes five main steps: (1) making annual time series, (2) calculating 11 descriptive statistics for the time series, (3) generating training/validation points, (4) training a random forest classifier, and (5) validating the classification.

Sample design: A sample-based approach is used to complete area estimation. This approach is preferred over pixel-counting methods because all maps have errors. Sample based

approaches create unbiased estimates of area and the error associated with your map. An agreement map generated from the results of all four methods is used for sample design. The goal is to ensure that no strata is under-sampled. The resulting strata is anywhere 1-4 algorithms agreed there was a certain kind of change event or stable forest/non-forest, anywhere the different algorithms labeled different types of change events, anywhere all 4 algorithms labeled non-forest, and anywhere all 4 algorithms labeled forest. Final strata values for the agreement map and their human-readable labels are 1: DEG, 2: LOSS, 3: GAIN, 4: Non-forest, and 5: Forest. The number of points randomly selected depend on the relative area available in each stratum, the human resources available to do interpretations, and a target standard error. A total of **1,522** points were randomly selected, with a specified number from that total within each strata, to be used for sample-based area estimation.

Reference data collection (completed in CEO): To estimate emissions from deforestation, carbon enhancement removals, and forest degradation emissions, reference data were collected through a time series analysis of 1,522 sampling plots in CEO. To identify the age of forest gain cohorts and differentiate between secondary and permanent forests, the sampling points were visually interpreted for the same period that the forest change map was created (1983 to 2021). This period was divided into four subperiods: 1984-2003, 2004-2014. 2015-2017 and 2018-2021 (see Figure 4). The canopy cover was visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

v. *Generating a CEO project from a template:* Nepal created a template to collect land-use change and degradation reference data in Collect Earth Online (CEO[54]) for the following periods: Pre-reference period (t0)–- 1983-2003, Reference Period (t1) – 2004-2014, First monitoring period (t2) – 2015-2017 and Second monitoring period (t3) – 2018-2021.

vi. *Sampling unit*: The Sampling Unit (SU) is a 70 x 70 meter plot. Inside SU, a 3x3 points sub-grid (9 points) was created to estimate forest canopy cover percentage within each sampling unit.

vii. *Number of Sampling Unit*s: A total of 1,522 sampling points, selected via stratified random sampling, were visually assessed.

viii. *Interpretation ke*y: Nepal produced an interpretation key that should be reused and updated as needed. The land use categories considered are the following:

Forest lands:	**Non-forest lands**
1 Intact Forest 2 Degraded Forest Very 3 Degraded Forest 4 Secondary natural forest 5 Plantation Forest 6 Shaded croplands	7 Grasslands 8 Other lands 9 Settlements 10 Unshaded croplands (tree canopy cover 10% or less)

- Note, the first three types of forest land (intact, degraded, and very degraded) were indirectly labeled in post-processing using the number of tree-covered points out of a 9-point grid over each plot.

Area and uncertainty estimation: Nepal employs a sample-based approach to estimate the Activity Data for Deforestation, Forest gain and Degradation. All 1,522 samples were used as the basis for calculating area estimates and their uncertainty. The estimation of Activity Data was done using the stratified random estimator based on the formulas described by Cochran (1977)[55]. Estimates are made for each of the land use categories considered (10 classes) and

[54] CEO is a custom built, open-source, satellite image viewing and interpretation system. Collect Earth Online promotes consistency in locating, interpreting, and labeling reference data plots for use in classifying and monitoring land cover / land use change (see https://app.collect.earth).

[55] Cochran, W.G. (1977) Sampling Techniques. 3rd Edition, John Wiley & Sons, New York.

	in terms of changes from one period to another representing a total of more than 26 effective combinations (Deforestation 14, Forest Gain 3, and Degradation 9).
QA/QC procedures applied:	**QAQC manual Manual Reference data collection:** **Reference data compilation:** To ensure accuracy, the data collected from the CEO was compiled in R for each period of the time series analysis (t0, t1, t2, and t3). The compilation process identifies land-use interpreted points with impossible transitions, and these points are sent back to the interpreted for review, until the compilation process detects no inconsistencies. **Area estimate**: To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheet[56] (**Activity Data Tool**). This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok".
Uncertainty for this parameter:	To determine the uncertainty for Activity Data, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. This calculation only takes sampling errors into account and does not consider the interpreter error. **Deforestation** **2018-2021** **Initial** / **Final** / **Area (ha)** / **±90% CI** / **%E** Intact Forest / Grasslands / - / - / - Intact Forest / Other Land / 3,698 / 4,297 / 116% Intact Forest / Settlements / - / - / - Intact Forest / Unshaded Cropland (TCC 10% or less) / 1,462 / 2,394 / 164% Degraded Forest / Grasslands / - / - / - Degraded Forest / Other Land / - / - / - Degraded Forest / Settlements / - / - / - Degraded Forest / Unshaded Cropland (TCC 10% or less) / - / - / - Very Degraded Forest / Grasslands / - / - / - Very Degraded Forest / Other Land / 1,848 / 3,036 / 164% Very Degraded Forest / Settlements / - / - / - Very Degraded Forest / Unshaded Cropland (TCC 10% or less) / 445 / 727 / 163% secondary natural forest / other land / 1,848 / 3,036 / 164% **Forest gain** **Forest Type** / **2018-2021** / **Area (ha)** / **±90% CI** / **%E** natural secondary forest gain / 11,087 / 7,408 / 67% plantation forest gain / 3,696 / 4,290 / 116% shaded cropland gain / 9,084 / 6,661 / 73%

[56] https://docs.google.com/spreadsheets/d/1iKcoKAHrOTz0uQmL8_lCaZf-Bm57WUAs/edit?usp=sharing&ouid=105157325593840136113&rtpof=true&sd=true
(Please read this file "READ" before accessing it)

Degradation

Initial	Final	2018-2021 Area (ha)	±90% CI	%E
Intact forest	Intact forest	1,283,775	26,011	2%
Degraded forest	Degraded forest	61,890	16,365	26%
Very degraded forest	Very degraded forest	18,701	9,131	49%
Intact forest	Degraded forest	4,877	4,299	88%
Intact forest	Very degraded forest	445	727	163%
Degraded forest	Very degraded forest	1,334	1,248	94%
Degraded forest	Intact forest	12,178	7,116	58%
Very degraded forest	Intact forest	-	-	-
Very degraded forest	Degraded forest	3,988	4,177	105%

Any comment:

4 QUANTIFICATION OF EMISSION REDUCTIONS

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

Technical Corrections applied to the Reference Level

The technical corrections applied to the original Reference Level have been made. All the technical modifications are in line with paragraph 2 of the "Guideline on the application of the methodological framework Number 2: Technical corrections to GHG emissions and removals reported in the Reference Period". Technical corrections do not compromise the consistency of GHG emissions and removals estimates between the Reference Period and monitoring periods, as both calculations apply the improvements. None of the improvements relate to a change in policy and design decisions affecting the Reference Level. Carbon pools and gases, GHG sources, reference period, forest definition, REDD+ activities and Accounting Area remain unchanged. Changes in data sources, methods, and the re-estimation of Activity Data and Emission Factors have been made in calculating the FREL/FRL of Nepal ER-P. The changes made are detailed below.

i. **Reference period**: There is an error in the ER-PD's Reference Period (RP) : the number of years was mistakenly defined as 10 years which should have been 11 years, considering the start and end of the RP (Start 1/1/2004, End 31/12/2014). Therefore, the Forest Reference Emission Level was calculated considering a Reference Period of 11 years.

ii. **Activity Data:** The ER-PD Activity Data assessment is a yearly analysis of tree canopy cover estimations, done in collaboration with the University of Maryland and supported by the USGS SilvaCarbon program. The assessment involves removing bias and making area estimates based on stratified random sampling. This method is used to establish changes observed between 2004 and 2014 and to determine the extent of deforestation and forest degradation. The emissions estimates for deforestation and forest degradation are based on the changes observed in the tree canopy cover.

   For the current monitoring report, Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. The forest change map spanning from 1983 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO.

   To differentiate between secondary and permanent forests and identify the age of forest gain cohorts, the sampling points are visually interpreted for the same period that the forest change map was created. This period is divided into four subperiods: 1984-2003, 2004-2014. 2015-2017, and 2018-2021. The canopy cover is visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

iii. **Forest carbon densities**: In the ER-PD, the NFI provided average estimates for each independent physiographic region by combining all sampled forest types based on the stratification used. For the ERPD, a single average was proposed for CORE and EDGE classes based on MSPA analysis results. The existing total biomass stocks calculated for each NFI plot were reclassified into an overall CORE and EDGE class using the MSPA analysis. The mean biomass and variance were calculated following Birigazzi et al (2018) [57].

   To ensure consistency between the Emission Factors and land-use transitions area, the NFI plots were evaluated and categorized according to their land use type, such as non-Forest land use, Permanent Forest, or Secondary Forests, for the current monitoring report. The same time series analysis and data collection methods used in CEO were replicated for the NFI permanent plot locations. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points). The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands

[57] Birigazzi, L, JGP Gamarra, TG Gregoire. 2018. Unbiased emission factor estimators for large-area forest inventories: domain assessment techniques. Environmental and Ecological Statistics. https://doi.org/10.1007/s10651-018-0397-3

was based on 14 NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. The forest regrowth removal rate calculation is based on a sample of 16NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.

iv. **Forest degradation:** Nepal initially did not include increased forest biomass observed in forests remaining as forests. For this monitoring report, a net emission from forest degradation was calculated, including biomass recovery.

The following table shows the Reference Level for the ER Program for the Reporting Period .

Year of Monitoring/Reporting period *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2018	429,722	296,643	-963,005	0	-236,640
2019	429,722	296,643	-1,058,016	0	-331,651
2020	429,722	296,643	-1,153,027	0	-426,662
2021	429,722	296,643	-1,248,038	0	-521,672
Total	1,718,889	1,186,571	-4,422,085	0	-1,516,625

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

Quantifying emissions by sources and removals by sinks from the ER Program during the Monitoring Period is shown below. Emission Reductions calculation tool (Nepal_TAL_Integration_tool.xlsx) can be accessed at https://docs.google.com/spreadsheets/d/1umtyj9z5gaSOLFBj-ULCS5QYWCnKsNkZ/edit?usp=sharing&ouid=105157325593840136113&rtpof=true&sd=true.[58] ER estimate tool provides sample calculations using the actual values from section 3 above. This tool also includes all formulas used for the ER estimate.

Year of Monitoring/Reporting Period	Emissions from deforestation (tCO_{2-e}/yr)	If applicable, emissions from forest degradation (tCO_{2-e}/yr)*	If applicable, removals by sinks (tCO_{2-e}/yr)	Net emissions and removals (tCO_{2-e}/yr)
2018	725,826	213,033	-2,094,805	-1,155,946
2019	725,826	213,033	-2,188,253	-1,249,393
2020	725,826	213,033	-2,281,700	-1,342,841
2021	725,826	213,033	-2,375,147	-1,436,288
Total	2,903,302	852,134	-8,939,904	-5,184,468

4.3 Calculation of emission reductions

Total Reference Level emissions during the Monitoring Period (tCO_2-e)	-1,516,625
Net emissions and removals under the ER Program during the Monitoring Period (tCO_2-e)	-5,184,468

[58] (Please read this file "READ" before accessing it)

Emission Reductions during the Monitoring Period (tCO_2-e)	3,667,844
Length of the Reporting period / Length of the Monitoring Period (# days/# days)	0.88
Emission Reductions during the Reporting Period (tCO_2-e)	**3,235,741**

5 UNCERTAINTY OF THE ESTIMATE OF EMISSION REDUCTIONS

x To estimate the Emission Reductions, a pro-rata factor of 0.88 was applied, as the reporting period differed from the monitoring period. The uncertainty of ERs was estimated with and without the application of the pro-rata factor[59]. The application of the pro-rata factor reduced the overall uncertainty by 2%. The uncertainty of ERs calculated without the pro-rata factor is estimated at 170%, whereas with the application, it is estimated at 168%.

5.1 Identification, assessment and addressing sources of uncertainty

Table 7 shows the nature and level of uncertainty associated with Activity Data, Emission Factors as well as integration model.

Table 7. Levels of Uncertainty in Activity Data, Emission Factors and Integration

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High -H /Low - L)	Addressed through QA/QC?	Residual uncertainty estimate?
Activity Data						
Measurement	☑	☑	Activity Data is based on sampling. Systematic and random errors during the visual interpretation of land-use and land-use change in satellite imagery contribute to the overall uncertainty. Nepal has taken measures to address this issue by implementing QA/QC procedures for collecting reference data. This involves using the best available imagery and providing detailed interpretation keys. The interpreters have been trained to follow the correct land-use and land-use change interpretation procedures. To guarantee accuracy, the collected reference data is compiled in R for each period of the time series analysis (t0, t1, t2, and t3). During the compilation process, land-use interpretation points with impossible transitions are identified and sent back to the interpreter for review until the compilation process detects no inconsistencies.	H (bias/random)	Yes	No
Representativeness	☑	☒	Sampling was carried out over the entire accounting area and all reference and monitoring periods. It can therefore be concluded that the impact of this source of uncertainty is low.	L (bias/random)	Yes	Yes
Sampling	☑	☒	To determine the number of points needed for the study, we must consider the area of each stratum. Once the total number of samples is calculated, they must be distributed across the strata proportionally. If any of the strata receive too few samples, they should have a minimum sample size requirement, and the remaining points should be proportionally distributed to the larger strata. However, changes in the study area are small, resulting in a high variance in some change categories. To select the estimator, we follow Cochran's (1977) recommendations.	H (bias)	Yes	No
Extrapolation	☑	☒	The estimates were made based on the samples collected for which the interpretation of the land cover classes is exhaustive and covers the whole	L (bias)	Yes	No

[59] Uncertainty calculation tool can be accessed at the following link: https://docs.google.com/spreadsheets/d/1K65PK--4iCnnYxG0dCu8peF9f5gsjhud/edit?usp=sharing&ouid=105157325593840136113&rtpof=true&sd=true

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High -H /Low - L)	Addressed through QA/QC?	Residual uncertainty estimate?
			reference and monitoring periods. This source of error is therefore unlikely to be present in the approach adopted.			
Approach 3	☑	☒	This source of uncertainty exists when there is no land monitoring or IPCC Approach 3 of monitoring, which is not valid for the Nepal ER program. Four non-independent surveys were conducted covering reference and monitoring periods (t0, t1, t2, and t3), conducting lands tracking.	Not apply	Yes	No
Emission Factors						
DBH measurement	☑	☑	The permanent sample plots were selected from the National Forest Resource Assessment. The sampling design was adopted from Forest Resource Assessment Design 2011[60]. In the selected sample plots, all trees with more than 5 cm diameter were measured. For more details, please refer to the FRA field manual[61]. The height of every fifth tree was measured and for the remaining trees, their height was predicted using the model developed based on the height-diameter relationship of neighboring trees. The model prepared and used during the calculation is presented in Annex 2 of the report "Terai Forests of Nepal"[62]. A strong QA/QC was carried out for all the above-mentioned processes using the QA/QC Manual approved by the FRTC. Comprehensive training was conducted for field staff to minimize field measurement errors. In addition, the continuous monitoring of the field personnel was carried out by the FRTC's officials. As a result of the robust QA/QC process, the error for field measurement is below 5%.	L (bias) & L (random)	Yes	No
H measurement	☑	☑		L (bias) & L (random)	Yes	No
Plot delineation				L (bias) & L (random)	Yes	No
Wood density estimation	☑	☑	The species-specific wood density is referenced from Table 1 of Sharma and Pukkala, 1990[63].	H (bias) & L (random)	Yes	No
Biomass allometric model	☑	☑	The volume of the tree, which is further converted into biomass and carbon, is calculated using the allometric equation developed by Sharma and Pukala, 1990. [Table 2 of Sharma_and_Pukkala_1990_Volume_equations_and_biomass_prediction_of_forest_trees_of_Nepal.pdf] There are more than 21 species of trees with specific parameters and an additional two groups of species found in lower altitudes and higher altitudes with their respective parameters. The maximum and minimum standard error percentage of the regression model is 9.9 % and 5.8 % respectively. The R^2 of the model for every species is higher than 95 % (Sharma and Pukala, 1990).	L (bias) & L (random)	Yes	No
Sampling	☒	☑	The sampling is done based on the Inventory Design (ID) of the National Forest Inventory. The error of the Inventory Design is 7.34% at a 95 % confidence interval. [Please refer to page 40 of the report "State of Nepal's Forests"[64].	L (random/bias)	Yes	Yes
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	☑	☑	Other relevant parameters like root-to-shoot ratio and carbon fraction are taken from the 2006 IPCC guideline. The error provided by the IPCC guideline is also factored in while carrying out the Monte Carlo simulation for uncertainty estimation.	H (bias/random)	Yes	Yes
Representativeness	☑	☒	The carbon densities and removal rates used for the ER monitoring report are Tier 2 (country-specific data) and have been derived from the latest NFI (FRA) except the removal rates for forest plantation and shaded crops. The NFI (FRA) involved remeasurement in 2022 of the permanent sample plots established by the FRA Nepal Project (2010-2014) including an additional number of plots established and measured using the same methodology. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. The carbon densities of natural forests categorized as intact, degraded, and very	L (bias)	Yes	No

[60] https://drive.google.com/file/d/142FYFebXTCruimqe1wKbDoi-oBdwfERh/view?usp=drive_link
[61] https://drive.google.com/file/d/1EvrStTmfNAZVW7ewAqEXuKiUm-OzqUVB/view?usp=drive_link
[62] https://drive.google.com/file/d/1EFpJXYa7GZRiGfP0WJIWwu-zljs9C65v/view?usp=drive_link
[63] https://drive.google.com/file/d/1SRAc-nT7xhc8Sf3UjZGe2zhDJi2NX5d9/view?usp=drive_link
[64] https://drive.google.com/file/d/1FtJEXZdA7xlwVZ6E1GOead4YbwBEEBHo/view?usp=drive_link

Sources of uncertainty	Systematic	Random	Analysis of contribution to overall uncertainty	Contribution to overall uncertainty (High -H /Low - L)	Addressed through QA/QC?	Residual uncertainty estimate?
			degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands was based on fourteen NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI. The forest regrowth removal rate calculation is based on a sample of sixteen NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.			
Integration						
Model	☑	☒	To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheets. This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "OK".	L (bias)	Yes	No
Integration	☑	☒	Activity Data and Emission Factors are comparable. Carbon densities have been estimated according to the forest types, and non-forest land uses interpreted in the visual assessment. To ensure consistency, the Emission Factors (EF) have been aligned with the estimates of land-use transition area (AD). To achieve this, the same time series analysis and data collection methods that were used in CEO were replicated for the NFI permanent plot's locations. The NFI plots have been classified as Non-Forest land use (grassland, other land, unshaded cropland), Permanent Forest, or Secondary Forests. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points).	L (bias)	Yes	No

5.2 Uncertainty of the estimate of Emission Reductions

5.2.1 Parameters and assumptions used in the Monte Carlo method

Nepal's ER Program applied Monte Carlo methods (IPCC Approach 2) for quantifying the Uncertainty of the Emission Reductions. Because the MC propagation analysis includes 55 parameter values, it has been provided access to uncertainty and Emission Factor calculation tool[65] to see all parameter values used in the analysis. The sources of uncertainty propagated in the Monte Carlo (MC) analysis are provided in the following Table.

Parameter included in the model	Parameter values	Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Assumptions
Deforestation and Degradation Emission Factors	The MC analysis included **7** Carbon density values for forest types and non-forest land uses categories considered in emission estimate. See all values in the Uncertainty calculation tool "Parameters and Models" Sheet – (cells F17..F23)	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).

[65] Uncertainty calculation tool can be accessed at the following link: https://docs.google.com/spreadsheets/d/1K65PK--4iCnnYxG0dCu8peF9f5gsjhud/edit?usp=sharing&ouid=105157325593840136113&rtpof=true&sd=true

Removal factors	The MC analysis included **3** Removal factors. See all values in the Uncertainty calculation tool "Parameters and Models" Sheet cells E14..E16.	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Deforestation Activity Data	**Forty-six** values for the Reference Period and **18** Activity Data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Parameters and Models" sheet, cells F42..F85.	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Activity Data for estimating inherited removals	The MC analysis included **11** Activity Data values for estimating inherited removals. See all values in the Uncertainty calculation tool "Parameters and Models" sheet, cells F27..F41.	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Permanent Forest's Degradation	**Fifteen** values for the Reference Period and **17** Activity Data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Parameters and Models" sheet, cells F98..F115.	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).

5.2.2 Quantification of the uncertainty of the estimate of Emission Reductions

		Reporting Period	Crediting Period
		Total Emission Reductions*	**Total Emission Reductions***
A	**Median**	**2,454,322**	**2,454,322**
B	**Upper bound 90% CI** (Percentile 0.95)	**6,703,380**	**6,703,380**
C	**Lower bound 90% CI** (Percentile 0.05)	**-1,559,290**	**-1,559,290**
D	**Half Width Confidence Interval at 90% (B – C / 2)**	**4,131,335**	**4,131,335**
E	**Relative margin (D / A)**	**168%**	**168%**
F	**Uncertainty discount**	**15%**	**15%**

*Remove forest degradation from the estimate if forest degradation has been estimated with proxy data. **Remove the column if forest degradation has not been estimated using proxy data.

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

The following table show each parameter's contribution to the Emissions Reduction's uncertainty. Four parameters represent 51% of total ER's uncertainty: i. Area of change from Intact Forest to Other Land during 2018-2021 (28.5%), ii. Area of change from Intact Forest to Unshaded Cropland during 2018-2021 (8.0 %), iii. Degraded area from Very degraded forest to Degraded forest during 2018-2021 (7.9%) and iv. Root-to-shoot ratio (6.4%).

Input Variable	Corresponding Input Value			Swing	Percent Swing^2
	Low Output	Base Case	High Output		
Deforestation_Intact Forest_Other Land_2018-2021	7,995	3,698	0	2,874,935	28.5%

Deforestation_Intact Forest_Unshaded Cropland_2018-2021	3,856	1,462	0	1,526,354	8.0%
Degradation_Very degraded forest_Degraded forest _2018-2021	0	3,988	8,165	1,511,807	7.9%
ratio R::S	0.1364	0.44	0.7436	1,364,404	6.4%
Forest Gain_Secondary natural forest 1988_other land_2018-2021	4,884	1,848	0	1,300,292	5.8%
Deforestation_Intact Forest_Unshaded Cropland_2004-2014	966	5,319	9,673	1,253,249	5.4%
Degradation_Degraded forest _Inctact forest_2018-2021	5,063	12,178	19,294	1,129,482	4.4%
Removal factor-natural secondary forest gain	-8.12	-12.52	-16.92	1,080,623	4.0%
Forest Gain_Non-forest lnads_Natural forest_2004-2014	33,353	48,423	63,492	958,918	3.2%
Deforestation_Degraded Forest_Unshaded Cropland_2004-2014	0	3,696	7,986	919,014	2.9%
Degradation_Very degraded forest_Inctact forest_2004-2014	7,995	3,698	0	769,051	2.0%
carbon density-natural degraded forest	223.78	181.09	138.40	763,533	2.0%
Degradation_Very degraded forest_Degraded forest _2004-2014	10,805	5,546	288	708,090	1.7%
Forest Gain_Non-forest lnads_Plantation forest_2015-2017	290	5,233	10,176	692,518	1.7%
Degradation_Inctact forest_Degraded forest _2018-2021	9,176	4,877	579	682,336	1.6%
Forest Gain_Non-forest lnads_Natural forest_2015-2017	1,078	6,436	11,793	681,799	1.6%
carbon density-natural very degraded forest	162.62	96.51	30.40	665,464	1.5%
Degradation_Degraded forest _Very degraded forest_2004-2014	174	4,591	9,007	594,680	1.2%
Forest Gain_Non-forest lnads_Natural forest_2018-2021	3,679	11,087	18,494	589,219	1.2%
Degradation_Degraded forest _Inctact forest_2004-2014	30,007	20,512	11,018	548,042	1.0%
Degradation_Inctact forest_Degraded forest _2004-2014	13,205	22,596	31,988	542,088	1.0%
Forest Gain_Non-forest lnads_Shaded cropland_2015-2017	674	5,833	10,992	536,329	1.0%
Deforestation_Very Degraded Forest_Other Land_2018-2021	4,884	1,848	0	464,281	0.7%
Degradation_Degraded forest _Very degraded forest_2018-2021	2,582	1,334	86	462,200	0.7%
Removal factor-plantation forest gain	-9.39	-13.79	-18.18	461,005	0.7%
Forest Gain_Non-forest lnads_Shaded cropland_2018-2021	2,422	9,084	15,745	432,848	0.6%
Forest Gain_Non-forest lnads_Plantation forest_2004-2014	293	5,543	10,794	367,824	0.5%
Forest Gain_Non-forest lnads_Plantation forest_2018-2021	0	3,696	7,986	349,664	0.4%
Removal factor-shaded cropland gain	-7.77	-10.23	-12.69	339,596	0.4%
Forest Gain_Secondary natural forest 1988_other land_2015-2017	4,884	1,848	0	310,784	0.3%
Degradation_Inctact forest_Very degraded forest_2018-2021	1,172	445	0	310,025	0.3%
Forest Gain_Non-forest lnads_Shaded cropland_2004-2014	200	4,200	8,199	207,905	0.1%
Deforestation_Intact Forest_Settlements_2004-2014	0	445	1,172	197,302	0.1%
Degradation_Inctact forest_Very degraded forest_2004-2014	0	889	1,913	184,036	0.1%
Deforestation_Very Degraded Forest_Other Land_2004-2014	0	1,848	4,884	168,830	0.1%
Deforestation_Degraded Forest_Settlements_2004-2014	0	445	1,172	163,476	0.1%
Deforestation_Very Degraded Forest_Unshaded Cropland_2018-2021	1,172	445	0	153,901	0.1%
Deforestation_Intact Forest_Other Land_2004-2014	0	445	1,172	153,251	0.1%

carbon density-natural inctat forest	209.85	217.34	224.83	120,981	0.1%
Deforestation_Degraded Forest_Other Land_2004-2014	0	445	1,172	119,426	0.0%
Forest Gain_Secondary natural forest 1988_other land_2015-2017	1,172	445	0	74,581	0.0%
Deforestation_Very Degraded Forest_Unshaded Cropland_2004-2014	0	445	1,172	55,964	0.0%
Forest Gain_Non-forest lnads_Plantation forest_1983-2003	4,884	1,848	0	0	0.0%

6 TRANSFER OF TITLE TO ERS

6.1 Ability to transfer title

The Carbon Fund (Carbon Fund) of the FCPF requires the ER Program Entity to demonstrate its ability to transfer Title to Emission Reductions (ERs). The term 'Title to ERs' has been defined in the Methodological Framework to mean "full legal and beneficial title and exclusive right to ERs contracted for under the ERPA." Indicator 36.2 of the Framework requires that the Program Entity "demonstrates its ability to transfer to the Carbon Fund Title to ERs, while respecting the land and resource tenure rights of the potential rights-holders, including Indigenous Peoples (i.e., those holding legal and customary rights, as identified by the assessment conducted under Criterion 28), in the Accounting Area." Indicator 36.3 of the Framework also specifies that the Program Entity needs to demonstrate its ability to transfer Title to ERs before signing the ERPA, or at the latest, before transferring of ERs to the Carbon Fund.

Further, Section 15.01(a) of the General Conditions Applicable to ERPAs for FCPF Emission Reductions Programs (November 1, 2014) provides that "the Program Entity shall ensure throughout the [term of the ERPA] and in accordance with the Methodological Framework that the Program Entity has the ability to transfer Title to ERs to the Trustee, free of any interest, encumbrance or claims of a Third Party other than in accordance with the ERPA."

While the ERPD (p.194) of this ER Program has established the MoFE as the national authority and REDD Implementation Center (and its subsequent version National REDD+ Center) as the duly recognized legal entity to transfer the Title to ER, further opinion was sought from the Attorney General of Nepal on this matter in view of the changes in some legislation. The opinion from Nepal's Attorney General concludes that "the Government of Nepal has the ability to transfer Title to Emissions Reductions as required to the Carbon Fund Methodological Framework of the Forest Carbon Partnership Facility."[66] The following constitutional and legal instruments define the Ministry of Forests and Environment (MoFE) as the national authority on forests and REDD+, and as the legal entity with the ability to transfer Title of ERs, including to the Carbon Fund under the Emission Reductions Program Documents (ER-PD).

> **Constitution of Nepal:** The Constitution of Nepal Schedule 5 (27) has identified carbon as a service. According to article 57(1) and Schedule 5 (27) of the Constitution, national forest policy and carbon services shall be regulated by the Federal government in accordance with federal laws. The Government of Nepal, in February 2017, approved an unbundling report[67] by detailing the list of exclusive and concurrent powers of the Federation, the Province and the Local Level. This report specified carbon service as the jurisdiction

[66] Attorney General of Nepal. 2020. Note on the Ability of Program Entity to Transfer Title to Emission Reductions. October 21, 2020. Letter from Attorney General to Ministry of Forest and Environment, Ref 48-077/078.

[67] Government of Nepal, 2017. Unbundling/Detailing of List of Exclusive and Concurrent Powers of the Federation, the State and the Local Level Provisioned in the Schedule 5,6,7,8,9 of the Constitution of Nepal (report), Federalism Implementation and Administration Restructuring Coordination Committee, February, 2017

of the federal level and clearly stated that authority on the enhancement of carbon stocks, as well as fiscal management of the carbon service will be under federal jurisdiction.

Forest Act 2019: According to the Forest Act 2019, carbon stocks are not included under forest products and not counted as forest products/goods, but included under or counted as an environmental service, which will be managed and utilized based on Forest Regulation. Section 2 of the Forest Act defines forest carbon stocks as environmental services. Section 44 (1.a) of the Act authorizes the Government of Nepal to make arrangements for the management, utilization and distribution of benefits arising out of the environmental services, including carbon stock from emission reduction program. Similarly, the sub section (1) of section 3 states that the land ownership of the national forest lies with the Government of Nepal. As such, this Act defines forest carbon as an environmental service, and gives resource rights to communities on the products or goods produced in the forest but not to the land, intangible property, nor environmental services (e.g., carbon stocks).

FUGs prepare forest management plans and get them approved by DFOs as per Section 18 of the Forest Act 2019. According to the Community Forest Development Guideline 2015 (revised), FUGs may include provisions for the conservation and utilization of environmental services, including carbon stocks, in their plans. Section 44 (1.b) of the Act empowers the FUG to manage, use and distribute benefits arising out of the environmental services other than carbon stock and emission reduction. The use rights of communities and individuals are also established for PA Buffer Zones and Conservation Areas, according to National Parks and Wildlife Conservation (NPWC) Act, 1973. Thus, the forestry and protected area legislation provide resource rights to communities on the products or goods produced in the forest but not to the land, intangible property, nor environmental services (e.g., carbon stocks).

Environment Protection Act 2019: The Act's Section 28 of the Act authorizes the GoN to participate in carbon trading for emission reduction and carbon stock enhancements with international mechanism, foreign Governments or entity or professional entity or private sector established under international conventions.

Government of Nepal (Business Allocation) Regulation 2018: This Regulation authorizes MoFE to develop and approve plans and programs related to carbon service and carbon stock. National REDD+ Steering Committee (NRSC) formed as per Nepal National REDD+ Strategy (2018 – 2022) as the apex decision-making body endorsed REDD+ ER Program for the 13 Terai Arc Landscape Districts through its meeting on April 19, 2018. The Ministry of Finance signed the ERPA with the FCPF Carbon Fund upon the request of REDD IC as the Secretariat of the NRSC, as forwarded through MoFE, pursuant to Section 2(9) of the Government of Nepal (Business Allocation) Regulation 2018. The Regulation authorizes the Ministry of Finance to sign an Emission Reductions Payment Agreement with an international entity, including FCPF's Carbon Fund.

Assessment of carbon rights

The Constitution of Nepal (2015) Schedule 5, No 27, puts the following matter under the sole jurisdiction of federal power. The following matter is dealt with by the Federal Government, as opposed to the provincial or local government: "National and international environment management, national parks, wildlife reserves and wetlands, national forest policies, carbon services." Therefore, it is clear that the Government of Nepal has the right to transfer the Title to ER to international entities on the basis of this jurisdiction. However, it may transfer the Title to ER generated by private person or entity only when there is equitable benefit sharing, as the Constitution's commitment in its State Policy and Principles imply that the benefits to natural resources, including the benefits from carbon services, are equitably distributed.

The National REDD+ Strategy, 2018 states that "*under the existing land and forest tenure regimes, substantive measures will be taken to secure carbon rights of the right holders. For this, forest legislation will clearly define carbon rights and its right holder.*" Consequently, Forest Act, 2019 included carbon sequestration/stock as an environmental service, which should be regulated according to the constitutional provision and the regulations.

Carbon rights and emission reduction title

REDD+ comes under both national and international environment management. On the one hand, the activities and interventions for implementing Emission Reduction Programs, or any other programs in the National REDD+ Strategy, are guided by national laws, policies and the annual budget/program of the government. On the other hand, REDD+ is also guided by UNFCCC and any contract made by the Government of Nepal with any international entities such as the World Bank's Carbon Fund and UN-REDD. Therefore, carbon rights and Emission Reduction Title directly belong to national and international environment management and carbon services. They are also a matter of national forest policies as defined by the constitution.

It is clear that the Federal Government (that is, the Government of Nepal) has the right to transfer Title of Emission Reduction to international entities based on its right over national and international environment management and carbon services, as well as the right to issue national forest policies. There has been no contestation on the ability and jurisdiction of the Government of Nepal to transfer the Title of ER in the program area. The Federal Government has power over carbon services as well as the land ownership of national forests. The land under national forests, including community forests, collaborative forest, block forest or protected areas is owned by the Federal Government and authority over carbon services is vested in the Federal government (Constitution Schedule 5 (27)), no person (biological or legal) can transfer Title to ERs apart from the Federal Government. The Federal Government pursuant to other legislation (Article 25) and equitable benefit-sharing plans (Article 51) can transfer Title to ERs to any entity.

6.2 Implementation and operation of Program and Projects Data Management System

Existing REDD Implementation Center, under the Ministry of Forest and Environment (MoFE), is the program entity for ER program. It has been mandated as the entity for the development, implementation and management of ER programs on behalf of the Government of Nepal. It is a specialized body within MoFE and is dedicated to the implementation of the National REDD+ Strategy and associated implementation plan. Its main function is to coordinate with all stakeholders, including government agencies, civil society, academia and practitioners for the development and implementation of REDD+ in Nepal. It also serves as the operating entity for the Forest Carbon Partnership Facility (FCPF), the Forest Investment Program (FIP) and the UN-REDD Program. The following are key responsibilities of REDD IC:[68]

- Identification of and access to national and international funds for results-based REDD+ payments
- Coordination with different sectors and stakeholders for the development of REDD policies and decision-making
- Coordination for the regulation of greenhouse gas emissions from the forest sector
- Coordination for the sharing of benefits arising from REDD+
- Coordination of the implementation and monitoring of REDD+ safeguards
- Establishment and operation of national forest information system
- Coordination for the implementation of National REDD+ strategy and emissions reduction program
- Studies, research, and publication on REDD issues and their dissemination

[68] ToR of REDD Implementation Center, in REDD IC. 2022 Sep. Proactive Disclosure Shrawan to Ashoj 2079. Available at https://redd.gov.np/assets/2/Proactive_Disclosure_Shravan_to_Ashoj_2079_REDDIC.pdf/file. The text is the translation from original Nepali version.

- Establishment forest carbon registry and national forest monitoring system and coordination with Forests Research and Training Center for carbon measurement, report preparation and verification
- Development of a system/procedure for entering into agreements with private forest owners for encouraging them in emissions reduction program.

Further institutional evolvement of REDD IC is currently under process. Nepal's REDD+ Strategy 2018 as well as fourteenth periodic plan (2017-19) had committed to the establishment of National REDD Center (RIC). The RIC is envisioned to evolve as semi-autonomous, designated entity according to the Warsaw Framework for REDD+. The upgradation of the REDD IC into the National REDD Center by issuance of a federal "formation order" or other legal instrument is currently under consideration. Until that materializes, all functions of designated national REDD+ entity will be served by REDD IC.

Projects Data Management System. REDD IC has developed National Forest Database (NFD) and National Forest Information System (NFIS, website: http://nfis.redd.gov.np/nfis) as web-based platforms for the entry and visualization of data on forest and ER projects. Because REDD IC (and subsequent NRC) will be responsible for ER project development and implementation for all of country's government-owned forests, this arrangement forestalls and avoids multiple claims to ER. It requires updating and consolidation to account for and updating project data, by including the following information:

- The proponent of the ER program or project
- Geographic boundaries of the ER program or project
- Scope of REDD+ activities and carbon pools
- The reference level used
- MRV data to specific REDD+ projects or programs
- Safeguard plans of specific REDD+ projects or programs.

6.3 Implementation and operation of ER transaction registry

"People and Forests- A Sustainable Forest Management -Based Emission Reduction Program in the Terai Arc Landscape" is the first ER program being implemented in the government-owned forest in Nepal. Accordingly, Nepal is still in the process of preparing to develop, implement and operationalize the registration of ER transactions for future programs. Thus, Nepal's REDD entity has decided to use a centralized ER transaction registry managed by a third party on its behalf – the REDD IC will use the World Bank ER transaction registry.

6.4 ERs transferred to other entities or other schemes

"People and Forests- A Sustainable Forest Management -Based Emission Reduction Program in the Terai Arc Landscape" is the first REDD+ program that is being implemented in Nepal in government-owned forests. After the approval of this ER Monitoring Report and according to the ERPA, the contract ER units will be transferred to FCPF Carbon Fund on a 100% basis. No ERs will be transferred from this program to other entities during the crediting period.

7 REVERSALS

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

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7.2 Quantification of Reversals during the Reporting Period

Using the table below, please confirm and quantify any Reversals of ERs that have been previously transferred to the Carbon Fund, that might have occurred during the Reporting Period.

*Refer to **indicator 19.1** of the Methodological Framework and the FCPF ER Program Buffer Guidelines*

A.	**ER Program Reference level for this Reporting Period (tCO_2-e)**	*from section 4.1*	**Intentionally left blank**	
B.	**ER Program Reference level for all previous Reporting Periods in the ERPA (tCO2-e).**	*from previous ER Monitoring Reports*	**Intentionally left blank**	+
C.	**Cumulative Reference Level Emissions for all Reporting Periods [A + B]**		**Intentionally left blank**	
D.	**Estimation of emissions by sources and removals by sinks for this Reporting Period (tCO_2-e)**	*from section 4.2*	**Intentionally left blank**	
E.	**Estimation of emissions by sources and removals by sinks for all previous Reporting Periods in the ERPA (tCO_2-e)**	*from previous ER Monitoring Reports*	**Intentionally left blank**	
F.	**Cumulative emissions by sources and removals by sinks including the current reporting period (as an aggregate accumulated since beginning of the ERPA) [D + E]**		**Intentionally left blank**	–
G.	**Cumulative quantity of Total ERs estimated including the current reporting period (as an aggregate of ERs accumulated since beginning of the ERPA) [C – F]**		**Intentionally left blank**	

H.	**Cumulative quantity of Total ERs estimated for prior reporting periods (as an aggregate of ERs accumulated since beginning of the ERPA)**	*from previous ER Monitoring Reports*	**Intentionally left blank**
I.	**[G – H], negative number indicates Reversals**		**Intentionally left blank**
If I. above is negative and reversals have occurred complete the following:			
J.	**Amount of ERs that have been previously transferred to the Carbon Fund, as Contract ERs and Additional ERs**		**Intentionally left blank**
H.	**Quantity of Buffer ERs to be canceled from the Reversal Buffer account [J / H × (H – G)]**		**Intentionally left blank**

7.3 Reversal risk assessment

The ER-PD development team estimated that the risk of reversal, both natural and human-induced, was 11%. However, this estimate did not account for the default risk value of 10%. Therefore, the risk of reversal was reviewed and revised. The FCPF Buffer Guidelines were used to determine acceptable values, and the discounts were applied accordingly. The updated estimate of the overall risk due to reversals is 16%.

Risk Factor	Risk indicators	Default Reversal Risk Set-Aside Percentage	Discount	Resulting reversal risk set-aside percentage
Default risk	*N/A*	**10%**	*N/A*	*10%*
Lack of broad and sustained stakeholder support	Stakeholders have been engaged throughout the REDD+ process with multiple consultations at all levels. There is broad support for the ER Program across stakeholder groups. There is a low risk of land conflict with the handover of forests to the communities, and the chances of internal migrations and forest land encroachments are also low. At places in the ERPA area, localized instances of forest land encroachment were observed. To address this, the government has put in place an institutional mechanism that includes the Ministry of Home Affairs, Ministry of Forests and Environment, Nepal Police and Provincial governments. Furthermore, handing over of the national forests to CBFM groups will result in management and protection of forest areas. Nepal has recently formulated National Land Use Act 2019 and Land Use Regulation 2022. The Land Use Act has provision to safeguard land use classes and it requires a	**10%**	*10%*	*0%*

	rigorous process to change and transform land use from one class to another.			
Lack of institutional capacities and/or ineffective vertical/cross sectorial coordination	The forests are managed by 84 Division Forest Offices (DFOs) and 528 sub-division Forest Offices which are under the jurisdiction of the Provinces since 2018. This has enhanced the capacity of the provincial ministry and institutions to effectively carry out the mandates stipulated in the Nepal's constitution, Forest Act and Forest Regulation. The local levels have started establishing 'Forest and Environment Section' to implement the responsibilities as per the Forest Act and the Forest Regulation. These agencies are responsible for horizontal and vertical coordination. Since forest management is a concurrent power between federal, provincial and local governments, the Federation, Province and Local Level (Coordination and Inter-relation) Act, 2020, ensures collaboration between the three levels. In addition, Forest Act, pursuant to clause 121, has mandated that province and federal forestry sector bodies coordinate and collaborate on forest and forestry issues. This risk has been classified as low. There is a broad buy-in for the ERPD process, and Annex 10 shows the strong level of commitment across ministries for the ER Program. However, the evolving process of devolution represents a risk in terms of the vertical collaboration between the federal, provincial, local l and the community levels. The government is mitigating this risk through the development of a risk matrix that provides options for ERPD implementation under the different institutional arrangements that might emerge.	**10%**	*10%*	*0%*
Lack of long term effectiveness in addressing underlying drivers	Several factors may impact the risk of reversals due to a lack of long-term effectiveness in addressing the underlying drivers. These have overall been assessed to be low risk. Infrastructure: The demand for infrastructure will keep growing with the growth in population. This risk is mitigated through land use planning intervention, which will help to minimize deforestation that may result from infrastructure development. Trade disruption and road blockages resulting in demand for fuelwood: Nepal is a landlocked country and is dependent on neighboring countries for trade. Any delay on trade and transit arrangements may exert undue pressure on forests for various issues including fuel. Nepal has substantially increased hydropower capacity and is diversifying its energy mix by expanding biogas and solar programs, which will provide alternative energy sources and minimize the pressure on forest for fuelwood. Uncontrolled grazing due to increased stray cattle: The handover of forests to communities will reduce the risks of uncontrolled grazing , but the stray cattle, especially oxen, may lead to uncontrolled grazing to some extent.	**5%**	*2%*	*3%*
Exposure and vulnerability to natural disturbances	Several factors affect the risk due to climate-related and non- anthropogenic impacts. Overall, these have been given a low risk Increased demand for timber due to non-climatic hazards such as earthquakes: Nepal lies in a seismic zone and there is potential of a big earthquake in the western region. The	**5%**	*2%*	*3%*

	earthquake that struck Nepal in April 2015 saw an increased demand for home construction which caused limited pressure on forests for timber. The interventions proposed here should significantly increase the supply of timber, and this risk is considered to be low. Floods, soil erosion, and landslides in riverine forest areas: Though there is the possibility of floods and soil erosion, the impact on forest loss has historically been low. Similarly, there is a chance of forest degradation on hill slopes, but generally, areas that have less vegetation bear the brunt of landslides compared to forested areas that hold the soil. Climate change and droughts: Nepal faced acute droughts in 2009 and during winter and summer periods in 2016. The droughts have not impacted forest areas because there has been no demand for expansion of agricultural land and direct impact on tree mortality due to droughts. The ERPD also proposes several interventions to increase understanding of climate vulnerability and to address climate change impacts through improved tree species selection. Forest Fire: the frequency and intensity of forest fires are increasing due to the impact of climate change. However, the majority of forest areas are under the CBFM and this has ensured timely action to mitigate the impact and losses from the forest fires. Further, the DFOs are well-equipped and are effectively managing forest fire incidents in collaboration with local communities.			
		Total reversal risk set-aside percentage		*16%*
		Total reversal risk set-aside percentage from ER-PD or previous monitoring report (whichever is more recent)		*11*

8 EMISSION REDUCTIONS AVAILABLE FOR TRANSFER TO THE CARBON FUND

A.	**Emission Reductions during the Reporting period (tCO_2-e)**	*from section 4.3*		**3,235,741**
B.	**If applicable, number of Emission Reductions from reducing forest degradation that have been estimated using proxy-based estimation approaches (use zero if not applicable)**			0
C.	**Number of Emission Reductions estimated using measurement approaches (A-B)**			**3,235,741**
D.	**Percentage of ERs (A) for which the ability to transfer Title to ERs is clear or uncontested**	*from section 6.1*		100%
E.	**ERs sold, assigned or otherwise used by any other entity for sale, public relations, compliance or any other purpose including ERs accounted separately under other GHG accounting schemes or ERs that have been set-aside to meet Reversal management requirements under other GHG accounting schemes**	*from section 6.4*		0 –
F.	**Total ERs (B+C)*D-E**			**3,235,741**
G.	**Conservativeness Factor to reflect the level of uncertainty from non-proxy based approaches associated with the estimation of ERs during the Crediting Period**	*from section 5.2*		15%
H.	**Quantity of ERs to be allocated to the Uncertainty Buffer (0.15*B/A*F)+(G*C/A*F)**			485,361 –
I.	**Total reversal risk set-aside percentage applied to the ER program**	*from section 7.3*		16%
J.	**Quantity of ERs to allocated to the Reversal Buffer (F-H)*(I-5%)**			302,542
K.	**Quantity of ERs to be allocated to the Pooled Reversal Buffer (F-H)*5%**			137,519
L.	**Number of FCPF ERs (F- H – J – K)**			**2,310,319**

ANNEX 1: INFORMATION ON THE IMPLEMENTATION OF THE SAFEGUARDS PLANS

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

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

ANNEX 4: CARBON ACCOUNTING - ADDENDUM TO THE ERPD

Technical corrections

The technical corrections applied to the original Reference Level have been made. All the technical modifications are in line with paragraph 2 of the "Guideline on the application of the methodological framework Number 2: Technical corrections to GHG emissions and removals reported in the Reference Period". Technical corrections do not compromise the consistency of GHG emissions and removals estimates between the Reference Period and monitoring periods, as both calculations apply the improvements. None of the improvements relate to a change in policy and design decisions affecting the Reference Level. Carbon pools and gases, GHG sources, Reference Period, forest definition, REDD+ activities and Accounting Area remain unchanged. Changes in data sources, methods, and the re-estimation of Activity Data and Emission Factors have been made in calculating the FREL/FRL of Nepal ER-P. The changes made are detailed below.

i. **Reference Period**: There is an error in the ER-PD's Reference Period (RP), the number of years was mistakenly defined as 10 years which should have been 11 years, considering the start and end of the RP (Start 1/1/2004, End 31/12/2014). Therefore, the Forest Reference Emission Level was calculated considering a Reference Period of 11 years.

ii. **Activity Data:** The ER-PD Activity Data assessment is a yearly analysis of tree canopy cover estimations, done in collaboration with the University of Maryland and supported by the USGS SilvaCarbon program. The assessment involves removing bias and making area estimates based on stratified random sampling. This method is used to establish changes observed between 2004 and 2014 and to determine the extent of deforestation and forest degradation. The emissions estimates for deforestation and forest degradation are based on the changes observed in the tree canopy cover.

   For the current monitoring report, Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. The forest change map spanning from 1983 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO.

   To differentiate between secondary and permanent forests and identify the age of forest gain cohorts, the sampling points are visually interpreted for the same period that the forest change map was created. This period is divided into four subperiods: 1984-2003, 2004-2014. 2015-2017, and 2018-2021. The canopy cover is visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

iii. **Forest carbon densities**: In the ER-PD, the NFI provided average estimates for each independent physiographic region by combining all sampled forest types based on the stratification used. For the ERPD, a single average was proposed for CORE and EDGE classes based on MSPA analysis results. The existing total biomass stocks calculated for each NFI plot were reclassified into an overall CORE and EDGE class using the MSPA analysis. The mean biomass and variance were calculated following Birigazzi et al (2018) [69].

   To ensure consistency between the Emission Factors and land-use transitions area, the NFI plots were evaluated and categorized according to their land use type, such as non-Forest land use, Permanent Forest, or Secondary Forests, for the current monitoring report. The same time series analysis and data collection methods used in CEO were replicated for the NFI permanent plot locations. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points). The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands

[69] Birigazzi, L, JGP Gamarra, TG Gregoire. 2018. Unbiased emission factor estimators for large-area forest inventories: domain assessment techniques. Environmental and Ecological Statistics. https://doi.org/10.1007/s10651-018-0397-3

was based on 14 NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. The forest regrowth removal rate calculation is based on a sample of 16 NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.

iv. **Forest degradation:** Nepal initially did not include increased forest biomass observed in forests remaining as forests. For this monitoring report, a net emission from forest degradation was calculated, including biomass recovery.

Start Date of the Crediting Period

The start date of the crediting period is June 28, 2018. This date corresponds to the definition of the start date of the crediting period provided in the FCPF Glossary, i.e., follows:
- It is no earlier than June 22, 2018, the date of inclusion of the program in the portfolio of the Carbon Fund (Resolution CFM/18/2018/3).
- It does not fall under the reference period 2004-2014.

7. CARBON POOLS, SOURCES AND SINKS

7.1 Description of Sources and Sinks selected

Sources/Sinks	Included?	Justification/Explanation
Emissions from deforestation	*Yes*	Emissions from deforestation are significant sources of GHG emissions in TAL and therefore are included in the Reference Level (RL). The RL analysis shows that during the 11-year period between 2004 and 2014, a total of **4,726,946** tCO_2e was emitted from deforestation in the TAL, an average annual emission of 429,722 tCO_2e/yr.
Emissions from forest degradation	*Yes*	Emissions from degradation are significant sources of GHG emissions in TAL and therefore are included in the Reference Level (RL). The RL analysis shows that during the 11-year period between 2004 and 2014, a total of **3,263,071** tCO_2e was emitted from degradation in the TAL, an average annual emission of 296,643 tCO_2e/yr.
Enhancement of forest carbon stocks	*Yes*	Enhancement of forest carbon stocks by forest cover gain is included in the Reference Level (RL). The RL analysis shows that during the 11-year period between 2004 and 2014, a total of **-12,683,295** tCO_2e was removed via forest gain and canopy cover recovery in permanent forest in the TAL, an average annual emission of -1,153,027 tCO_2e/yr.
Conservation of forest	*No*	Any emissions or removals that occur in protected areas or managed forests are included in three, aforementioned, REDD+ activities. The impact of sustainable forest management, especially in community forests, can be seen in the enhancement of carbon stocks and afforestation that are included in the emission estimates.
Sustainable management of forests	*No*	

7.2 Description of carbon pools and greenhouse gases selected

Carbon Pools	Selected?	Justification/Explanation
Above Ground Biomass (AGB)	*Yes*	The ERPD follows suit with the Nepal submission of its FRL to the UNFCCC. The NFI data indicates a carbon accounting area average of 100.7 tC/ha, constituting the largest pool.
Below Ground Biomass (BGB)	Yes	Below-ground biomass was estimated using a root-to-shoot ratio of 0.44 (2019 refinement to the 2006 IPCC guidelines for national GHG inventory, Table 4.4 (Subtropical dry Asia, AGB > 125 tons/ha).
Dead Wood	*No*	Based on NFI analysis, it is estimated that dead organic matter, litter, and debris contribute 1.19 t C/ha (2.25 t C/ha per WWF report [Gurung and Koch, 2011]) against an average aboveground forest biomass of 100.7 tC/ha (113.01 t C/ha [Gurung and Koch, 2011]). As such, both pools do not seem to constitute a significant pool and are initially excluded (**see below analysis for non-CO_2 gasses**). Since primary activities are related to avoiding deforestation and degradation and do not include significant ground disturbance, exclusion of soil carbon is likely conservative even though available estimates indicate high values representing about 29% of total biomass (Gurung and Koch, 2011).
Litter	*No*	
Soil Organic Carbon (SOC)	*No*	

GHG	Selected?	Justification/Explanation
CO2	Yes	The ER Program accounts for CO_2 emissions and removals.

CH4	No	Nepal has no coastline or mangroves; thus, there are no CH_4 or N_2O emissions associated with organic and mineral soils for the management activities of extraction (including construction of aquaculture and salt production ponds), drainage and rewetting and revegetation as provided in the 2013 Wetlands Supplement to the 2006 IPCC Guidelines. Experience under the Kyoto Protocol's CDM also suggests that emissions from using fertilizer and planting leguminous plants and trees will not be significant (FCPF Decision Support Tool Part 1). A significant proportion of CH_4 emissions in Nepal come from enteric fermentation, solid waste disposal and wastewater treatment as well as from the rice fields as reported by the Initial National Communication (2004). These are not directly associated with forestry, though, so they are not relevant for the FRL calculation. Additionally, some of the implementation's actions proposed by this ERPD, like the use of biogas units, will indirectly target emissions from enteric fermentation resulting from grazing inside forest areas, minimizing even further the relevance of this gas. The excluded GHGs therefore are CO, CH_4 and N_2O because: ● There are no mangroves in Nepal. ● There are no seasonal or permanently flooded forest areas in Nepal. ● Emissions from fire can contribute to CH_4 and N_2O concentrations in the atmosphere, but this source of emissions is not considered significant, as described in Section 4.1.3.
N2O	No	In the case of the national Reference Level (RL), to understand whether non-CO_2 emissions associated with forest fires provide a significant contribution to total emissions from forests, we considered the Global Forest Resources Assessment 2015 (FAO 2015) report for Nepal. In the report, Nepal provides a burned forest area estimate of on average 9,738 ha/yr for the period 2003–2010. They indicate this number concerns mainly fire events in remaining forestland, a sub-category which is currently not fully covered by the FRL. For the FRL, Nepal performed an estimation of annual non-CO_2 emissions from fire using equation 2.27 (IPCC 2006, Volume 4, Chapter 2). Input data in the equation was derived from the Global Forest Resources Assessment 2015's burned forest area estimate for Nepal (the average for the years 2003–2010), the average above-ground biomass (mass of fuel available for combustion) as obtained from Nepal's National Forest Inventory (2010) and IPCC default values for fuel biomass consumption, the combustion factor, and Emission Factor of dry matter burnt per mass. This calculation suggests a total of nonCO_2 emissions of 281,470 tCO_2e, which consists of 12% of the total annual emissions included in Nepal's FRL. As such, Nepal concluded the contribution of non-CO_2 gasses was not significant and considering the country doesn't dispense reliable fire data, it was decided to omit non-CO_2 gasses associated with fire. Additional analyses were carried out for the TAL area for 2004–2014. MODIS Area Burnt data were used to assess patterns of fire occurrence between 2004 and 2014. Results indicate fires occur mostly within forest areas that are also within protected areas (see figures below). Discussing the results with the relevant agencies such as the DFRS and NRC as well as with FAO, it was indicated these are prescribed burnings for the most part that do not affect the main biomass content of the forests and are targeted at the litter and deadwood pools (less than 2% of the available

biomass). When assessing NFI plot data from areas within MODIS derived burnt area estimates vs areas with no fire, following Birigazzi et al (2018), areas with fire presence appeared as having higher biomass than areas without fire.

DOMAIN	domain mean (t/ha)	$\frac{1}{\hat{N}_d^2}$	$V(\tilde{y}_{sd})$	Confidence interval at 95%	% CI (95%)	Confidence Interval at 90%	% CI (90%)
FIRE	**219.11**	6.46168E-14	189.9	**27.0**	12.3%	**22.7**	10.3%
NO FIRE	**180.25**	1.65974E-15	44.1	**13.0**	7.2%	**10.9**	6.1%

Currently, reliable emissions estimates are not possible because Nepal fundamentally lacks burnt area data. The MODIS data highlights the presence of an active fire within an area 500m x 500m (25 ha) pixel. However, this does not mean that all that area has been burnt.

The estimations made based on the MODIS data for the TAL (2004–2014) assuming all 25 ha MODIS pixel-1 litter, and deadwood pool were fully burnt (1.19 t biomass/ha; as per NFI data) and fully recovered year after year (some pixels are flagged as burnt in all years), which is unlikely, yields an estimated average of 196,646 tCO2e/yr^{-1}. This corresponds to about 27% of total average gross emissions from the TAL 2004–2014.

Year	# MODIS pixels Flagged	Emissions from Litter Burning
2004	7140	307,771.49
2005	6957	299,883.23
2006	6468	278,804,76
2007	5675	244,622.30
2008	5136	221,388.57
2009	4403	189,792.42
2010	3544	152,795.01
2011	3249	140,048.96
2012	2080	89,658.92
2013	968	41,725.88
Average emission		196,646.00

Nepal considers these numbers to be a large overestimation of emissions, as it is clear that not all the area of a given MODIS pixel highlighted as having fire presence (25 ha) is necessarily burnt; which is highly unlikely (the fact some of these pixels were highlighted every single year without apparent tree canopy damage and related burn scars supports this fact) plus a full recovery of the biomass burnt is also unlikely.

Based on this, Nepal considers the percentage of emissions resulting from these fires to be very well below the 10% threshold for their inclusion as significant sources in a conservative manner and therefore left them out of this version of the Reference Level in addition to derived N2O, CH4 and CO (non-CO2) gasses.

However, Nepal is aware of the need for better informing the estimated emissions from these fires and is currently defining the terms of reference to carry out, with the support of FAO, an area burnt

		characterization that will deliver the necessary quality data required for the sound assessment of emissions resulting from these fires.

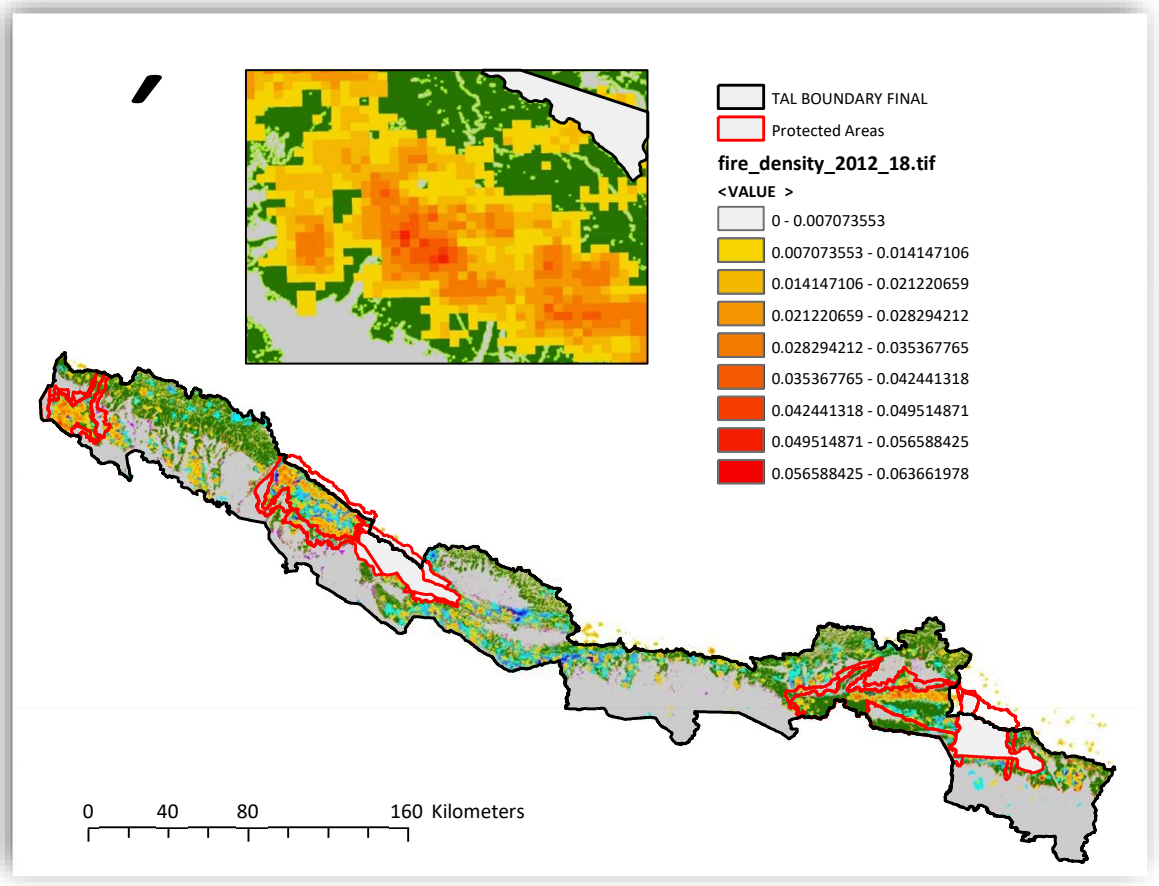


Figure 11: MODIS-derived fires frequency data with protected areas in the TAL; occurrence density 2012–2018. The data show how most of the fires occur within protected areas boundaries.

8 REFERENCE LEVEL

8.1 Reference Period

The Reference Period starts on January 1st, 2004, and ends on December 31st, 2014, making it a duration of 11 years. These dates are consistent with the available data used to inform the stratification used for unbiased estimation of Activity Data and elements of permanence in Nepal's definition of deforestation and forest degradation—particularly those involved with their permanence. We used 2002–2004 forest conditions to define a benchmark or forest stratum area and used changes observed as of 2014 and that remained as such as of 2015 and 2016 as a means to assess permanence of relevant accounting strata: stable forest, stable non-forest (all non-forest classes), forest gain, and forest loss.

8.2 Forest definition used in the construction of the Reference Level

The definition of forest used in Nepal is "**forest as an area of land of at least 0.5 ha and a minimum width/length of 20 m with a tree crown cover of more than 10% and tree heights of 5 m at maturity."**

Forest definition operationalization:
The ER-PD uses Landsat data (30m resolution) for mapping of tree canopy cover estimated data following Hansen et al (2012) from 2002 to 2016, to derive corresponding Activity Data. Given the fact Nepal's area component of its forest definition refers to 0.5 ha and 10% tree cover, Nepal considers that 30m resolution TCC estimates inform its forest definition, as any given pixel represents an area of 0.09 ha or 18% of 0.5 ha.

Use of TCC data for unbiased estimation of AD via stratified random sampling following Tyukavina et al. 2013,65 2015,66 Global Forest Observation Initiative's Methods and Guidance (MGD) update *in process* as well as pixel level sample assessment of tree canopy cover permanence, loss and gain complies with the operationalization of the forest definition as well as of its definition of deforestation (permanent forest loss: TCC below 10% threshold) and forest degradation (partial loss while still above 10%).

8.3 Average annual historical emissions over the Reference Period

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

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)
Emissions from deforestation were estimated based on the Deforestation Sheet of Activity Data tool following the 2006 IPCC Guidelines, the annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta C_{B_{defo,t}}$) would be estimated through the following equation:

$$\Delta C_{B_{defo,t}} = \Delta C_G + \Delta C_{CONVERSION} - \Delta C_L$$ **Equation 3** (Equation 2.15, 2006 IPCC GL)

Where:

$\Delta C_{B_{defo,t}}$	Annual change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1};
ΔC_G	Annual increase in carbon stocks in biomass due to growth on land converted to another land-use category, in tones C yr^{-1};
$\Delta C_{CONVERSION}$	Initial change in carbon stocks in biomass on land converted to other land-use category, in tones C yr^{-1}; and
ΔC_L	Annual decrease in biomass carbon stocks due to losses from harvesting, fuel wood gathering and disturbances on land converted to other land-use categories, in tones C yr^{-1}.

Following the recommendations set in chapter 2.2.1 of the GFOI Methods Guidance Document[70] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified and it will be assumed that: a) the annual change in carbon stocks in biomass (ΔC_B) is equal to the initial change in carbon stocks ($\Delta C_{CONVERSION}$); b) it is assumed that the biomass stocks immediately after conversion are the biomass stocks of the resulting land-use. Therefore, the annual change in carbon stocks would be estimated as follows:

$$\Delta C_B = \Delta C_{CONVERSION}$$

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) x\, CF\, x \frac{44}{12} \times A(j,i)_{RP}$$ **Equation 4** (Equation 2.16, 2006 IPCC GL)

[70]Page 44, GFOI (2013) Integrating remote-sensing and ground-based observations to estimate emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

Where:

$A(j,i)_{RP}$ Area converted/transited from forest type j to non-forest type i during the Reference Period, in hectares per year. In this case, sixteen forest land conversions are possible:

1 Intact Forest to Grasslands
2 Intact Forest to Other Land
3 Intact Forest to Settlements
4 Intact Forest to Unshaded Cropland (TCC 10% or less)
5 Degraded Forest to Grasslands
6 Degraded Forest to Other Land
7 Degraded Forest to Settlements
8 Degraded Forest to Unshaded Cropland (TCC 10% or less)
9 Very Degraded Forest to Grasslands
10 Very Degraded Forest to Other Land
11 Very Degraded Forest to Settlements
12 Very Degraded Forest to Unshaded Cropland (TCC 10% or less)
13 Secondary natural forest to Grasslands
14 Secondary natural forest to Other Land
15 Secondary natural forest to Settlements
16 Secondary natural forest to Unshaded Cropland (TCC 10% or less)

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest Land Use categories.

CF Carbon fraction of dry matter in tC per ton dry matter. The value used is:

- **0.47** is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.

$44/12$ Conversion of C to CO_2

R: :S Root-to-shoot ratio (0.44).

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$)

Following the 2006 IPCC Guidelines the annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{DEG}}$) could be estimated through the Gain-Loss Method or the Stock-Difference Method as described in Chapter 2.3.1.1 of Volume 4 of the 2006 IPCC Guidelines.

$$\Delta C_B = \Delta C_G - \Delta C_L$$ **Equation 5** (Equation 2.7, 2006 IPCC GL)

$$\Delta C_B = \frac{(C_{t_2} - C_{t_1})}{(t_2 - t_1)}$$ **Equation 6** (Equation 2.8 (a), 2006 IPCC GL)

ΔC_B Annual change in carbon stocks in biomass for each land sub-category, in tones C yr^{-1}

ΔC_G annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tones C yr-

ΔC_L annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tones C yr-1

C_{t_2} total carbon in biomass for each land sub-category at time t_2, tonnes C
C_{t_1} total carbon in biomass for each land sub-category at time t_1, tonnes C

Following the recommendations set in chapter 2.2.2 of the GFOI Methods Guidance Document[71] for applying IPCC Guidelines and guidance in the context of REDD+, the above equation will be simplified, and it will be assumed that: a) the annual change in carbon stocks in biomass (ΔC_B) due to degradation is equal to the annual decrease in carbon stocks (b) the decrease in carbon stocks occurs the year of conversion. The long-term decrease in carbon stocks indicated in equation (1) of the GFOI MGD is assumed here to be zero. Therefore, considering the GFOI MGD the IPCC equation for forest degradation could be expressed as an Emission Factor time Activity Data as follows:

$$\Delta C_{B_{DEG}} = \sum_j \left\{ EF_j \times A(a,b)_{RP} \right\} \qquad \textbf{Equation 7}$$

Where:
EF_j Emission factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.
$A(a,b)_{RP}$ Area of forest type a converted to forest type b (transition denoted by a,b) during the Reference Period, ha yr^{-1}.

Annual change in carbon stocks in biomass on non-forestland converted in forestland ($\Delta C_{B_{reg}}$)

Land converted to forest land CO_2 removals has been estimated following the recommendations set in the Guidance Note for accounting of legacy emissions/removals of the FCPF (version 1). Since the FCPF Methodological Framework requires IPCC Tier 2 or higher method, the net annual CO_2 removals are calculated using equations 2.15 and 2.16 from the 2006 IPCC Guidelines, Volume 4, Chapter 2. These equations were simplified by assuming that the conversion from non-forest to forest occurs during a period from average carbon stocks in non-forest to average carbon stocks in forests. A conservative default period of 20 years is assumed for the forest to grow from the carbon stock levels of non-forest to the level of biomass in the average forest. The removal estimate considers changes in carbon stocks in aboveground and belowground biomass. Using the outcome of equation 2.15 and 2.16, it was determined the changes in the total carbon stocks in biomass (removals) during the Reference Period as the sum of the total carbon stocks in biomass of all land units. From the point of view of notations, the Emission Factors in equation EQ7 above would be replaced by **RF**$_{SREG}$ in enhancement of carbon stocks in new forests.

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \left\{ RF_{reg} \times A(i,j)_{RP} \right\} \qquad \textbf{Equation 8}$$

Where:
RF_{reg} Above and belowground biomass removal rate in new forests [tCO2*ha*year^{-1}].
$A(j,i)_{RP}$ Area of non-forestland i converted to forestland j (transition denoted by i,j) in the Reference Period, ha yr^{-1}.
LU Land unit.

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

Activity Data

[71]Page 48, GFOI (2013) Integrating remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases in forests: Methods and Guidance from the Global Forest Observations Initiative: Pub: Group on Earth Observations, Geneva, Switzerland, 2014.

*Provide an overview of the **activity data** that are available and of those that were used in calculating the average annual historical emissions over the Reference Period in a way that is sufficiently detailed to enable the reconstruction of the average annual historical emissions over the Reference Period. Use the table provided (copy table for each parameter). Attach any spreadsheets, spatial information, maps and/or synthesized data.*

If different data sources exist for the same parameter, please list these under the 'Sources of data'. In this case, discuss the differences and provide justification why one specific dataset has been selected over the others.

*Refer to **criterion 6, 7, 8 and 9** of the Methodological Framework*

Parameter:	Activity Data: $A(j,i)_{RP}$ Equation 4; $A(a,b)_{RP}$ Equation 7; $A(j,i)_{RP}$ Equation 8.
Description:	● Deforestation: Area converted/transited from forest type j to non-forest type i during the Reference Period ● Degradation: Area of forest type a converted to forest type b (transition denoted by a,b) during the Reference Period, ha yr^{-1} ● Forest gain: Area of non-forestland i converted to forestland j (transition denoted by i,j) in the Reference Period, ha yr^{-1}.
Data unit:	hectare
Source of data and description of measurement /calculation methods and procedures applied:	Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. A forest change map spanning from 1983 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO. **Forest change mapping**: The following four mapping algorithms that utilize remote sensing imagery, training data points, land cover maps, and time series data analysis was used to map areas experiencing forest loss, degradation, and/or regrowth. ix. **CCDC-SMA**: Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) monitors abrupt and gradual forest degradation. x. **CODED**: Continuous Degradation Detection (CODED) algorithm detects forest canopy disturbances and classifies them as degradation or deforestation based on land cover. CODED uses linear spectral unmixing to generate subpixel fractions of spectral endmembers, which are used to calculate a time series of the Normalized Degradation Fraction Index (NDFI). xi. **LandTrendr**: The LandTrendr algorithms use simple statistical techniques to simplify a time-series of spectral values into a sequence of connected straight-line segments that capture the overall shape of that pixel's trajectory while omitting year-to-year noise. The resultant segments can then be examined to select periods where the trajectory displays behaviors of interest such as disturbance or growth. xii. **MTDD**: Multi-variate Time-series Disturbance Detection (MTDD) classifies initially forested areas into stable forest, degraded, and deforested by training a random forest classifier with 66 metrics. These metrics are derived from six annual time-series (i.e., NDVI, two SWIR spectral regions, two NDWI indices, and SAVI) which are used to calculate eleven descriptive statistics (i.e., minimum, maximum, range, mean, standard deviation, coefficient of variation, kurtosis, skewness, slope, maximum 5-year slope, and most recent value). Overall MTDD's process includes five main steps: (1) making annual time series, (2) calculating 11 descriptive statistics for the time series, (3) generating

training/validation points, (4) training a random forest classifier, and (5) validating the classification.

Sample design: A sample-based approach is used to complete area estimation. This approach is preferred over pixel-counting methods because all maps have errors. Sample based approaches create unbiased estimates of area and the error associated with your map. An agreement map generated from the results of all four methods is used for sample design. The goal is to ensure that no strata is under-sampled. The resulting strata is anywhere 1-4 algorithms agreed there was a certain kind of change event or stable forest/non-forest, anywhere the different algorithms labeled different types of change events, anywhere all 4 algorithms labeled non-forest, and anywhere all 4 algorithms labeled forest. Final strata values for the agreement map and their human-readable labels are 1: DEG, 2: LOSS, 3: GAIN, 4: Non-forest, and 5: Forest. The number of points randomly selected depend on the relative area available in each stratum, the human resources available to do interpretations, and a target standard error. A total of **1,522** points were randomly selected, with a specified number from each strata, to be used for the sample-based area estimation.

Reference data collection (completed in CEO): To estimate emissions from deforestation, carbon enhancement removals, and forest degradation emissions, reference data were collected through a time series analysis of 1,522 sampling plots in CEO. To identify the age of forest gain cohorts and differentiate between secondary and permanent forests, the sampling points were visually interpreted for the same period that the forest change map was created (1983 to 2021). This period was divided into four subperiods: 1984-2003, 2004-2014, 2015-2017, and 2018-2021 (see Figure 4). The canopy cover was visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

ix. *Generating a CEO project from a template:* Nepal created a template to collect land-use change and degradation reference data in Collect Earth Online (CEO[72]) for the following periods: Pre-reference period (t0) - 1983-2003, Reference period (t1) – 2004-2014, First monitoring period (t2) – 2015-2017 and Second monitoring period (t3) – 2018-2021.

x. *Sampling unit*: The Sampling Unit (SU) is a 70 x 70meter plot. Inside SU, a 3x3 points sub-grid (9 points) was created to estimate forest canopy cover percentage within each sampling unit.

xi. *Number of Sampling Units*: A total of 1,522 sampling points, selected via stratified random sampling, were visually assessed.

xii. *Interpretation key*: Nepal produced an interpretation key that should be reused and updated as needed. The land use categories considered are the following:

Forest lands:	**Non-forest lands**
1 Intact Forest 2 Degraded Forest 3 Very Degraded Forest 4 Secondary natural forest 5 Plantation Forest 6 Shaded croplands	7 Grasslands 8 Other lands 9 Settlements 10 Unshaded croplands (tree canopy cover 10% or less)

- Note, the first three types of forest land (intact, degraded, and very degraded) were indirectly labeled in post-processing using the number of tree-covered points out of a 9-point grid over each plot

Area and uncertainty estimation: Nepal employs a sample-based approach to estimate the Activity Data for Deforestation, Forest gain and Degradation. All 1,522 samples were used as

[72] CEO is a custom built, open-source, satellite image viewing and interpretation system. Collect Earth Online promotes consistency in locating, interpreting, and labeling reference data plots for use in classifying and monitoring land cover / land use change (see https://app.collect.earth).

	the basis for calculating area estimates and their uncertainty. The estimation of Activity Data was done using the stratified random estimator based on the formulas described by Cochran (1977)[73]. Estimates are made for each of the land use categories considered (10 classes) and in terms of changes from one period to another representing a total of more than 26 effective combinations (Deforestation 14, Forest Gain 3, and Degradation 9).
Value applied	**Deforestation** **2004-2014** **Initial** / **Final** / **Area (ha)** / **±90% CI** Intact Forest — Grasslands — - — - Intact Forest — Other Land — 445 — 727 Intact Forest — Settlements — 445 — 727 Intact Forest — Unshaded Cropland (TCC 10% or less) — 5,319 — 4353 Degraded Forest — Grasslands — - — - Degraded Forest — Other Land — 445 — 727 Degraded Forest — Settlements — 445 — 727 Degraded Forest — Unshaded Cropland (TCC 10% or less) — 3,696 — 4290 Very Degraded Forest — Grasslands — - — - Very Degraded Forest — Other Land — 1,848 — 3036 Very Degraded Forest — Settlements — - — - Very Degraded Forest — Unshaded Cropland (TCC 10% or less) — 445 — 727 secondary natural forest — other land — - — - **Forest gain** **Forest Type** / **2004-2014** (**Area (ha)** / **±90% CI**) natural secondary forest gain — 48,423 — 15,069 plantation forest gain — 5,543 — 5,250 shaded cropland gain — 4,200 — 3,999 **Degradation** **Initial** / **Final** / **2004-2014** (**Area (ha)** / **±90% CI**) Intact forest — Intact forest — 1,255,942 — 26,692 Degraded forest — Degraded forest — 59,597 — 16,315 Very degraded forest — Very degraded forest — 22,603 — 10,297 Intact forest — Degraded forest — 22,596 — 9,391 Intact forest — Very degraded forest — 889 — 1,024 Degraded forest — Very degraded forest — 4,591 — 4,416 Degraded forest — Intact forest — 20,512 — 9,495 Very degraded forest — Intact forest — 3,698 — 4,297 Very degraded forest — Degraded forest — 5,546 — 5,258
QA/QC procedures applied:	**QA QC Manual <u>Reference data collection:</u>** **Reference data compilation:** To ensure accuracy, the data collected from the CEO was compiled in R for each period of the time series analysis (t0, t1, t2, and t3). The compilation process identifies land-use interpreted points with impossible transitions, and these points are sent back to the interpreted for review, until the compilation process detects no inconsistencies. **Area estimate**: To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheet (**<u>Activity Data Tool</u>**). This

[73] Cochran, W.G. (1977) Sampling Techniques. 3rd Edition, John Wiley & Sons, New York.

includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok".

Uncertainty for this parameter:

To determine the uncertainty for Activity Data, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. This calculation only takes sampling errors into account and does not consider interpreter error.

Deforestation

Initial	Final	2004-2014		
		Area (ha)	±90% CI	%E
Intact Forest	Grasslands	-	-	0%
Intact Forest	Other Land	445	727	163%
Intact Forest	Settlements	445	727	163%
Intact Forest	Unshaded Cropland (TCC 10% or less)	5,319	4353	82%
Degraded Forest	Grasslands	-	-	0%
Degraded Forest	Other Land	445	727	163%
Degraded Forest	Settlements	445	727	163%
Degraded Forest	Unshaded Cropland (TCC 10% or less)	3,696	4290	116%
Very Degraded Forest	Grasslands	-	-	0%
Very Degraded Forest	Other Land	1,848	3036	164%
Very Degraded Forest	Settlements	-	-	0%
Very Degraded Forest	Unshaded Cropland (TCC 10% or less)	445	727	163%
secondary natural forest	other land	-	-	0%
secondary natural forest	other land	-	-	0%

Forest gain

Forest Type	2004-2014		
	Area (ha)	±90% CI	%E
natural secondary forest gain	48,423	15,069	31%
plantation forest gain	5,543	5,250	95%
shaded cropland gain	4,200	3,999	95%

Degradation

Initial	Final	2004-2014		
		Area (ha)	±90% CI	%E
Intact forest	Intact forest	1,255,942	26,692	2%
Degraded forest	Degraded forest	59,597	16,315	27%
Very degraded forest	Very degraded forest	22,603	10,297	46%
Intact forest	Degraded forest	22,596	9,391	42%
Intact forest	Very degraded forest	889	1,024	115%
Degraded forest	Very degraded forest	4,591	4,416	96%
Degraded forest	Intact forest	20,512	9,495	46%
Very degraded forest	Intact forest	3,698	4,297	116%
Very degraded forest	Degraded forest	5,546	5,258	95%

Any comment:

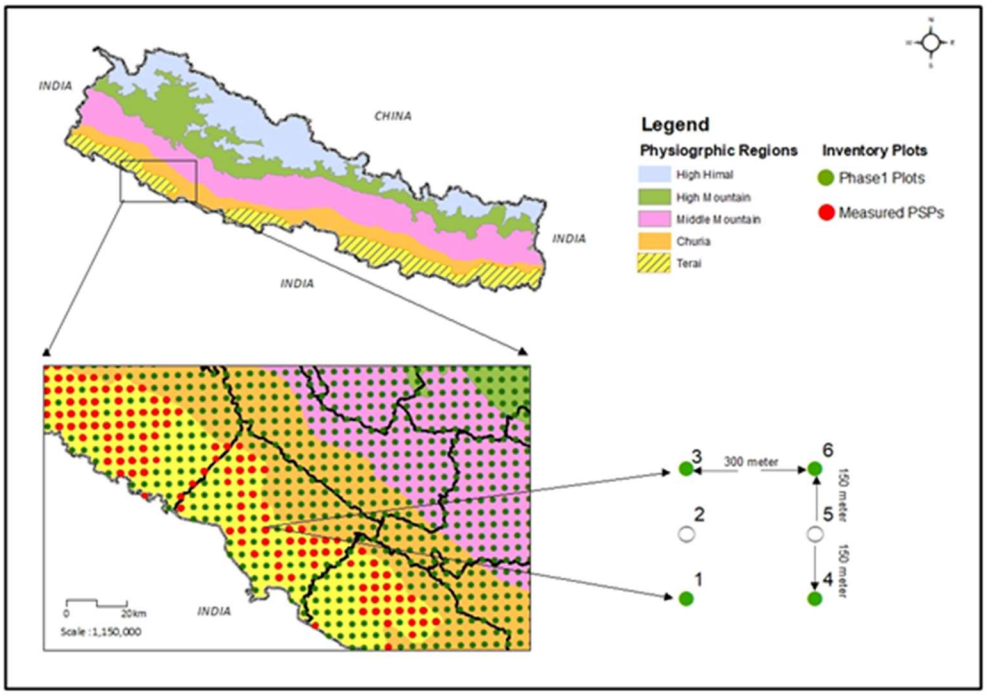
Emission Factors

Parameter:	$B_{Before,j}$ **Equation 4;** $B_{After,i}$ **Equation 4;** RF_{reg} **Equation 8**
Description:	**B Before**: Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground (AGB_(Before,j)) and belowground biomass (BGB_(Before,j)) and it is defined for each forest type. **B after**: Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest Land Use categories. **Removal rate**: Above and belowground biomass removal rate in new forests [tCO2*ha*year^{-1}].
Data unit:	Tonne/ha (dry matter),
Source of data or description of the method for developing the data including the spatial level of the data (local, regional, national, international):	The carbon densities and removal rates used for the ER monitoring report are Tier 2 (country specific data) and has been derived from the latest NFI (FRA) except the removal rates for forest plantation and shaded crops. The NFI (FRA) involved remeasurement in 2022 of the permanent sample plots established by the FRA Nepal Project (2010-2014) including an additional number of plots established and measured using the same methodology. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. **NFI (FRA) inventory design**: The inventory design adopted was based largely on methods developed by Kleinn (1994)[74] and finalized by the DFRS/FRA 2010-2014 (see Figure below). The detailed methodology adopted for sample selection is presented in DFRS, 2014[75]. NFI data from 622 permanent sample plots located within the ER accounting area were derived (see NFI_dataset sheet in Carbon density calculation tool[76]).

[74] Kleinn, C. 1994. Forest Resources Inventories in Nepal Status, Qou, Needs, Recommendations. FRISP, HMGN/FINNIDA

[75] https://drive.google.com/file/d/1EFpJXYa7GZRiGfP0WJIWwu-zljs9C65v/view?usp=drive_link

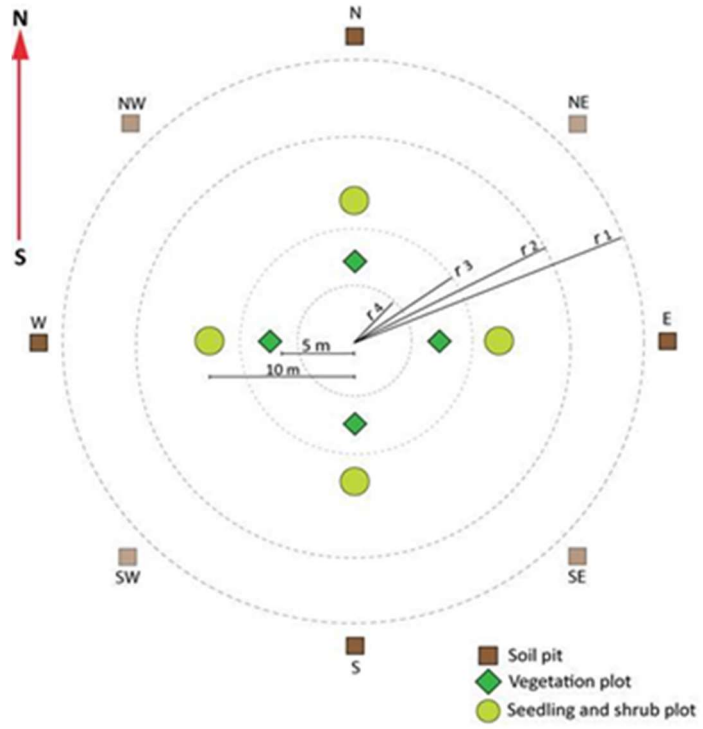
[76] https://docs.google.com/spreadsheets/d/1ibHCmjnV16J4UD9GT7eqTx8Yr2k0_z4-/edit?usp=drive_link&ouid=101304895378504185754&rtpof=true&sd=true



Inventory Sample plot design and data collection: The Concentric Circular Sample Plot (CCSP) design was adopted as used by the FRA Nepal Project (2010-2014). Each sample plot had four concentric circles of different radii (see Figure below), which were used to measure trees with different DBH as follows:

- trees having 30 cm DBH or more enumerated within a 20 m radius plot (area: 1256.6 m^2)
- trees having 20-29.9 cm DBH enumerated within a 15 m radius plot (area:706.9 m^2)
- trees having 10-19.9 cm DBH enumerated within an 8 m radius plot (area:201.0 m^2)
- trees having 5-9.9 cm DBH enumerated within a 4 m radius plot (area: 50.3 m^2)

Other subplots were established to assess forest attributes other than trees, such as dead woods and disturbances, seedlings, saplings, shrubs, and herbs, etc.



Layout of the concentric circular plot with other sub-plots

The plots were used for data collection of standing trees (diameter at breast height (dbh) ≥5 cm), which were used in the estimation of the biomass and carbon stocks. Data collected included tree information (bearing, distance from plot center, species code, local name, scientific name, DBH, quality class, crown class and total and crown heights. In addition, data on other important variables like dead woods, disturbances, shrub and small trees, soil characteristics and soil samples, leaf litter and debris, non-wood forest products, epiphytes, parasites, herbaceous plants, bamboo, invasive and alien plant species, forest diseases and pests, etc. have been collected in regular NFI/FRA. One of the important characteristics of NFI in Nepal is hidden permanent sample plots leaving "no marks" above ground. Instead, the plots are georeferenced and plot centers consist of metal pegs inserted a few inches below the ground level. The reason behind hidden plots in NFI is to maintain consistency in anthropogenic activities and forest products use by local people both inside and outside the plots. This characteristics of NFI plots of Nepal might even aid to control leakage of GHG emission.

Volume and Biomass estimation: Tree stem volumes and biomass were estimated using standard methodology with national allometric equations adopted since NFI / FRA 2010-2014[77]. To ensure consistency between the Emission Factors and land-use transitions area, the NFI plots were evaluated and categorized according to their land use type, such as non-Forest land use, Permanent Forest, or Secondary Forests, for the current monitoring report. The same time series analysis and data collection methods used in CEO were replicated for the NFI permanent plot locations. Additionally, the canopy cover of Permanent Forest plots was evaluated to

[77] https://drive.google.com/file/d/1Z1h0Q2JiXlEXCHW1qDNcBrj1B38GEhi7/view?usp=drive_link

	determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points). The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands was based on 14 NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI. The forest regrowth removal rate calculation is based on a sample of 16 NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.
Value applied:	Due to the homogeneity of the forest in the Emission Reduction Program accounting area, the whole forest was considered as the same unit for the calculation.

Forest type	Average	CI	Unit
Natural intact forest	217.34	7.49	tdm/ha
Natural degraded forest	181.09	42.69	tdm/ha
Natural very degraded forest	96.51	66.11	tdm/ha

Non- Forest Lands	Average	CI	Unit
Grassland	3.97	5.88	tdm/ha
Other land	39.95	53.09	tdm/ha
Unshaded cropland	48.31	36.53	tdm/ha

Note: It was assumed the carbon density of grasslands for Settlements.

In order to calculate the Emission Reductions, the entire forest was treated as a single unit due to its uniformity. The removal rate in new forests is country specific data and has been derived from the NFI (FRA). For Plantation forests and Shaded croplands, removal factors established by the IPCC were utilized.

Forest type	Average	CI	Unit
Natural secondary forest gain	-12.52	4.40	tCO_2/ha/yr
Plantation forest gain [1]	-13.79	4.40	tCO_2/ha/yr
Shaded cropland gain [2]	-10.23	2.46	tCO_2/ha/yr

[1] Table 4.10 (Updated) ABOVE-GROUND NET BIOMASS GROWTH IN TROPICAL AND SUB-TROPICAL PLANTATION FORESTS (TONNES D.M. HA-1 YR-1). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 4: Forest Land.

[2] Table 5.2 (Updated) DEFAULT COEFFICIENTS FOR ABOVE- AND BELOW-GROUND BIOMASS IN AGROFORESTRY SYSTEMS CONTAINING PERENNIAL SPECIES. 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 5: Cropland.

QA/QC procedures applied	**Quality assurance of forest inventory data:** Use of periodically revised field manual, training to field members and regular monitoring and feedbacks were some of the measures applied to maintain the quality of the inventory results. For the statistical analysis to check the quality of the results, over 10% of the total Permanent Sampling Plots measured were systematically

	selected (with a random start) and re-measured[78]. Furthermore, standard protocols and manuals on modeling of required parameters e.g., diameter-height modeling & taper function curve, calculation of volume and biomass using the allometric models, and error estimation were developed under supervision of the experts from Finnish Forest Research Institute (METLA, now LUKE Finland) during the FRA 2010-2014. Also, documentation on the assemble of the QAQC protocol is available, as well as QAQC report of 2021[79].
Uncertainty associated with this parameter:	To determine the uncertainty in carbon density, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. This calculation only takes sampling errors into account and does not consider model or allometric errors.
Any comment:	

Forest type	Average	CI	% Error	n	Std Dev	Unit
Natural intact forest	217.34	7.49	3%	558	107.37	tdm/ha
Natural degraded forest	181.09	42.69	24%	23	119.22	tdm/ha
Natural very degraded forest	96.51	66.11	68%	10	114.04	tdm/ha

Non- Forest Lands	Average	CI	% Error	n	StdDev	Unit
Grassland	3.97	5.88	148%	5	6.17	tdm/ha
Other land	39.95	53.09	133%	4	45.12	tdm/ha
Unshaded cropland	48.31	36.53	76%	5	38.32	tdm/ha

Forest type	Average	CI	% Error	n	DevStd	Unit
Natural secondary forest gain	-12.52	4.40	35%	16	5.82	$tCO_2/ha/yr$
Plantation forest gain	-13.79	4.40[1]	32%	-	-	$tCO_2/ha/yr$
Shaded cropland gain	-10.23	2.46[2]	24%	-	-	$tCO_2/ha/yr$

[1] In the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 4 - Forest Land, the Table 4.10 does not have any reference to uncertainty. As a result, it was assumed that the uncertainty of Natural secondary forest for Plantation Forest.

[2] Uncertainty indicated in Table 5.2 (Updated) of 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 5: Cropland.

[78] https://drive.google.com/file/d/1YmbHZSOIxfsnfotBbb3elCBSemh4cA8h/view?usp=drive_link
[79] https://drive.google.com/file/d/1Xhboag3rtykW2p0oiIYuz9Rj0H6VQsg8/view?usp=drive_link

8.4 Estimated Reference Level

ER Program Reference level

Crediting Period year *t*	Average annual historical emissions from deforestation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical emissions from forest degradation over the Reference Period (tCO_{2-e}/yr)	If applicable, average annual historical removals by sinks over the Reference Period (tCO_{2-e}/yr)	Adjustment, if applicable (tCO_{2-e}/yr)	Reference level (tCO_{2-e}/yr)
2004	429,722	296,643	-677,973	0	48,393
2005	429,722	296,643	-772,983	0	-46,618
2006	429,722	296,643	-867,994	0	-141,629
2007	429,722	296,643	-963,005	0	-236,640
2008	429,722	296,643	-1,058,016	0	-331,651
2009	429,722	296,643	-1,153,027	0	-426,662
2010	429,722	296,643	-1,248,038	0	-521,672
2011	429,722	296,643	-1,343,048	0	-616,683
2012	429,722	296,643	-1,438,059	0	-711,694
2013	429,722	296,643	-1,533,070	0	-806,705
2014	429,722	296,643	-1,628,081	0	-901,716
Total	**4,726,946**	**3,263,071**	**-12,683,295**	**0**	**-4,693,278**

Calculation of the average annual historical emissions over the Reference Period

Reference Level (RL_{RP})

Net emissions of over Reference Period (RL_{RP}) are estimated as the sum of annual change in total biomass carbon stocks (deforestation and degradation), and annual removals (ΔC_{B_t}).

$$RL_{RP} = \frac{\sum_t^{RP} \Delta C_{LU_{RP,i,t}}}{RP} \qquad \textbf{Equation 2}$$

Where:

$\Delta C_{LU_{RP,i,t}}$ = Balance of emissions during the Reference Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each REDD+ activity *i* at year t; tCO_2*year^{-1}.

RP = Reference Period; years.

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

Explanation and justification of proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

Intentionally left blank.

Quantification of the proposed upward or downward adjustment to the average annual historical emissions over the Reference Period

Intentionally left blank.

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

Intentionally left blank.
The Forest Reference Level (FRL) for Nepal, aligning with UNFCCC standards, focuses on the historical period of 2000-2010 and primarily considers deforestation, degradation due to fuelwood extraction, and forest enhancement activities. The FRL, constructed following IPCC guidelines, relies on national forest inventory (NFI) data, remote sensing information from Landsat TM, and proxy methodologies for the period 2000-2010. The current greenhouse gas inventory during the preparation of the first ER monitoring report follows a similar process and the application of remote sensing techniques for the period 2018 to 2021.

During the development of FREL three activities i.e., Degradation, Deforestation, and Enhancement were included which is replicated during the current greenhouse gas inventory process. In FREL, the definition of degradation was based on the short-term and long-term disturbance while the current method adopts the concept of canopy cover. Deforestation has a static definition i.e., permanent conversion of forest land to other land-use classes in both FREL and current GHG inventory procedures. For enhancement, there are two categories in FREL: the afforestation or reforestation, i.e., permanent conversion or other land use classes into the forest, and the restoration, i.e., permanent improvement of carbon stock in forest land that remains as forest land. But currently, only conversion of other land to forest is being considered as regarded as both terms i.e., restoration or gain.

In terms of methodology, during FREL simple landcover change assessment and change assessment were used but the current method follows the ensemble method i.e., agreement map among four algorithms (1. CCDCSMA, 2. LandTrendR, 3. MTDD, and 4. CODED) was used to calculate the area under each activity.
In both methods, only one greenhouse gas was considered i.e., CO2.

9 APPROACH FOR MEASUREMENT, MONITORING AND REPORTING

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

Table 8 provides a systematic and step-by-step description of the measurement and monitoring approach applied for the establishment of the Reference Level and estimating Emissions and Emissions reductions during the Monitoring / Reporting Period for estimating the emissions and removals from the Sources/Sinks, Carbon Pools, and greenhouse gases selected in the ER-PD.

Table 8: ***Step-by-step description of the monitoring parameter and data integration tools to establish the Reference Level and estimate Emissions and Emissions reductions during the Monitoring Period for the Carbon Pools and greenhouse gases selected in the ER-PD.***

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
1	**Activity Data estimate and associated uncertainty.**	**CCDC-SMA**[80]: 1_CCDC_SMA_UI_C2 2_ViewExportDegDefMapp 3_LTMakeLossGainPostprocessed 4_AssembleMap **CODED**[81] Forest Disturbance Mapping GUI **LandTrendr**[82] 1_UI-ImageScreener (optional) 2_LT-Data-Visualization-NepalTool **MTDD**[83] 1MTDD_app_trainingpoints 2MTDD_app_changemap **Forest change maps**	**Nepal Forest change area estimation tool**: Documentation on how to use this tool and a compiled set of links to user interfaces of all the tools needed to complete the forest change area estimation for Nepal can be accessed at the following link: https://training.sig-gis.com/NEPALworkshopAE/ 8. **Forest change mapping**: To estimate the area, Nepal employs a sample-based approach. For the sample design, a forest change map spanning from 1983 to 2021 was prepared. The following four mapping algorithms that utilize remote sensing imagery, training data points, land cover maps, and time series data analysis was used to map areas experiencing forest loss, degradation, and/or regrowth. v. **CCDC-SMA**: Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) monitors abrupt and gradual forest degradation. vi. **CODED**: Continuous Degradation Detection (CODED) algorithm detects forest canopy disturbances and classifies them as degradation or deforestation based on land cover. CODED uses linear spectral unmixing to generate subpixel fractions of spectral endmembers, which are used to calculate a time series of the Normalized Degradation Fraction Index (NDFI). vii. **LandTrendr**: The LandTrendr algorithms use simple statistical techniques to simplify a time-series of spectral values into a sequence of connected straight-line segments that capture the overall shape of that pixel's trajectory while omitting year-to-year noise. The resultant segments can then be examined to select periods where the trajectory displays behaviors of interest such as disturbance or growth. viii. **MTDD**: Multivariate Time-series Disturbance Detection (MTDD) classifies initially forested areas into stable forest, degraded, and deforested by training a random forest classifier with 66 metrics. These metrics are derived from six annual time-series (i.e., NDVI, two SWIR spectral regions, two NDWI indices, and SAVI) which are used to calculate eleven descriptive statistics (i.e., minimum, maximum, range, mean, standard deviation, coefficient of variation, kurtosis, skewness, slope, maximum 5-year slope, and most recent value). Overall MTDD's process includes five main steps: (1) making annual time series, (2) calculating 11 descriptive statistics for the time series, (3) generating training/validation points, (4) training a random forest classifier, and (5) validating the classification.
		Map Visualization tool **1_VisualizationApp_Nepal** (in Visualization App folder of GEE repository)	9. **Map visualization and comparison:** Each of the mapping algorithms is useful for detecting changes in a slightly different manner. However, all maps are susceptible to bias, which is why the area of map classes from the resulting maps should not be directly used for Activity Data reporting. Each map is visually assessed so any concerning results can be addressed with parameter adjustment as needed.
		Agreement map preparation **1_MakeAgreementMap_Nepal**[84] (Agreement Map in Google Drive folder) **Forest Change Agreement Map**[85]	10. **Sample design:** A sample-based approach is used to complete area estimation. This approach is preferred over pixel-counting methods because all maps have errors. Sample based approaches create unbiased estimates of area and allows calculation of the uncertainty of each estimate. An agreement map generated from the results of all four methods is used for sample design. The goal is to ensure that no strata is under-sampled. The 1_MakeAgreementMap_Nepal tool (in Map Agreement App folder of GEE repository) is used to combine the maps of the four forest change detection algorithms. Final strata values for the agreement map and their human-readable labels are 1: DEG, 2: LOSS, 3: GAIN, 4: Non-forest, and 5: Forest.

[80] Procedure document of CCDCSMA can be accessed at the following link https://github.com/shijuanchen/forest_degradation_georgia

[81] Tools CODED of the GEE repository can be accessed at the following link https://code.earthengine.google.com/?accept_repo=users/bullocke/coded

[82] Procedure document of LandTrendr can be accessed at the following link https://docs.google.com/document/d/1GfdMSSaU4tiDv1Sf2L8S4k2144ptpU9seB1UkPURDCA/edit

[83] Procedure document of MTDD can be accessed at the following link https://docs.google.com/document/d/1TukNQOuEqw9OoeZgcHWUrv-ER-87TkhU9HVuV_x6HZA/edit

[84] https://drive.google.com/drive/folders/1SJq6ZGzVTM4g1IB5ALSq6z2JHJdyFX7d?usp=sharing

[85] https://drive.google.com/file/d/1VtYM-xCunuRpjfOgeAO9aLDMMGwj_H71/view?usp=drive_link

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
		Area available in each stratum[86] **Spreadsheet for Sample Size/Distribution Design**[87]	When combining the results of the four algorithms into one map, the following logic rules are applied for each pixel: ● A GAIN supersedes all other labels ● If an equal number of DEG and LOSS labels occur across the four algorithms, LOSS supersedes ● If the number of DEG labels is more than the number of LOSS labels or DEG is the only type of change detected, a DEG label is given ● If the number of LOSS labels is more than the number of DEG labels or LOSS is the only type of change detected, a LOSS label is given ● A Non-forest label is given only if all four algorithms label it as Non-forest ● A Forest label is given only if all four algorithms label it as Forest Final strata definitions: DEG (1) = more algorithms detected degradation than loss, and GAIN is not detected LOSS (2) = more algorithms detected LOSS than DEG or an equal number of algorithms detected LOSS and DEG, and GAIN is not detected GAIN (3) = one or two algorithms labeled the pixel as GAIN, even if others detected LOSS or DEG Nonforest (4) = all algorithms labeled pixel as stable nonforest Forest (5) = all algorithms labeled pixel as stable forest 11. The number of points randomly selected depends on the relative area available in each stratum, the human resources available to do interpretations, and a target standard error. The linked spreadsheet in tools columns contains equations needed to calculate the ideal sample size to hopefully achieve the target standard error. A total of 1,522 points were selected via stratified random sampling to be used for sample-based area estimation. For the smaller strata a minimum of 110 points was required.
		Nepal's CEO institution **Interpretation key** **SOP for QA/QC Procedures** **Activity Data CEO Survey Questions** **NFI CEO Survey Questions**	**12. Reference data collection (completed in CEO):** To estimate emissions from deforestation, carbon enhancement removals, and forest degradation emissions, reference data were collected through visual imagery interpretation and **time series analysis** of 1,522 sampling plots in CEO. The sampling points were visually interpreted for the same period that the forest change map was created (2004 to 2021. However, to identify the age of forests in order to differentiate between secondary and permanent forests, an additional pre-period was examined. The time period of examination was divided into four subperiods with distinct sets of survey questions: 1984-2003, 2004-2014. 2015-2017 and 2018-2021 (see Figure 4). The canopy cover was visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021. vi. *Generating a CEO project from a template*: FRTC created a template to collect land-use change and degradation reference data in Collect Earth Online (CEO[88]) for the following periods: Pre-reference period (t0) - 1983-2003, Reference Period (t1) – 2004-2014, First monitoring period (t2) – 2015-2017 and Second monitoring period (t3) – 2018-2021.

[86] https://docs.google.com/spreadsheets/d/1Wp0lxDpqKMFlro7OdeTuaLwAQSVb2VqJ/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true

[87] https://docs.google.com/spreadsheets/d/1AfZTmd-KQHMy_amBkz03ZepFhrUIcqCG/edit?usp=sharing&ouid=101304895378504185754&rtpof=true&sd=true

[88] CEO is a custom built, open-source, satellite image viewing and interpretation system. Collect Earth Online promotes consistency in locating, interpreting, and labeling reference data plots for use in classifying and monitoring land cover / land use change (see https://app.collect.earth).

<table>
<tr><th>Step</th><th>Monitoring parameters and Data Integration tools</th><th>Tools and datasets</th><th>Description of the measurement and monitoring approach</th></tr>
<tr><td></td><td></td><td></td><td>vii. <u>Sampling unit</u>: The Sampling Unit (SU) is a 70 x 70 meter plot. Inside the SU, a 3x3 points sub-grid (9 points) was created to estimate forest canopy cover percentage within each sampling unit. Negative changes in this value were used to indicate whether a degradation event had occurred.
viii. <u>Number of Sampling Units</u>: A total of 1,522 sampling points, selected via stratified random sampling, were visually assessed.
ix. <u>Interpretation key</u>: Nepal produced an interpretation key that should be reused and updated as needed. The key was used to increase consistency across the team of interpreters. The land use categories considered are the following:
<table><tr><th>Forest lands:</th><th>Non-forest lands</th></tr><tr><td>1 Intact Forest
2 Degraded Forest
3 Very Degraded Forest
4 Secondary natural forest
5 Plantation Forest
6 Shaded croplands</td><td>7 Grasslands
8 Other lands
9 Settlements
10 Unshaded croplands (tree canopy cover 10% or less)</td></tr></table>● Note, the first three types of forest land (intact, degraded, and very degraded) were indirectly labeled in post-processing using the number of tree-covered points out of a 9-point grid over each plot.

SOP for QA/QC Procedures</td></tr>
<tr><td></td><td></td><td><u>Reference data compilation R-script CompiledData_CEO</u></td><td>13. Reference data compilation: The data collected in the CEO was compiled in R for each period (t0, t1, t2, and t3) to obtain necessary information that was then used to estimate the Activity Data:
i. Deforestation Activity Data
● tx_disturbance_type_subcat: type of forest loss and gain, stable forest, and stable non-forest.
● Non.forest.land.use.type.in.[year of interest]. Non forest land use type in the period.
● Number.of.tree.covered.samples.[year of interest]. Number from 9-point grid of sample points within plot that are covered by tree canopies. sampling points with canopy cover.
● GEEcombo_strata_readable: Agreement map strata.
● tx_type_final: Land use / land cover type
● tx_yr_secondaryforest_establ: year of secondary forest establishment
ii. Forest gain Activity Data
● tx_disturbance_type_subcat: type of forest loss and gain, stable forest, and stable non-forest.
● GEEcombo_strata_readable: Agreement map strata.
iii. Degradation Activity Data
● tx_type_final: Land use / land cover type
● tx_numbretrees: canopy cover
● GEEcombo_strata_readable: Agreement map strata</td></tr>
<tr><td></td><td></td><td><u>Activity Data Tool</u>
(Please read this file “READ” before accessing it)</td><td>14. Area and uncertainty estimation: Nepal employs a sample-based approach to estimate the Activity Data for Deforestation, Forest gain and Degradation. All 1,522 samples were used as the basis for calculating area estimates and their uncertainty. The estimation of Activity Data was done using the stratified random estimator based on the formulas described by Cochran (1977)[89]. Estimates are made for each of the land use categories considered (10 classes) and in terms of changes from one period to another representing a total of more than 26 effective combinations (Deforestation 14, Forest Gain 3, and Degradation 9).
Estimates and associated uncertainties are produced in the Activity Data Tool (Nepal_TAL_AD_tool.xlsx) for each combination considering the stratification applied.</td></tr>
</table>

[89] Cochran, W.G. (1977) Sampling Techniques. 3rd Edition, John Wiley & Sons, New York.

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
			The Activity Data tool comprises various spreadsheets that estimate different types of Activity Data. These include the Dataset that is used to estimate sample-based Activity Data (CompiledData_CEO_GEE(7) sheet), as well as spreadsheets for estimating Activity Data for deforestation (Deforestation sheet), forest restoration (Forest_gain sheet), and area of change in canopy cover (loss and gain) in permanent forest lands (Degradation sheet). To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheets. This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok".
2	**Forest regrowth removal rates and forest carbon densities calculation, including the uncertainty estimate.**	**NFI dataset**	1. **National Forest Inventory**: The biomass estimates used for the ER monitoring report are Tier 2 (country specific data) and have been derived from the National Forest Inventory-Forest Resource Assessment (NFI-FRA). The NFI-FRA involved remeasurement of the permanent sample plots established by the FRA Nepal Project (2010-2014) in addition to an additional number of plots established and measured using the same methodology. The inventory design adopted was based largely on methods developed by Kleinn (1994) and finalized by the DFRS/FRA 2010-2014. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. One of the important characteristics of NFI in Nepal is hidden permanent sample plots leaving "no marks" above ground. Instead, the plots are georeferenced and plot centers consist of metal pegs inserted a few inches below the ground level. The reason behind hidden plots in NFI is to maintain consistency in anthropogenic activities and forest products used by local people both inside and outside the plots. These characteristics of NFI plots of Nepal might even aid to control leakage of GHG emission. The detailed methodology adopted for sample selection is presented in DFRS, 2014, link: https://frtc.gov.np/downloadfile/The-TeraiForestsofNepal_1579845265.pdf . NFI data from 591 permanent sample plots located within the Emission Reduction Program area were derived. **i. Inventory / Sample plot design and data collection**: The Concentric Circular Sample Plot (CCSP) design was adopted as used by the FRA Nepal Project (2010-2014). Each sample plot had four concentric circles of different radii (Figure), which were used to measure trees with different DBH as follows: ▪ trees having 30 cm DBH or more enumerated within a 20 m radius plot (area: 1256.6 m2) ▪ trees having 20-29.9 cm DBH enumerated within a 15 m radius plot (area:706.9 m2) ▪ trees having 10-19.9 cm DBH enumerated within an 8 m radius plot (area:201.0 m2) ▪ trees having 5-9.9 cm DBH enumerated within a 4 m radius plot (area: 50.3 m2) Other subplots were established to assess forest attributes other than trees, such as dead woods and disturbances, seedlings, saplings, shrubs, and herbs, etc. **ii. Volume and Biomass estimation**: Tree stem volumes and biomass were estimated using standard methodology with national allometric equations adopted since NFI / FRA 2010-2014. Details provided in link: Final FRA data analysis manual 2021.pdf (frtc.gov.np) **iii. Quality assurance of forest inventory data:** Use of periodically revised field manual, training to field crews and regular monitoring and feedback were some of the measures applied to maintain the quality of the inventory results. For the statistical analysis to check for the quality of the results, over 10% of the total PSPs measured were systematically selected (with a random start) and re-measured, link: 1 QAQC manual.pdf (frtc.gov.np). Furthermore, standard protocols and manuals on modeling of required parameters e.g. diameter-height modeling & taper function curve, calculation of volume and biomass using the allometric models, and error estimation were developed under supervision of the experts from Finnish Forest Research Institute (METLA, now LUKE Finland) during the FRA 2010-2014.

Step	Monitoring parameters and Data Integration tools	Tools and datasets	Description of the measurement and monitoring approach
		Nepal's CEO institution	2. **Land use change analysis of the NFI permanent plots stratification for carbon densities, and removal rate estimate**. To ensure consistency, the Emission Factors (EF) have been aligned with the estimates of land-use transitions area (AD). To achieve this, the same time series analysis and data collection methods that were used in CEO were replicated for the NFI permanent plot's locations. The NFI plots have been classified as Non-forest land use (grassland, other land, unshaded cropland), Permanent Forest, or Secondary Forests. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points).
		CarbonDensitiesTools.xlsx (Please read this file "READ" before accessing it)	3. **Carbon densities and removal rates calculation**: Nepal developed a calculation tool (CarbonDensitiesTools.xlsx), to estimate carbon densities for both forest and non-forest areas based on the NFI plots dataset. This tool also facilitates the determination of forest regrowth removal rates. Confidence intervals and errors are computed based on the number of sampling plots and standard deviation within each respective land use type or removal rate: i. *Natural Forest carbon densities calculation*: The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots (pl_total_bio_mrv). ii. *Non-Forest carbon densities calculation*: The determination of average carbon densities for non-forest lands was based on fourteen NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI (pl_total_bio_mspa). iii. *Forest regrowth removal rates estimate*: The forest regrowth removal rate calculation is based on a sample of sixteen NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements (pl_yr) was used to estimate the average removal rate.
3	**Emission and removals calculation**	**Nepal_TAL_Integration_tool.xlsx** (Please read this file "READ" before accessing it)	To calculate the Emission Reductions of the Nepal Emission Reduction Program, an Excel tool named Nepal_TAL_Integration_tool.xlsx is used. This tool generates estimates for emissions and removals, along with their associated uncertainties, for both the reference and reporting periods. The estimates are generated for Deforestation, Carbon Enhancement, and Degradation - the three REDD+ activities involved in the carbon accounting of the program. iv. *Calculation of emissions and removals*: **The Parameters and Model sheet** generate estimates for Emissions and Removals. These estimates are calculated using Activity Data and Carbon Density tools. v. *Emission Reductions calculation*: **Results sheet** generates estimates of Emission Reductions for the Reporting Period (June 22, 2020 – December 31, 2021). These estimates are calculated using the Parameters and Model sheet calculations. vi. *Emission Reductions available for transfer to the Carbon Fund*: The **Table-8-ER-MR sheet** computes the available ER for transfer in accordance with Section 8 of the ER monitoring report.
4	**Emission reduction uncertainty estimate and sensitivity analysis.**	**NEPAL_TAL_Integration_tool_MC.xlsx** **NEPAL_TAL_Integration_tool_SensitivityAnalysis.xlsx** (Please read this file "READ" before accessing it)	Nepal has developed two distinct Excel tools utilizing the ER calculation tool (NEPAL_TAL_Integration_tool.xlsx). The first one, NEPAL_TAL_Integration_tool_MC.xlsx, is designed to carry out Monte Carlo simulations and estimate the uncertainty of the ER calculation. The second tool, NEPAL_TAL_Integration_tool_SensitivityAnalysis.xlsx, is utilized for sensitivity analysis purposes.

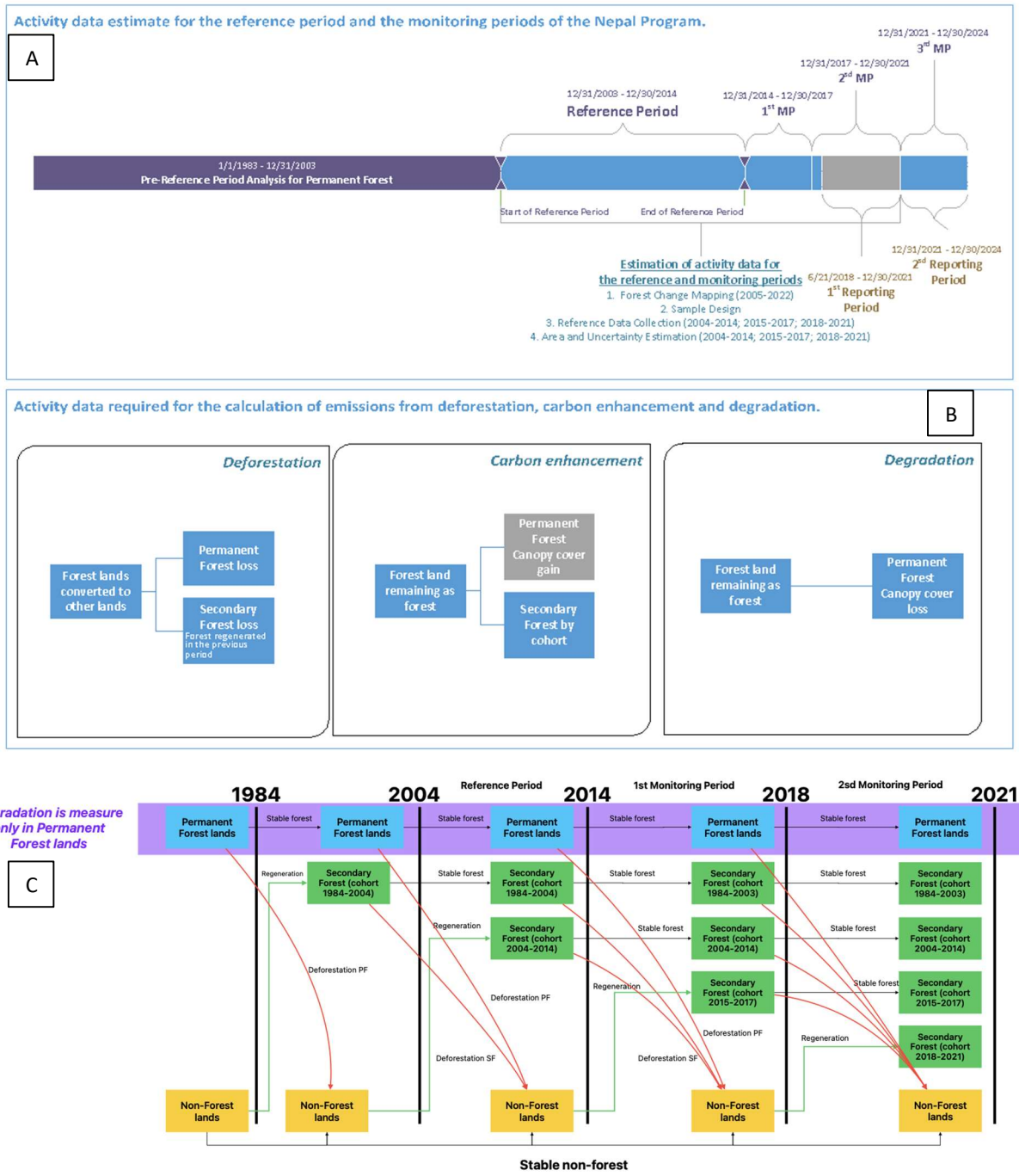
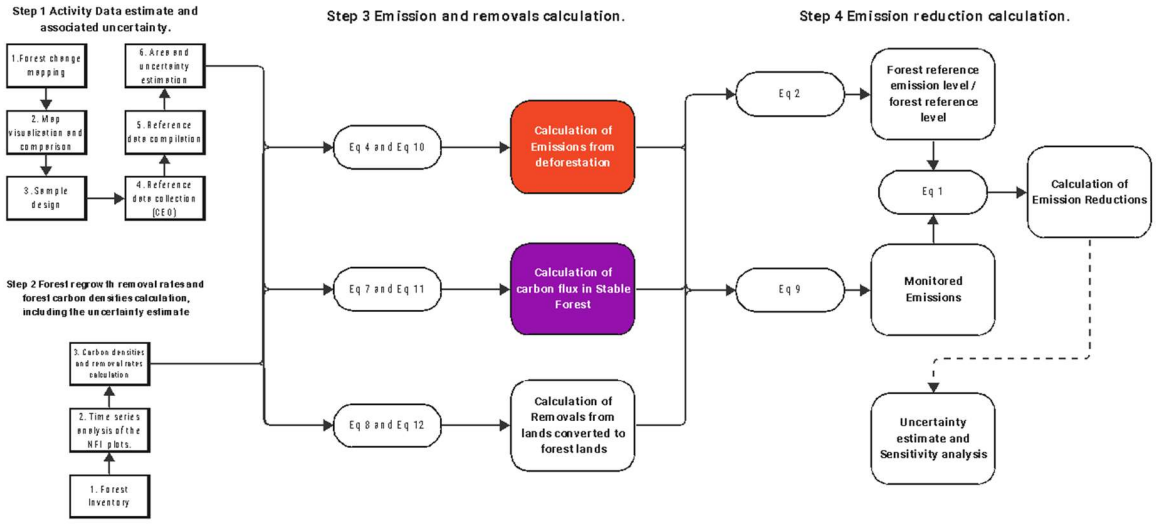


Figure 12: A. Reference Period and monitoring periods considered in collecting reference data for AD estimate. B. Activity Data that required for the estimate of emissions from deforestation, carbon enhancement removals, and emissions from degradation. C. Forest cover type definition (permanent and secondary) based on time-series analysis.

Line diagrams



Calculation steps

Emission reduction calculation $(ER_{ERP,t})$**:**
To determine GHG emission reductions, the same IPCC methods and equations described in Annex 4 Section 8.3 were used over the monitoring period.

$$ER_{ERP,t} = RL_t - GHG_t \qquad \textbf{Equation 1}$$

Where:

ER_{ERP}	=	Emission Reductions under the ER Program in the Reporting Period; tCO_2.
RL_{RP}	=	Net emissions of the Reference Level over the Reference Period; tCO_2e. This is sourced from Annex 4 to the ER Monitoring Report and equations are provided below.
GHG_t	=	Monitored gross emissions from deforestation during the Reporting Period; tCO_2e;
T	=	Number of years during the reporting period; dimensionless.

<u>Monitored emissions (GHG_t)</u>

Annual gross GHG emissions over the monitoring period in the Accounting Area (GHG_t) are estimated as the sum of annual change in total biomass carbon stocks (ΔC_{B_t}).

$$GHG_t = \frac{\sum_t^T \Delta C_{LU_{MP,i,t}}}{T} \qquad \textbf{Equation 9}$$

Where:

$\Delta C_{LU_{MP,i,t}}$	=	Balance of emissions during the Monitoring Period in the Accounting Area of the ER Program that corresponds to the sum of annual change in carbon stocks and removals for each of i REDD+ activities at year t; tCO_2*year^{-1}.
T	=	Number of years during the monitoring period; dimensionless.

Annual change in total biomass carbon stocks forest land converted to another land-use category ($\Delta C_{B_{defo,t}}$)
The annual change in total biomass carbon stocks forest land converted to other land-use category ($\Delta C_{B_{defo,t}}$) would be estimated through **Equation 4** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_t} = \sum_{j,i} \left(B_{Before,j} - B_{After,i}\right) x\ CF\ x \frac{44}{12} \times A(j,i)_{MP}$$ ***Equation 10*** **(Equation 2.16, 2006 IPCC GL)**

Where:

$A(j,i)_{RP}$ Area converted/transited from forest type j to non-forest type *i* during the Monitoring Period, in hectares per year. In this case, sixteen forest land conversions are possible:

1 Intact Forest to Grasslands
2 Intact Forest to Other Land
3 Intact Forest to Settlements
4 Intact Forest to Unshaded Cropland (TCC 10% or less)
5 Degraded Forest to Grasslands
6 Degraded Forest to Other Land
7 Degraded Forest to Settlements
8 Degraded Forest to Unshaded Cropland (TCC 10% or less)
9 Very Degraded Forest to Grasslands
10 Very Degraded Forest to Other Land
11 Very Degraded Forest to Settlements
12 Very Degraded Forest to Unshaded Cropland (TCC 10% or less)
13 Secondary natural forest to Grasslands
14 Secondary natural forest to Other Land
15 Secondary natural forest to Settlements
16 Secondary natural forest to Unshaded Cropland (TCC 10% or less)

$B_{Before,j}$ Total biomass of forest type j before conversion/transition, in tons of dry matter per ha. This is equal to the sum of aboveground ($AGB_{Before,j}$) and belowground biomass ($BGB_{Before,j}$) and it is defined for each forest type.

$B_{After,i}$ Total biomass of non-forest type i after conversion, in tons dry matter per ha. This is equal to the sum of aboveground ($AGB_{After,i}$) and belowground biomass ($BGB_{After,i}$) and it is defined for each of the non-forest IPCC Land Use categories.

CF Carbon fraction of dry matter in tC per ton dry matter. The value used is:

- **0.47** is the default for (sub)tropical forest as per IPCC AFOLU guidelines 2006, Table 4.3.

$44/12$ Conversion of C to CO_2

R: :S Root-to-shoot ratio (0.44).

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$)

The Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{deg,t}}$) would be estimated through **Equation 7** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

$$\Delta C_{B_{DEG}} = \sum_{j} \left\{EF_j \times A(a,b)_{MP}\right\}$$ **Equation 11**

Where:

EF_j Emission Factor for degradation of forest type a to forest type b, tones CO2 ha^{-1}.

$A(a,b)_{MP}$ Area of forest type a converted to forest type b (transition denoted by a, b) during the Monitoring Period, ha yr^{-1}.

Annual change in carbon stocks in biomass on non-forest land converted in forestland ($\Delta C_{B_{reg}}$)

Annual change in carbon stocks in biomass on forestland remaining forestland ($\Delta C_{B_{reg}}$) would be estimated through **Equation 8** above. Making the same assumptions as described above for the RL the change of biomass carbon stocks could be expressed with the following equation:

:

$$\Delta C_{B_{reg}} = \sum_{LU=1}^{n} \{RF_{reg} \times A(i,j)_{MP}\} \qquad \textbf{Equation 12}$$

Where:

RF_{reg} Above and belowground biomass removal rate in new forests [tCO2*ha*$year^{-1}$].

$A(j,i)_{MP}$ Area of non-forestland *i* converted to forestland *j* (transition denoted by *i,j*) in the Monitoring Period, ha yr^{-1}.

LU Land unit.

Parameters to be monitored

Parameter:	Activity Data: $A(j,i)_{MP}$ Equation 10; $A(a,b)_{MP}$ Equation 11; $A(j,i)_{MP}$ Equation 12.
Description:	● Deforestation: Area converted/transited from forest type j to non-forest type i during the Monitoring Period ● Degradation: Area of forest type a converted to forest type b (transition denoted by a,b) during the Monitoring Period, ha yr^{-1} ● Forest gain: Area of non-forestland i converted to forestland j (transition denoted by i,j) in the Monitoring Period, ha yr^{-1}.
Data unit:	hectare
Value monitored during this Monitoring / Reporting Period:	**Deforestation** **Forest gain**

Deforestation

Initial	Final	Monitoring period	
		Area (ha)	±90% CI
Intact Forest	Grasslands		
Intact Forest	Other Land		
Intact Forest	Settlements		
Intact Forest	Unshaded Cropland (TCC 10% or less)		
Degraded Forest	Grasslands		
Degraded Forest	Other Land		
Degraded Forest	Settlements		
Degraded Forest	Unshaded Cropland (TCC 10% or less)		
Very Degraded Forest	Grasslands		
Very Degraded Forest	Other Land		
Very Degraded Forest	Settlements		
Very Degraded Forest	Unshaded Cropland (TCC 10% or less)		
secondary natural forest	other land		
secondary natural forest	other land		

Forest gain

Forest Type	Monitoring period	
	Area (ha)	±90% CI

natural secondary forest gain	
plantation forest gain	
shaded cropland gain	

Degradation

Initial	Final	Monitoring period	
		Area (ha)	±90% CI
Intact forest	Intact forest		
Degraded forest	Degraded forest		
Very degraded forest	Very degraded forest		
Intact forest	Degraded forest		
Intact forest	Very degraded forest		
Degraded forest	Very degraded forest		
Degraded forest	Intact forest		
Very degraded forest	Intact forest		
Very degraded forest	Degraded forest		

Source of data and description of measurement /calculation methods and procedures applied:

Nepal uses a sample-based approach to estimate the Activity Data for Deforestation, Forest gain, and Degradation. This approach ensures unbiased estimates of the area and the error associated with the map. A forest change map spanning from 1983 to 2021 is used for the sample design, and four mapping algorithms are used to map areas experiencing forest loss, degradation, and/or regrowth. The agreement map is used for sample design, and reference data are collected through a time series analysis of 1,522 sampling plots in CEO.

Forest change mapping: The following four mapping algorithms that utilize remote sensing imagery, training data points, land cover maps, and time series data analysis was used to map areas experiencing forest loss, degradation, and/or regrowth.

xiii. **CCDC-SMA**: Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) monitors abrupt and gradual forest degradation.

xiv. **CODED**: Continuous Degradation Detection (CODED) algorithm detects forest canopy disturbances and classifies them as degradation or deforestation based on land cover. CODED uses linear spectral unmixing to generate subpixel fractions of spectral endmembers, which are used to calculate a time series of the Normalized Degradation Fraction Index (NDFI).

xv. **LandTrendr**: The LandTrendr algorithms use simple statistical techniques to simplify a time-series of spectral values into a sequence of connected straight-line segments that capture the overall shape of that pixel's trajectory while omitting year-to-year noise. The resultant segments can then be examined to select periods where the trajectory displays behaviors of interest such as disturbance or growth.

xvi. **MTDD**: Multi-variate Time-series Disturbance Detection (MTDD) classifies initially forested areas into stable forest, degraded, and deforested by training a random forest classifier with 66 metrics. These metrics are derived from six annual time-series (i.e., NDVI, two SWIR spectral regions, two NDWI indices, and SAVI) which are used to calculate eleven descriptive statistics (i.e., minimum, maximum, range, mean, standard deviation, coefficient of variation, kurtosis, skewness, slope, maximum 5-year slope, and most recent value). Overall MTDD's process includes five main steps: (1) making annual time series, (2) calculating 11 descriptive statistics for the time series, (3) generating training/validation points, (4) training a random forest classifier, and (5) validating the classification.

Sample design: A sample-based approach is used to complete area estimation. This approach is preferred over pixel-counting methods because all maps have errors. Sample based

approaches create unbiased estimates of area and the error associated with map. An agreement map generated from the results of all four methodsis used for sample design. The goal is to ensure that no strata is under-sampled. The resulting strata is anywhere 1-4 algorithms agreed there was a certain kind of change event or stable forest/non-forest, anywhere the different algorithms labeled different types of change events, anywhere all 4 algorithms labeled non-forest, and anywhere all 4 algorithms labeled forest. Final strata values for the agreement map and their human-readable labels are 1: DEG, 2: LOSS, 3: GAIN, 4: Non-forest, and 5: Forest. The number of points randomly selected depend on the relative area available in each stratum, the human resources available to do interpretations, and a target standard error. A total of **1,522** points were selected via stratified random sampling to be used for sample-based area estimation.

Reference data collection (completed in CEO): To estimate emissions from deforestation, carbon enhancement removals, and forest degradation emissions, reference data were collected through a time series analysis of 1,522 sampling plots in CEO. To identify the age of forest gain cohorts and differentiate between secondary and permanent forests, the sampling points were visually interpreted for the same period that the forest change map was created (1983 to 2021). This period was divided into four subperiods: 1984-2003, 2004-2014. 2015-2017 and 2018-2021 (see Figure 4). The canopy cover was visually evaluated in permanent forest only for the years 2003/2004, 2014/2015, 2017/2018, and 2021.

xiii. *Generating a CEO project from a template:* Nepal created a template to collect land-use change and degradation reference data in Collect Earth Online (CEO[90]) for the following periods: Pre-reference period (t0) - 1983-2003, Reference Period (t1) – 2004-2014, First monitoring period (t2) – 2015-2017 and Second monitoring period (t3) – 2018-2021.

xiv. *Sampling unit*: The Sampling Unit (SU) is a 70 x 70 meter plot. Inside SU, a 3x3 points sub-grid (9 points) was created to estimate forest canopy cover percentage within each sampling unit.

xv. *Number of Sampling Units*: A total of 1,522 randomly selected sampling points were visually assessed.

xvi. *Interpretation key*: Nepal produced an interpretation key that should be reused and updated as needed. The land use categories considered are the following:

Forest lands:	**Non-forest lands**
1 Intact Forest 2 Degraded Forest 3 Very Degraded Forest 4 Secondary natural forest 5 Plantation Forest 6 Shaded croplands	7 Grasslands 8 Other lands 9 Settlements 10 Unshaded croplands (tree canopy cover 10% or less)

Area and uncertainty estimation: Nepal employs a sample-based approach to estimate the Activity Data for Deforestation, Forest gain and Degradation. All 1,522 samples were used as the basis for calculating area estimates and their uncertainty. The estimation of Activity Data was done using the stratified random estimator based on the formulas described by Cochran (1977)[91]. Estimates are made for each of the land use categories considered (10 classes) and in terms of changes from one period to another representing a total of more than 26 effective combinations (Deforestation 14, Forest Gain 3, and Degradation 9).

[90] CEO is a custom built, open-source, satellite image viewing and interpretation system. Collect Earth Online promotes consistency in locating, interpreting, and labeling reference data plots for use in classifying and monitoring land cover / land use change (see https://app.collect.earth).

[91] Cochran, W.G. (1977) Sampling Techniques. 3rd Edition, John Wiley & Sons, New York.

QA/QC procedures applied:	**Reference data collection:** **Reference data compilation:** To ensure accuracy, the data collected from the CEO was compiled in R for each period of the time series analysis (t0, t1, t2, and t3). The compilation process identifies land-use interpreted points with impossible transitions, and these points are sent back to the interpreted for review, until the compilation process detects no inconsistencies. **Area estimate**: To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheet (**Activity Data Tool**). This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok". QA/QC procedure employed is explained in detail in the link: https://training.sig-gis.com/NEPALworkshopAE/#CEO-Reference-data
Uncertainty for this parameter:	To determine the uncertainty for Activity Data, we calculated the half-width of the 90% confidence interval as a percentage of the estimated emissions. This calculation only takes sampling errors into account and does not consider the interpreter error.
Any comment:	

9.2 Organizational structure for measurement, monitoring and reporting

>> Chapter 2 provides full details on the organizational structure for measurement, monitoring and reporting, including selection and management of GHG data and information, process, systems, and related matters.

9.3 Relation and consistency with the National Forest Monitoring System

>>Refer to Section 2.1.4 for the details related to the relation and consistency with the national forest monitoring system.

12 UNCERTAINTIES OF THE CALCULATION OF EMISSION REDUCTIONS

12.1 Identification and assessment of sources of uncertainty

>>

Sources of uncertainty	Analysis of contribution to overall uncertainty
Activity Data	
Measurement	Activity Data is based on sampling. Systematic and random errors during the visual interpretation of land-use and land-use change in satellite imagery contribute to the overall uncertainty. Nepal has taken measures to address this issue by implementing QA/QC procedures for collecting reference data. This involves using the best available imagery and providing detailed interpretation keys. The interpreters have been trained to ensure they follow the correct procedures for land-use and land-use change interpretation. To guarantee accuracy, the collected reference data is compiled in R for each period of the time series analysis (t0, t1, t2, and t3). During the compilation process, land-use interpretation points with impossible transitions are identified and sent back to the interpreter for review until the compilation process detects no inconsistencies.
Representativeness	Sampling was carried out over the entire accounting area and all reference and monitoring periods. It can therefore be concluded that the impact of this source of uncertainty is low.
Sampling	To determine the number of points needed for the study, we must consider the area of each stratum. Once the total number of samples is calculated, they must be distributed across the strata proportionally. If any of the strata receive too few samples, they should have a minimum sample size requirement, and the remaining points should be proportionally distributed to the larger strata. However, changes in the study area are small, resulting in a high variance in some change categories. To select the estimator, we follow Cochran's (1977) recommendations.
Extrapolation	The estimates were made on the basis of the samples collected and for which the interpretation of the land cover classes are exhaustive and cover the whole reference and monitoring periods. This source of error is therefore unlikely to be present in the approach adopted.
Approach 3	This source of uncertainty exists when there is no land monitoring or IPCC Approach 3 of monitoring, which is not valid for the Nepal ER-Program. Four non-independent surveys were conducted covering reference and monitoring periods (t0, t1, t2, and t3), conducting lands tracking.
Emission Factors	
DBH measurement	The permanent sample plots were selected from the National Forest Resource Assessment. The sampling design was adopted from Forest Resource Assessment Design 2011. Please refer to the link: https://drive.google.com/file/d/1VRGGNoMOy-_92qg8ktk3xH82YNsEraym/view?usp=sharing. In the selected sample plots, all trees that have a diameter of more than 5 cm were measured. For more details, please refer to FRA field manual provided in the following link: Field Manual Inner (1)_1656760691.pdf (frtc.gov.np). The height of every fifth tree was measured and for the remaining trees, their height was predicted using the model developed on the basis of the height-diameter relationship of neighbor trees. The model prepared and used during the calculation is presented in Annex 2 of the report provided in the following link: The-TeraiForestsofNepal_1579845265.pdf (frtc.gov.np) For all above-mentioned processes, a strong QA/QC was carried out using QA/QC Manual approved by the FRTC. A comprehensive training was conducted for field staff to minimize the field measurement errors. In addition, the continuous monitoring of the field personnels were carried out by the FRTC's officials. As a result of the robust QA/QC process, the error for field measurement is below 5%.
H measurement	
Plot delineation	
Wood density estimation	The species-specific wood density is referenced from Table 1 of Sharma and Pukkala, 1990. [Sharma_and_Pukkala_1990_Volume_equations_and_biomass_prediction_of_forest_trees_of_Nepal.pdf]
Biomass allometric model	The volume of the tree, which is further converted into biomass and carbon, is calculated using the allometric equation developed by Sharma and Pukala, 1990. [Table 2 of Sharma_and_Pukkala_1990_Volume_equations_and_biomass_prediction_of_forest_trees_of_Nepal.pdf] There are more than 21 species of trees with specific parameters and, additional two groups of species found in lower altitude and higher altitude with their respective parameters. The maximum and minimum standard error percentage of regression model is 9.9 % and 5.8 % respectively. The R^2 of model for every species is higher than 95 % (Sharma and Pukala 1990).

Sources of uncertainty	Analysis of contribution to overall uncertainty
Activity Data	
Sampling	The sampling is done based on the Inventory Design (ID) of National Forest Inventory. The error of the Inventory Design is 7.34% at 95 % confidence interval. [Please refer to page 40 of the report provided in the link below: https://frtc.gov.np/downloadfile/state%20%20forest%20of%20Nepal_1579793749_1579844506.pdf]
Other parameters (e.g. Carbon Fraction, root-to-shoot ratios)	Other relevant parameters like root-to-shoot ratio and carbon fraction are taken from the 2006 IPCC guideline. The error provided by the IPCC guideline is also factored while carrying out the Monte Carlo simulation for uncertainty estimation.
Representativeness	The carbon densities and removal rates used for the ER monitoring report are Tier 2 (country specific data) and has been derived from the latest NFI (FRA) except the removal rates for forest plantation and shaded crops. The NFI (FRA) involved remeasurement in 2022 of the permanent sample plots established by the FRA Nepal Project (2010-2014) including an additional number of plots established and measured using the same methodology. Nepal is conducting NFI by re-measuring the permanent sample plots at an interval of every five years. The carbon densities of natural forests categorized as intact, degraded, and very degraded were estimated using the second measurement from NFI's 591 plots. The determination of average carbon densities for non-forest lands was based on fourteen NFI plots, which provided biomass estimates for grassland, other land, and unshaded cropland. These estimates were obtained during the initial measurement phase of the NFI. The forest regrowth removal rate calculation is based on a sample of sixteen NFI plots established in secondary forests. Two biomass measurements were taken in these plots, and the difference in biomass over the years between measurements was used to estimate the average removal rate.
Integration	
Model	To ensure accurate Activity Data estimates, material errors are controlled through specific mechanisms in the estimation spreadsheets. This includes matching forest-type sampling points with sample size to prevent double counting in the sample-based Activity Data estimate. The accuracy of deforested, forest gain, and degraded areas are checked in cells Deforestation: I41-N58, Forest_gain: E19-K47, and Degradation: F30-V50 respectively. Before reporting AD values, a quality assurance/quality control procedure is conducted to verify that all these cells are labeled "Ok".
Integration	Activity Data and Emission Factors are comparable. Carbon densities have been estimated according to the forest types, and non-forest land uses interpreted in the visual assessment. To ensure consistency, the Emission Factors (EF) have been aligned with the estimates of land-use transitions area (AD). To achieve this, the same time series analysis and data collection methods that were used in CEO were replicated for the NFI permanent plot's locations. The NFI plots have been classified as Non-Forest land use (grassland, other land, unshaded cropland), Permanent Forest, or Secondary Forests. Additionally, the canopy cover of Permanent Forest plots was evaluated to determine whether they were intact (7-9 points), degraded (4-6 points), or very degraded forest (1-3 points).

12.2 Quantification of uncertainty in Reference Level Setting

12.2.1 Parameters and Assumptions Used in the Monte Carlo Method

Parameter included in the model	Parameter values	Range or standard deviations		Error sources quantified in the model (e.g. measurement error, model error, etc.)	Probability distribution function	Source of assumptions made
		Lower	Upper			
Deforestation and Degradation Emission Factors	The MC analysis included **7** Carbon density values for forest types and non-forest land uses categories considered in emission estimates. See all values in the Uncertainty calculation tool "Parameters and Models" Sheet – (cells F17..F23)	5.88 tdm/ha	66.11 tdm/ha	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Removal factors	The MC analysis included **3** Removal factors. See all values in the Uncertainty	2.46 tCO2/ha/yr	4.40 tCO2/ha/yr	90% Confidence Interval.	Normal	Truncated Normal

	calculation tool "Parameters and Models" Sheet cells E14..E16.					distribution (values > 0).
Deforestation Activity Data	**Forty-six** values for the Reference Period and **18** Activity Data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Parameters and Models" sheet, cells F42..F85.	727 ha	4,353 ha	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Activity Data for estimating inherited removals	The MC analysis included **11** Activity Data values for estimating inherited removals. See all values in the Uncertainty calculation tool "Parameters and Models" sheet, cells F27..F41.	3,999 ha	15,069 ha	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).
Permanent Forest's Degradation	**Fifteen** values for the Reference Period and 1**7** Activity Data for the Monitoring Periods were included in MC analysis. See all values in the Uncertainty calculation tool, "Parameters and Models" sheet, cells F98..F115.	1,024 ha	9,495 ha	90% Confidence Interval.	Normal	Truncated Normal distribution (values > 0).

12.2.2 Quantification of the Uncertainty of the Estimate of the Reference Level

		Deforestation	Forest degradation	Enhancement of carbon stocks
A	**Median**	**595,938**	**292,212**	**-1,216,402**
B	**Upper bound 90% CI** (Percentile 0.95)	**997,882**	**764,816**	**-596,049**
C	**Lower bound 90% CI** (Percentile 0.05)	**269,896**	**-25,762**	**-2,080,506**
D	**Half Width Confidence Interval at 90% (B – C / 2)**	**363,993**	**395,289**	**742,229**
E	**Relative margin (D / A)**	**61%**	**135%**	**-61%**
F	**Uncertainty discount**	**12%**	**15%**	**12%**

12.2.3 Sensitivity Analysis and Identification of Areas of Improvement of MRV System

The following table shows each parameter's contribution to the Emissions Reduction's uncertainty. Four parameters represent 51% of total ER's uncertainty: i. Area of change from Intact Forest to Other Land during 2018-2021 (28.5%), ii. Area of change from Intact Forest to Unshaded Cropland during 2018-2021 (8.0 %), iii. Degraded area from Very degraded forest to Degraded forest during 2018-2021 (7.9%) and iv. Root-to-shoot ratio (6.4%).

Input Variable	Corresponding Input Value			Swing	Percent Swing^2
	Low Output	Base Case	High Output		
Deforestation_Intact Forest_Other Land_2018-2021	7,995	3,698	0	2,874,935	28.5%
Deforestation_Intact Forest_Unshaded Cropland_2018-2021	3,856	1,462	0	1,526,354	8.0%
Degradation_Very degraded forest_Degraded forest _2018-2021	0	3,988	8,165	1,511,807	7.9%
ratio R::S	0.1364	0.44	0.7436	1,364,404	6.4%
Forest Gain_Secondary natural forest 1988_other land_2018-2021	4,884	1,848	0	1,300,292	5.8%
Deforestation_Intact Forest_Unshaded Cropland_2004-2014	966	5,319	9,673	1,253,249	5.4%
Degradation_Degraded forest _Inctact forest_2018-2021	5,063	12,178	19,294	1,129,482	4.4%
Removal factor-natural secondary forest gain	-8.12	-12.52	-16.92	1,080,623	4.0%

Forest Gain_Non-forest lnads_Natural forest_2004-2014	33,353	48,423	63,492	958,918	3.2%
Deforestation_Degraded Forest_Unshaded Cropland_2004-2014	0	3,696	7,986	919,014	2.9%
Degradation_Very degraded forest_Inctact forest_2004-2014	7,995	3,698	0	769,051	2.0%
carbon density-natural degraded forest	223.78	181.09	138.40	763,533	2.0%
Degradation_Very degraded forest_Degraded forest _2004-2014	10,805	5,546	288	708,090	1.7%
Forest Gain_Non-forest lnads_Plantation forest_2015-2017	290	5,233	10,176	692,518	1.7%
Degradation_Inctact forest_Degraded forest _2018-2021	9,176	4,877	579	682,336	1.6%
Forest Gain_Non-forest lnads_Natural forest_2015-2017	1,078	6,436	11,793	681,799	1.6%
carbon density-natural very degraded forest	162.62	96.51	30.40	665,464	1.5%
Degradation_Degraded forest _Very degraded forest_2004-2014	174	4,591	9,007	594,680	1.2%
Forest Gain_Non-forest lnads_Natural forest_2018-2021	3,679	11,087	18,494	589,219	1.2%
Degradation_Degraded forest _Inctact forest_2004-2014	30,007	20,512	11,018	548,042	1.0%
Degradation_Inctact forest_Degraded forest _2004-2014	13,205	22,596	31,988	542,088	1.0%
Forest Gain_Non-forest lnads_Shaded cropland_2015-2017	674	5,833	10,992	536,329	1.0%
Deforestation_Very Degraded Forest_Other Land_2018-2021	4,884	1,848	0	464,281	0.7%
Degradation_Degraded forest _Very degraded forest_2018-2021	2,582	1,334	86	462,200	0.7%
Removal factor-plantation forest gain	-9.39	-13.79	-18.18	461,005	0.7%
Forest Gain_Non-forest lnads_Shaded cropland_2018-2021	2,422	9,084	15,745	432,848	0.6%
Forest Gain_Non-forest lnads_Plantation forest_2004-2014	293	5,543	10,794	367,824	0.5%
Forest Gain_Non-forest lnads_Plantation forest_2018-2021	0	3,696	7,986	349,664	0.4%
Removal factor-shaded cropland gain	-7.77	-10.23	-12.69	339,596	0.4%
Forest Gain_Secondary natural forest 1988_other land_2015-2017	4,884	1,848	0	310,784	0.3%
Degradation_Inctact forest_Very degraded forest_2018-2021	1,172	445	0	310,025	0.3%
Forest Gain_Non-forest lnads_Shaded cropland_2004-2014	200	4,200	8,199	207,905	0.1%
Deforestation_Intact Forest_Settlements_2004-2014	0	445	1,172	197,302	0.1%
Degradation_Inctact forest_Very degraded forest_2004-2014	0	889	1,913	184,036	0.1%
Deforestation_Very Degraded Forest_Other Land_2004-2014	0	1,848	4,884	168,830	0.1%
Deforestation_Degraded Forest_Settlements_2004-2014	0	445	1,172	163,476	0.1%
Deforestation_Very Degraded Forest_Unshaded Cropland_2018-2021	1,172	445	0	153,901	0.1%
Deforestation_Intact Forest_Other Land_2004-2014	0	445	1,172	153,251	0.1%
carbon density-natural inctat forest	209.85	217.34	224.83	120,981	0.1%
Deforestation_Degraded Forest_Other Land_2004-2014	0	445	1,172	119,426	0.0%
Forest Gain_Secondary natural forest 1988_other land_2015-2017	1,172	445	0	74,581	0.0%
Deforestation_Very Degraded Forest_Unshaded Cropland_2004-2014	0	445	1,172	55,964	0.0%
Forest Gain_Non-forest lnads_Plantation forest_1983-2003	4,884	1,848	0	0	0.0%

Document history

Version	Date	Description
2.4	May 2022	● Page 1 and section 8 have been adjusted to reflect the dentition of Total ERs
2.3	December 2021	● Section 5.2 was adjusted to allow the reporting of the uncertainty estimates for both the reporting period and the crediting period. ● Section 8 has been adjusted to clarify that countries can also report ERs jointly and not only in separate calendar years.
2.2	August 2021	● Cross-references have been corrected ● Information about the start date of the crediting period has been requested in annex 4.
2.1	November 2020	Aspects on uncertainty analysis were revised based on the guidelines on uncertainty analysis.
2	June 2020	Version approved virtually by Carbon Fund Participants. Changes made: ● Update to consider the changes made to the Methodological Framework (Version 3.0) and Buffer Guidelines (Version 2.0) ● Update to consider the changes made to the Validation and Verification Guidelines
1	January 2019	The initial version was approved by Carbon Fund Participants during a three-week non-objection period.