SUB-NATIONAL FOREST MONITORING SYSTEM (M&MRV SYSTEM)

Gilgit Baltistan

JULY 15, 2022

GOVERNEMNT OF PAKISTAN, MINISTRY OF CLIMATE CHANGE

ISLAMABAD

Report Prepared by

WWF-Pakistan

Table of Contents

List of figures

List of Tables

ACRONYMS

AD	Activity data
AGB	Above Ground Biomass
AJK	Azad Jammu & Kashmir (autonomous territory)
AKRS	Aga Khan Rural Support Program
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BGB	Belowground Biomass
BGC	Belowground Carbon
CCF	Chief Conservator Forest
CCW	Chief Conservator Wildlife
CD	Community Development
CF	Conservator Forest
CO2	Carbon Dioxide
COP	Conference of Parties
CP	Conference of Parties (Decision references)
CSO	Civil Society Organization
CSV	Comma-separated Values
DBH	Diameter at Breast Height
DEM	Digital Elevation Model
D-H	Diameter-Height
DW	Dead Wood
EF	Emission Factor
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
FD	Forest Department (provincial)
FATA	Federally Administered Tribal Areas
FOSS	Free and Open-Source Software
FPIC	Free, prior and informed consent
FREL	Forest Reference Emissions Levels
FRL	Forest Reference Levels
FSMP	Forestry Sector Master Plan
GB	Gilgit-Baltistan (autonomous territory
GCISC	Global Change Impact Studies Centre
GCP	Ground Control Point
GDEM	Global Digital Elevation Model
GHG-I	Greenhouse Gas Inventory
GIS	Geographic Information System
GOP	Government of Pakistan
GPS	Global Positioning System
GPS	Global Positioning System
GUI	Graphical User Interface ha Hectare (1 ha = 10,000 m2)

HR	High Resolution
ICIMOD	International Centre for Integrated Mountain Development
ICT	Islamabad Capital Territory (federal capital territory)
INGO	International Non-Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technology
IUCN	International Union for Conservation of Nature
km / km2	Kilometer / Square kilometer
KP	Khyber Pakhtunkhwa (province)
KIU	Karakorum International University
LCCS	FAO's Land Cover Classification System
LiDAR	Light Detection and Ranging
LULC	Land Use Land Cover
LULUCF	Land Use, Land Use Change and Forestry
MBIGS	Multiple benefits, impacts, governance, safeguards
MMRV	Monitoring & Measurement, Reporting and Verification
MMU	Minimum Mapping Unit
MOCC	Ministry of Climate Change
MOE	Ministry of Environment
MRV	Measurement, Reporting and Verification
MSS	Multispectral Scanner
NASA	National Aeronautics and Space Administration
NCCA	National Climate Change Authority
NFI	National Forest Inventory
NFMS	National Forest Monitoring System
NGO	Non-governmental Organization
NRP	National REDD+ Program
NSC	National REDD+ Steering Committee
NSDI	National spatial data infrastructure
NTFP	Non-Timber Forest Product
NUST	National University of Sciences and Technology (NUST)
O&M	Operationalization and Maintenance
OBIA	Object Based Image Analysis
OGC	Open Geospatial Consortium
OIGF	Office of Inspector General of Forests
OLI	Operational Land Imager
PAMs	REDD+ Policies and Measures
PB	Punjab (province)
PBI	MS Power BI (A Microsoft Data Analysis Software)
PES	Payment of Ecosystem Services
PFI	Pakistan Forest Institute

PSU	Primary Sampling Unit
QA	Quality assurance
QC	Quality control
QGIS	Quantum GIS (Open-Source GIS Software)
R&D	Research & Development
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
RF	Removal Factor
ROI	Regions of Interest
R-PP	Readiness Preparation Proposal
RS	Remote Sensing
SAGA	System for Automated Geoscientific Analysis
SAR	Synthetic Aperture Radar
SCP	Semi-Automatic Classification
SD	Sindh (province)
SECP	Securities & Exchange Commission of Pakistan
SIS	Safeguard Information System
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
SOP	Survey of Pakistan
SPOT	Satellite Pour l'Observation de la Terre (French satellite image provider)
SSL	Secure Sockets Layer
SSU	Secondary Sampling Unit
TWG	Technical REDD+ Working Group
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	The United Nations Framework Convention on Climate Change
UoBS	University of Baltistan
US	The United States of America
USGS	US Geographical Survey
UTM	Universal Transverse Mercator (coordinate system)
VHR	Very High Resolution
WCS	The Open Geospatial Consortium Web Coverage Service Interface Standard
WWF-Pakistan	World Wide Fund for Nature

EXECUTIVE SUMMARY

The Sub-National Forest Monitoring System is developed keeping in view; the provision provided under the UNFCCC Decision 4/CP.15, Decision 1/CP.16 (paragraph 71(c)), and Decision 11/CP.19; the fact that forestry sector is a provincial and sub-national subject and managed independently, and; the keen interest of the provincial governments for demonstrating the REDD+ activities on the ground.

The Gilgit Baltistan province is situated between latitude 35.8026° N, and longitude 74.9832° E about 400 kilometers North of Islamabad. Total area of the Gilgit Baltistan province is 72,971 sq. km and its total population is around 1.8 million (GB EPA, 2017; UNDP, 2020 The Gilgit Baltistan province has two major forest types; 1) Sub-Alpine Forest and; 2). Dry Temperate Forest. Major flora consists of Fir, Spruce, Blue pine, Juniper spp., Chilghoza pine, Deodar, Salix spp., Hippophae rhamnoides (Sea Buckthorn) and Artimesia martima. Major faun of Gilgit Baltistan includes Snow leopard, Tibetan lynx, Brown bear, Asian black bear, Tibetan wolf, Red fox, Corsac fox, Stone marten, Golden marmot, Markhor, Himalayan ibex, Ladakh urial, Snow cock, Chukar, Snow pigeon, Booted eagle and Common kestrel. (UNDP, 2020).

The institutional framework for the Sub-NFMS (M&MRV) comprises of the responsible bodies, their functions and their coordination and linkages. The recommended Sub-National Institutional Structures consist of; 1). Provincial REDD+ Steering Committee; 2). Provincial REDD+ Management Committee; 3). Provincial REDD+ Coordination Unit; 4). District REDD+ Coordination Unit; 5). Quality Assurance Committee.; 6). Provincial GHG-Inventory Unit; 7). REDD+ Research Unit, and; 8). TWGs (MRV/ SLMS/ GHG/ Governance/ Finance).

The Sub-NFMS has two functions; 1) Monitoring Function and 2). Measurement Reporting and Verification of REDD+ activities and programs. The Monitoring function is related to monitor the REDD+ policies and measures as well as other aspects of the forest management and sustainability while MRV function is related to measure the Activity Data through SLMS, measure the forest biomass and assess the carbon emissions and removals through robust, transparent and verifiable methods and approaches.

A systematic, step wise and participatory approach was adopted for the development of the current Sub-NMFS (M&MRV) system. It comprised of detailed literature reviews for each component of the Sub-NFMS and development of working papers, consultations with stakeholders, training of the team and relevant teams of the FD (in case of FIs), development of definitions and methodologies (for forest degradation and assessment), data entry and analysis, development and sharing of draft results (AD and EFs), and finalization of the Sub-NFMS and Carbon Stock Assessment Reports.

The methodological framework for SLMS was mainly adopted from the NFMS and FRL/ FREL 2020 with addition of new method for assessment of forest degradation under the current assignment. The already notified national definition of forest was adopted for the SLMS. The national definition defines the forest as “A minimum area of land of 0.5 ha with a tree crown cover of more than 10 % comprising trees with the potential to reach a minimum height of 2 meters. This will also include existing irrigated plantations as well as areas that have already been defined as forests in respective legal documents and expected to meet the required thresholds as defined in the national forest definition of Pakistan.” Definition for forest degradation was developed and notified under current assignment of developing the Sub-NFMS (M&MRV). The same was adopted for assessment of the forest degradation through SLMS. Forest degradation is defined as ““Human induced long-term losses within forest persisting of at least four years or more due to changes in canopy cover i.e., open (11-30%), sparse (31-50%), medium (51-70%), dense

(>70%) resulting in reduction in forest carbon stock and not qualifying as deforestation". Freely available optical satellite imagery and a desktop-based workflow using QGIS, Orfeo Toolbox and limited Python/R Programming were agreed and used for implementing of the SLMS.

The methodological framework for the Sub-National Forest Inventory was also adopted mainly from the NFMS, 2020 with slight modification and adjustments. The Sub-National Forest Inventory comprised of two parts; 1) Field Surveys and data collection and; 2). Data storage, analysis and development of EFs. The inventory design comprised of sample design, layout of sample plots, teams building and trainings, collection of plot data and samples, lab tests and determination of carbon contents in litter, shrubs and soil. Systematic 10' x 10' grids were generated over the entire country, which were adjusted to the forest mask of 2012 and then densified to 5' x 5', 2.5' x 2.5', 1.5' x 1.5' grids according to the number of calculated plots using the WINROCK Sample Calculator. A total of 465 plots (93 clusters) were initially decided for forest inventory in GB. However, due to issues of accessibility during winter as well as limited time available for the assignment a total of 239 plots (57 clusters) could be surveyed. For data storage and processing OF Collect data management software and MS Power BI software were used. Moreover, excel spreadsheets were also used to crosscheck the Power BI analysis.

In addition to available diameter-height estimation models, new models were developed from the collected inventory data in excel spreadsheet and were then reviewed and improved using Powe BI and R software. For tree biomass estimation existing allometric equations developed by Ali et al. 2017, Ali, 2019 and Ali 2020 were used which covered 64% of tree species with around 90% of the basal area. For remaining conifer species generic coniferous allometric equation used by Ali et al., 2017 was applied. Similarly, for the remaining broadleaved species, the allometric equation developed by Chave et.al. 2014 was used.

The methodological Framework of GHG-Inventory mainly comprises guidelines for compilation and reporting on human induced forest-related GHG emissions by sources and removals by sinks. Though, the GHG-I is mainly prepared at the national level however, under the Sub-NFMS requisite data and information will be compiled at the Sub-national level and will be shared with national focal point for preparing and reporting the national level GHG-Inventory and reporting to the UNCCC secretariate.

The framework for MBIGS consists of institutional and monitoring framework for assessment of the non-carbon benefits, impacts, governance and safeguards related to implementation of REDD+ activities and programs. The framework provides overall institutional structure, functions and process for assessment, compilation and reporting of the MBIGS indicators. Main responsibility of compilation, analysis and reporting of the MBIGS indicators rests with the REDD+ focal points (REDD+ management units/ implementation and coordination units). While most of the data collection and assessment will be done by the district level REDD+ units (DFOs and their teams) and specialized units, directorates and circles.

For operationalization and institutionalization of the Sub-NFMS following steps (mainly for formal establishment of the recommended Sub-NFMS institutions and bodies and their regular functioning) will be ensured. Necessary arrangements will be made to make the existing bodies functional. Initially the Sub-NFMS will be implemented as project till its regularization and shifting to normal program.

The Sub-NFMS methodologies need further improvement over time.

- Sufficient time should be provided for the SLMS, Forest Inventory and data analysis. During the current Sub-NFMS assignment limited time remained a major constraint;
- Sufficient equipment should be provided to ensure quality and timely data collection. Limited number of equipment was one of the hurdles during the current assignment. The provinces have limited sets of modern survey equipment, however to timely and properly complete the inventories in the field there is need for provision of more sets of equipment.
- The surveys should be conducted in summer in the high-altitude areas and during winter in the low-lying southern areas. Selection of proper season is very important factor in timely and properly completion of forest inventories. Due to time limitation and delays in initial finalization of contracts the forest inventories had to be conducted during autumn and winter season which resulted in difficulty in accessing the high-altitude forests especially the sub-alpine forests.
- Instead of using post-monsoon, cloud-free, least haze a single image, in the era of data-cube, intense temporal coverage of Landsat 8 and 9, it is recommended to use an annual composite for the image classification. The yearly composite will better understand phonological stages to distinguish vegetation classes (Cropland, Shrubland, etc.) from the forest.
- Instead of relying only on the spectral response of the images, it is recommended to integrate spectral indices of vegetation, water, snow, soil, etc. along with the spectral reflectance.
- In terms of forest degradation, the combination of SMA and time series could improve the results
- There is strong need for improvement of the forest ecological and forest types boundaries and maps. The forest ecological zones and forest types mapping prepared during the NFMS development phase, was mainly based on elevation, which resulted in miss classification of forest types. The WWF-Pakistan GIS and Forestry experts tried to correct these mistakes and adjust the maps using local knowledge about the area and VHR Google maps, however further improvement is needed to avoid any miss classification.
- Manual recording of field survey data on paper data-sheets need to be replaced by Mobile Data Entry Aps (FAO Opensource Aps) to save time and reduce errors in data entry and recording as well as increase transparency and ensure quality. This will need proper training of the forest inventory teams.

1. INTRODUCTION

1.1 National and Sub-National Forest Monitoring System in Pakistan

Development and implementation of a robust and transparent National Forest Monitoring System (NFMS) and if necessary, the Sub-national Forest Monitoring Systems are among the key requirements for implementing REDD+ activities as mentioned under the UNFCCC Decision 4/CP.15, Decision 1/CP.16 (paragraph 71(c)), and Decision 11/CP.19 (MoCC, 2020). Decision 4/CP.15, outlining methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries, also requests the developing country parties “to establish, according to national circumstances and capabilities, robust and transparent national (and sub-national) forest monitoring systems that; i). use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes; ii). provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account

national capabilities and capacities; and iii). are transparent and their results are available and suitable for review as agreed by the Conference of the Parties" (UNFCCC 2009; MoCC, 2020). Moreover, Decision 1/CP.16 Paragraph 71 (c) recommends "a robust and transparent national forest monitoring system for the monitoring and reporting of REDD+ activities, with, if appropriate, subnational monitoring and reporting as an interim measure, in accordance with national circumstances, and with the provisions contained in Decision 4/CP.15, and with any further elaboration of those provisions agreed by the Conference of the Parties" (UNFCCC, 2010; MoCC, 2020).

As required under these decisions, the Government of Pakistan under the first phase of its REDD+ Readiness Preparation Project of the "Readiness Fund for Forest Carbon Partnership Facility", developed the National Forest Monitoring and Measurement Reporting and Verification System and the Forest Reference Emission Levels in 2020. The National Forest Monitoring System and the Forest Reference Emission Levels, provide standardized methodological frameworks for the SLMS, assessment of Activity Data, conducting of Forest Inventory, estimation of Emission Factors, and guideline for the development of Sub-National Forest Monitoring Systems. The need for development of Sub-National Forest Monitoring Systems in Pakistan was felt due to three reasons; 1). in Pakistan forestry is a provincial subject and forests are independently managed by the concerned provinces while the federal government is responsible for policy formulation, coordination, and leading as a focal point for international conventions and treaties; 2). the UNFCCC decisions have provision to develop Sub-National Forest Monitoring Systems; 3). Provinces showed their keen interest to develop their own carbon estimations and go for some voluntary carbon markets to show some on ground results to various stakeholders. Accordingly, the development of Sub-National Forest Monitoring Systems was planned during the second phase of the REDD+ Readiness Preparation Project of the "Readiness Fund for Forest Carbon Partnership Facility". This document therefore, presents the Sub-National Forest Monitoring System for the Gilgit Baltistan province.

1.2 The Gilgit Baltistan Province

The Gilgit Baltistan province, formerly called Northern Areas, is situated between latitude 35.8026° N, and longitude 74.9832° E about 400 kilometers North of Islamabad. Total area of the Gilgit Baltistan province is 72,971 sq. km and its total population is around 1.8 million (GB EPA, 2017; UNDP, 2020). Administratively the Gilgit Baltistan province is divided in to 10 districts; Ghanche, Skardu, Shigar, Kharmang, Gilgit, Ghizer, Hunza, Nagar, Diamer and Astore. Geographically it has three mountain regions; Himalaya, Karakorum and Hind Kush with their confluence point lying around 20 km south of Gilgit city along the KKH highway (UNDP, 2020). It has the highest number of mountain peaks including K2, Nanga Parbat and Rakaposhi. Moreover, it has some of the world's longest glaciers outside the Polar Region i.e., Baltoro glacier (63 km), Biafo glacier (67 km) and Hispar glacier (49 km) (UNDP, 2020). Three main rivers are flowing through Gilgit Baltistan; 1). Indus River; 2). Ghizer River and 3). Hunza River. From climate point of view the Gilgit Baltistan Province falls in arid and semi-arid zones and Undifferentiated Highland. Average annual temperature varies from 9.6°C to -2.7°C. Average annual precipitation is 208 mm (Khan et al. 2020). The Gilgit Baltistan province has two major forest types; 1) Sub-Alpine Forest and; 2). Dry Temperate Forest. Major flora consists of Fir, Spruce, Blue pine, Juniper spp., Chilghoza pine, Deodar, Salix spp., Hippophae rhamnoides (Sea Buckthorn) and Artimesia martima. Major faun of Gilgit Baltistan includes Snow leopard, Tibetan lynx, Brown bear, Asian black bear, Tibetan wolf, Red fox, Corsac fox, Stone marten, Golden marmot, Markhor, Himalayan ibex, Ladakh urial, Snow cock, Chukar, Snow pigeon, Booted eagle and Common kestrel. (UNDP, 2020).

1.3 Structure of the Sub-NFMS document

This report is organized in four main headings. Heading-1 "Introduction", elaborates the development of the Sub-NFMS in light of the UNFCCC decisions and guidelines, and the structure of the Sub-NFMS report; Heading-2 "Methodological framework and design for the Sub-NFMS" elaborates the institutional framework, monitoring function of Sub-NFMS, development of the Sub-NFMS, and methodological frameworks for SLMS, Forest Inventory, GHG-Inventory, and MBIGS; Section-3 "Operation and institutionalization of the Sub-NFMS" elaborates data ownership, custodianship and sharing agreement, data policy and sharing protocol; Section-4 "Sub-NFMS funding arrangements" includes funding arrangements for the SLMS, Sub-National Forest Monitoring System–Measuring, Reporting and Verification, Forest Inventory, Sub-National GHG Inventory and reporting, REDD+ Monitoring, monitoring of the MBIGS; Section-5: "Recommendations for improvement" gives key recommendations based on the experience and lessons learnt during the current assignment.

2. METHODOLOGICAL FRAMEWORK AND DESIGN FOR THE SUB-NFMS

2.1 Institutional Framework

2.1.1 Guiding principles and process for developing the Sub-NFMS institutional framework

The institutional framework for the Sub-National Forest Monitoring System (Sub-NFMS) has been defined in light of the guiding principles and criteria laid down in the National Forest Monitoring Systems-MRV report, 2020. The guiding principles include defining institutions and their mandates, and developing and formalizing processes and methodologies in the context of the Sub-NFMS activities. The criteria provided in the NFMS 2020 are;

a) *A solid, sustainable network of institutions with the required variety of expertise;*
b) *Clearly documented roles and responsibilities with a single body assigned for overall coordination;*
c) *Good coordination and clear lines of communication; d) Continuity of staff and succession planning;*
d) *High level of ownership by the participating stakeholders; and*
e) *Efficient use of existing institutions and frameworks to minimize establishment and operational costs.*

While following the abovementioned principles and criteria a detailed consultation and review process was adopted for the recommended institutional framework for the Sub-NFMS. The process comprised of; 1). Review of literature and best practices, development of a review paper and proposing draft institutional framework for each Sub-National entity; 2). Sub-National level stakeholders' consultations and development of the institutional framework, and development a roadmap for establishment of the recommended framework; 3). Final validation workshop and further refinement of the institutional framework and roadmap. While developing the institutional structures, efforts have been made to use the existing institutions and frameworks, with slight changes and improvements (as recommended under NFMS 2020 criteria).

2.1.2 Recommended institutional framework for the Sub-NFMS

The institutional framework for the Sub-NFMS (M&MRV) comprises of the responsible bodies, and their roles including their coordination and linkages. The recommended institutional structure for the Sub-National Forest Monitoring (M&MRV) System include; 1). Provincial REDD+ Steering Committee; 2). Provincial REDD+ Management Committee; 3). Provincial REDD+ Coordination Unit; 4). District REDD+

Coordination Unit; 5). Quality Assurance Committee.; 6). Provincial GHG-Inventory Unit; 7). REDD+ Research Unit, and; 8). TWGs (MRV/ SLMS/ GHG/ Governance/ Finance). Figure 1 below gives an overall institutional framework. The proposed Sub-National Institutions, their structure, key functions and the roadmap to establish them are elaborated as under and also summarized in tabulated form as Annex-1.

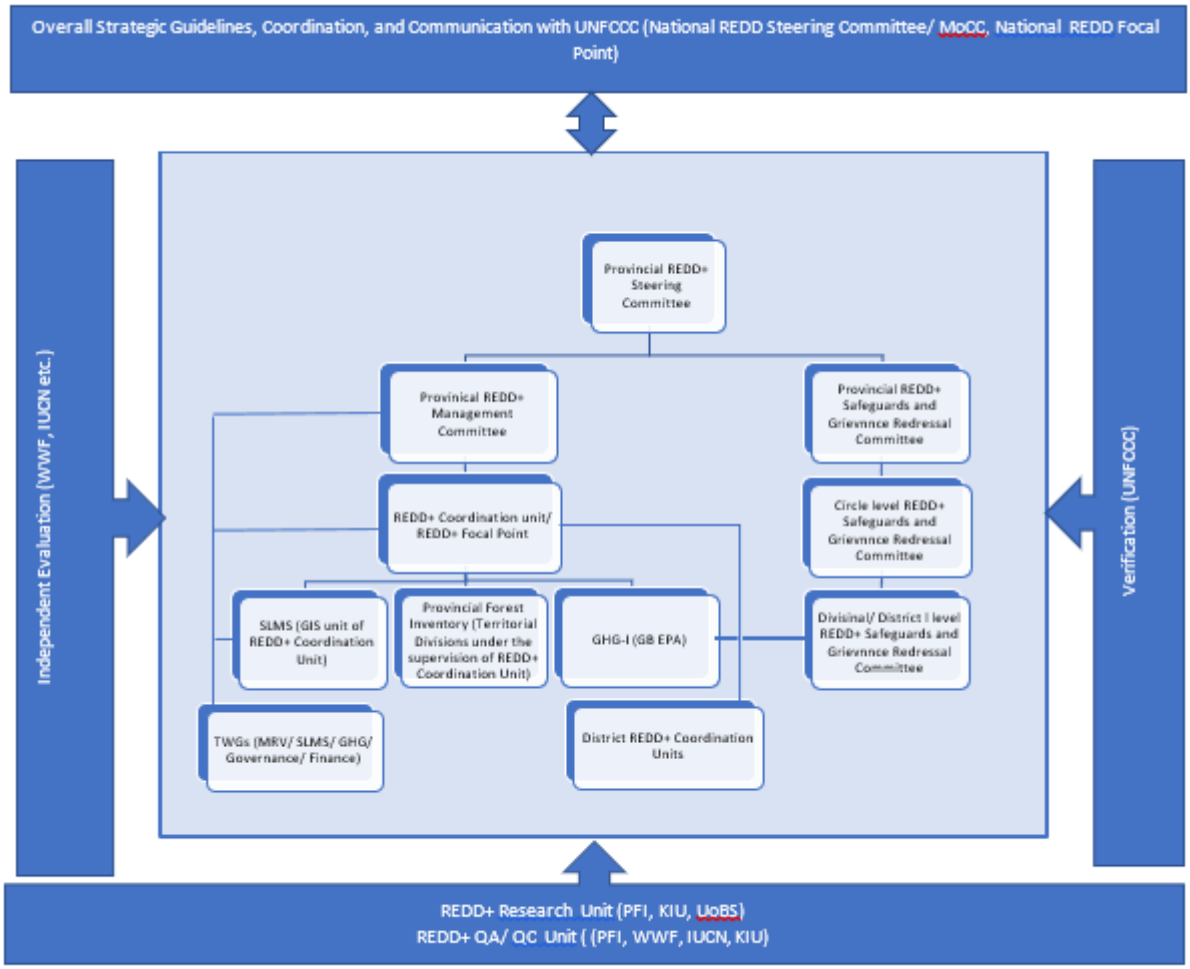


Figure 1: Institutional framework for the Sub-NFMS (GB)

2.1.2.1 Provincial REDD+ Steering Committee

The Provincial REDD+ Steering Committee is a new body recommended under the current Sub-NFMS (M&MRV) System. The Provincial REDD+ Steering Committee will be an apex body and will comprise of; 1). Secretary Forest, Wildlife and Environment (Chair); 2). Chief Conservator Forest (member); 3) Conservators Forest (CFs) (member); 3). Technical heads of line departments (members); 4) Academia (KIU, UoBS) (members); 5). NGOs (WWF, IUCN, AKRSP) (members). Key functions of the Provincial REDD+ Steering Committee will include policy and strategic decision making related to REDD+ in Gilgit Baltistan. The Provincial REDD+ Steering Committee will be notified the competent authority within one month of the endorsement of the Sub-NFMS for GB.

2.1.2.2 Provincial REDD+ Management Committee

The Provincial REDD+ Management Committee is also a new body recommended under the current Sub-NFMS (M&MRV) System. The committee will comprise of Chief Conservators Forest (CCF) (chair), Provincial REDD+ Coordinator (member), Conservators Forest (CFs) (member), and Conservator Wildlife (member). Key functions of the committee will include provincial REDD+ management reviews and decision making related to REDD+ implementation. The Provincial REDD+ Management Committee will be notified within one month of the formal endorsement of the Sub-NFMS.

2.1.2.3 Provincial REDD+ Coordination Unit

The Provincial REDD+ Coordination Unit, is already established by the GB government and is to some extent functional. However, the unit has only three positions; a provincial REDD+ coordinator, a GIS specialist and an admin and finance officer. Under the current Sub-NFMS, a relatively stronger structure has been recommended, which will include;

- REDD+ Coordinator (existing)
- Forest Inventory Specialist (new)
- GIS/ SLMS specialist (existing)
- GIS Analyst (new)
- RS Analyst (new)
- IT Specialist (new)

Functions of the Provincial REDD+ Management Unit will include;

- Provincial REDD+ implementation and coordination
- Forest Inventory & SLMS data production, with the support of territorial staff of concerned forest divisions
- Quality Control of SLMS and Inventory data production
- Grievance Feedback & Redressal at provincial level

The provincial REDD+ Coordination unit will be strengthened and additional positions provided within 12 months of the endorsement of the Sub-NFMS.

2.1.2.4 District REDD+ Management Units

These are new bodies based on the available structures and positions at district and forest division level. The District REDD+ Management Units will comprise of; 1). Divisional Forest Officer (Chair); 2). District officers/ heads of all concerned line departments (members); 3). Representative of Revenue department s(member); 4). Representatives of local NGOs/ CSOs/ LSOs; 5). Key functions will include;

- District REDD+ implementation and coordination
- Grievance Feedback & Redressal at district level
- Provision of district and local level information and data on REDD+ including MBIGS

The District REDD+ Management Units will be formally notified within two months of the endorsement of the Sub-NFMS.

2.1.2.5 Provincial REDD+ Quality Assurance Committee

The Provincial REDD+ Quality Assurance Committee is a new body recommended under the Sub-NFMS. It will comprise of experts from PFI (as chair), and WWF, IUCN, KIU, UoBS, EPA (as members). Key functions

of the committee will be Quality Assurance and Independent Verification of REDD+ activities especially activities being carried out under the SLSM and FI including production of activity data, emission factors and carbon estimations. The Provincial REDD+ Quality Assurance Committee will be notified within one month of the endorsement of the Sub-NFMS.

2.1.2.6 Provincial GHG-I Unit

The Provincial GHG-I Unit is newly recommended unit under the current assignment. The unit will be established in GB EPA (as it is the focal organization for development and implementation of provincial climate change policies and strategies). The Provincial GHG-I Unit will comprise of Director EPA, Deputy Directors of EPA and technical experts from academia. Main function of the unit will be to prepare the GHG-Inventory of gases related to LULUC and Forestry Sector. The Provincial GHG-Inventory Unit will keep regular liaison with the Provincial REDD+ Coordination Unit. The provincial GHG-I unit will be formally notified within one month of the endorsement of the Sub-NFMS.

2.1.2.7 Provincial REDD+ Research Unit

Provincial REDD+ Research Unit is a new arrangement based on the existing structures. The Provincial REDD+ Research Unit will consist of key experts from Pakistan Forest Institute (PFI), Karakoram International University, University of Baltistan and NGOs (WWF, IUCN, AKRSP). Key functions will include conducting REDD+ related research and REDD+ related data sharing. The provincial REDD+ Research unit will be notified within three months of the endorsement of the Sub-NFMS.

2.1.2.8 Provincial REDD+ Thematic Working Groups

Four Thematic Working Groups (TWGs) are recommended under the Sub-NFMS; TWG for FRL/ FREL; TWG for Forest Inventory and MRV; TWG for SES/ GRM; and TWG for REDD+ Finance. These TWGs will comprise of; 1). Technical experts from GB Forest, Environment and Wildlife Dept; 2). Technical experts from NGOs; 3). Technical experts from academia, and; 4). Individual technical experts. Key functions of the TWGs will be; 1). Providing technical advice and support to the provincial REDD+ Steering Committee, and; 2). Providing technical advice and support to provincial REDD+ management committee; 3) provincial REDD+ Coordination Unit, and; 4). Provincial GHG-I Unit on their respective themes. The provincial REDD+ TWGs will be notified within two months of the endorsement of the Sub-NFMS.

2.2 Monitoring and MRV Function of the Sub-NFMS

The Sub-NFMS has two functions; 1) Monitoring Function and 2). Measurement Reporting and Verification of REDD+ activities and programs. The present Sub-NFMS will cater for both of these functions.

2.2.1 Monitoring and MRV Function of the Sub-NFMS

The monitoring function of the Sub-NFMS is to monitor the sustainability of forest management and forest policies at sub-national level through collection, assessment, evaluation, interpretation and reporting of data, generating of information and monitoring changes and trends over time. The monitoring function will be used as a domestic tool building on the existing systems to assess wider range of forest information including the impacts and outcomes of the REDD+ demonstration activities, and national and sub-national REDD+ policies and measures during the sub-sequent replication phases. The monitoring function of the Sub-NFMS will include assessment of indicators like forest uses, Non-Timber Forest Products (NTFPs), forest health, biological diversity, productive, protective and socioeconomic functions of forests, implementation of legal and policy frameworks, and forest governance etc., depending on the monitoring needs that are likely to evolve over time (MoCC, 2020; FAO, 2013). As a result of reviews and sub-national

level consultations several such indicators, the required information and data, the tools for assessment and the responsible institutions, units, offices were identified and are provided as part of this Sub-NFMS for monitoring and assessment of the non-carbon aspects of the REDD+ projects and activities.

2.2.2 The MRV Function of the Sub-NFMS

The MRV function of the Sub-NFMS will be based on the three pillars; 1). Satellite Land Monitoring System (SLMS): for collection and assessment of Activity Data of deforestation, forest degradation and enhancement over specific time period; 2). National/ Sub-National Forest Inventory: for collection and analysis of information and data about forests and associated parameters for assessment of carbon emissions and removals and development of emission factors and; 3). National/ Sub-National GHG Inventory: a tool for reporting on anthropogenic forest-related GHG emissions by sources and removals by sinks (FAO, 2013).

2.3 Approach adopted for the development of the Sub-NFMS

The approach adopted for the development of the Sub-National Forest Monitoring Systems included; 1). detailed literature review regarding definition of forest degradation, SLMS, Forest Inventory and, institutional and monitoring frameworks for the Sub-NFMS and MBIGS; 2). Revised frameworks for SLMS and Forest Inventory and manuals, and draft definition of forest degradation; 3). Inception workshop and sharing of methodological frameworks, and national definition of forest degradation; 3). Holding of Sub-national level stakeholders' consultations; 4) trainings on forest inventory protocols; 5). Conducting of forest inventories, entry and analysis of FI data, and development of Emission Factors; 7). Acquisition, and processing of satellite data and development of activity data (deforestation, enhancement and forest degradation); 8). Presenting findings to the National REDD+ Steering Committee; 9). Holding of national validation workshop and sharing of activity data, emission factors, carbon stocks, and Sub-NFMS and MBIGS monitoring frameworks, and; 10) Writing of the MBIGS and Sub-NFMS reports.

2.4 Methodological Framework for Satellite Land Monitoring System (SLMS)

Satellite Land Monitoring System (SLMS) is a key component of the National and Sub-National Forest Monitoring Systems. The objective of the SLMS is to assess and collect continuous Activity Data (AD) resulting from Land Use and Land Cover Change due human activities. The SLMS will contribute information for both the monitoring function of the Sub NFMS and carbon stock assessment. Under the current assignment the SLMS design, implementation and operationalization process has been mainly adopted from the process adopted for the SLMS during the development of the NFMS, 2020. However, new method of Spectral Mixture Analysis (SMA) for assessment of forest degradation was adopted from literature. Table 1 below summarizes this process. In addition to tracking land use and land cover changes, the SLMS will also support tracking and analysis of the drivers of deforestation and forest degradation to design REDD+ actions and monitor their effectiveness. As identified during the NFMS, 2020 information on the drivers of deforestation and forest degradation from different sources will be collected, verified and analyzed by SLMS. Drivers of deforestation and forest degradation, source of information and verification have been adopted from the NFMS, 2020 and provided as Annex-2.

Table 1: Summary of process adopted for the design of SLMS for the Sub-NFMS

Steps	Process	Outcome/Design Decisions
Step 1	• Definition of reference monitoring periods for LULC Change Assessment and AD	• 2016 and 2020 at 4 years interval

Steps	Process	Outcome/Design Decisions
Step 2	• National Definition of Forest and its endorsement • Development of National definition of 'Forest Degradation' Determining harmonized Land Use Categories • Determining harmonized sub-classes for forest (forest types) • Determination of Minimum Mapping Unit (MMU)	• Forest Definition Notified • IPCC land use classes • Minimum mapping unit (0.36 hectares equaling to 2 x 2 pixels in Landsat imagery)
Step 3	• Compilation of existing RS data • Identification of data gaps	• Mid-resolution Landsat imagery (cloud free) • Use of +/- 2 years normalized years for data gaps • Use of available secondary imageries e.g., Spot 5, Sentinel 2 and others
Step 4	• Defining accuracy targets and QA/QC protocols for RS interpretation and analysis	• >80% overall and class wise producers' accuracies with area estimation at 95% confidence Interval
Step 5	• Determining LULUC categories (LU conversion)	• Forest remaining as Forest • Cropland, Grassland, Wetland, Settlement, Other Land converted to Forest • Forest converted to Cropland, Grassland, Wetland, Settlement, Other Land • Cropland, Grassland, Wetland, Settlement, Other Land remaining as the same classes • Cropland, Grassland, Wetland, Settlement, Other Land converted to others
Step 6	• Designing stratified sampling technique for RS classification and areas estimation • Developing method for stratification of samples (visual interpretation) and QA/QC of visual interpretation method • Developing protocol for visual interpretation	• 10'x10' systematic grids throughout the country • Densified at 5'x5' and 2.5'x2.5', 1.25'x1.25' and 0.625'x0.625' at provincial levels as necessary to attain defined accuracy targets • OpenForis Collect Earth GUI developed for visually interpreting • Visual interpretation protocol document
Step 7	• Designing and piloting RS processing method (desktop based and/or cloud based) • Developing protocol and methodology document for RS processing and analysis for LULUC for reference years • Developing methodology for mapping and estimating forest degradation	• Free and Open-Source Software (FOSS) platform using QGIS, Orfeo Toolbox and limited Python/R Programming • Non-parametric regression models such as Random Forests for land use mapping, kNN forest biomass estimation,

Steps	Process	Outcome/Design Decisions
	• Developing methodology for mapping forest types • Developing methodology for estimating aboveground woody biomass and other forest parameters • Integration of NFI field data for mapping and modeling, validation and accuracy assessment	• Pixel based analysis for land use change using Multivariate Alteration Detection and other algorithms • NFI (harvest/disturbance) data and complementary visual canopy analysis on VHR imagery for degradation assessment

2.4.1 Key Decisions of Definitions

Major decisions regarding definitions of forest and forest degradation were made during the development of the NFMS and Sub-NFMS. These are elaborated as following.

1). Development, endorsement and notification of the National Definition of Forest (2017). "A minimum area of land of 0.5 ha with a tree crown cover of more than 10 % comprising trees with the potential to reach a minimum height of 2 meters. This will also include existing irrigated plantations as well as areas that have already been defined as forests in respective legal documents and expected to meet the required thresholds as defined in the national forest definition of Pakistan" (MoCC, 2020). Notification of the National Definition of forest is given as Annex-3

2). Development, endorsement and notification of the National Definition of Forest Degradation (2021). This definition was drafted and finalized under the current assignment of Sub-National Forest Monitoring System. The definition of forest degradation was developed as a result of detailed literature review and consultative process both at sub-national and national level. The degradation is defined as "Human induced long-term losses within forest persisting of at least four years or more due to changes in canopy cover i.e., open (11-30%), sparse (31-50%), medium (51-70%), dense (>70%) resulting in reduction in forest carbon stock and not qualifying as deforestation". Notification of the National Definition of forest degradation is given as Annex-4.

3). Methodology for assessment of the forest degradation as per the national definition of forest degradation was developed and agreed during the current assignment of developing the Sub-NFMS. The methodology is based on Spectral Mixture Analysis (SMA), which was piloted for the first time in Pakistan. The SMA is a technique for estimating the proportion of each pixel that is covered by a series of known cover types. The SMA model decomposes proportional cover based on the reflectance of 'end-members' or pixels containing 100% of the land cover types of interest. Both the SMA and time series analysis are combined to detect forest degradation.

4). Selection of base-year for forest degradation: It was agreed during the inception workshop that the baseline year will be decided on the bases of analysis of the satellite data for 2004, 2008, 2012, and 2016. Accordingly, the analysis was carried out and based on the findings the baseline of 2016 was selected for assessment of forest degradation. For forest degradation, the baseline data is forest cover. The forest degradation statistics are affected if the forest cover is over/underestimated. During the project's initial phase, 2004, 2008, and 2012 forest covers were carefully spatially and statistically evaluated and observed inconsistency among themselves. In the given assignment, the 2016 and 2020 land/forest covers were produced and validated through three methods; 1. The statistical method using collected ground truth samples from the Google Earth very high-resolution satellite images, 2. Consultative workshops with the

key stakeholders and end users (e.g., Forest Department) provided critical remarks and feedback for the correction and modification of land cover maps, and 3. Statistical and spatial comparison with developed land cover maps at the global and local scales in recent years. Based on the validation, the 2016 forest cover data was considered the baseline for forest degradation. Near to realistic ground findings, the forest degradation change assessment was carried out at the provincial and national scale from 2016 to 2020.

2.4.2 Harmonization of Existing Definitions

Decisions regarding harmonization of national forest stratification and existing land use categories to the 6 IPCC land use categories (forestland, cropland, grassland, settlement, wetland, other land) were made during the NFMS development process in 2016-2020. These were adopted with slight modification for the current assignment of the Sub-NFMS development (Table 2).

Table 2: National Forest type stratification with adjustments

Climate Zone	Ecological Zone		Adjustments made during the Sub-NFMS process
	Main Ecological Zone/ Forest Type	Sub-Ecological Zone/ Forest Type	
1. Tropical	1.1 Littoral and swamp forest	1.1.1 Mangroves	
	1.2 Tropical dry deciduous		
	1.3 Tropical thorn forest		
	1.4 Riverain forests		
2. Sub-Tropical	2.1 Sub-tropical broad-leaved evergreen forests	2.1.1 Montane sub-tropical scrub Forests	Combined as scrub forests
		2.1.2 Sub-tropical broad-leaved forests	
	2.2 Sub-tropical pine forests		
3.Temperate	3.1 Moist Temperate Forests		
	3.2 Dry Temperate Forests	3.2.1 Montane Dry Temperate Coniferous Forests	Combined Dry Temperate Coniferous, Dry Temperate Broad-leaved Forests and Northern Dry Scrub Forests as Dry Temperate Forests
		3.2.2 Dry temperate Juniper and Chilgoza Forests	
		3.2.3 Dry Temperate Broad-leaved Forests	
		3.2.4 Northern Dry Scrub	
4. Alpine	4.1 Sub-Alpine Forests		
	4.2 Alpine Scrub		
5. Plantation	5.1 Linear Plantations	5.1.1 Road side plantations	
		5.1.2 Railway side plantations	
		5.1.3 Canal side plantations	
	5.2 Irrigated Plantations		

Land use categories other than forest land were discussed and harmonized in the Thematic Working Group's meetings during the NFMS development process in 2016/2020. Following broader land use categories of IPCC were further defined in the context of NFMS and FRL/ FREL in Pakistan (Table 3).

Table 3: Harmonization of Other Land Use categories

Other Land Use Categories	Definitions/Descriptions
Cropland	This category includes arable and tillage land, and Agroforestry systems where vegetation falls below the thresholds used for the Forest Land category, consistent with the selection of national definitions.
Grassland	This category includes rangelands and pastureland that is not considered as Cropland. It also includes systems with vegetation that fall below the threshold used in the Forest Land category and which are not expected to exceed, without human intervention, the threshold used in the Forest Land category. The category also includes all Grassland from wild lands to recreational areas as well as agricultural and silvo-pastoral systems, subdivided into managed and unmanaged consistent with national definitions.
Wetlands	This category includes land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. The category can be subdivided as "managed" and "unmanaged" according to national definitions. It includes reservoirs as managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
Settlements	This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.
Other land	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data is available.

Source: MoCC. 2020. National Forest Monitoring System –Measuring, Reporting and Verification- Final Report.

As provided under the NFMS and National FRL/ FREL 2020, the land use and land cover reporting will be updated every four years. A permanent land use and cover change could be declared when the forest has not been restored by the end of the following 4-year monitoring period (MoCC, 2020).

2.4.3 Satellite Imagery Data for LULUC and Continuous Forest Monitoring

During the NFMS development phase use of freely available cloud-free Landsat-8 Collection 2 Level 2, Tier1 for 2016 & 2020 optical satellite imagery was agreed to be used for the land use and land cover mapping (Figure 2). These images were acquired for the post-monsoon season months between September-November.

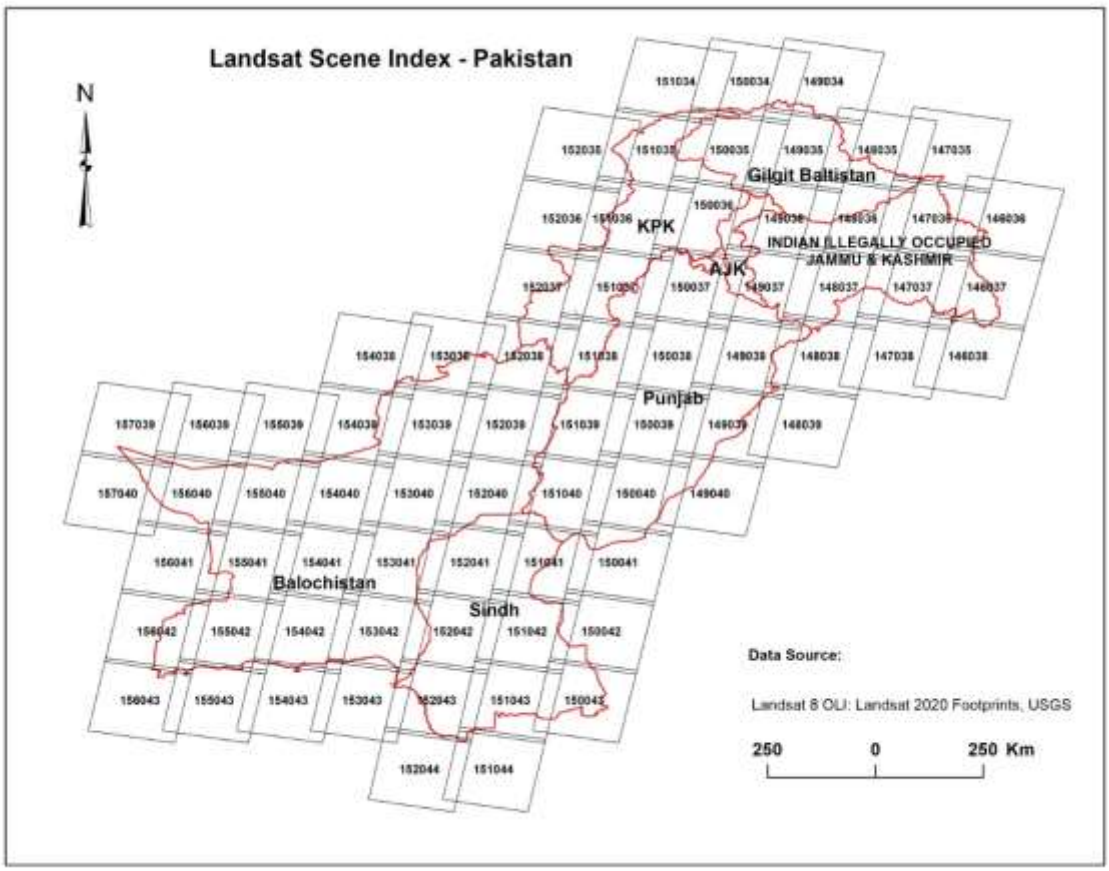


Figure 2: Landsat image scenes covering the territory of Pakistan

2.4.4 Design of Desktop Based SLMS Workflow

The NFMS 2020 also recommends using desktop-based workflow for implementing Forest Land Assessment as a part of SLMS in Pakistan (Figure 3). Moreover, Free and Open-Source Software (FOSS) is recommended, like Quantum GIS (QGIS), Orfeo Toolbox, SAGA processing tools in QGIS, and FAO OpenForis Collect Earth along with the Google Earth engine plugin to be used in QGIS. For the current assignment desktop-based workflow and QGIS and OpenForis Collect Earth were used for the Forest Land Assessment under the SLMS.

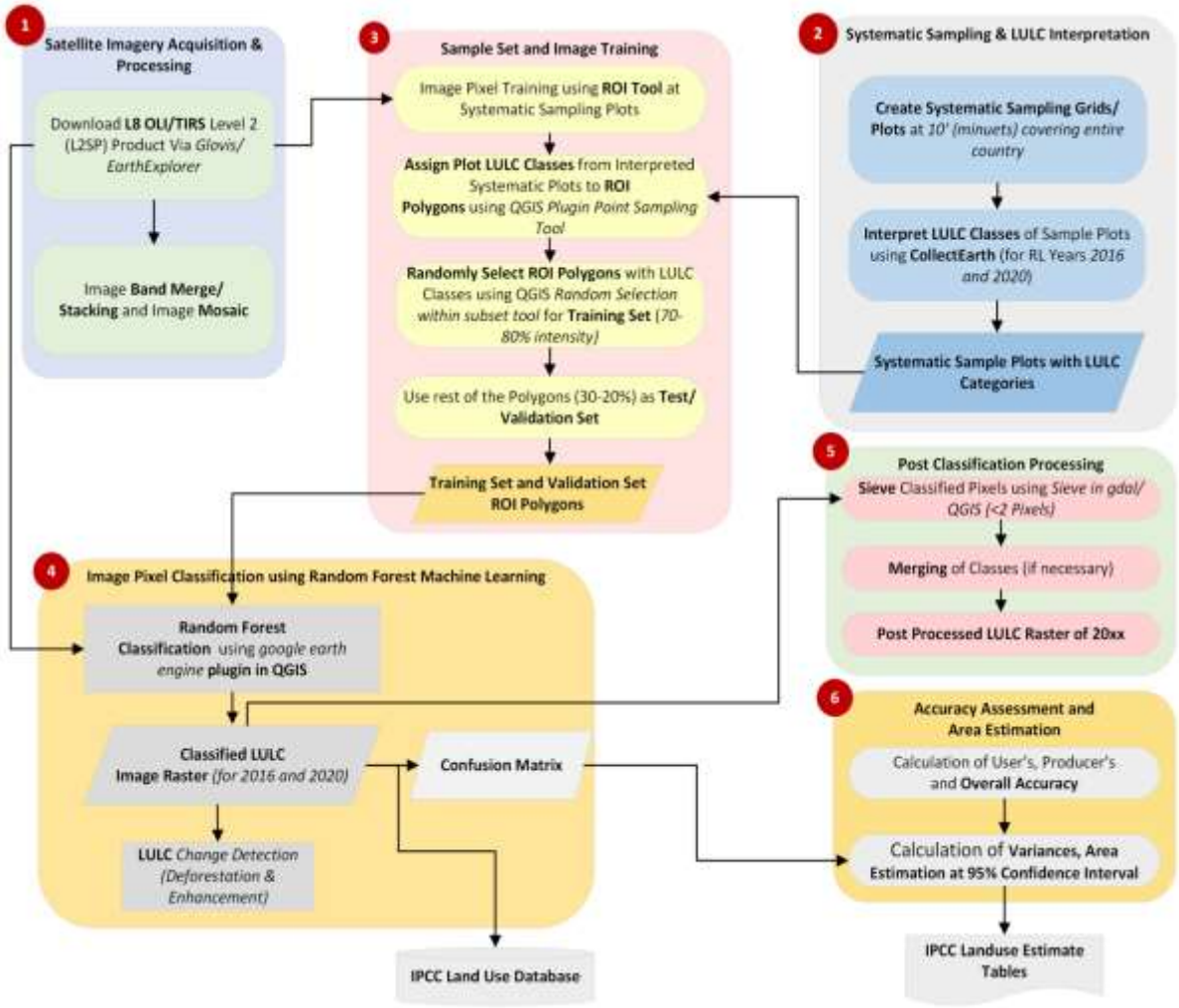


Figure 3: Workflow for desktop based SLMS for forest land and activity (Source: MoCC. 2020. National Forest Monitoring System – Measuring, Reporting and Verification Final Report.)

2.4.5 Land Use, Land Use Change Analysis

For the land use, land use change analysis, the Random Forest machine learning algorithm was applied to the freely available cloud free Landsat-8 images of 2016 and 20120, respectively. For training and validation of land use, land use map, systematic sampling of plots to be visually interpreted using OpenForis Collect Earth tool. Each map's accuracy was assessed using the error matrix method while change matrix method was applied for land use, land use change between 2016-2020. At the province level statistics were computed and provided for the Forest Emissions (Deforest, Forest Degradation and Enhancement). The details of each step followed are given under following sub-headings.

Process 1: Satellite Imagery Acquisition and Processing

Activity data mapping is based on the Land Use and Land Cover classification using Landsat-8 imagery for the reference years 2016 and 2020. Top-of-Atmosphere (TOA) calibrated reflectance, Landsat-8 L2SP (Collection 2, level 2, and Tier 1 Science Product) cloud-free (less than 10%) images were downloaded from the USGS Earth Explorer web portal using https://earthexplorer.usgs.gov.

Post-monsoon season (September-November) satellite images were acquired for the classification. A total of 65 Landsat-8 scenes (185 x 185 km each) cover the country. 130 Landsat-8 images (65 for reference year 2016 & 65 for 2020) were downloaded (Table 4). Each Landsat-8 Operational Land Imager (OLI) spectral bands (Blue, Green, Red, NearInfrared, Shortwave InfraRed) were stacked in QGIS, and ultimately all the overlaying scenes were mosaiced at the province level (Table 5).

Table 4: Details of the Landsat-8 images downloaded for one Year

Path	Rows										Total
	34	35	36	37	38	39	40	41	42	43	
147		1	1								2
148		1	1		1						3
149	1	1	1	1	1	1	1				7
150	1	1	1	1	1	1	1	1	1	1	10
151	1	1	1	1	1	1	1	1	1	1	10
152		1	1	1	1	1	1	1	1	1	9
153					1	1	1	1	1	1	6
154					1	1	1	1	1	1	6
155						1	1	1	1	1	5
156						1	1	1	1	1	5
157						1	1				2
Total	3	6	6	4	7	9	9	7	7	7	65

Province wise mosaics were developed in QGIS to use for the classification. More than 130 images were processed and mosaicked (Table 5).

Table 5: Province wise Landsat-8 images processed for Classification

Province	Images for 2016/ 2020
AJ&K	4
Balochistan	33
Gilgit Baltistan	12
Khyber Pakhtunkhwa	13
Punjab	17
Sindh	14

Process 2: Systematic Sampling Design and Land Use and Land Cover Interpretation

Systematic 10'x10' or 5'x5' sample grids were generated to collect the training and validation samples for classification. Visually interpretation for IPCC Land Use six classes (Forest, Cropland, Grassland, Wetland, Settlement, Other land) was done using very high-resolution (VHR) satellite imagery from the Google Earth, False color composites of Landsat-8 and Sentinel-2 and their time series vegetation analysis available in FAO's OpenForis Collect Earth tool. For Forest plots, sub-plots with tree cover were counted to estimate tree cover in the plot. Observable disturbances in the plot were also interpreted in the VHR images, which mainly include: Logging, Fire, Grazing, Landslide, Tree Plantation, Shifting Cultivation, Construction and others. Total 4514 visual squared plots with 50x50-meter dimensions were sampled and visually interpreted better to represent six land use and cover types. During the image classification, wherever misclassification or low intensity against any particular class were observed, a total of 1,418

manual training samples were added to systematic samples of all the six Land Use and Land Cover classes. Table 6 gives province wise number of interpreted plots.

Five GIS analysts/ operators were involved in the original interpretation process for different years of assessment, and interpretation results were cross-checked by two GIS experts and the forest experts in the team. The supervisors harmonized all the conflicting observations detected in and between the developed maps in 2016 and 2020.

Table 6: Province wise number of interpreted plots and plots density

Province Name	10x10 Interpreted Plots	5x5 Interpreted Plots	Manually added plots	Total interpreted plots
AJ&K	48	194	55	249
Balochistan	1138	-	762	1900
Gilgit Baltistan	358	-	-	358
Khyber Pakhtunkhwa	246	-	184	430
Punjab	701	-	405	1106
Sindh	459	-	12	471
Total	**3096**	**194**	**1418**	**4514**

Process 3: Designing Sample Set for Image Training

Satellite image classification was carried out using the Google Earth Engine (GEE) Plugin in QGIS. Region growing algorithm in QGIS was used to generate the Region of Interest (ROI) polygons from interpreted plots termed as seeds. The minimum area of ROI was set at 2 pixels. In contrast, the maximum size was 10 pixels to generate the ROIs. These ROIs delimited the spectral signature information against each sample using the SCP Plugin. The analysts have selected a representative training set sample with regions of interest (ROI) for training image pixels for Land Use and Land Cover classification. 70% of the generated ROIs were used as training samples and 30% for the accuracy assessments.

Process 4: Image Classification

Random forest is a robust and powerful machine learning algorithm adopted for image classification. The scientific community widely uses Random Forest due to its capabilities for earth observational studies (Belgiu et al. 2016). Random Forest is a non-parametric regression model capable of using continuous and categorical data, is non-sensitive to overfitting, can handle outliers in training data, and calculates ancillary information such as classification error and variable importance.

The Random Forest algorithm is based on an ensemble model that uses the results from many different models to calculate the outcome. In Random Forest, a large number of decision trees are created by randomly selecting a subset of the training data. The result is calculated based on the majority outcome of all decision tree classifications. The Random Forest approach has numerous applications in remote sensing, such as forest carbon pool estimation, land cover and land use application, urban area mapping, etc. (Immitzer et al. 2012). Whether majority voting calculates the random forest algorithm's final result in categorical data (e.g., land cover classes) or by calculating the average in the case of continuous data (e.g., carbon storage).

We used the Google Earth Engine plugin in QGIS to perform the classification process iteratively. This plugin, which is free and open source, allows the user to perform the same tasks that can be done on the web-interface platform of Google Earth Engine. This plugin requires installing the Python environment on the system (https://www.python.org/). The plugin can be downloaded using the link (https://plugins.qgis.org/plugins/ee_plugin/).

Process 5: Post Classification Processing on Land Use and Land Cover Maps

Post-classification processing in terms of Minimum Mapping Unit (MMU) was applied to each classified data to remove noise such as 'salt and pepper' effects. This was done by "sieving" tool available in QGIS which isolated pixels and replaced them with the surrounding majority class pixels. The threshold for sieving was set to two pixels for Land Use Land cover maps. At local scale, all the relevant Forest department GIS labs were contacted and the data was shared for the accuracy assessment and error removal, whereas on the Global level, Sentinel data was also used as a reference for improving accuracy. In addition, feedback from provincial forest departments was obtained during validation consultations using field inventory data and experts' ground knowledge. Based on feedback, misclassifications in the land use and land cover classification map were identified and corrected manually.

Process 6: Accuracy Assessment and Area Estimations

Accuracy assessment and area estimation of the Land Use and Land Cover maps were conducted using the sample of reference observations of the study area. The basic assumption is that the mapped land cover areas are biased because of image classification errors, which were identified by comparing the map to a sample of reference observations (Olofsson et al., 2014).

Out of total, approximately 30% random samples were selected for the accuracy assessment of classified images of 2016 and 2020. In the QGIS post-processing tool "Accuracy" was used to obtain the result and generate the standard error matrix for Land Use and Land Cover analysis. The area estimation of each IPCC class was generated using the classification report tool. Due to classification errors, these areas can be biased and may not correctly represent the true land cover. To adjust these areas, the standard guidelines of REDD+ were followed using referenced samples, representing an accurate estimation of each class's cover areas. The forest area of each province was calculated by keeping in mind the standard approved definition of the forest and forest areas were validated with the support of inventory data and forest representatives of each administrative unit.

Process 7: Land Use and Land Cover Change Assessment

Deforestation activity data generation is based on the visual plots interpreted for the Land Use and Land Cover statistics and analyzed with GIS raster analysis operations. A hotspot layer, indicating the potential locations for deforestation, was produced. The objective of this layer was to calculate statistics on area changes there have been converted from forest to other land use categories. For the accuracy assessment and change matrix, systematically interpreted plots (over 3,096 plots) and some additional randomly sampled visual interpretation plots (1,418 plots) were investigated. The deforestation area proportions (percentages) by forest types was derived by using the hotspot maps.

For accuracy assessment and permanence check, the final maps were interpreted/checked with the support of experienced provincial forestry field officials with good ground knowledge, who could judge if the forest cover loss was permanent. Pixel-based change detection was conducted using a change matrix with the spatial distribution. A sieve tool with 5 pixels was applied to the deforestation raster to extract the rate of deforestation and enhancement at the national as well as sub-national levels.

2.4.6 Forest Degradation mapping and change assessment

The same preprocessed Landsat-8 images were used in Google Earth Engine for forest degradation mapping using the Spectral Mixture Analysis (SMA). End members were defined as the pure component of Forest, Water, and Others. Based on designated end members, the images were converted into fractional cover. The fraction cover of the forest class was separated from the other two defined categories (Water and Others). The forest fraction data were masked based on produced forest cover data from 2016 and 2020, which were categorized into forest canopy cover, i.e., open (11-30%), sparse (31-50%), medium (51-70%), dense (>70%). The field-collected forest inventory data were used to assess forest degradation accuracy. A cross-tabulation module was used for change detection between years (2016-2020). Figure 4 illustrates the method and process followed for forest degradation mapping and change assessment.

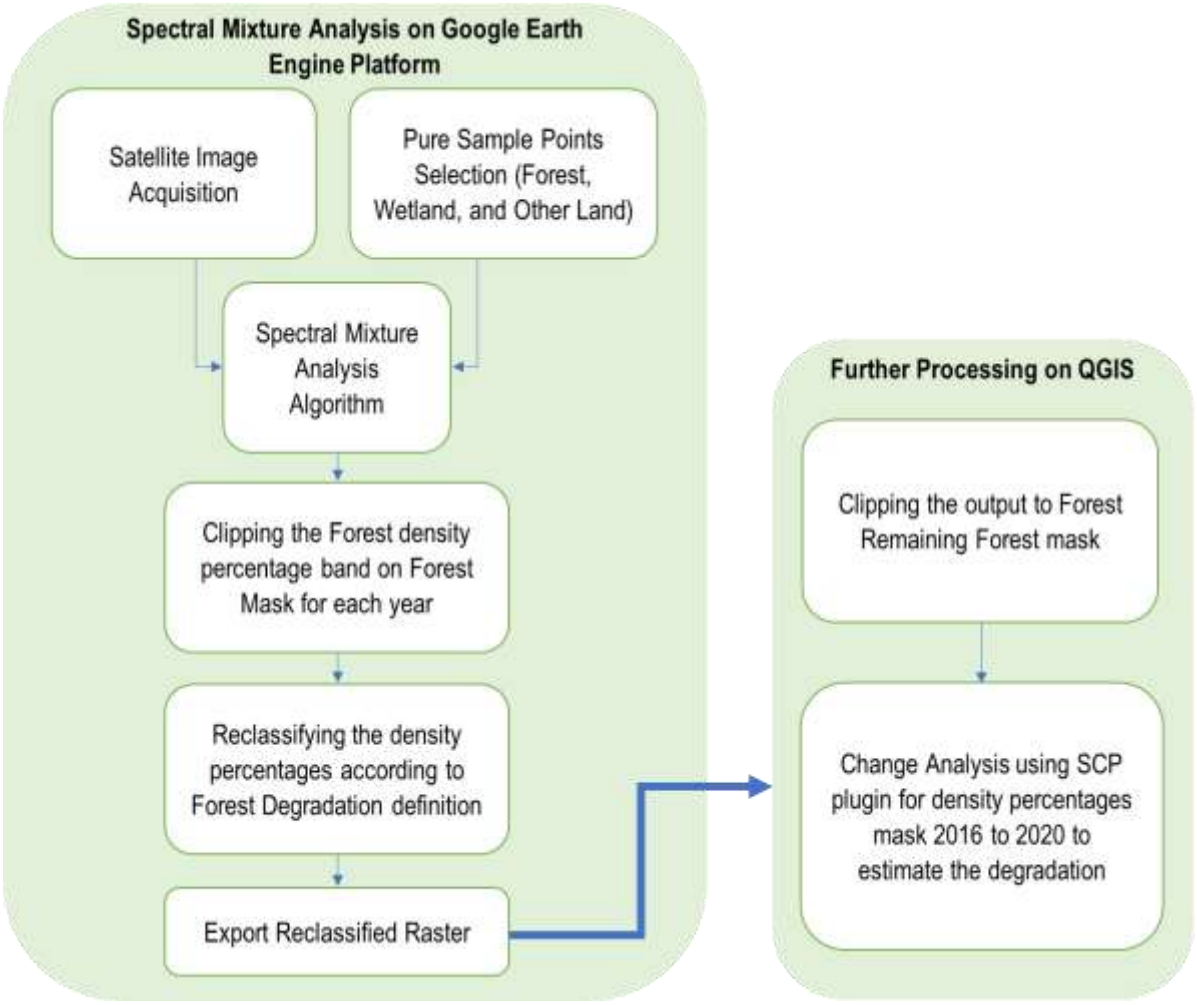


Figure 4: Workflow of forest degradation mapping and change assessment

2.5 Methodological Framework for National Forest Inventory (NFI)

The objective of the Provincial Forest Inventory is to collect reliable data to estimate the Emission/Removal Factors (EF/RF) for various forest strata of each province/region (MoCC, 2020). The methodological framework developed and used for the pilot National Forest Inventory 2018 was adopted

with several modifications for the forest inventory conducted under the current assignment. The design of the current Provincial Forest Inventory is based on the previous inventory, existing capacities and the requirement for developing reliable data on emissions and removal factors. Moreover, it followed a stepwise participatory process to conduct the forest inventory. Similar process and approach were followed for the national forest inventory conducted under this assignment. The inventory design included sample design, layout of sample plots and collection of data, quality assurance and quality control, storage and processing of inventory data. The inventory design process and steps are given in Table 7.

Table 7:Forest Inventory design process

Steps	Sub steps
1. Sampling scheme and mapping	• Calculation of the number of plots • Consultation with the National REDD+ Office and Provincial Focal Points and finalization of the number and layout of sample plots • Adjustment and finalization of number of plots and maps
2. Training and team building for the National Forest Inventory at Sub-National level	• Trainings of the provincial forest departments' officials in the forest inventory techniques and protocols in each province including AJK and GB; • Training of the young forestry graduates and professionals in Quality Control and Assurance protocols and procedure (German Consultants) • Trainings of young forestry graduates in data entry and cleansing (German Consultants) • Development of forest inventory (surveyors) and data entry and management teams: Developed three teams in each province having a combination of young forestry graduates and concerned forest departments filed staff.
3. Review and updating of the National Forest Inventory Manual	• Review and updating by the National Consultant • Review of the updated manual by the international consultants • Urdu translation of the manual
4. Execution of forest inventory	• Collection of field data • Review and cleansing of data forms • Development of new diameter-height models for major tree species • Collection of control data in 10% clusters (tree and dead wood data were collected in the PSUs) • Regular consultation and updating of the NRO and concerned forest department officials including the REDD+ focal points
5. Data entry, cleansing and processing	• Data entry on OF Collect (data entry forms designed by the German Consultants) • Data cleansing using both the exported excel files and OF data entry sheets; • Data analysis in Power BI software • Uncertainty analysis

2.5.1 Sample Design

The sampling scheme was designed using the stratified two-phase sampling approach with integration of the SLMS process. During the first phase a systematic grid of 10'x10' was generated which was used for visual interpretation of land use and forest cover analysis. During the second phase 10'x10' grid was adjusted to 5'x5'/2.5'x2.5'/1.25'x1.25 according to the provincial level forest mask to determine the number of sample plots and accessibility criteria. The stratification was done on the basis of forest types using the forest mask (2012) and the forest type boundaries developed during the pilot NFI 2018. The

two-phase sampling process, the number of sample plots calculated and stats applied during the sample plots calculations are given in Table 8 below and Figure 5, Figure 6 and Figure 7. The sample design included the following steps.

- Systematic generation of 10' x 10' grids (at national level)
- Adjustment of grids to provinces and forest types (5' x 5', 2.5' x 2.5', 1.5' x 1.5'). The 10' x 10' grids, when did not fit according to the number of sample plots, the forest types then the girds were adjusted accordingly to (5' x 5', 2.5' x 2.5', 1.5' x 1.5').
- Calculation of province and forest type wise number of sample plots on the basis of mean biomass and standard deviation using the Win Rock Sample Plot Calculator. The mean biomass and standard deviations were taken from the NFMS data 2018. Forest types were used as forest strata and the province and forest type wise areas were taken from the 2012 forest mask and forest statistics.
- A total of 465 plots (93 clusters) were initially decided for forest inventory in GB (Table 8). However, due to issues of accessibility during winter as well as limited time available for the assignment a total of 239 plots (57 clusters) could be surveyed.
- Plotting of sample plots on maps (province wise and forest wise). Used the 2012 forest mask (cover map) for laying out and mapping of the sample plots.
- Repeating previous inventory plots. The sample plots of 2018 forest inventory as well as the provincial forest inventories in KP, GB and Punjab were repeated.
- Development of province wise, district wise and cluster wise maps of sample plots.

Table 8: Province wise number of sample plots

Forest Type/Strata	KP		GB		AJK		Punjab		Sindh		Balochistan		Total	
	Plot	Cluster	Plot	Cluster	Plot	Cluster	Plot	Cluster	Plot	Cluster	Plot	Cluster	Plot	Cluster
Sub-Alpine	15	3	55	11	15	3	0	0	0	0	0	0	85	17
Dry Temperate	91	18	410	82	20	4	0	0	0	0	200	40	721	145
Moist Temperate	225	45	0	0	150	30	15	3	0	0	0	0	390	78
Pine	100	20	0	0	35	7	135	27	0	0	0	0	270	54
Scrub	15	3	0	0	25	5	85	17	15	3	15	3	155	31
Thorn	15	3	0	0	0	0	20	4	55	11	15	3	105	21
Riverine	0	0	0	0	0	0	15	3	60	12	0	0	75	15
Mangrove	0	0	0	0	0	0	0	0	60	12	15	3	75	15
Irrigated Plantations	0	0	0	0	0	0	100	20	50	10	0	0	150	30
Total	461	92	465	93	245	49	370	74	240	48	245	49	**2,026**	**406**

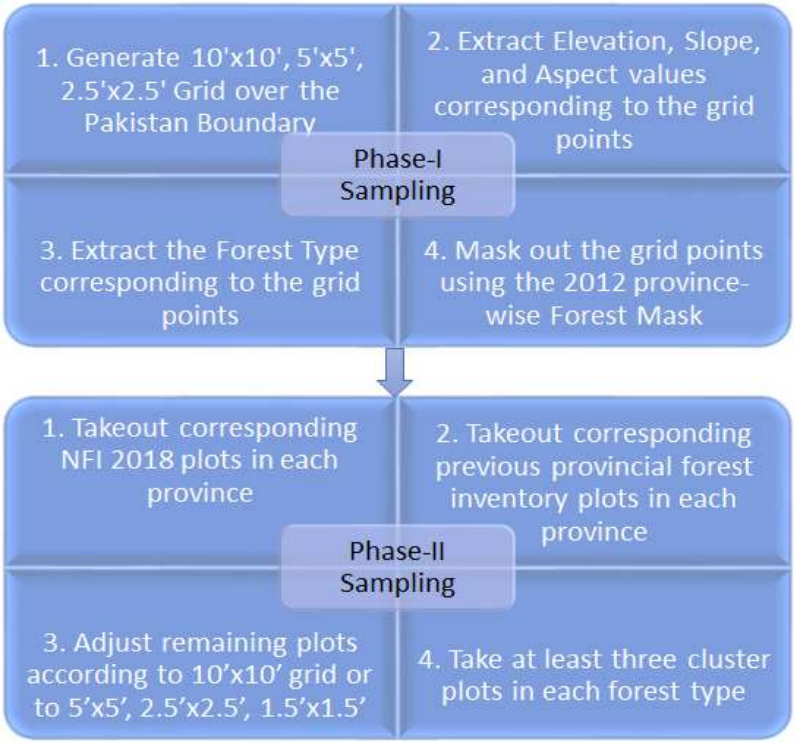


Figure 5: Stratified two-phase sampling process with integration of the SLMS process

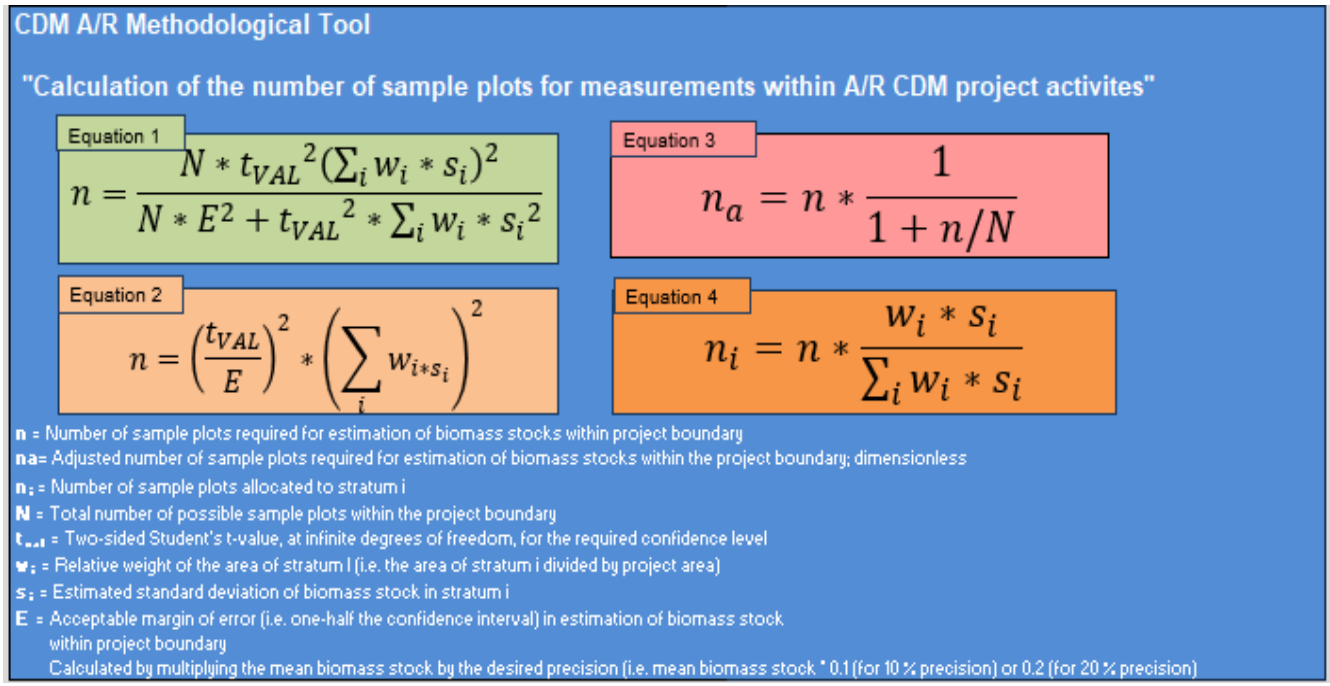


Figure 6:WINROCK Sample Plot Calculator Spreadsheet Tool (Source: https://winrock.org/document/winrock-sample-plot-calculator-spreadsheet-tool/)

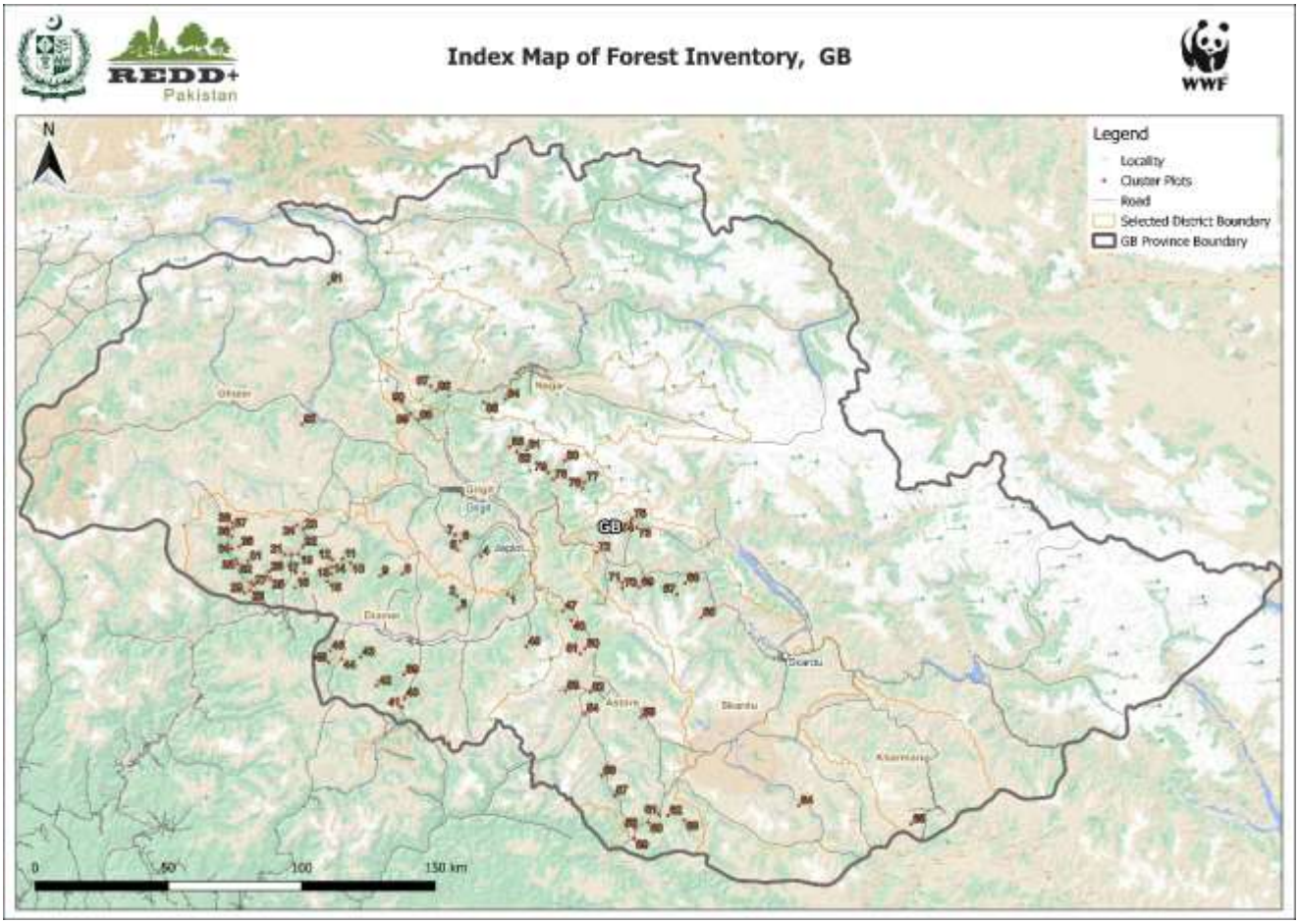


Figure 7: Distribution of sample plots in GB

Cluster sample design as adopted during the pilot National Forest Inventory, 2018 was followed to have consistency with previous inventory (MoCC, 2020). A cluster sample plot comprises of five subunits or sub-plots; a Primary Sub Unit (PSU) situated at the center of the cluster and four Secondary Sub Units (SSUs) located at the four corners 200 meters apart from each other (**Error! Reference source not found.**). Each sub-unit or sub-plot comprised of three concentric circular plots; 1). A plot with a radius of 17.84 meters (~1000 m^2) for measuring all living trees and standing deadwood stems with DBH1 above 5 cm; 2). A sub-plot with a radius of 5.64 meters (~100 m^2) for counting seedlings and measurement of shrubs, and; 3). A sub-plot with a radius of 0.56 meter (~1 m^2) for measuring and taking above-ground non-tree, litter and soil samples (Figure 8). Complete workflow of the forest inventory is given in Figure 9.

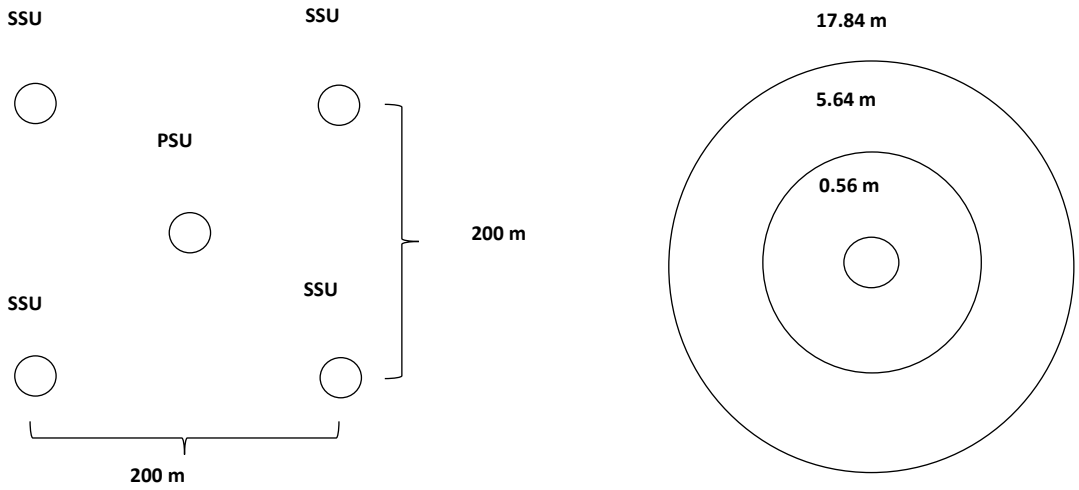


Figure 8: Clustered primary and secondary sample units (plots). Source: NFMS Report, 2020

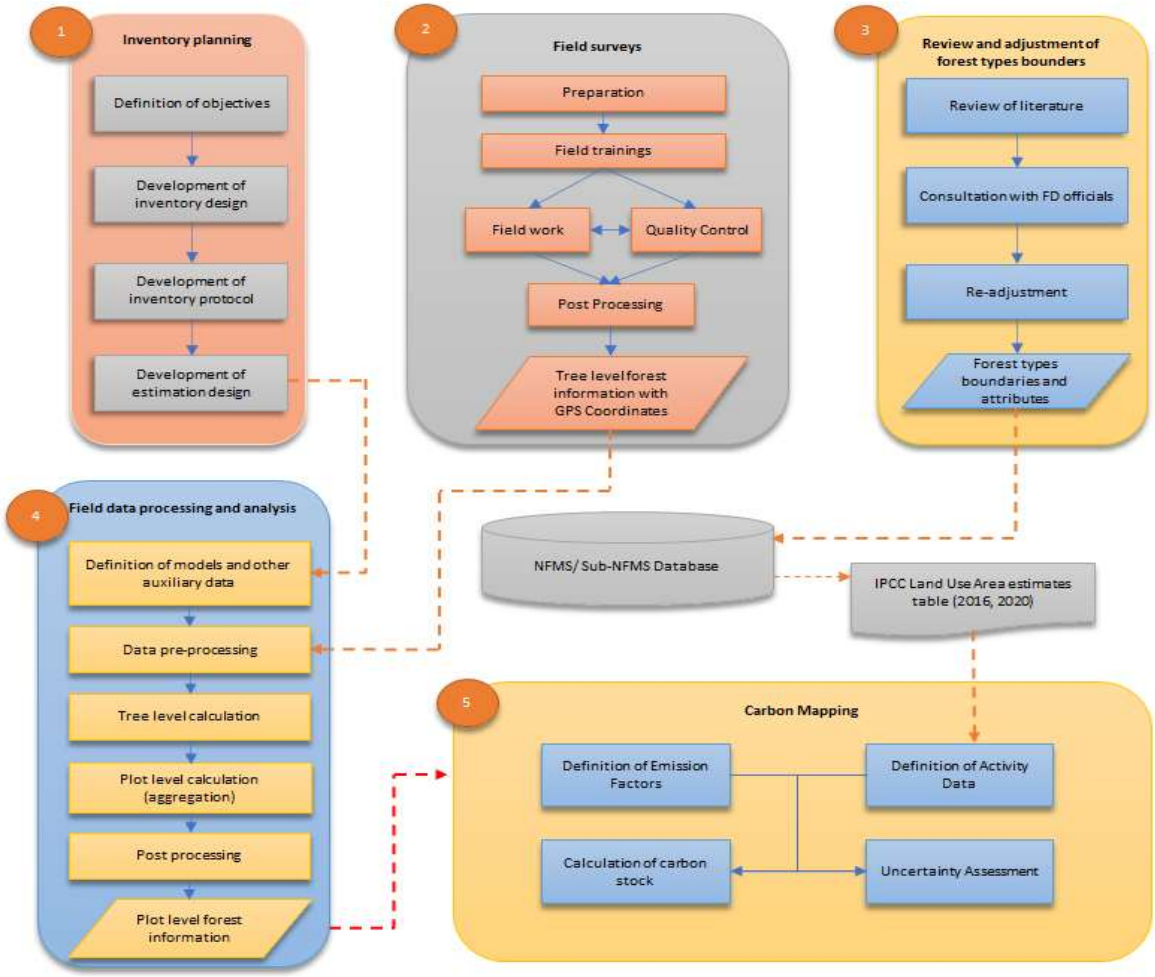


Figure 9: Forest Inventory Workflow (Source: adopted from NFMS-MRV Report, MoCC, 2020)

2.5.2 Sub-National Forest Inventory protocol and quality assurance

The Sub-National Forest Inventory Protocol were mainly adopted from the National Forest Inventory Manual developed during the NFMS development in 2017-2020 with minor adjustments according to the new situation. The protocol mainly consisted of; 1) formation of field teams (team leader and members, and their duties); 2) Proper field measurements and collection of samples during the field work (general information of the plot i.e., coordinates, elevation, aspect, slope, disturbance etc., measurement of tally trees, measurement of sample trees, measurement of dead wood, litter, shrubs and regeneration, and soil, and taking samples for lab test); 3) Quality Control and Quality Assurance during the forest inventory as well as the post inventory data entry, cleansing and processing phases.

2.5.2.1 Forest Inventory protocol

Due to limited time available for the forest inventory a total of 12 teams (two teams for each province/ administrative unit) were established. Each team consisted of five members with two forestry graduates engaged by WWF-Pakistan or provided by the concerned forest department, and three forester/ forest guard level field staff from the concerned forest departments. National and provincial level trainings were conducted for the field teams on forest inventory protocols (one at national level for the forestry graduates and six at provincial level for the forest department staff (one in each province/ administrative unit). Table 9 below gives details of field teams established for the forest inventory under the current assignment. For quality control and quality assurance a separate team of three members was constituted and trained in Quality Control protocol.

All carbon pools i.e., Above Ground Biomass, Below Ground Biomass, Dead Wood, Litter & Shrubs and Soil Organic Carbon were considered during the current forest inventory and development of the Sub-National Forest Monitoring Systems. Following protocols for measurements were considered during the forest inventory. Detailed protocols are provided in “Revised Forest Measurement Manual, 2022” (Annex-5).

- Cluster Information (Primary Sampling Unit)
    - Time log (starting time and reaching time)
    - Coordinates of waypoints
    - GPS coordinates of PSU location
- Plot information and Land Use
    - Measurement Time Log
    - GPS Coordinates
    - Terrain Parameters (Slope in %, Aspect, Erosion, Main site type (mineral soil, peat lands, wetlands))
    - Land Use type (forest land (and type), cropland, grassland, settlements, wetlands, other land)
    - Canopy cover (<10%, 10-30%, 31-50%, 51-70%, and >70%)
    - Disturbances
    - Land Use and Land Use Change (Deforestation, Forest Degradation and causes)
- Measurement of tally trees
    - All trees with DBH-1 above 5 cm are measured from the sample plots with radius of 17.84 m
    - Species and DBH-1 (at 1.3 meters). In case of anomaly at 1.3 m the DBH was measured slightly above that point. In case of forked tree below DBH, two trees were considered.
    - Broken top or not. Broken top trees were not selected as sample trees.
- Measurement of sample trees

- Sample trees were selected from all measured alive trees by selecting every 5th tree starting from tree no. 1.
- If the selected tree had a broken top or had some anomaly at the breast height, it was not selected as sample tree. In that case the next tree in order was selected as sample tree, however, the next sample tree was selected based on the same order.
- The sample trees were measured for second DBH with breast height at 1.37 meters, top height, bole height, and in case of leaning trees also base length for both top height and bole height.

- Dead wood measurement
  - Species Name
  - Category (Standing Dead Wood, Down Dead Wood and Stump)
  - Standing Dead Wood:
    - All the standing dead trees with DBH1 measured at 1.3 m height greater than 5 cm were enumerated within the full 17.84 m plot.
    - DBH1, top height and decomposition state were recorded for all the standing dead trees.
    - The specific decomposition stage classes for standing dead wood are:
      - 1) Tree with branches and twigs and resembles a live tree (except for leaves);
      - 2) Tree with no twig, but with persistent small and large branches;
      - 3) Tree with large branches only;
      - 4) Bole (trunk) only, no branches
  - Downed Dead Wood:
    - Downed branches and stems of trees and brush with minimum DBH above 5 cm, which were fallen and lied on or above the ground were measured from the 17.84 m.
    - Only the proportions of dead wood stems and their fragments lying inside were measured.
    - The measurements included the length (m) inside the plot and diameters (cm) at the two ends of the wood or fragment particle.
  - Stumps: All the stumps with diameter above 5 cm were enumerated within the full 17.84 m plot.
    - The stump diameter was measured in two diagonal directions, its lowest and highest heights with a measuring tape from the level of seeding point.
    - For dead wood following decomposition levels were assessed;
      - 1) Sound (blade does not sink or is bounced off).
      - 2) Intermediate (blade partly sinks into the piece of wood or there has been some wood loss).
      - 3) Rotten (blade sinks well into the piece, there is extensive wood loss and the piece is crumbly).
  - DBH/Diameter 1 (x.x cm): The first end diameter measurement for downed deadwood, stump diameter or DBH at 1.3 meters for standing trees.
  - Diameter 2 (x.x cm): The second end diameter measurement for downed deadwood or stump.
  - Tree height / length (x.x m): Tree height or particle length measured in meters

  - Standing tree, base length (x.x m): The standing dead tree base length is only measured for heavily leaning sample trees. Tree base length is the distance on the ground from the base of the tree to the top of the trunk.
  - Standing tree broken top (1/0): All the standing dead trees were marked as broken top or not. 1 was for broken top, and 0 was for normal.
- Measurement of litter and shrubs
  - Shrubs were measured through destructive sampling in the 5.64 m plot. Shrubs were cut, weighed and recorded. The shrubs were then chopped and a certain portion was taken, weighed, packed and labelled as sample for lab testing (for determining oven dry weight.
  - Non-tree biomass Litter, herbs, grasses and soil biomass are extracted from the 0.56 m sub-plots.
  - The litter layer is defined as include all dead organic surface material on top of the mineral soil.
  - All the leaf litter and wood litter less than 5 cm in diameter within the subplot were collected and their fresh weights determined in the field with a weighing balance.
  - The sample weighted on site after excluding the plastic bag weight.
  - A sub-sample for plot was taken, weighed, placed in a zip-locked polythene bag, labelled and then taken to the laboratory to determine the oven dry mass and carbon content.
- Measurements for soil organic carbon
  - Due to time constraint soil samples were collected only from the PSUs in each cluster.
  - For Soil Organic Content collected the soil samples using the auger/ chisel and put it in a clean bucket.
  - Samples from the different depths were placed in separate buckets.
  - Mixed the soil in the bucket thoroughly and took sub-samples, put in a sampling bag.
  - The sample was weighed and labelled with sample ID and fresh weight.
  - For bulk density the soil sample was taken using a cylindrical metal sampler of 5 cm diameter and 5 cm length.
  - The core was driven to the desired depth (0 – 10 cm, 10 – 20 cm and 20 – 30 cm) using a hammer and the soil sample carefully removed to preserve the known soil volume existed in situ using the soil knife.
  - Volume and fresh weight of the soil collected in the core from each depth were recorded.
  - The soil sample was then transferred into a clean sampling bag without spilling it and label the sample bag clearly.
  - Filled in soil sample information sheet including the details (name of sample collector, address, date, area and location).
  - Packed the samples in clean bags and took to the laboratory for analysis.
- Plot photos
  - Photographs at each PSU and SSU were taken towards the compass direction in North, East, South and West from the plot center.
  - The corresponding Photo number/ID/ file name with other site characteristics were noted in the field sheets.

2.5.2.2 Quality Control and Quality Assurance for field measurements

A separate QC/ QA team was constituted consisting of three members; 1). Atif Ali Khan Forestry Graduate (team leader), who was then replaced by Rab Nawaz Sahmal Forestry Graduate; 2). Mr. Muhammad Asad Forestry Graduate (member), and 3). The concerned provincial REDD+ coordinators (member). In addition to these members where possible the REDD+ focal points also visited the field survey teams especially in AJK, and GB. As recommended in the revised forest inventory manual both hot and cold checks were performed. The hot checks consisted of spot visits by the WWF-Pakistan's provincial coordinators and sometimes the concerned provincial REDD+ focal persons to the inventory sites and checked the data collection procedures in the field. For the cold checks the team visited the forest inventory teams, randomly picked 10% clusters and re-measured the tree parameters and dead wood in the PSUs of the selected clusters. The data was entered in OF Collect entry sheets and the error was assessed using the Power BI software using the formula below (Annex-5, and 6).

$$Measurement\ error\ (\%) = \frac{(biomass\ before\ corrections - biomass\ after\ corrections)}{biomass\ after\ corrections}\ \text{X}\ 100$$

Table 9: List of filed teams for FI in Gilgit Baltistan

S#	Name, designation	Qualification	Designation/ role	Remarks
Team-A				
1	Fiasal Hussain	MSc Forestry	Team leader (WWF)/ Forest Surveyor	During the second phase second team was engaged: • Ali Abbas (MSc Forestry) • Muhammad Qasid (MSc Forestry) • Local FGs
2	Zahid Hameed	Forestry Graduate	RFO GB FD/ Forest Surveyor	
3	Faizan Dukhi	Forestry Graduate	RFO GB FD/ Forest Surveyor	
4	Arfi Hussain	Certificate Course in forestry	GIS Analyst TBTTP, GB FD/ Surveyor	
5	Local Forest Guard	Certificate Course in forestry	Forest Guard, GB FD/ Surveyor	
Team-B				
1	Muhammad Ali	MSc Forestry	Team leader (WWF)	During the second phase second team was engaged: • Farrukh Quraishi (MSc Forestry) • Abu Bakar (MSc Forestry) • Usama (MSc Forestry) • Local FGs
2	Noor ud Din	Forestry graduate	Forest Surveyor (WWF)/ Team leader	
3	Ghulamullah Baig	Forestry Graduate	Forester/ GB FD (Surveyor)	
4	Imran Changazi	Forestry Graduate	Forester/ GB FD (Surveyor)	
5	Suhail Amin	MSc Forestry	Intern WWF/ Surveyor	
6.	Local Forest Guard	Certificate Course in forestry	Forest Guard, GB FD/ Surveyor	

2.5.3 Data Storage and Processing

The entire process of data storage and processing consisted of three phases: I) data acquisition, II) data entry, III) data cleansing and IV) data analysis. Measured and/or estimated data was recorded in the field on the field sheets during the NFI (I. Field data acquisition). Duly filled in field sheets were delivered to

the office where the recorded values were crosschecked and entered into the OF data management software (II. Data Entry). The software runs several validation rules against the entered data and indicates erroneously entered or missing values. Once the (per cluster) data sets were complete, they were promoted to the data cleansing stage (III. Data Cleansing). Consequently, these were exported to PBI for a systematic data cleansing. In PBI the values were systematically checked again for completeness and plausibility, e.g., value ranges, conspicuous values, etc.

Following the data entry and cleansing procedures of NFI field data in OF, the ("analysis ready") data is exported as data tables in MS Excel format (IV: Data Analysis). The data processing workflow is illustrated in Figure 6. The entire workflow can be summarized as under. Details are given in the "Data Storage and Processing" report provided as Annex-6 (separate zip folder).

- Measurement/estimates values were recorded on field sheets.
- Field sheets data were entered in OpenForis Collect.
- Data was controlled (cross-checks), validated (plausibility) and checked for completeness.
- Complete data sets were promoted to "data cleansing" and exported to PBI.
- In PBI, systematic data cleansing was applied, considering completeness and plausibility.
- Cleansed data was promoted to "data analysis" and exported to PBI for analysis.
- Data issues (i.e., outliers, etc.) observed during data analysis result in data sets were demoted to "data cleansing".

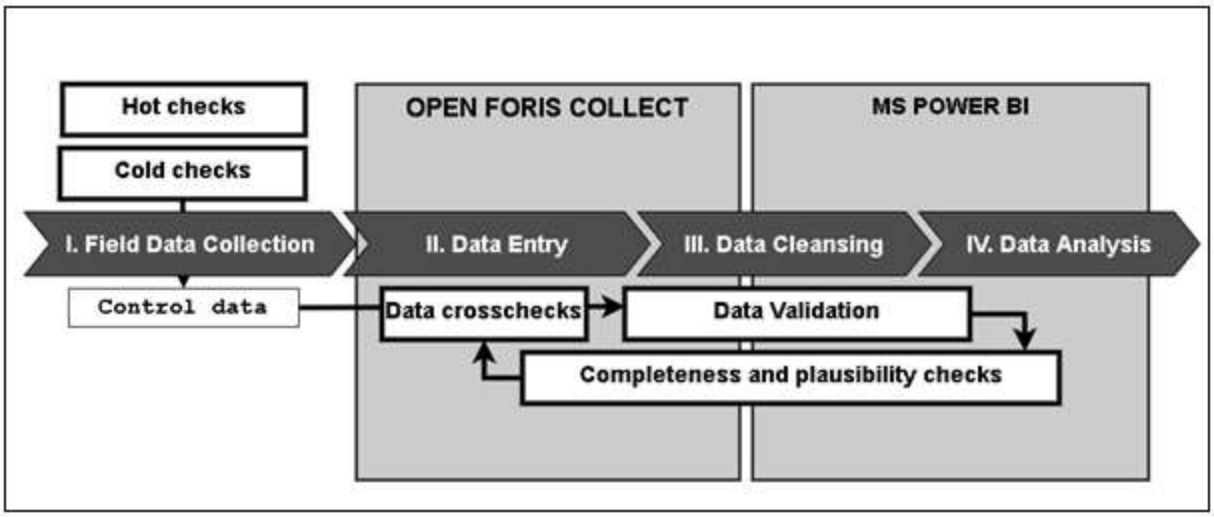


Figure 10:Data storage and processing workflow

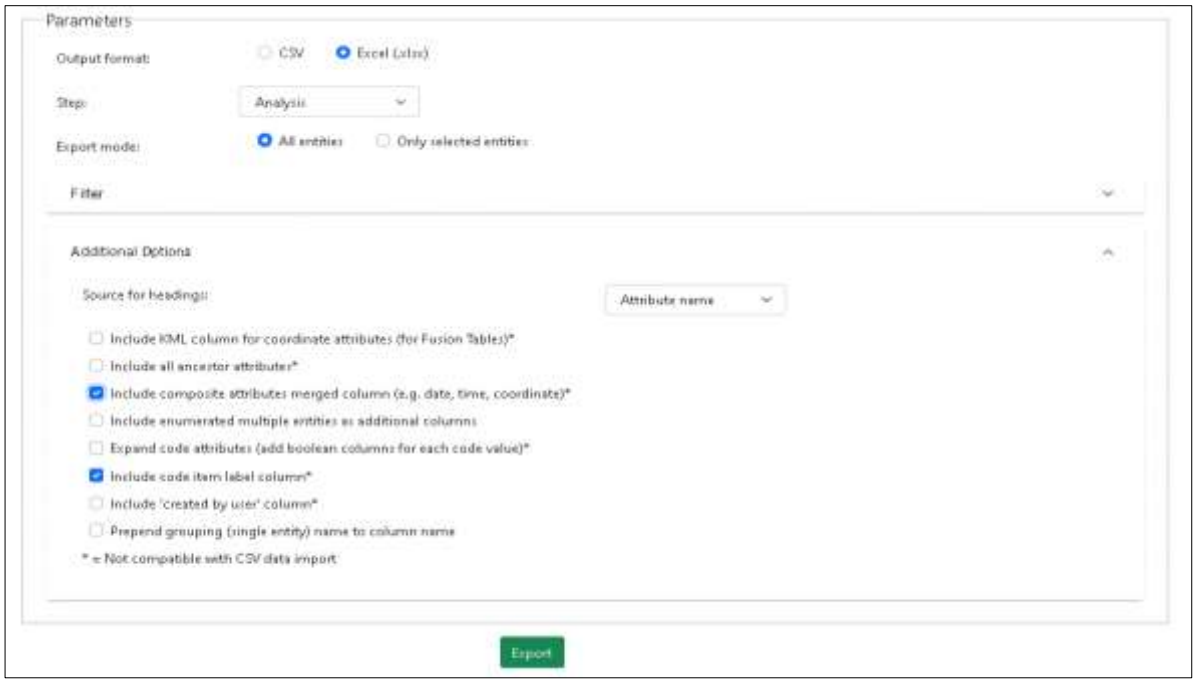


Figure 11: Data export settings in OF Collect.

During data export to PBI, the export settings in OF were defined as shown in Figure 11 to minimize additional editing on data table level and increase facility of inspection.

By checking the options shown in Figure 11, time, date and coordinates columns were merged so they were directly available as column values. Setting the "Include code item label column" parameter provided additional code label (string) as text columns to the otherwise only numerical code attribute columns. The exported and zipped (.zip) Excel files were stored in the same folder from where these were loaded into the PBI project.

To update all or individual data tables, the respective Excel files that the PBI connects to (see "Data Source Settings" under "File"→"Options and Settings" in PBI) are simply replaced/overwritten. Performing a "Refresh" in PBI accesses the data tables and loads the updated data into the "Power Query Editor". Should the refresh be unsuccessful, opening the "Power Query Editor" (via "Transform data") and using "Refresh Preview" ("Refresh all") can help. Once all previews (data tables) are refreshed, using "Close & Apply" closes the "Power Query Editor" upon which a "Refresh" in the "Report"/" Data" view should work.

2.5.4 Diameter-Height model development

Initially the Diameter-Height models were developed for species, genera or species groups having more than 30 height measurements. Species or genera having less than 30 height measurements were grouped as other coniferous species and other broadleaved species (for each province). These models were developed using excel spreadsheets based on R values (Table 10). The initially developed models (representing the DBH-H relationships per species, genera or species group) were then adjusted and used to determine the missing tree-height values for each species. For the PBI analysis, the performance of available Diameter-Height models was assessed visually (Figure 12).

Table 10: Diameter-Height Models developed during initial stage

Species	Range of DBH (cm)	Range of height (m)	Number of sample trees	Model with R^2 value
Abies pindrow	5-120	3.9-49.5	135	H = 2.5597*(DBH)^0.5929 R^2 = 0.7636
Acacia modesta	5-46	2-11.6	131	H = 3.7547*Ln(DBH) - 3.7217 R^2 = 0.6105
Aesculus indica	9-116.33	4.4-47.2	44	H= 0.0016*(DBH)^2 + 0.2037*(DBH) + 3.2397 R^2 = 0.9094
Cedrus deodara	5-94.5	2-39.4	210	H= 1.1322(DBH)^0.7551 R^2 = 0.7937
Juniperous excelsa	5-168	1.5-10.1	190	H = -0.0002*(DBH)^2 + 0.0731*(DBH) + 2.5815 R^2 = 0.5179
Olea ferruginea	5-64	2.9-11.9	307	H = -0.001*(DBH)^2 + 0.2077*(DBH) + 2.9166 R^2 = 0.5139
Picea smithiana	5-108.2	2-41.2	149	H = -0.0035x2 + 0.6912x + 0.2213 R^2 = 0.7367
Pinus wallichiana	4-134	1.5-44.5	611	H = -0.0015*(DBH)^2 + 0.504*(DBH) + 2.3565 R^2 = 0.8037
Pinus gerardiana	5-41	3.5-12.2	74	$H = 4.1531e^{0.0272(DBH)}$ R^2 = 0.5317
Quercus ilex	5-51	3-21	197	H = 0.002*(DBH)^2 + 0.1873*(DBH) + 2.5811 R^2 = 0.5725
Quercus incana	5-45	2-27	241	H = 0.0099*(DBH)^2 - 0.1211 *(DBH) + 4.8764 R^2 = 0.5789
Tamarix spp.	5-50	2.9-17.2	83	H = -0.0002*(DBH)^2 + 0.3243*(DBH) + 2.6741 R^2 = 0.6423
Other (broadleaved) species	5-54	2-19	121	H = -0.0018*(DBH)^2 + 0.3569*(DBH) + 2.4247

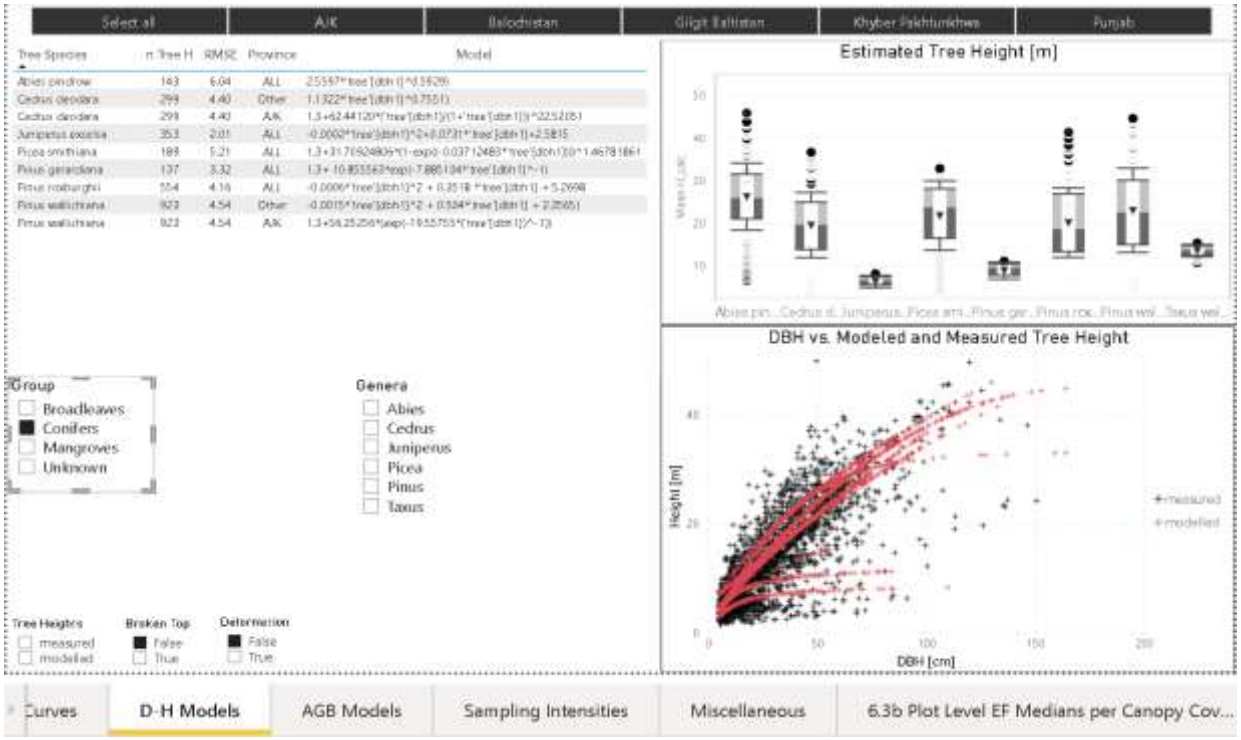


Figure 12: Visual assessment of D-H models for conifers in PBI analysis.

All models that visually appeared to grossly over or underestimate observed tree heights were re-modelled. In addition, the Diameter-Height relationship of all species with less than 30 measured tree heights were grouped together for re-modelling. To this aim, species found in GB were grouped either as broadleaves and conifers and the imputation of tree heights was done outside of PBI in R Studio using the provided script by FAO (https://drive.google.com/file/d/1tJRBraFGXhTN01oRXB1Ls7ROvNWHoGdO/view). The resulting graphs were exported to pdf in the defined folder structure. Figure 13 shows the resulting graphical output for *Picea smithiana*.

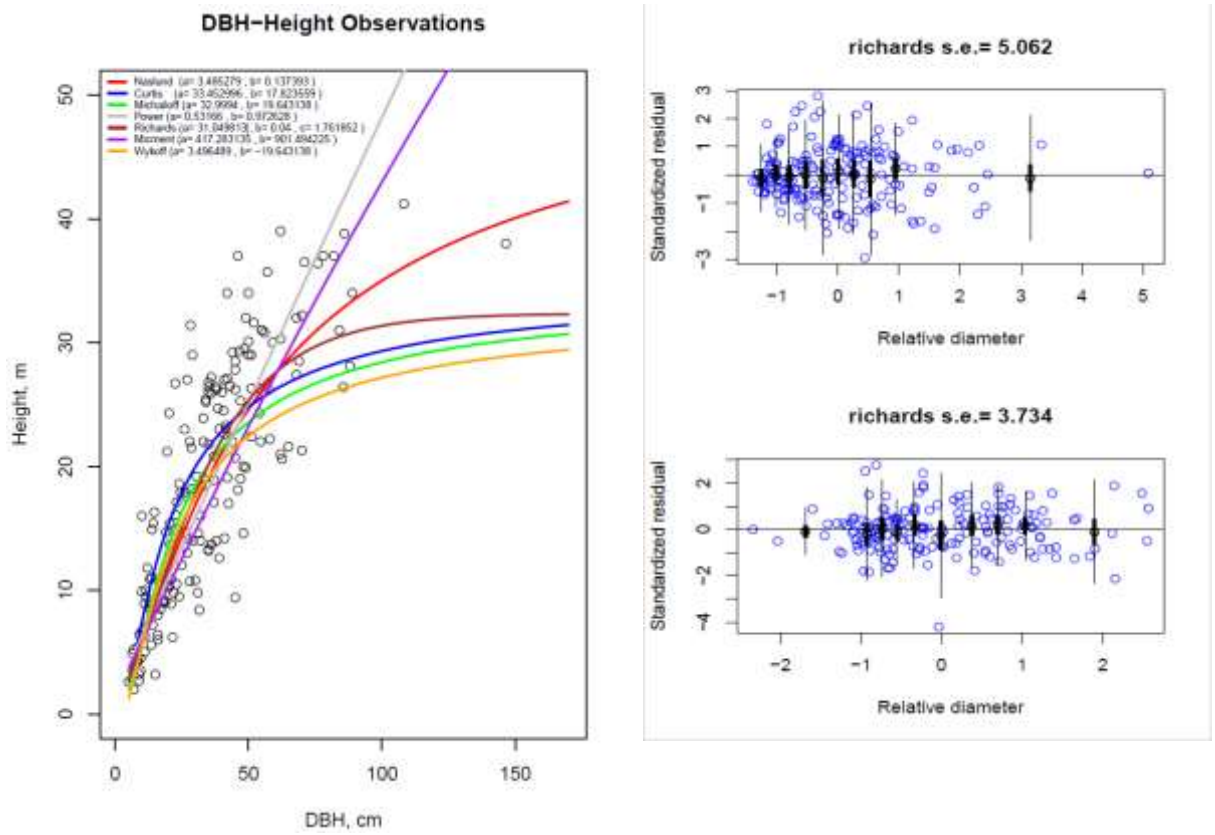


Figure 13: Graphical output of the general fit of 7 fixed models to pairs of DBH – H observations (left) and the fitting of Chapman-Richards model for Picea smithiana.

The left side of Figure 13 shows the performance of 7 fitted fixed-effect models to pairs of DBH – H observations of *Picea smithiana*. The resulting residuals from fitting the Chapman-Richards model calibrated for species (above) and cluster (below) is shown on the right. "S.E." reports the resulting standard error (in m). According to the graph shown in Figure 13 (left), the models "Naslund", "Curtis" and "Chapman-Richards" were selected for further evaluation. During the subsequent height imputation, the selected models were evaluated against mixed effects. The resulting graphs of the model fit for *Picea smithiana* are shown in Figure 13 (right). Based on visual interpretation of the residuals (range, distribution) and the resulting standard error (s.e. in Figure 13), the most suitable calibration is selected for each model. To visualize the performance of the different calibrations, the tree height estimates are plotted on an X/Y-scatterplot for each model and exported as pdf file (Figure 14).

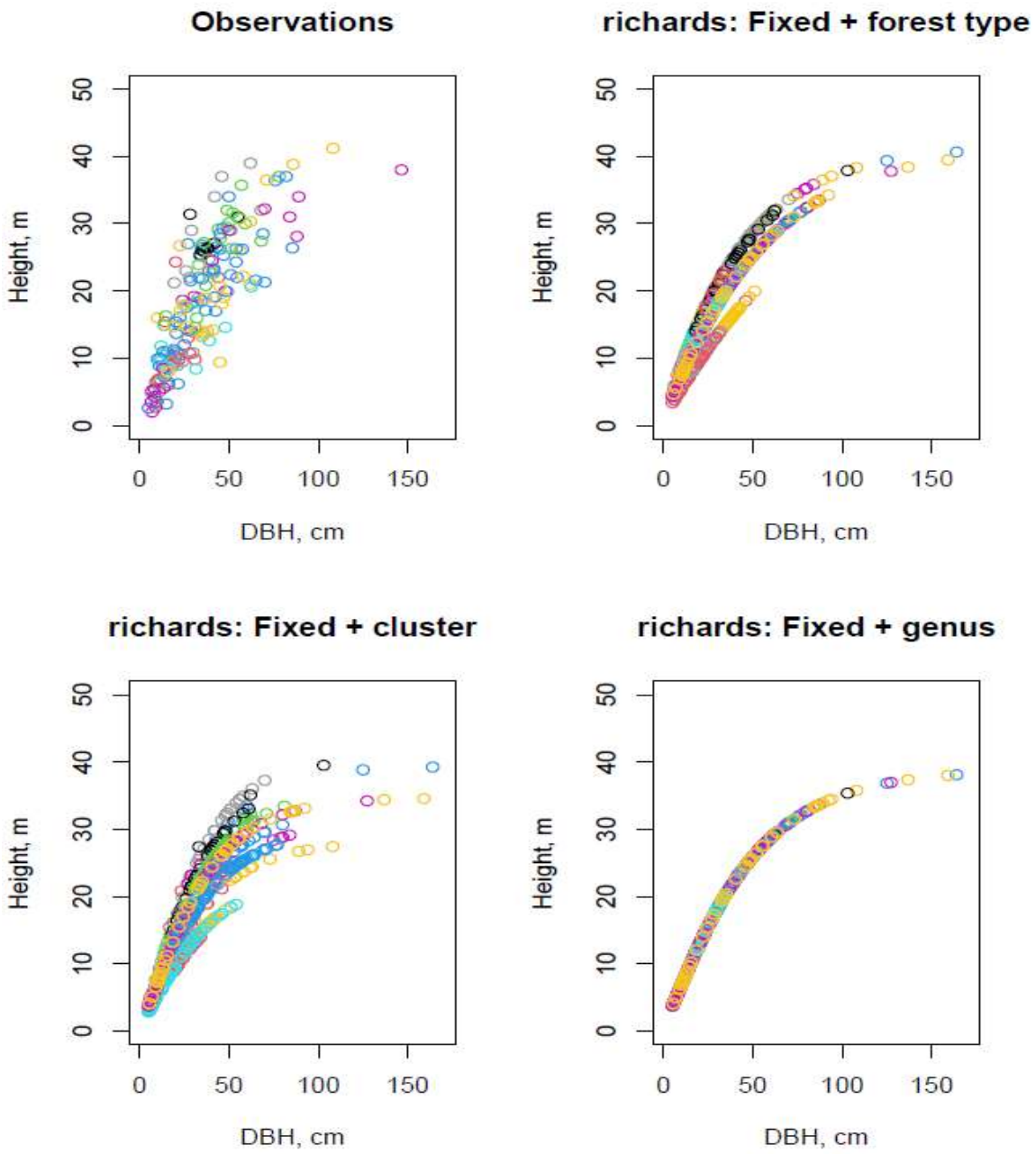


Figure 14: Model fits resulting from different calibrations (colors are representing different clusters) to the DBH-H observations of Picea smithiana.

Subsequent to the selection of best performing calibration, the three adjusted models are compared based on the resulting root-mean-square error (RMSE) and the coefficient of determination (R^2). Based on an evaluation of the model specific RMSE and R^2 values, the most suitable model is selected. Descriptive statistics of the finally selected models for GB are given in Table 11 below.

Table 11: Finally selected Diameter-Height Models with descriptive statistics

Tree Species	Model	n Tree H	RMSE	RMSE (%)
Abies pindrow	2.5597*'tree'[dbh1]^0.5929)	143	6.04237	0.641715
Acacia modesta	3.7547*LN('tree'[dbh1]) - 3.7217	178	2.056678	0.94073
Aesculus indica	0.0016*'tree'[dbh1]^2 + 0.2037*'tree'[dbh1] + 3.2397	47	2.657656	0.304918
Ailanthus altissima	'-0.0018*'tree'[dbh1]^2+0.3569*'tree'[dbh1]+2.4247	15	2.748417	0.824467
Betula utilis	1.3+8.244514*exp(-7.752015*'tree'[dbh1]^-1)	15	5.34088	1.040321
Cedrus deodara	1.1322*'tree'[dbh1]^0.7551)	299	4.395158	0.595499
Ficus carica	'-0.0018*'tree'[dbh1]^2+0.3569*'tree'[dbh1]+2.4247	16	1.932007	0.948785
Juglans regia	'-0.0018*'tree'[dbh1]^2+0.3569*'tree'[dbh1]+2.4247	24	2.512621	0.636264
Juniperus excelsa	'-0.0002*'tree'[dbh1]^2+0.0731*'tree'[dbh1]+2.5815	353	2.008111	1.102367
Morus alba	'-0.0018*'tree'[dbh1]^2+0.3569*'tree'[dbh1]+2.4247	24	3.803151	0.8319
Olea ferruginea	'-0.001*'tree'[dbh1]^2 + 0.2077*'tree'[dbh1] + 2.9166	504	1.970239	0.897573
Picea smithiana	1.3+31.70924806*(1-exp((-0.03712483*'tree'[dbh1])))^1.46781861	189	5.211965	0.543062
Pinus gerardiana	1.3+ 10.855563*exp(-7.885104*'tree'[dbh1]^-1)	137	3.319694	0.868547
Pinus wallichiana	'-0.0015*'tree'[dbh1]^2 + 0.504*'tree'[dbh1] + 2.3565)	923	4.543665	0.55644
Platanus orientalis	1.3+8.244514*exp(-7.752015*'tree'[dbh1]^-1)	1	0.283511	
Populus spp.	'-6.9198+8.4004*LN('tree'[dbh1])	14	7.801454	2.454332
Prunus armeniaca	1.3+8.244514*exp(-7.752015*'tree'[dbh1]^-1)	3	0.872722	0.789048
Quercus ilex	0.002*'tree'[dbh1]^2 + 0.1873*'tree'[dbh1] + 2.5811	418	4.959459	1.851418
Quercus incana	0.0099*'tree'[dbh1]^2-0.1211*'tree'[dbh1]+4.8764	350	5.151243	1.598699
Robinia pseudoacacia	'-0.0018*'tree'[dbh1]^2+0.3569*'tree'[dbh1]+2.4247	1	1.8358	
Salix tetrasperma	1.3+8.244514*exp(-7.752015*'tree'[dbh1]^-1)	25	3.532232	0.932172
Tamarix dioca	1.3+8.244514*exp(-7.752015*'tree'[dbh1]^-1)	11	2.229631	1.400198

2.5.5 Allometric models for Above-Ground Tree Biomass estimation

Above-ground biomass models are available for 63% of all observed tree species. For coniferous species, which did not have any national level models, the generic coniferous species allometric model used by Ali etal., 2017 was applied. For the remaining species the allometric equation developed by Chave et.al. 2014 was used. Table 12 presents the allometric models applied for Above Ground Biomass estimation.

Table 12: Allometric models applied for Above Ground Biomass estimation

Sr. No	*Species Type*	Allometric Equation	Reference/ Province
1	*Abies pindrow*	M=0.0954*(DBH^2*H) ^0.8114	Ali et al. 2017 (GB)
2	*Abies pindrow*	M= 0.0495(D^2H)^0.8935	Ali 2020 (KP)
3	*Acacia modesta*	M= 0.2267(D^2H)^0.8226	Ali 2020 (KP)
4	*Cedrus Deodara*	M=0.1779*(DBH^2*H) ^0.8103	Ali et al. 2017 (GB)
5	*Cedrus deodara*	M= 0.0458(D^2H)^0.92	Ali 2020 (KP)

6	*General (Coniferous)*	M=0.1645*(WD*DBH^2*H) ^0.8586	Ali et al. 2017 (GB)
7	*Olea ferruginea*	M= 7.8863+0.0556(D^2H)	Ali 2019 (Sindh & Punjab)
8	*Olea ferruginea*	M= 7.8863+0.0556(D^2H)	Ali 2020 (KP)
9	*Other Mix*	M=0.0673*(WD*DBH^2*H) ^0.976	RFEL/NFMS, 2020
10	*Other species*	M=Exp (-2.187+0.916*ln (WD*D^2*H))	RFEL/NFMS, 2020
11	*Picea smithiana*	M= 0.0821(D^2H)^0.8363	Ali 2020 (KP)
12	*Picea smithina*	M=0.0843*(DBH^2*H) ^0.8472	Ali et al. 2017 (GB)
13	*Pinus roxburghii*	M= 0.0224(D^2H)^0.9767	Ali 2020 (KP)
14	*Pinus wallichiana*	M=0.0631*(DBH^2*H) ^0.8798	Ali et al. 2017 (GB)
15	*Pinus wallichiana*	M= 0.0594(D^2*H)^0.881	Ali 2020 (KP)
16	*Populous spp.*	M= 0.0194(D^2H)^0.9654	Ali 2020 (KP) model for Populous deltoides
18	*Quercus ilex*	M=0.8277*(DBH^2*H) ^0.6655	Ali et al. 2017 (GB)
19	*Quercus ilex*	M= 0.0795(D^2H)^ 0.9688	Ali 2020 (KP)
20	*Robinea pseudoacacia*	M= 0.2586(D^2H)^0.7786	Ali 2020 (KP)
21	Tamarix dioca	M=0.477*(D^2*H)^0.5755	Ali 2019

2.5.6 Plot level and stratified aggregation

Calculations of biomass and carbon content of trees, deadwood, litter and shrubs and soil organic carbon were aggregated at plot level and then at cluster levels. The aboveground biomass densities per hectare were calculated from the aboveground biomass densities per plot. Belowground biomass densities for plots were calculated using the default IPCC root-shoot ratios (Table 13). For calculating carbon content from the biomass, the default IPCC fraction (0.47) was applied. The plot level averages were applied to calculate the average carbon and then per hectare average carbon.

Table 13: IPCC root-shoot ratios adapted

Domain	Vegetation type	Aboveground biomass (t/ha)	Mean value (BGB: AGB)
Tropical/Subtropical Forest (Dry)	Riverine forest	>20	0.28
	Riverine forest	<20	0.56
	Mangroves	NA	0.29
	Eucalypt plantation	<50	0.44
	Eucalypt plantation	50-150	0.28
	Eucalypt plantation	>150	0.20
Sub-tropical & Temperate Forest	Conifers	<50	0.40
	Conifers	50-150	0.29
	Conifers	>150	0.20
Temperate Forest	Oak forest	>70	0.30
	Other broadleaf forest	<75	0.46
	Other broadleaf forest	75-150	0.23

	Other broadleaf forest	>150	0.24

Source: Table 4.4 of the IPCC Good Practice Guidance (2006)

2.6 Methodological Framework of GHG-I

A greenhouse gas inventory is a comprehensive listing of GHG emissions and removals resulting directly from human activities by sources. An inventory estimates emissions and removals for one year or several years. The IPCC 2006 Guidelines for National Greenhouse Gas Inventories refer to five inventory categories including; energy; industrial processes and products; agriculture, forestry and other land use; waste and other. Within these sectors, individual sources and sinks categories are defined. Parties to the UNFCCC are required to report their inventories in line with the definitions and structure of these sectors, and the source and sink categories within each sector, so that reporting is comparable across Parties. GHG inventory shall be prepared using the IPCC Guidelines 2006 and 2019 Refinements to the 2006 IPCC Guidelines

The GHG-I reports contain the following contents:

- Tables of annual emission and removal estimates by source, with estimates expressed in units of mass per year, and the year or years;
- Worksheets showing how emissions are calculated, including all parameters used for calculations;
- For each source, a description of the methodology, the sources of data (e.g., activity data, emission factors, methodologies), the actual data and a description of uncertainties, and quantitative assessment of uncertainties (if possible); and
- Other informative background data (e.g., a national energy balance, a description of GHG sources that are believed to be important but cannot be estimated).

The GHG-I processes must be transparent, consistent, comparable, complete and accurate in the context of the UNFCCC reporting:

Transparency means that the assumptions and methodologies used for an inventory are clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental for the success of the process for the communication and consideration of information;

Consistency means that an inventory is internally consistent in all its elements with inventories of other years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under some circumstances, an inventory using different methodologies for different years can be consistent if it has been recalculated in a transparent manner, in accordance with the IPCC good practice guidance;

Comparability means that estimates of emissions and removals reported by COP Parties in their inventories are comparable;

Completeness means that an inventory covers all sources and sinks, as well as all gases, included in the IPCC Guidelines, as well as other existing relevant source/sink categories which are specific to individual Parties and, therefore, may not be included in the IPCC Guidelines. Completeness also means full geographic coverage of sources and sinks of a Party;

Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable.

Though, the GHG- Inventory is mainly prepared at the national level however, under the Sub-NFMS requisite data and information will be compiled at the Sub-national level and will be shared with national focal point for preparing and reporting the national level GHG-Inventory and reporting to the UNCCC secretariate. The Sub-NFMS provides all the relevant information for the national GHG-I for forestland remaining forest land, forestland converted to other land use or other land use converted to forestland. All Forest Land in Pakistan is considered as Managed Land. The emissions and removals in Forestry sector will be calculated by combining emissions/removal factors and activity data. The activity data is sourced from SLMS and the emission/removal factors from the Forest Inventory.

2.7 Methodological Framework for MBIGS

As required under the "UNFCCC Decision 1/CP.16, Para 71 d" the NFMS and Sub-NFMS may integrate data and information related to other components of REDD+ information system such as the Safeguards Information System (SIS) (MoCC, 2020). The MBIGS system monitors such information. The Multiple Benefits, Impacts, Governance and Safeguards (MBIGS) comprise of complete system which covers aspects regarding Non-carbon Benefits, Impacts, Governance and Safeguards, their indicators, tools for assessment and the responsible organizations/ units to assess and report these indicators (MoCC, 2020). The MBIGS include: non-carbon benefits of REDD+ initiatives (such as enhanced NTFP production and harvesting etc.); land-based impacts (such as desertification control, erosion control, and watershed protection etc.); governance (forest policies, including land tenure, rights to forest resources, carbon rights etc.) and; social and environmental safeguards (like protection of natural forests and biodiversity, full and effective participation of indigenous peoples and local communities etc.) (MoCC, 2018). The Non-Carbon Benefits are defined as "***the positive socio-economic, environmental or bio-cultural effects of well-governed activities that also contribute to climate change mitigation or adaptation without necessarily being related to carbon sequestration***" (Christoffersen and Lisbet, 2019).

3.1.1 MBIGS Institutional and process framework

As illustrated in Figure 15, the MBIGS Framework consists of different institutions and units, their roles regarding assessment of the MBIGS indicators, compilation, verification and reporting. MBIGS institutional and monitoring framework, and compiled data on indicators are given as Annex-7 and 8. The Provincial REDD+ Coordination and Implementation Unit (focal point) will have the overall responsibility of MBIGS coordination, compilation and reporting. The territorial forest divisions/ circles will assess the MBIGS Indicators related to forest management, law enforcement, forests statistics, erosion control and watershed protection, and REDD+ implementation, and benefit distribution. They will assess, compile and share the district level information and data with the Provincial REDD+ Coordination and Implementation Unit. Similarly, specialized units/ directorates/ circles such as Research & Development, Planning, Monitoring & Evaluation, Community Development and Non-Timber Forest Products will assess indicators related to these specialized fields such as community participation and conflict resolution, biodiversity and socioeconomic impacts, NTFPs, proposals regarding new projects and schemes etc. They will also share these information and data with the provincial REDD+ Management (Coordination and Implementation) Units. The framework also consists of an overarching review and approval mechanism at district, forest region and province levels by the concerned REDD+ management and steering

committees (as provided under the Sub-NFMS institutional arrangements). The framework also consists of the technical support regarding MBIGS related to various REDD+ thematic areas. This support will be provided by the provincial level REDD+ Thematic Working Groups (provided under the Sub-NFMS institutional arrangements). Once the collection, compilation, review and approval processes are completed at the provincial level the compiled MBIGS information and data will then be reported to the national focal point (the Office of the Inspector General Forests, Ministry of Climate Change).

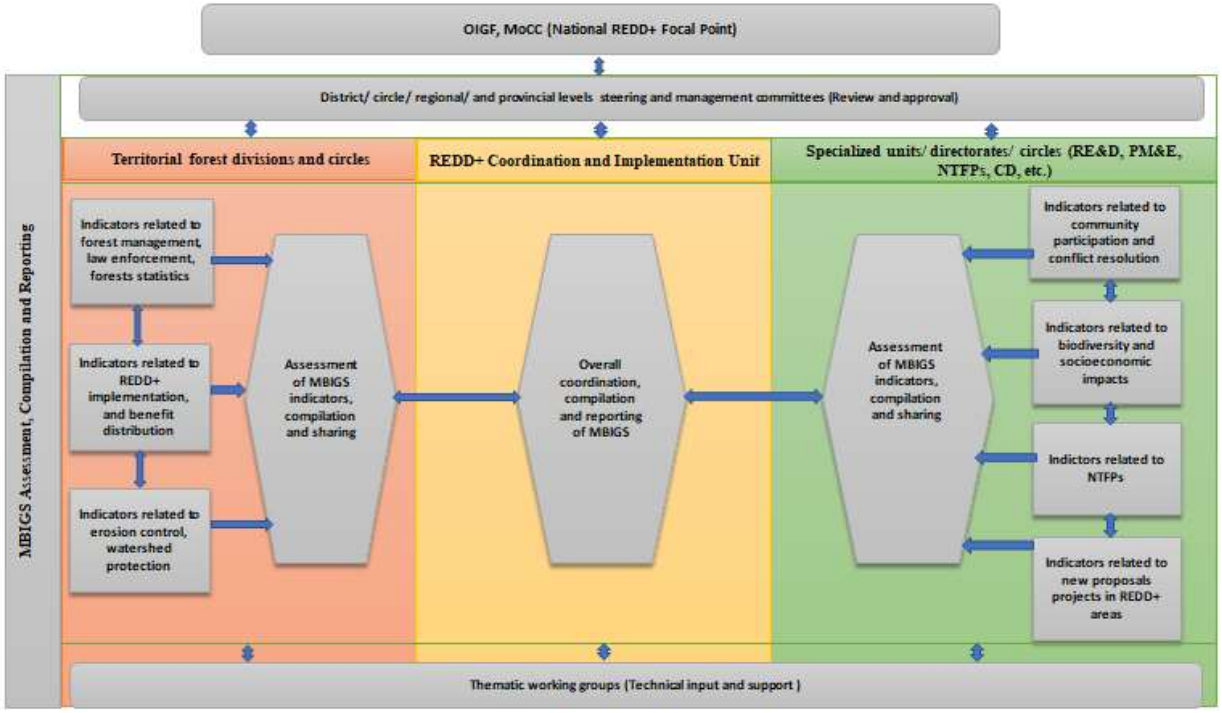


Figure 15: Overall provincial level institutional and process framework for assessment of MBIGS

3 OPERATION AND INSTITUTIONALIZATION OF SUB-NFMS

3.1 Establishment of the recommended Sub-NFMS (M&MRV) bodies

For operationalization of the Sub-NFMS, establishment of the recommended bodies and units (as provided under sub-section 2.1.2, sub-section 2.7.1 and Annex-1 of the current report), will be ensured and made functional. Most of the recommended bodies are either already notified (but not functional) or exist but their role not yet formally notified. Following actions will be taken to formally establish the Sub-NFMS bodies and implementation of the Sub-NFMS;

- Develop and implement the Sub-NFMS project for either the provincial ADP or Federal PSD funding.
- Further strengthening of the Provincial REDD+ Coordination Unit by providing additional positions of GIS and RS analysts, a Forest Inventory Specialist (DFO Position) and an IT expert/ web portal operator.
- Develop proposal for formal approval and notification of various bodies, units and offices for adoption of their role as provided under this document.
- Preparation of plan of action for implementation of the Sub-NFMS.

- Develop proposals for REDD+ projects for donors or government funding.
- Regular trainings of the Sub-NFMS teams in SLMS methodologies, conducting of forest inventories, use of OpenForis Collect and Power BI software.

3.2 Data Ownership, Custodianship and Sharing Agreement

The NFMS 2020 has provided detailed considerations regarding data ownership, custodianship and data sharing agreement. Same considerations will be adopted for the current Sub-NFMS. A brief summary is given as under;

- The Sub-National/ Provincial REDD+ units will collect, manage and disseminate the NFMS data for their own territories.
- The primary NFMS/ Sub-NFMS data ownership will rest with the concerned provinces (mainly forest departments)
- A data center within MOCC (in GCISC) to be established to manage NFMS data and to further regulate data dissemination.
- Data Custodianship will be kept by MOCC through GCISC.
- Data sharing will be done through an online data request form by various users including communities, commercial entities, research organizations & academicians, NGOs and INGOs.
- Clear terms and conditions regarding data sharing and use (as provided under the NFMS 2020) will be uploaded to NFMS web portal and made available data users.

3.3 Data Policy and Sharing Protocol

The NFMS 2020 also provides data policy and sharing protocol in the form of an outlined agreement. The same will be adopted for data sharing at the sub-national level by the concerned forest departments. These mainly include; 1). Description of data to be shared; 2). Purpose of data sharing; 3). Granting license to use data; 4). Liabilities and limitations for the accuracy of data provided; 5). Production of printed or digital maps/reports/publication products using the provided digital data; 6). Sharing of the provided digital data with other persons or entities.

3.4 Terms and Conditions on using NFMS Web Portal

An outline of the terms and conditions regarding using the NFMS Web Portal has been provided in the NFMS report 2020. These terms and conditions include; NFMS Terms of Service; Format of data to be uploaded; Instructions for use of NFMS data; Restrictions regarding access, use, transfer, selling and sharing of the NFMS data; Termination of agreement in case of unlawful and prohibited use, and; Changes to the agreement. During the current phase Sub-National level Web Portals are also developed and operationalized. The national level terms and conditions will be applied at the Sub-National level.

4 SUB-NFMS FUNDING ARRANGEMENTS

In order to implement and sustain the Sub-National Forest Monitoring System regular funding is needed to be ensured. During the first phase of implementation the Sub-NFMS could be implemented in project mode till all the recommended institutional and policy arrangements are made. The subsequent phases of the Sub-NFMS implementation will be shifted as a regular program funded from the regular budget allocations. As recommend in the NFMS, 2020 one of the funding options could be the results-based payments of the REDD+ program to ensure self-financing. However, legal and procedural amendments will be needed in consultation with stakeholders to ensure this source of funding. Eexamples of such

arrangements are the Forest Development Fund (FDF) created from the revenue generated by the KP Forest Development Corporation, and the Forest Regeneration Fund created by the GB Forest Department. Separate rules have been developed regarding operation of these funds including allocation of funds to forestry development projects. Similar approaches could be adopted for allocation of the funds generated from the results-based payment of REDD+ programs for implementing REDD+ programs, however active involvement local communities and other key stakeholder in decision regarding distribution of REDD+ funds will need to be ensured. Table 14 gives outputs and activities under major components of the Sub-NFMS for Phase-1 (the current assignment), Phase-2 (the short-term period) and Phase-3 (the long-term period) and the human, equipment and financial resources required for implementing the REDD+ activities during Phase-2 and Phase-3. Key outputs and activities have been adopted from the NFMS, 2020. Further detailed costing and budgeting could be done on the basis of the table below.

Table 14: Outputs and activities, and required resources for implementing the Sub-NFMS

S#	Key components/ outputs/ activities	Phase-1 (current)	Phase-2 (short-term)	Phase-3 (long-term)	Resources required (phase-2 and 3)
1	**Satellite Land Monitoring Systems**				
1.1	Institutional framework decided (reviews, meetings, validation workshops)	X			
1.2	Necessary legal process and notifications for establishment of new or amending existing institutions (units, bodies, positions) finalized (preparation of proposals, approvals from higher management, notifications)		X		One GIS specialist; Two GIS analysts
1.3	SLMS methodology standard prepared (reviews, discussions with NRO, consultations with provinces, trainings of SLSMS teams)	X			
1.4	SLMS methodology standard adopted and replicated by the recommend concerned unit in provincial FDs (reviews, discussions and trainings)		X	X	Financial resources for meetings, consultation sessions and trainings
1.5	Periodic reassessment and adjustments of Forest Land sub-classification as per IPCC guidelines (reviews, proposals, discussions, consultations and notification).			X	Financial resources for meetings, consultation sessions and trainings
1.6	Preparation of land use and cover maps for 2016 and 2020 prepared (acquisition of satellite data, image processing and analysis, ground truthing, publication of maps)	X			
1.7	Full sub-classification on Forest Land, using IPCC Approach 3 (image processing and analysis, ground truthing, publication of maps)		X		Financial resources for equipment (computers and survey equipment), satellite data, field surveys and publication of maps.
1.8	Full assessment of Forest Land subcategory transfers. Land use and cover mapping repeated every 4 years; (Acquisition of satellite data, image processing and analysis, ground truthing, publication of maps, production of activity data)			X	Financial resources for equipment (computers and survey equipment), satellite data, field surveys and publication of maps.

S#	Key components/ outputs/ activities	Phase-1 (current)	Phase-2 (short-term)	Phase-3 (long-term)	Resources required (phase-2 and 3)
1.9	Deforestation and forest degradation assessment conducted with reported climate zone and provincial results for 2016-2020 (review and finalization of methodologies, discussions with NRO, acquisition of satellite data, processing and analysis, and production of activity data)	X			
1.10	Sampling approach based on high-resolution optical satellite imagery to assess degradation, specifically in relation to field data collection in relevant areas (reviews, development of methodology/ approach, meetings and consultations, notification of agreed methodology and approach)		X		Financial resources for meetings, consultation sessions and trainings
1.11	Implementing previous/ agreed sampling approach, focusing on hotspots that have been identified from previous assessments (processing of satellite imageries, on-screen visual sampling, ground truthing, production of results)			X	Financial resources for equipment (computers and survey equipment), VHR satellite data, field surveys and publication of maps.
2	**Sub-National Forest Inventory**				
2.1	Previous NFI design and measurement protocol reviewed and adjusted to the Sub-NFI. The Sub-national forest inventory design covers both state lands and non-state lands (private/ communal lands).	X			
2.2	The Sub-NFI design is reviewed and further intensified by concerned provinces/ territories/ states (increasing sample size, time and human resources)		X		Financial resources for meetings, consultation sessions and trainings
2.3	The Sub-NFI design is adopted and fully operational in all state-owned forests and all forest types. The Sub-NFI is repeated every 3 years and sample plots re-measured.			X	One DFO level forest inventory specialist; Four RFO level forest surveyors; Concerned territorial foresters and forest guards to support field data collection; Financial resources for equipment (survey equipment and computers), trainings, field surveys and printing of survey forms and other stationary
2.4	The Sub-NFI design is adopted and fully operational in all non-state-owned forests and all forest types. The			X	As above

S#	Key components/ outputs/ activities	Phase-1 (current)	Phase-2 (short-term)	Phase-3 (long-term)	Resources required (phase-2 and 3)
	Sub-NFI is repeated every 3 years and sample plots re-measured.				
2.5	Further allometric equations for biomass estimation developed at provincial levels			X	One DFO level REDD+ research officer; Financial resources for research work (field work, lab analysis and data entry and analysis)
3	**National GHG Inventory and reporting**				
3.1	Emission/removal factors have been developed based on the Sub-NFI by forest types and provinces for deforestation, degradation and enhancement	X			
3.2	Key category assessment for carbon pools completed for major forest types.	X	X	X	Financial resources for field work and lab analysis
3.3	Carbon stock estimation for all forest types and provinces completed for 2016-2020 and performance against the previous FRL/ FREL assessed.	X			
3.4	Carbon stock estimation in all forests and assessment against applicable FREL/ FRL to establish performance every four years			X	One DFO level forest inventory specialist Four RFO level forest surveyors Financial resources for equipment (survey equipment and computers), trainings, field surveys.
3.5	Activity data reported on the basis of land use categorization. Emission factors derived for all forest types. Provinces shared full report on reduced emissions and enhanced removals on Forest Land for generating national level report.		X	X	One DFO level Sub-NFMS reporting officer appointed at the State REDD+ cell
4	**REDD+ Monitoring**				
4.1	No systematic monitoring for fuelwood and timber harvesting	X			
4.2	Internal displacement of emissions within the forestry sector assessed from field data on forest degradation (e.g., fuelwood, timber), specifically in conditions of forest degradation.		X		One GIS expert and one GIS analyst; One DFO level forestry expert/ monitoring expert; Financial resources for field surveys

S#	Key components/ outputs/ activities	Phase-1 (current)	Phase-2 (short-term)	Phase-3 (long-term)	Resources required (phase-2 and 3)
4.3	All Forest Land is monitored by the Sub-NFMS so no domestic leakage within the forestry sector. Cross-sectoral domestic leakage (e.g., with energy sector) assessed at the Sub-national level.			X	One GIS expert and one GIS analyst; One DFO level forestry expert/ monitoring expert; Financial resources for field surveys
4.4	Carbon registry under the NFMS, 2020 allows registering the projects and monitoring interventions.	X			
4.5	Carbon registry developed and maintained at the Sub-National Level for registering the projects and monitoring interventions at Sub-National level.		X	X	Provincial forest management information systems as sources for forest management data; Provincial carbon registry
4.6	All strategies and interventions are assessed for their effectiveness and performance, with due regard to environmental conditions.			X	One GIS expert and one GIS analyst; One DFO level forestry expert/ monitoring expert; Financial resources for field surveys; REDD+ Thematic Working Groups to review the national strategies and interventions
4.7	Sub-NFMS developed to monitor effectiveness and performance of REDD+ program at Sub-National level and provide information for monitoring of the NRP.	X			One GIS expert and one GIS analyst; One DFO level forestry expert/ monitoring expert; Financial resources for field surveys; REDD+ Thematic Working Groups to review the national strategies and interventions
4.8	Effectiveness of Sub-national and national REDD+ programs are evaluated and their contribution to the achievement of the Sub-National and National Policies		X	X	One GIS expert and one GIS analyst; One DFO level forestry expert/ monitoring expert; Financial resources for field surveys; REDD+ Thematic Working Groups to review the national strategies and interventions
5	**MBIGS/SIS**				
5.1	The SIS/MBIGS institutional framework, indicators and monitoring tolls linked with the NFMS system are updated and adjusted to the Sub-National Level	X			
5.2	Safeguards are integrated as part of the MBIGS into the design of the Sub-NFMS and supported according to the level of development of the Sub-NFMS.	X			

S#	Key components/ outputs/ activities	Phase-1 (current)	Phase-2 (short-term)	Phase-3 (long-term)	Resources required (phase-2 and 3)
5.3	All safeguards based on resource data and participation in the Sub-National REDD+ programs are supported by the Sub-NFMS.			X	REED+ focal point; TWGs and their consultation and meetings; Financial resources for
5.4	Available baseline data regarding assessment of indicators on MBIGS collected at Sub-National level.	X			
5.5	The baselines will be updated and refined at the REDD+ project sites level		X	X	Concerned territorial DFOs and conservators; concerned staff from specialized units/ directorates/ circles (RE&D, PM&E, NTFPs, CD, etc.); REDD+ focal point/ coordinator; Thematic Working Groups; Financial resources for collection, compilation and digitalization of data on SIS/ MBIGS indicators; Financial resources for equipment (data collection equipment, computers and stationery etc.)
5.6	Regular assessment of the SIS/ MBIGS indicators on annual basis in the REDD+ project areas; compilation and sharing the SIS/ MBIGS reports with national level focal point			X	
5.7	Development and 0peration and maintenance of the SIS/ MBIGS data repository and integration with the Sub-National and National Web Portal		X	X	One data administrator to handle the data requests and data exchanges; Chief data officer to support the activities; External system consultant for maintenance and development support

5 RECOMMENDATIONS

- Sufficient time should be provided for the SLMS, Forest Inventory and data analysis. During the current Sub-NFMS assignment limited time remained a major constraint;
- Sufficient equipment should be provided to ensure quality and timely data collection. Limited number of equipment was one of the hurdles during the current assignment. The provinces have limited sets of modern survey equipment, however to timely and properly complete the inventories in the field there is need for provision of more sets of equipment.
- The surveys should be conducted in summer in the high-altitude areas and during winter in the low-lying southern areas. Selection of proper season is very important factor in timely and properly completion of forest inventories. Due to time limitation and delays in initial finalization of contracts the forest inventories had to be conducted during autumn and winter season which resulted in difficulty in accessing the high-altitude forests especially the sub-alpine forests.
- Instead of using post-monsoon, cloud-free, least haze a single image, in the era of data-cube, intense temporal coverage of Landsat 8 and 9, it is recommended to use an annual composite for the image classification. The yearly composite will better understand phonological stages to distinguish vegetation classes (Cropland, Shrubland, etc.) from the forest.
- Instead of relying only on the spectral response of the images, it is recommended to integrate spectral indices of vegetation, water, snow, soil, etc. along with the spectral reflectance.
- In terms of forest degradation, the combination of SMA and time series could improve the results
- There is strong need for improvement of the forest ecological and forest types boundaries and maps. The forest ecological zones and forest types mapping prepared during the NFMS development phase, was mainly based on elevation, which resulted in miss classification of forest types. The WWF-Pakistan GIS and Forestry experts tried to correct these mistakes and adjust the maps using local knowledge about the area and VHR Google maps, however further improvement is needed to avoid any miss classification.
- Manual recording of field survey data on paper data-sheets need to be replaced by Mobile Data Entry Aps (FAO Opensource Aps) to save time and reduce errors in data entry and recording as well as increase transparency and ensure quality. This will need proper training of the forest inventory teams.

6 REFERENCES

Ali, A., Hussain.K., Ismail.M, and Hussain.K. 2017. "Forest Carbon Inventory Of Gilgit Baltistan". Gilgit: Forest, Environment and Wildlife Department Gilgit Baltistan.

Ali, A. 2019. "Biomass And Carbon Tables Tree Species Of SFM Project Areas Of Punjab And Sindh". Peshawar: Pakistan Forest Institute.

Ali, A. 2020. "Biomass And Carbon Tables For Major Tree Species Of Khyber Pakhtunkhwa". Peshawar: Pakistan Forest Institute.

Belgiu, M., & Drăguţ, L. (2016). Random forest in remote sensing: A review of applications and future directions. ISPRS journal of photogrammetry and remote sensing, 114, 24-31.

Chave, Jérôme, Maxime Réjou-Méchain, Alberto Búrquez, Emmanuel Chidumayo, Matthew S. Colgan, Welington B.C. Delitti, and Alvaro Duque et al. 2014. "Improved Allometric Models To Estimate The Aboveground Biomass Of Tropical Trees". *Global Change Biology* 20 (10): 3177-3190. doi:10.1111/gcb.12629.

Climate Law and Policy/Hagler Bailly Pakistan, 2018. Framework for Design of a Safeguard Information System in Pakistan. Government of Pakistan, Ministry of Climate Change.

Climate Law and Policy/Hagler Bailly Pakistan, 2018. Framework for Feedback Grievance Redress Mechanism in Pakistan. Government of Pakistan, Ministry of Climate Change.

Christoffersen, Lisbet. 2019. Defining Non-Carbon Benefits, Working Paper Vol. 1, Forests of the World, Aarhus & Copenhagen. Available: https://www.forestsoftheworld.org/policy-documents

FAO, 2013. National Forest Monitoring Systems: Monitoring and Measurement, Reporting and Verification (M & MRV) in the context of REDD+ Activities. Available at www.fao.org/ publications.

FAO, 2016. Map Accuracy Assessment and Area Estimation: A Practical Guide. Food and Agriculture Organization of the United Nations. Rome. No.46/E.

Gilgit-Baltistan Environmental Protection Agency. 2017. "Gilgit-Baltistan Climate Change Strategy And Action Plan". Gilgit: Gilgit-Baltistan Environmental Protection Agency, Government of Gilgit Baltistan.

Government of Pakistan, 2013. Readiness Preparation Proposal (RPP) for Pakistan. In: Government of Pakistan Ministry of Climate Change.

Government of Pakistan, 2015. Action Plan for the Implementation of the National Forest Monitoring System of Pakistan. Ministry of Climate Change, Government of Pakistan.

Government of Pakistan, 2018. Framework For Design of a Safeguard Information System in Pakistan. Government of Pakistan, Ministry of Climate Change.

Government of Pakistan, 2018. National REDD+ Strategy and its Implementation Framework. Government of Pakistan, Ministry of Climate Change.

Government of Pakistan, 2020. Develop Forest Reference Emission Levels/Forest Reference Level and National Forest Monitoring System, Measurement, Reporting and Verification System For REDD+:

National Forest Monitoring System – Measuring, Reporting and Verification-Final Report. Government of Pakistan, Ministry of Climate Change.

Government of Pakistan, 2020. Develop Forest Reference Emission Levels/Forest Reference Level and National Forest Monitoring System, Measurement, Reporting and Verification System For REDD+: National Forest Reference Emission Level for Pakistan-Final Report. Government of Pakistan, Ministry of Climate Change.

Hussain, K.; Khan, M.I.; Afrasiyab, M., 2016. Capacity Based Need Assessment: National Forest Monitoring System (NFMS) for REDD+ in Pakistan. Ministry of Climate Change/WWF Pakistan/UN-REDD.

Hussain, K.; Shah, G. Q.; Nizami, A.; Ali, J.; Werter, F. 2021. Multi-stakeholder Self-Aassessment of REDD+ Readiness in Pakistan (R-Package). Government of Pakistan, Ministry of Climate Change.

Immitzer, M., Atzberger, C., & Koukal, T. (2012). Tree species classification with random forest using very high spatial resolution 8-band WorldView-2 satellite data. Remote sensing, 4(9), 2661-2693.

Intergovernmental Panel on Climate Change, 2003. Good Practice Guidance for Land Use Land-Use Change and Forestry.

Intergovernmental Panel on Climate Change, 2003b. Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types.

Intergovernmental Panel on Climate Change, 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Agriculture, Forestry and Other Land Use.

Intergovernmental Panel on Climate Change,1997. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

Khan, Ishfaq Ahmad, Waseem Razzaq Khan, Anwar Ali, and Mohd Nazre. 2021. "Assessment Of Above-Ground Biomass In Pakistan Forest Ecosystem's Carbon Pool: A Review". *Forests* 12 (5): 586. doi:10.3390/f12050586.

Khan, Saifullah, Zahoor Hussain Javed, Abdual Wahid, Asif Naveed Ranjha, and Mahmood Ul Hasan. 2020. "Climate Of The Gilgit-Baltistan Province, Pakistan". *International Journal Of Economic And Environmental Geology* 11 (3).

Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V.,Woodcock, C. E., & Wulder, M. A. (2014). Good practices forestimating area and assessing accuracy of land change. RemoteSensing of Environment, 148, 42–57.https://doi.org/10.1016/j.rse.2014.02.015

Olofsson, P.; Foody, G.M.; Herold, M.; Stehman, S.V.; Woodcock, C.E., & Wulder, M.A., 2014. Good practices for estimating area and assessing accuracy of land change. Remote Sensing of Environment, 148, 42-57

UNDP Pakistan. 2020. "Mountain Protected Areas Management And Responsible Tourism In Gilgit Baltistan". Islamabad: UNDP Pakistan.

UNFCCC, 2009. Decision 4/CP.15. COP15: Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009. FCCC/CP/2009/11/Add.1. https://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf#page=11

UNFCCC, 2011. Decision 1/CP.16 Paragraph 71 c. COP16: Report of the Conference of the Parties on its sixteenth session, held in Cancun from 29 November to 10 December 2010. FCCC/CP/2010/7/Add.1. https://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf#page=12

UNFCCC, 2014. Decision 11/CP.19. COP19: Report of the Conference of the Parties on its nineteenth session, held in Warsaw from 11 to 23 November 2013. FCCC/CP/2013/10/Add.1. https://unfccc.int/resource/docs/2013/cop19/eng/10a01.pdf#page=31

USGS, 2021. Landsat Processing Details | Landsat Missions. https://landsat.usgs.gov/landsat-processing-details. Accessed 19 September 2021.

7 ANNEXES

Annex-1: Institutional framework for Sub-NFMS (Gilgit Baltistan)

Recommended Institutional structure for PFMS					**Roadmap**		
Recommended unit	Composition	Functions/ Roles/ Responsibilities	Existing/ New	Any changes/ adjustments needed	Milestones for changes to be made	Timeline	Responsible person/ unit/ organization
Provincial REDD+ Steering Committee	• Secretary Forest and Wildlife and Environment (Chair), • CCFs, CFs and REDD+ Coordinator, technical heads of line depts., WWF, IUCN, AKRSP, KIU and UoBS as Members).	Policy and strategic decision making for REDD+	New	N/A	• Develop detailed structure and TORs • Notification by Secretary	• One month from endorsement of the PFMS	• REDD+ Coordinator
Provincial REDD+ Management Committee	• CCF (chair), • REDD+ Coordinator, CFs, Conservator Wildlife (members)	Provincial REDD+ management reviews and decision making	New	Representation of PARC official	• Develop detailed structure and TORs • Notification by Secretary	• One month from endorsement of the PFMS	• REDD+ Coordinator
Provincial REDD+ Coordination Unit	• REDD+ Coordinator • Forest Inventory Specialist • GIS/ SLMS specialist • GIS Analyst • RS Analyst • IT Specialist	• Provincial REDD+ implementation and coordination • Forest Inventory & SLMS data production • Quality Control • Grievance Feedback & Redressal at provincial level	Existing	• Create additional positions to support REDD+ coordinator (RS Analyst, GIS Analyst, IT Specialist, Forest Inventory Specialist)	• Develop proposal with TORs for new positions • Approval by Secretary • Approval by Finance • Creation and induction	• 12 Months	• REDD+ Coordinator
District REDD+ Coordination Unit	• DFO as Chair, • Reps of all line depts, NGOs/ CSOs/ LSOs as members	• District REDD+ implementation and coordination • Grievance Feedback & Redressal at district level	New	Formal notification for the responsibility	• Proposal/ TORs/ Structure • Formal approval by the Secretary	• 2 Months	• REDD+ Coordinator

		• Provision of district and local level information and data on REDD+ including MBIGS					
Quality Assurance Committee	PFI, WWF, IUCN, KIU, UoBS, EPA	Quality Assurance and Independent Verification	New	N/A	• TORs • Notification by Sec FW&E Dept. GB	• One month from endorsement of the PFMS	REDD+ Coordinator
Provincial GHG-Inventory Unit	• Director EPA • Deputy Director EPA • Representation of Academia	GHG Inventory	Existing	Formal notification for the responsibility	• TORs • Notification by Sec FW&E Dept. GB	• One month from endorsement of the PFMS	REDD+ Coordinator and Director Environment
REDD+ Research Unit	PFI, KIU, UoBS, NGOs (WWF, IUCN, AKRSP)	Research & Data Sharing	New		• Structure/ TORs • MoUs	• Three months from endorsement of the PFMS	REDD+ Coordinator/ KIU
TWGs (MRV/ SLMS/ GHG/ Governance/ Finance)	• Technical experts from Forest, Environment and Wildlife Dept; • Technical experts from NGOs • Technical experts from academia • Individual technical experts.	Provide technical guidance and input to provincial REDD+ Steering Committee, Provincial REDD+ Management Committee and Provincial REDD+ Coordination Unit and Provincial REDD+ GHG-I Unit	New	TORs and Structure	• Proposal development • Approval (by Sec FD)	• Two months	REDD+ focal

Annex-2: Sources of information for the drivers of deforestation and forest degradation events

Drivers of Deforestation and Forest Degradation	Source for information to detect the degradation and deforestation event and its extent	Verification body
Infrastructure Development	• Forest Department Roads Department / Highway • Local Government Department • Department of Physical Planning and Housing • Land use planning and development department • WAPDA (Hydel Projects) • LGRD	• Revenue Authority • Land use planning and development department • Irrigation Department • Highway department • Local government • Forest Department

Drivers of Deforestation and Forest Degradation	Source for information to detect the degradation and deforestation event and its extent	Verification body
	• Forest Conservation Committees • Revenue Department (Irrigation, Agriculture Departments & NGOs) • National/Provincial mapping agencies ("urban planning unit") • Academic institutions • Political administration • Police Department	
Settlements Habitation Urban / Shanty town expansion	• Forest Department (field staff) • Revenue Department • Municipal Corporation • Provincial Development Authorities • Local Community • Researchers • National/ provincial mapping agency	• Town Planning Department • Revenue Department • Municipal corporations / committees / Local government • Forest department
Mining	• Forest Department (field staff/guard; illegal cases) • Revenue department (illegal cases) • Mining Department (requests NOC from forest Department in legal cases) • Small Industries Department • Community members • Geological survey of Pakistan	• Town Planning Department • Mining department • Forest Department
Forest fires	• Forest Department (Forest Guards) • Local community (member) • Police reports • Meteorological department • Political Administration	• Police and disaster management staff • Forest officer
Commercial agriculture expansion	• Local Community • Forest Department (field staffs) • Development Authorities (concerned, prior request in legal cases (Land) • Revenue Department • Town and City Management • Agriculture Department	• Local Administration • Agricultural Department • Forest Officer (GIS, forest history files/records)

Drivers of Deforestation and Forest Degradation	Source for information to detect the degradation and deforestation event and its extent	Verification body
	• Crop Reporting Services	
Subsistence agriculture expansion	• Local Community • Forest Staff (Forest Department) • Agriculture Department (Land) • Revenue Department (Patwari) • Crop Reporting Services	• Local Administration • Agricultural Department • Forest Officer (Compartment history files) • Revenue Department Police (reports)
Small-scale agricultural practice expansion	• Local Community • Forest Staff (compartment / forest history files / police reports) • Agriculture Department (field officer) • (Land) Revenue Department (Patwari) • Town and City Management, • Provincial mapping unit	• Local Administration • Agricultural Department • Forest Department • Revenue department
Encroachment	• Forest Department (staff/guards) • Local Community • Revenue Department • Police • Journalists • Provincial Development Agencies • NGOs	• Local development authorities • Forest Department (Demarcation unit of FD; GIS) • Revenue department
Forest clearing for security purposes	• Forest Department (field staff) • Revenue Department • Community • Army-Police • Security Agencies • Govt. officials	• Local development authorities Forest Department (ground verification) • Revenue Department
Unsustainable timber and fuelwood extraction	• Forest Department (field staff/guards) • AKLASC (Azad Kashmir logging and saw mills corporation, timber) • Local community (member) • Police or another law enforcing agency • NGOs • Media	• Local development authorities • Forest Department (forest office, damage reports ground verification, timber assessment reports, working plans /management plan data)) • PFI • Local community
Fish pond establishment	• Fishery Departments	• Local development authorities

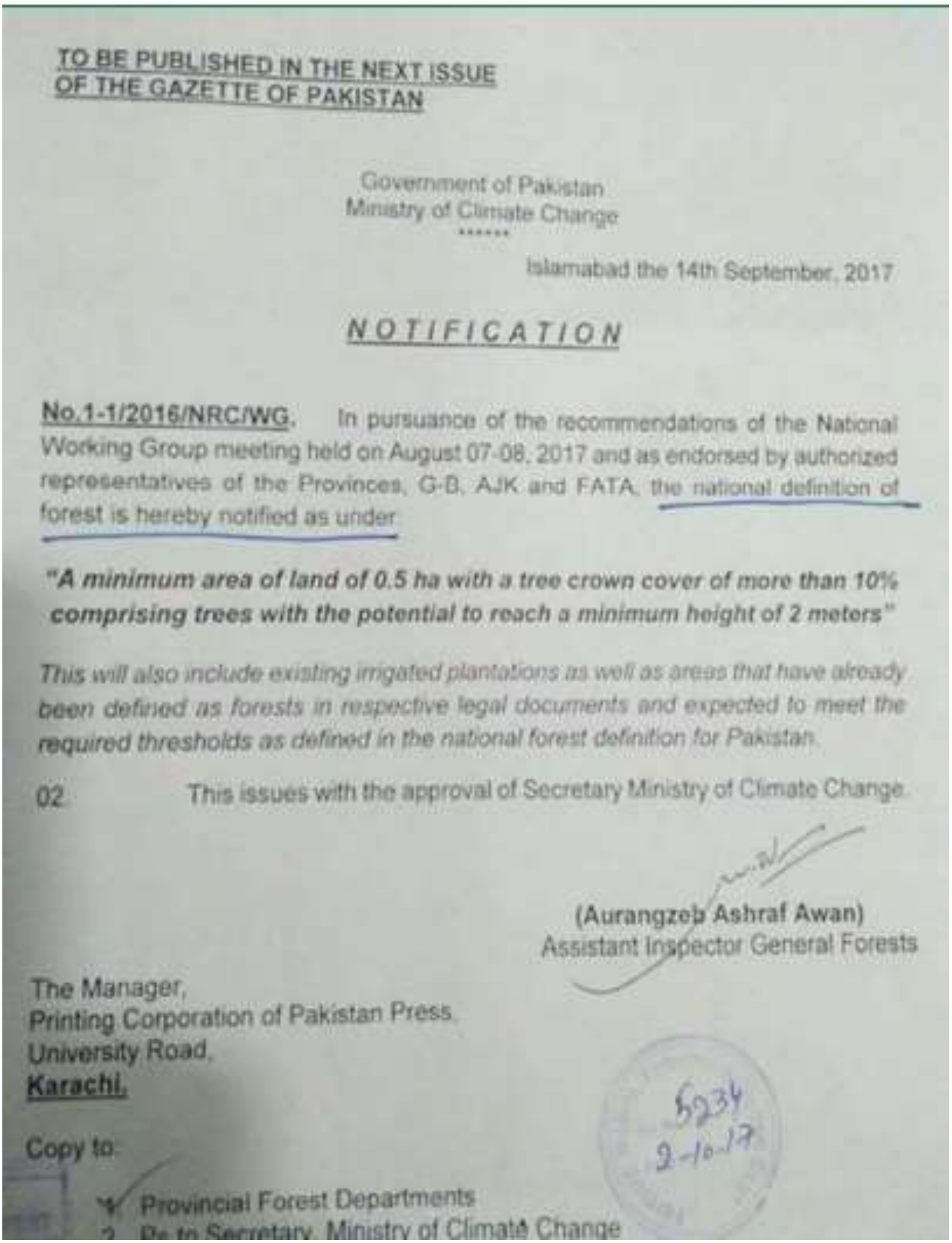
Drivers of Deforestation and Forest Degradation	Source for information to detect the degradation and deforestation event and its extent	Verification body
	• Forest Department (field staff) • Local community • Irrigation Department • WAPDA	• Forest Department (Staff/Officer)
Water-logging activities	• Agriculture Department • Land Department • Forest Department (field staff) • Local Farming communities • Soil Survey of Pakistan • National and Sub National mapping agencies • Irrigation department	• Local development authorities • Forest Officer (forest inventory reports)
Free / uncontrolled livestock grazing	• Forest Department / Forest Guards (local staffs) • Livestock Department • Revenue Department • Local Community (members)	• Any local person • Forest officer (Surveys conducted by forest department and livestock, damage and other reports)
Land lease / hand over	• Govt Dept/Provincial Development Agencies • Municipal Department • Forest Department (field staff/officer) • Revenue Department • Small industries • Tourism dept. • Mining department	• Revenue Department
Hotel industry development	• Forest Department (field staff) • Tourism Department • Local community • PPH • TDCP • Local development agencies	• Beneficiary • Forestry Officer (spot verification/GIS map/forest records, impact assessment reports, notes)
Unscientific forestry operations and management	• Forest Department (Forest officer) • Community • Media • Local administration	•
Atmospheric pollution	• Govt. dep • EPA	• Forest Staffs • Met Department

Drivers of Deforestation and Forest Degradation	Source for information to detect the degradation and deforestation event and its extent	Verification body
	• Meteorological department • Transport authority • Small industries department • Media	
Freshwater pollution	• Govt Dept • Agriculture Department • Fisheries Department • (Flood &) Irrigation Department • Municipal department • EPA • Forest Department • Health Department	• Forest Department • Environmental Department • Municipal Irrigation • EPA • Public Health
Floods	• Flood Relief Department • Flood Warning Centers • Forest Department • WAPDA • PDMA+NDMA • IRSA • Irrigation Department • Media Owners/Users • Pakistan Meteorological Department	• WAPDA • Meteorological Department
Forest diseases, and pest attacks	• Forest Department (DFO, field staff) • PFI • Pest Control Department • Community • Plant Protection Department	• Forest Department (Staffs/Officer) • PFI
Landslide impact areas	• Local community • Forest Department (field staff) • UNDP • NDMA Geological survey of Pakistan • FOMA	• Road Maintenance bodies • Forest Department (Forest officer) • RFO • Survey of Pakistan • AJK Land Use Planning • Communication & Works Department
Heavy snowfall impact area	• Local community & members • Forest Department (Staff)	• Climate / Met. department • Forest Officer

Drivers of Deforestation and Forest Degradation	Source for information to detect the degradation and deforestation event and its extent	Verification body
	• NDMA, PDMA • Pakistan Meteorological Department	• Media
Earthquake impact area	• Local community & members • Forest Department (Staff) • Revenue Department • NDMA, PDMA (GBDMA, SDMA) • Meteorological Department • Geological Department • Political administration	• NDMA, PDMA (GBDMA, SDMA) • Forest Office
Run off/erosion impact area	• Local community & members • Forest department (Staff) WAPDA NDMA • Pak. Meteorological Department • Irrigation Department S • oil conservation Department	• Forest Officer
Drought impact area	• Local District Administration • NDMA+PDMA • Disaster Management Authority • Locals/Community • Agriculture/Forest Department (Staff; Rangeland officer) • Revenue Department • Pak. meteorological department	• Forest Officer • Met Department
Oceanic intrusion and tsunami impact area	• Locals / Forest Staff • Pak. Meteorological department Pak. • Navy. • Coastal Development Authority / Coastal Management Department • Marine Fisheries Department • Sea Port Authorities • Disaster Management Authority • Revenue Authority • WMO • WAPDA	• All national Departments

Source: National Forest Monitoring System – Measuring, Reporting and Verification Final Report, 2020

Annex-3: Notification of National Definition of Forest



TO BE PUBLISHED IN THE NEXT ISSUE
OF THE GAZETTE OF PAKISTAN

Government of Pakistan
Ministry of Climate Change

Islamabad the 14th September, 2017

NOTIFICATION

No.1-1/2016/NRC/WG. In pursuance of the recommendations of the National Working Group meeting held on August 07-08, 2017 and as endorsed by authorized representatives of the Provinces, G-B, AJK and FATA, the national definition of forest is hereby notified as under

"A minimum area of land of 0.5 ha with a tree crown cover of more than 10% comprising trees with the potential to reach a minimum height of 2 meters"

This will also include existing irrigated plantations as well as areas that have already been defined as forests in respective legal documents and expected to meet the required thresholds as defined in the national forest definition for Pakistan.

02. This issues with the approval of Secretary Ministry of Climate Change.

(Aurangzeb Ashraf Awan)
Assistant Inspector General Forests

The Manager,
Printing Corporation of Pakistan Press,
University Road,
Karachi.

5234
2-10-17

Copy to:

1. Provincial Forest Departments
2. PS to Secretary, Ministry of Climate Change

Annex-4 Notification of National Definition of Forest Degradation

TO BE PUBLISHED IN THE NEXT ISSUE OF GAZETTE OF PAKISTAN PART-I

Government of Pakistan
Ministry of Climate Change
******

Islamabad, the 19th November, 2021

NOTIFICATION

No.F.5-2/2016/NRC/F-Definition: In pursuance of the recommendations of the National Consultative Workshop held on October 26, 2021 and as endorsed by authorized representatives of all the Provinces, Gilgit-Baltistan (GB) and Azad Jamu and Kashmir (AJK), the national definition of "*Forest Degradation*" is hereby notified as under:-

> "***Human induced long-term losses within forest persisting for at least 4 years or more due to change in tree canopy cover i.e., open (11-30%), sparse (31-50%), medium (51-70%), dense (>70%) resulting in reduction of forest carbon stock and not qualifying as deforestation.***"

Explanatory note: This definition is only for REDD+ purpose.

2. This issues with the approval of Secretary, Ministry of Climate Change.

MINISTRY OF CLIMATE CHANGE R&I 19 NOV 2021 PH: 9245804 ISLAMABAD

(*Dr. Muhammad Rizwan Asghar*)
Section Officer (Forest)

The Manager,
Printing Corporation of Pakistan Press,
University Road,
Karachi

Copy to:

1. All Provincial Forest Departments, including Gilgit-Baltistan and Azad Jamu and Kashmir.
2. PS to Secretary, Ministry of Climate Change, Islamabad.

Annex-5: Revised Forest measurement manual (provided as separate file)

Annex-6: Data Storage and Processing report (provided as separate files)

Annex-7: MBIGS monitoring and institutional framework for Gilgit Baltistan

Noncarbon aspects and indicators	Indicators	Tools for assessment (secondary sources/ new information collection)	Responsible Unit
Multiple benefits			
Sustainable extraction of NTFPs by local communities for subsistence use and small-scale local enterprises	• Description of non-timber forest products extracted • Volume of extracted non-timber products	• Mountain and Market Project reports • Reports of NTFP Project GB FD • DFOs records • NTFP Permits' record GB FD • Fresh NTFPs surveys in REDD+ project areas	• DFO office • CF and CCF offices
Increased production of timber in forests, potential for increase of income for local communities	• Production of timber from forests by species • Growing stock in forests by species	• DFOs record • CCF office record • Working plan • Provincial Forest Inventory (REDD+)	• REDD+ Coordination office • DFO office • CF and CCF offices
Increased production of timber from plantations	• Production of timber from plantations by species • Growing stock in plantations by species	• DFOs record • CCF office record • 10BTTAP Office record • AKRSP reports/ record/ data • Provincial Forest Inventory (REDD+)	• REDD+ Coordination office • DFO office • CF and CCF offices
Changes in natural values, biodiversity, wildlife, potential for eco-tourism	• General description of activities (and where possible, outcomes) relating to: the identification/valuation of ecosystem services, payment for ecosystem services, alternative livelihood/rural development, eco-tourism. ○ Total number of species (plants/wildlife) ○ Proportion of the native tree species to the total tree basal area ○ No of tourists visiting the area	• Record of CF Wildlife • Wildlife Survey Reports of CF • NGOs survey reports (WWF, IUCN, SLF etc.) • Provincial Forest Inventory (REDD+) • Tourism surveys in REDD+ project areas	• Concerned Forest and WL circles • CCF office • REDD+ Coordination office
Desertification control, erosion control, watershed protection, quantity and quality of streams	• Deserted/eroded area • Vulnerable area for hazards • Number and area of forest fires	• DFOs office record/ Forest fire reports • GIS data (REDD+ coordinator) • Provincial Forest Inventory (REDD+)	• REDD+ Coordination office • DFO office • CF and CCF offices

Noncarbon aspects and indicators	Indicators	Tools for assessment (secondary sources/ new information collection)	Responsible Unit
Impacts			
Socio-economic impacts from participation in forest management, changing forest resource utilization patterns, availability of raw materials for processing	• Forest related jobs or businesses created • Improvement in household income • Change in women's disposable income	• Records of DFOs • TBTTP progress reports (green jobs) • Community nurseries record • Women nurseries record • Socio economic surveys in REDD+ areas • NOGs reports	• REDD+ Coordination office • DFO office • CF and CCF offices
Resource impacts, including forest development, desertification control, erosion control, watershed protection	• General description of how natural/untouched forests and biological diversity has been recognized and protected during REDD+ implementation (EIAs developed/implemented), environmental assessment framework followed. • Confirmation that no natural/untouched forests have been converted as a result of REDD+ implementation. • Natural/untouched forest area before/after REDD+ implementation • Number of project proposals granted/refused authorization (percentage) on the basis of ecological integrity	• Record of territorial DFOs • GIS/ RS data (REDD+ Coordination Office) • Record of CCF office • Forest Monitoring Reports • Third Party Monitoring Reports • Provincial Forest Inventory (REDD+) • P&D Department Record /Reports	• CCF Office • REDD+ coordination office
Impact of distribution of benefits on local socio-economic conditions	• Improved access to social services (health, education, training, credit) • Improvement in women's access to services (health, education, training, credit)	• District Statistical Reports • District Census Reports • Health dept record • Education dept record • Social Welfare dept record • AKHS record • AKES record • Socio-economic surveys in REDD+ project areas	• REDD+ coordination office • GB P&D Department
Governance and Safeguards			
Forest policies, including land tenure, rights to forest resources, carbon rights and policy reform	• General description of the efforts made to recognize, document and enforce forest and land tenure claims including customary claims. • General description of the efforts made in respecting the rights of native communities and tribal communities in REDD+	• Working Plans • PFMS/ MRV Reports • Record of Revenue dept (DC office) • Grievance Related Reports/Litigation Data • Prosecution Reports/ record at DFO/ CF/ CCF offices	• REDD+ Coordination office • Concerned DFOs

Noncarbon aspects and indicators	Indicators	Tools for assessment (secondary sources/ new information collection)	Responsible Unit
	• Number of registered rights-holders (before/after implementation) • Number of unregistered rights-holders' areas (before/after implementation) • Number of tenure related disputes (before/after implementation) • Number of resettlements (after implementation) • Number of people from communities represented • Number of collectively owned/managed forests (before/after implementation) • Number of contested collectively owned/managed forests (before/after implementation)	• Reports from Community Organizations (VOs/ LSOs/ Conservation Organizations) • Record of REDD+ Coordination Unit/ Office	
Law enforcement	• Area encroached before and after implementation • Number of encroachment cases registered • Number of civil suitcases/ prosecution cases for encroachment	• Record of territorial DFOs • Prosecution record at CCF office	• REDD+ Coordination office • Concerned DFOs
Transparency and anticorruption	• General description of information sharing/dissemination activities undertaken in relation to each strategic option • Number of awareness-raising workshops held and number of attendees • Number of requests for information received and number dealt with (percentage rejected and granted) in each province • Number of appeals lodged in each province • Average time for dealing with requests/appeals in each province • Description of procurement processes (consultants, companies) involved in the implementation of each strategy option • Description of procurement outcomes • Evidence of how REDD+ finance has been spent (per-strategic option based on audited reports)	• CCF office record • Record of District and Provincial REDD+ Offices/ Units • GB FD Website • Audit record (CCF office)	• CCF office • REDD+ Coordination office
Management of the National REDD+ Program, inclusion of stakeholders in consultation and review	• General description of the efforts made to carry out consultations and involve local people in the REDD+ design and implementation process (awareness-raising, types of consultations held) • Number of meetings held, number of participants per meeting, categories of participant	• District and Provincial REDD+ Coordination office record • GIS Data • NGOs project reports • Prov REDD+ office record	• Concerned DFO • REDD+ Coordination office

Noncarbon aspects and indicators	Indicators	Tools for assessment (secondary sources/ new information collection)	Responsible Unit
	• General description of the efforts made in identifying and respecting traditional knowledge in REDD+ in Pakistan • Evidence of traditional knowledge/practices recognized/integrated into REDD+ implementation (intellectual property, traditional practice protocol) • General description of any additional measures taken to engage native communities, tribal population and vulnerable groups in REDD+ planning and implementation (culturally appropriate communications and outreach). • Description of FPIC processes followed where appropriate • Number of participants from native communities, tribal population and vulnerable groups engaged in consultations (percentage) • Number of FPIC processes carried out • Proportion of women involved in REDD+ planning/implementation Emission projections • Emission reductions. General description on the types of measures to identify and address risks of reversals. Rates of reversals of emissions • General description on the types of measures to identify and address risks of leakage of emissions • Rates of deforestation in neighboring areas before and after the REDD+ intervention implementation	• 10BTTAP and other projects reports/ data • Provincial Forest Inventory & SLMS Data/ reports of REDD+ project • Provincial PFMS submissions	
Benefit distribution policies	• Description of how benefits from REDD+ (monetary and non-monetary) are shared (with local populations) • Description of the efforts made to meaningfully involve women to share in the benefits (monetary and non-monetary). • Total finance disbursed • Total finance disbursed collectively to community owned/managed forests • Proportion of women receiving monetary/non-monetary benefits from REDD+	• REDD+ Projects Reports • Village Conservation Committees record • Women conservation committees record	• REDD+ coordination office
Conflict resolution mechanisms	• General description of the types of grievances received in relation to REDD+ by the FRGM and	• FGRM Reports • SES Implementation Reports	• FGRM committee • REDD+ coordination office

Noncarbon aspects and indicators	Indicators	Tools for assessment (secondary sources/ new information collection)	Responsible Unit
	other relevant entities and how they were dealt with • Number of grievances received • Number of grievances investigated • Number of grievances resulting in the establishment of a mediation assembly • Number of grievances appealed to the courts/unresolved (percentage)	• REDD+ Projects Reports • Village Conservation Committees record • Women conservation committees record	

Annex-8: Sectoral information and data on MBIGS indicators-Gilgit Baltistan

Description/ Indicators	Information/ Data	Reference	Remarks
Multiple Non-Carbon Benefits			
Sustainable extraction of NTFPs by local communities for subsistence use and small-scale local enterprises			
Description of NTFPs extracted	Major NTFPS being extracted by local communities in GB are: Wild mushrooms, Medicinal and aromatic plants, Nuts and berries.		
Volume of extracted NTFPs	Data not available		
Increased production of timber in forests, potential for increase of income for local communities			
Production of timber from forests.	9969 m^3 (2019-2020)	Gilgit Forest Department, 2022	
Growing stock in forests.	191.36m^3/ ha (57.48million m^3)	(MoCC and WWF-Pakistan, 2022)	The figures are assessed from the Provincial Forest Inventory data 2021.22
Increased production of timber from plantations/Farmlands/Agroforestry			
Production of timber from plantations/ farmlands	0.27 million cubic meters	(MoCC and PIDE, 2022)	Table 21, page 38
Growing stock in plantations/Farmlands	2.9 million cubic meters (24 cubic meter/ ha)	(MoCC and PIDE, 2022)	Table 17, page 36
Changes in natural values, biodiversity, wildlife, potential for eco-tourism			
General description of activities (and where possible, outcomes) relating to the identification/valuation of ecosystem services, payment for ecosystem services, alternative livelihood/rural development, eco-tourism.	• Soil and water conservation (landslide control, erosion control, groundwater recharge)		These are the main services.

	• Biodiversity and habitats improvement (species of flora and fauna, health habitats) • Ecotourism and livelihoods improvement (Improved livelihood opportunities (tourist guides/ services, shops, hotels, transport)		
Total number of species(trees/wildlife)	• Trees: 16 species • Wildlife: ○ Mammals =54, ○ Birds =500 ○ Reptiles =25 ○ Amphibians =22 ○ Fresh water Fish = 25 ○ Invertebrates =3000 ○ Flowering plants =5310 ○ Wildlife plants =8920	(MoCC and WWF-Pakistan, 2022), (Rasool *et al*, 2015)	Tree species listed during the FI 2021/22 by WWF-Pakistan
Proportion of the native tree species of the total tree species in forests	99.80%	(MoCC and WWF-Pakistan, 2022)	The figures are assessed from the Provincial Forest Inventory data 2021.22
Erosion control, watershed protection	• Erosion control: ○ Total area under forest cover: 0.30 million ha • Watershed protection: ○ Total area of catchments under forest cover: 0.30 million ha	(MoCC and WWF-Pakistan, 2022)	The catchment area figures are assessed from the Provincial Forest Inventory data 2021-22and LULC Change maps (2016-2020) (Forest areas in Sub-Alpine, Dry Temperate, Moist Temperate, Subtropical Pine and Scrub forests).
Desertification control, erosion control, watershed protection, quantity and quality of streams			
Deserted/eroded area	• Area without forest cover: 6.67 million ha.	(MoCC and WWF-Pakistan, 2022) (Shah 2022)	
Vulnerable area for hazards	**Landslides:** Remote villages across the region, Protracted blockade of KKH, Upper Hunza	Gilgit-Baltistan Environmental Protection Agency (GB-EPA). 2017	Forest fire is assessed from forest fire reported plots in forest inventory

	Avalanches: All areas situated near the seasonal snow cover areas are vulnerable to avalanche phenomena **Flash Floods:** All groups and population adjacent to natural streams and along the river banks are vulnerable to floods. Roads and infrastructure, power generating stations; and irrigation channels and drinking water supply systems have frequently been hit by flash floods. **GLOF:** Bagrote Valley, Gilgit, Khanday, Baltistan, Gojal, Upper Hunza and Scrub zone. Forest Fire prone: 0.02 million ha	(MoCC and WWF-Pakistan, 2022)	
Number and area of fires	• Not Available		
Description/ Indicators	**Information/ data and year**	**Source**	
Impacts			
Socio-economic impacts from participation in forest management, changing forest resource utilization patterns, availability of raw materials for processing			
Forest related jobs or businesses created	• Not Available	GBFD, 2022	
Improvement in household income	• Average household income of rural areas: PKRs. 22684 /month	(Ullah, Ali Khan and Ahmad 2014)	
Change in women's disposable income	Not Available		
Resource impacts, including forest development, desertification control, erosion control, watershed protection			
General description of how natural/untouched forests and biological diversity has been recognized and protected during REDD+ implementation (EIAs developed/implemented), environmental assessment framework followed.			These points to be described during the implementation of the REDD+
Confirmation that no natural/untouched forests have been converted as a result of REDD+ implementation.			These points to be elaborated during the REDD+ implementation
Natural/untouched forest area before/after REDD+ implementation	• Area before REDD+ implementation: 0.30 million ha	(MoCC and WWF-Pakistan, 2022)	Area of natural forests after implementation is to be provided after implementation of REDD+

Number of project proposals granted/refused authorization (percentage)			These points to be elaborated during the REDD+ implementation
Impact of distribution of benefits on local socio-economic conditions			
Improved access to social services (health, education)	• Enrolment ratio at government primary schools in rural areas of GB: 66.9% • Post-Natal Consultation ratio at health facilities in GB: 44.4%	(Planning & Development Department Government of Gilgit Baltistan 2017)	Education: Page, 16 Health: Page, 13
Improvement in women's access to services (health, education, training, credit)	• Post-Natal Consultation ratio at health facilities in rural areas of GB: 44.4%	(Planning & Development Department Government of Gilgit Baltistan 2017)	Health: Page, 13
Description/ Indicators	**Information/ data and year**	**Source**	
Governance and Safeguards			
Forest policies, including land tenure, rights to forest resources, carbon rights and policy reform			
General description of the efforts made to recognize, document and enforce forest and land tenure claims including customary claims.	The Gilgit-Baltistan Forest Act, 2019 legally recognizes forest and land tenure claims of local communities in Protected Forests, Village Forests and private Forests. Moreover, the Gilgit-Baltistan Forest Act, 2019 also recognizes community engagement in planning and decision-making regarding management of these forests.	(Government Of Gilgit-Baltistan Law and Prosecution Department 2019)	
General description of the efforts made in respecting the rights of native communities and tribal communities in REDD+	• Environmental and Social Management Framework [ESMF] developed under the National Forest Monitoring System (National Level) • Feedback and Grievance Redressal Mechanisms (FGRM) (National Level) • Safeguards Information System (SIS) (National Level) • KP REDD+ Strategy	(MoCC, 2018)	
Number of recognized/ registered rights-holders/ concession holders (before/after implementation)	• Not Available		
Number of resettlements (after implementation)	This will be provided after implementation of REDD+		
Number of people from communities represented	• Not Available		

Area of collectively owned/managed forests (before/after implementation)	Before REDD+ Implementation: Not Available After REDD+ implementation: (will be assessed after implementation)		
Law enforcement			
Area encroached before and after implementation	• Not Available		
Number of civil suit cases and prosecution cases	• Not Available		
Transparency and anticorruption			
General description of information sharing/dissemination activities undertaken in relation to each strategic option	• The Gilgit Baltistan citizen Corner, 2022 • Public Procurement Regulatory Authority Ordinance, 2002 • Establishment of the Gilgit Baltistan Public Procurement Authority • Gilgit Baltistan Public Procurement Authority Web portal	("GBPPRA" 2022) ("Citizen Corner | Gilgit Baltistan Portal" 2022)	
Number of awareness-raising workshops held and number of attendees	This will be assessed once the REDD+ implementation starts.		
Number of requests for information received and number dealt with (percentage rejected and granted) in each province	• Not Available	(GBFD, 2022)	
Number of appeals lodged in each province	The REDD+ FGRM is not yet developed and initiated. This will be assessed once the FGRM is operational.		
Average time for dealing with requests/appeals in each province	Same a above		
Description of procurement processes (consultants, companies) involved in the implementation of each strategy option	Procurement under REDD+ programme will be done as per GBPPRA rules and procedures. This includes; • Procurement plan (duly approved by the procurement entity); • Advertisement (on GBPPRA web portal and newspapers): Call for expression of interests and tenders. • Initial shortlisting of interested parties; • Call for proposals and bids; • Evaluation of proposals/ bids. ○ Technical evaluation	("GBPPRA" 2022)	Once the REDD+ FGRM is operational, it will also take up any grievances regarding procurement.

	○ Financial evaluation • Announcement of successful bidders (on the GBPPRA Web portal); • Grievance Feedback and Redressal • Award of contract		
Description of procurement outcomes	Procurement outcomes are displayed on the KPPRA web portal. Following procurement outcomes will be documented during the REDD+ implementation; • Timely procurement • Transparency ensured • Grievances properly redressed • Quality and quantity of goods and services ensured • Value for money	("GBPPRA" 2022)	
Evidence of how REDD+ finance has been spent (per-strategic option based on audited reports)	Following aspects will be assessed during implementation and completion of REDD+ projects; • Financial audit; • Physical verification and monitoring of activities; • GIS/ RS Based assessment; • Assessment of process adopted for implementation of activities; • Beneficiaries and stakeholders' feedback.		
Management of the National REDD+ Program, inclusion of stakeholders in consultation and review			
General description of the efforts made to carry out consultations and involve local people in the REDD+ design and implementation process (awareness-raising, types of consultations held)	• Consultation workshops on drivers of deforestation and degradation; • Consultation sessions with local communities. • Awareness sessions on REDD+ concept and its importance • Awareness material and guidebooks (on Climate Change and Role of Forests, REDD+ PES Monitoring, introduction to REDD+, Risks and Benefits of REDD+,		

	Trees of Pakistan), and Video Documentaries		
Number of meetings/ sessions held, number of participants and categories of participant	• Meetings/ sessions: 2 • Total participants: 25 (Male: 25, Female:0)	(Ministry of Climate Change 2021)	Total nationwide meetings/ sessions: 151 (2015-2021) Total nation-wide participants (local communities and indigenous community of Kalash): 911 (males: 769 and Females: 142)
General description of the efforts made in identifying and respecting traditional knowledge in REDD+ in Pakistan			
Evidence of traditional knowledge/practices recognized/integrated into REDD+ implementation (intellectual property, traditional practice protocol)	Will be assessed during implementation of REDD+		
General description of any additional measures taken to engage native communities, tribal population and vulnerable groups in REDD+ planning and implementation (culturally appropriate communications and outreach).	• Conducted tree plantation campaigns; • Developed awareness material • Media campaigns • Trainings		
Description of FPIC processes followed where appropriate	• Awareness and education of local and indigenous communities regarding REDD+ and their rights • Consultation during the REDD+ preparatory phase; • Consultations for REDD+ activities planning through community organizations • Hold dialogues through community organizations and development of agreements. • Implementation		The FPIC process will be documented at the start of the REDD+ projects. Only consultations at the preparatory phase have so far been held.
Number of participants from native communities, tribal population and vulnerable groups engaged in consultations (percentage)	• Total participants: 25(Male: 25, Female:0)	(Ministry of Climate Change 2021)	These are the numbers of participants in consultation

			during the REDD+ preparatory phase.
Number of FPIC processes carried out	Only one process completed at the REDD+ preparatory stage		
Proportion of women involved in REDD+ planning/implementation Emission projections	0% (at the REDD+ preparatory stage)	(Ministry of Climate Change 2021)	
Emission reductions. General description on the types of measures to identify and address risks of reversals. Rates of reversals of emissions.	Risks and measures to be identified; • Social Risks: (e.g., Land tenure disputes, conflicts regarding NR use rights and carbon benefits; Political and social instability; ill maintained benefits to communities.) • Economic Risks: (e.g., Insufficient finance to support project activities; Attractive alternative land uses; Activities of external parties reversing climate benefits.) • Environmental Risks: (e.g., Fire, Floods, GLOFs, Droughts, Earthquakes, Landslides) • Technical Risks: (e.g., inappropriate activities to deliver climate benefits, livelihood benefits, and insufficient/ low technical capacity for implementation of activities.) • Administrative risks: (e.g., premature transfer and posting or high turnover of project staff, policy changes, changing government priorities.)	(Plan Vivo, 2022)	The assessment and adoption of necessary measures will be documented during the planning and implementation REDD+ projects/ activities.
General description on the types of measures to identify and address risks of leakage of emissions	As recommended in the KP REDD+ Strategy following leakages will be assessed and addressed during the REDD+ project planning and implementation. • Market leakages: Assess risks of leakages of emissions due to changes in supply and demand wood and wood products.	(Forestry, Environment & Wildlife Department Government of Khyber Pakhtunkhwa 2018)	

	• Leakages by activity-shifting: Assess risks of leakages due to shifting of drivers of deforestation/ forest degradation from the project area to another area.		
Benefit distribution policies			
Description of how benefits from REDD+ (monetary and non-monetary) are shared (with local populations)	This will be compiled at the time of REDD+ projects design and implementation. Some potential aspects to be considered are given as under; • Provincial, district and community level Institutional arrangements for sharing of benefits • Sharing of benefits between communities, within communities and within households. • Sharing of monetary benefits among forest owners and recognized right holders. • Sharing of monetary benefits among non-owners and un-recognized users/ right holders; • Sharing of non-monetary benefits and compensations among the above types of beneficiaries. • Sharing of monetary and non- monetary benefits among women.		
Description of the efforts made to meaningfully involve women to share in the benefits (monetary and non-monetary).			
Total finance disbursed	This will be reported during and after implementation of REDD+ projects		
Total finance disbursed collectively to community owned/managed forests	This will be reported during and after implementation of REDD+ projects		
Proportion of women receiving monetary/non-monetary benefits from REDD+	This will be reported during and after implementation of REDD+ projects		
Conflict resolution mechanisms			

General description of the types of grievances received in relation to REDD+ by the FRGM and other relevant entities and how they were dealt with	This will be reported during and after implementation of REDD+ projects		
Number of grievances received	This will be reported during and after implementation of REDD+ projects		
Number of grievances investigated	This will be reported during and after implementation of REDD+ projects		
Number of grievances resulting in the establishment of a mediation assembly	This will be reported during and after implementation of REDD+ projects		
Number of grievances appealed to the courts/unresolved (percentage)	This will be reported during and after implementation of REDD+ projects		

Annex-9: Forest Inventory Results-Forest type wise carbon densities

Forest Type	AGC (t/ha)	BGC (t/ha)	DWC (t/ha)	Litter (t/ha)	Total (t/ha)	SOC (t/ha)	Total with SOC (t/ ha)
Sub-Alpine	31.5	7.9	0.01	0	39.3	26.9	66.2
Dry Temperate	41.7	10.4	0.09	0.001	52.3	49.3	101.6
Farm plantations	5.64	1.41	-	-	7.05	49.3	56.35

*AGB for farmland plantations has been taken from the PIDE report 2022 (24 m3/ha). Average wood density for farmland tree species is 0.5 tons/ m3. General root/shoot ratio has been taken as 0.25. SOC density for dry temperate (49.3 t C/ ha) has taken from the current study.