Ministry of Climate Change
Government of Pakistan

REDD+
Pakistan

FOREST REFERENCE EMISSION LEVELS PAKISTAN

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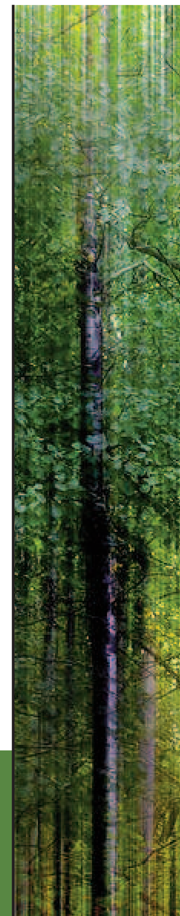

Forest Reference Emission Levels

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FOREWORD

Pakistan is one of the most vulnerable countries to Climate Change. The Global Climate Risk Index developed by Germanwatch for 2021 has placed Pakistan as the eighth most vulnerable country to climate change in spite of the fact that Pakistan's contribution to global greenhouse gas (GHG) emissions is very small.

National Climate Change Policy 2012 and National Forest Policy 2015 provide framework for addressing the challenges of Climate Change adaptation and mitigation which is one of the top most priorities of the present government. As a responsible member of the global community, the Government of Pakistan upholds its strong commitment to addressing issues of climate change and taking all possible steps towards achievement of the net-zero emission milestone.

In this regard, several initiatives have been taken at the federal and provincial levels to reduce deforestation and enhance national tree cover such as, Billion Tree Afforestation Project launched in 2015 by Khyber Pakhtunkhwa Province and large scale mangrove restoration along the coast. Taking its strong resolve forward, Ten Billion Tree Tsunami Programme has been initiated with public funding starting from 2019 targeting planting of 3.29 billion plants nationally during the first Phase. Post 2012 countrywide scientific assessment is planned to measure carbon sequestration potential of these initiatives for global climate benefits.

Pakistan is a party to the United Nations Framework Convention on Climate Change (UNFCCC). The Convention has recognised deforestation as one of the main sources of emissions of carbon resulting in global warming. Forests are also recognised as a key source for climate change mitigation in Article 5 of the Paris Agreement that came into force on November 04, 2016 during 22nd Conference of Parties (COP 22). The Article 5 encourages parties to take actions to implement and support, including through results-based payments, the existing framework as set out in related guidance and decisions already agreed under the Convention for: policy approaches and positive incentives for activities relating to REDD+.

Since 2015, Pakistan has embarked upon various readiness activities with the financial support from Forest Carbon Partnership Facility of World Bank to support implementation of Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Pakistan.

The National Forest and Rangeland Resource Assessment (NFRRA) study published in 2004 assessed the annual rate of deforestation in Pakistan as 27000 ha. The FREL report has scientifically assessed the average annual rate of deforestation of 11,442 hectares resulting in annual emissions of approximately 946,653 tons of carbon equivalent.

I am highly pleased to note that the UNFCCC experts have found Pakistan's FREL as transparent, complete and in overall accordance with guidelines contained in the annex to decision 12/CP.17. I am confident that this benchmark will support Pakistan in accessing result based payments that will create incentives for local communities and other stakeholders supporting forest conservation and reducing emissions from forestry sector, which are projected to rise. The Ministry of Climate Change has developed National Forest Monitoring System to scientifically monitor, measure and report greenhouse gas emissions from forestry sector against the established benchmark.

Lastly, I congratulate National REDD+ team for leading the process of formulation of this FREL with technical assistance from Arbonaut Oy. Finland jointly with WWF-Pakistan. I also appreciate the support extended by sub-national forestry departments, National UNFCCC Focal Point, REDD+ Focal Points and Working Groups, Global Climate Change Studies Centre (GCISC) and other relevant stakeholders towards achieving this important milestone.

Malik Amin Aslam
Special Assistant to Prime Minister on Climate Change
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MESSAGE

Pakistan is mainly a dryland country—80% of its land falls under arid and semi-arid regions. Pakistan's forest cover is low occupying 5.45% of the total geographical area of the country. In 2019-20, the forestry sector contributed 2.13% in agricultural and 0.41% in overall GDP (GoP, 2020) besides providing multitude of ecosystems services for the dependent communities. However, the forests in Pakistan are subject to continued deforestation and degradation, resulting in loss of biodiversity, land degradation due to erosion and desertification.

Government of Pakistan has assigned high priority to protecting natural forests as a central agenda under its commitments towards climate change actions. Based on the country's commitments under the SDGs and the Paris Agreement, the Government has committed significant investment in the forestry sector. The Ten Billion Tree Tsunami project envisaging a target to plant/ regenerate 3.2 billion trees in phase 1, across Pakistan is a massive intervention towards enhancing forest cover and conserving biodiversity. Simultaneously, there is commitment to contain deforestation and degradation through enforcement of existing legislation, greater engagement with communities and finding solutions for the deeply embedded factors that lead to deforestation.

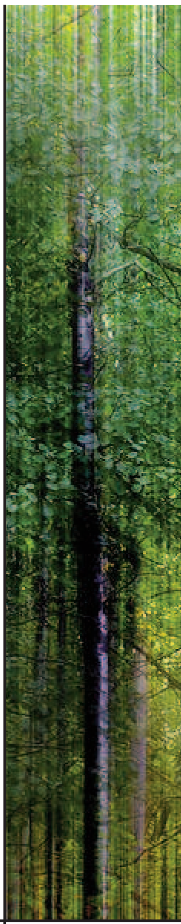
Since 2015, Pakistan has undertaken various readiness activities with the financial support from Forest Carbon Partnership Facility of World Bank to support implementation of Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Pakistan.

It is gratifying to note that this Forest Reference Emission Levels Report has set scientifically assessed benchmark for Pakistan to support actions for reducing emissions from forestry sector in accordance with national agenda and also to access any performance based RBP through multilateral and bilateral mechanisms and in partnership with private sector under REDD+. It is very satisfying to note that UNFCCC experts have found Pakistan's FREL being transparent, accurate, complete and consistent as per the guidelines contained in the annex to decision 12/CP.17.

I would like to thank the FCPF-World Bank for providing financial grant to support REDD+ readiness preparations in Pakistan and congratulate National REDD+ team for leading the process and appreciate support of National UNFCCC Focal Point, Global Climate Change Impact Studies Centre (GCISC) and sub-national forestry departments for their support and the technical assistance provided by M/S Arbonaut Oy. Finland jointly with WWF-Pakistan for achieving this milestone.

As a responsible member of global community, the Government of Pakistan upholds its strong commitment to addressing issues of climate change.

Naheed S. Durrani
Secretary
Ministry of Climate Change, Islamabad



ACKNOWLEDGEMENTS

The Ministry of Climate Change, Government of Pakistan acknowledges the support of the forestry departments of Azad Jammu & Kashmir (AJK), Balochistan, Gilgit Baltistan (GB), Khyber Pakhtunkhwa (KP), Punjab and Sindh during the preparation of this document, including the collection and verification of forestry data. In particular, the support of Provincial REDD+ Focal Points is greatly acknowledged and appreciated, including Mr. Irtiza Qureshi (AJK); Mr. Niaz Khan Kakar (Balochistan); Mr. Ismail (GB); Mr. Gohar Ali (KP); Mr. Shahid Rasheed Awan and Mr. Iftikharul Hassan Farooqui (Punjab); Mr. Riaz Ahmed Wagan and Mr. Abdul Jabbar Kazi (Sindh) and Mr. Anwar Ali, Pakistan Forest Institute (PFI).

The Ministry also commends the support provided by the Provincial REDD+ Working Groups representing forestry officials, civil society, INGOs (IUCN & WWF Pakistan), Survey of Pakistan, Pakistan Space and Upper Atmosphere Research Commission (SUPARCO), Global Change Impact Studies Centre (GCISC) and academia (PFI, Pir Mehar Ali Shah Arid Agriculture University, Rawalpindi and University of Punjab) during field data collection and consultation workshops.

The Ministry also acknowledges the technical input and supervision provided by the former Inspector General of Forests, Syed Mahmood Nasir and Late Dr. Shehzad Jehangir (DIGF) who played crucial roles in laying the foundation of REDD+ in Pakistan through formulation of Readiness Preparation Proposal for accessing financial grant from the FCPF-World Bank to support readiness preparation work in Pakistan.

The Ministry greatly appreciates Mr. Dirk Nemitz, Programme Officer UNFCCC for coordinating the technical review process of Pakistan's submission and Mr. Muhammad Irfan Tariq, UNFCCC National Focal Point for Pakistan for facilitating submission and steering the local coordination and review process.

The Ministry greatly acknowledges the support of the assigned UNFCCC team of technical experts, Mr. Rizaldi Boer (Indonesia) and Mr. Pierre Brender (UK) for their critical technical review of the first submission that has resulted in significant improvement in the technical aspects of this modified submission.

The technical and administrative support of ex-National REDD+ Coordinators, including Mr. Inamullah Khan, Dr. Ghulam Akbar, for initiating the process of preparation of this report is also highly acknowledged. The coordination and administrative support provided by the Dr. Raja Muhammad Omer (DIGF) and staff of National REDD+ Office, especially Research Associates is also appreciated.

The Ministry also acknowledges and appreciates the contribution of Mr. Anish Joshi towards capacity building of national stakeholders in national forest monitoring systems.

Last but not least, FREL is the first ever scientific carbon assessment using IPCC guidelines and standards. This work would not have been possible without the financial support of FCPF-World Bank as part of the Readiness Grant.

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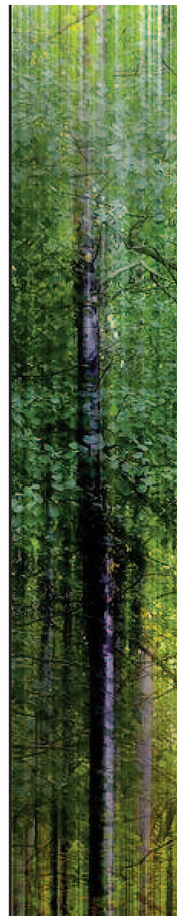


ABBREVIATIONS

AD	Activity Data
AFOLU	Agriculture, Forestry and Land Use
AGB	Above Ground Biomass
AGC	Above Ground Carbon
AJK	Azad Jammu & Kashmir (Autonomous Territory)
ASAD	Applied System Analysis Division
BAU	Business as Usual
BEF	Biomass Expansion Factor
BGB	Below Ground Biomass
BGC	Belowground Carbon
BN	Balochistan (province)
CH_4	Methane
cm	Centimetre
CO_2-e	Carbon Dioxide Equivalent
COP	Conference of the Parties
CPEC	China-Pakistan Economic Corridor
DBH	Diameter at breast height (at 1.3 m or 1.37 m height from the ground level)
DIGF	Deputy Inspector General Forests
DOS	Dark Object Subtraction
DWC	Deadwood Carbon
EF	Emission Factor
FAO	Food and Agriculture Organization of the United Nations
FATA	Federally Administered Tribal Areas (Now the Newly Merged Districts of Khyber Pakhtunkhwa)
FCPF	Forest Carbon Partnership Facility
FD	Forest Department (provincial)
FOSS	Free and Open Source Software
FREL	Forest Reference Emission Levels
GB	Gilgit Baltistan
GCISC	Global Change Impact Studies Centre
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GOP	Government of Pakistan
ha	Hectare
ICT	Islamabad Capital Territory
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KP	Khyber Pakhtunkhwa

L1T	Terrain Corrected Level 1
LIDAR	Light Detection and Ranging
LULC	Land Use Land Cover
MODIS	Moderate Resolution Imaging Spectroradiometer
MRV	Measurement, Reporting and Verification
N_2O	Nitrous Oxide
NFI	National Forestry Inventory
NFMS	National Forest Monitoring System
NTFP	Non-Timber Forest Products
PAMs	Policies and Measures
PB	Punjab
PFI	Pakistan Forest Institute
QA	Quality Assurance
QC	Quality Control
REDD+	Reducing Emissions from Deforestation and Forest Degradation in developing countries, and the role of conservation, sustainable management of forests, and enhancement of forest carbon stocks in developing countries
ROI	Regions of Interest
R-PP	Readiness Preparation Proposal
SD	Sindh
SLMS	Satellite Land Monitoring System
SOC	Soil Organic Carbon
SOP	Survey of Pakistan
SUAV	Small Unmanned Aerial Vehicles
SUPARCO	Pakistan Space and Upper Atmosphere Research Commission
SWIR	Short Wave Infrared
TOA	Top of Atmosphere
UNFCCC	United Nations Framework Convention on Climate Change
VHR	Very High-Resolution
VNIR	Visible and Near Infrared
WG	National Thematic Working Groups
WWF	World Wide Fund for Nature

EXECUTIVE SUMMARY

The total land area of Pakistan, as published by the Survey of Pakistan (SOP), is 796,096 km^2 including Islamabad Capital Territory (ICT), Balochistan (BN), Khyber Pakhtunkhwa (KP) including the merged FATA, Punjab (PB) and Sindh (SD). After including the territories of Gilgit-Baltistan (GB) and Azad Jammu & Kashmir (AJK), the total REDD+ programme area is defined as 879,106 km^2.

Status of Forest Cover at the National Level

The national forest cover has been assessed for 5 reference years[1] including 1996, 2000, 2004, 2008 and 2012 based on notified national forest definition. This does not include the fruit trees in orchards and farmland trees. The mean national forest cover estimates vary from 5.45 to 5.67 percent between the years with uncertainty of ± 0.8% between 2004 and 2012.

Table: Historical Assessment of Forest Cover at National Scale

Years	Forest Area (Ha)	% Area
2004	4 981 163	5.67%
2008	4 858 259	5.53%
2012	4 786 831	5.45%

By forest type, dry temperate forests have the largest proportional coverage (36%) followed by sub-tropical broadleaved scrub (19%), moist temperate (15%), Chir Pine (13%), riverine (4%), irrigated plantation (4%), thorn (3%), mangrove (3%) and sub-alpine forests (2%). The mean forest carbon stock was estimated to be 192 Million tons in 2004-2012.

Assessment of Deforestation

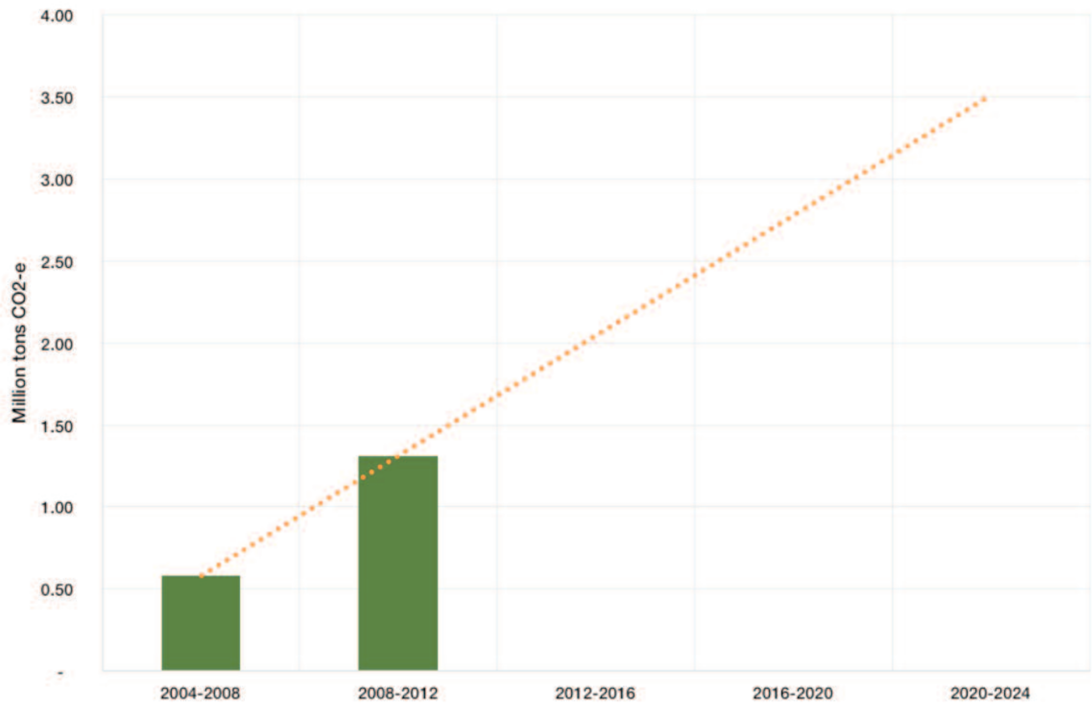
Due to limited reference data availability, the deforestation has been assessed from 2004-2012 period. The average annual deforestation during that period has been estimated up to about 11,000 hectares, whereas, an increasing trend of more than 17,000 ha was observed from 2008-2012.

Most of the area affected by deforestation between 2004-2012 consisted of riverine (34%), scrub (20%), dry temperate forests (19%), pine (13%) and thorn forests (9%).

National Forest Emissions Level (FREL)

The mean annual emissions from the deforestation were up to 1.0 Million tons of CO_2-e between 2004 and 2012 with the projected increasing emission trend from deforestation. The largest share of CO^2 emissions originated from dry temperate (34%), riverine (27%) and Chir pine forests (16%) followed by moist temperate (11%), scrub (9%) and thorn (3 %) forests in 2004-2012. Based on above, the FREL has been proposed as 946,653 Tonnes CO_2e.

Mean annual emissions (Mt CO_2-e) from deforestation (2004-2012) and projection (2012-2022) at national level



1 INTRODUCTION

Climate change is the single most important threat to humanity and ecosystems. The forestry sector, commonly considered as bearing a high natural capital value for the society and also a safeguard against climatic threats, has suffered heavily during the past two decades. The current forest cover of Pakistan is extremely inadequate when considering exposure of the country to future climatic threats. A number of factors have contributed to deforestation: prominent among these being poverty, population pressures and lack of fiscal space for strong policy initiatives in protecting forests. Even though Pakistan is a small emitter of global GHG emissions, it is included in the top eight countries in the world most vulnerable to the impacts of climate change, (Global Climate Risk Index developed by Germanwatch 2021).

The current population of 207.8 million (GoP, 2018) places Pakistan as the sixth most populous country of the world. At an average economic growth rate of 4.9 percent from 1952 to 2015 (GoP, 2016), with increase to 5.4 percent on average from 2016 to 2018 (GoP, 2018), Pakistan is classified primarily as a lower middle-income and agrarian country (GoP, 2016). The population directly and indirectly associated with the agriculture sector is estimated to be 42.3 percent (GoP, 2017) with a contribution of 18.9 percent to the overall GDP of the country. The forestry sector has a current share of 0.39 percent in the overall national GDP and posted a growth of 7.17 percent in 2018 (-2.37 percent in 2017) due to higher timber production reported by Khyber Pakhtunkhwa province (GoP, 2018).

Pakistan is mainly a dry land country with 80 percent of its land in arid and semi-arid areas. According to the definition of 'forest', the total forest land has been assessed as about 4.79 million hectares, which was 5.45 percent of the country's territory in 2012. The officially reported area subject to afforestation was about 123,500 hectares between 2009 and 2013. Besides, there were also about 57,912 km of linear plantations reported under control of the Provincial and State Forest Departments.

The official country territory, as reported and published by the Survey of Pakistan (SOP), is 796,096 km^2 including Islamabad Capital Territory (ICT), Balochistan (BN), Punjab (PB), Sindh (SD) and the Federally Administered Tribal Areas (FATA), which has now been merged administratively with Khyber Pakhtunkhwa (KP). Gilgit-Baltistan (GB) and Azad Jammu and Kashmir (AJK) are referred to as "Disputed Territory" without demarcating the international border (SoP, 2012, see Annex 1). Therefore, the land areas of these two provinces are not officially published.

1.1 Relevance

The country is highly exposed to future climatic threats. The forestry sector, commonly considered as bearing a high natural capital value for the society and a safeguard against climatic threats, has suffered heavily during the past two decades (R-PP MTR, 2017).The increasing trend in projected emissions from forest sector has been attributed to the threat of accelerated deforestation and forest degradation in many parts of the country in the wake of rising population and associated wood demands, weak tenure governance, encroachments and land cover changes superimposed by adverse impacts of climate change.

Several socio-economic factors have been reported to accelerate the deforestation trends in the country (GoP, 2016), prominent among these being poverty, population pressure and lack of fiscal space for strong policy initiatives in protecting forests. Considerable efforts are being taken by the GoP for the revival of forestry in the country. These efforts include expanding the forest cover through mega tree plantation programmes, strengthening the regulatory and forest protection policy mechanisms, and implementation of international mechanisms under the United Nations Framework Convention on Climate Change (UNFCCC), such as, reducing emissions from deforestation and forest degradation with conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+).

A solid foundation for REDD+ was laid by the MOCC in 2010 with the notification of the National Focal Point (NFP) for REDD+ followed by notification of provincial focal points in all provinces and territories of Pakistan. The REDD+ initiatives received full governmental ownership with the inclusion of REDD+ in the Climate Change Policy 2012 (GoP, 2012).

In 2013, four working groups were formed on governance and management of REDD+; stakeholder engagement and safeguards; national forest monitoring system (NFMS); measurement, reporting and verification (MRV); and drivers of deforestation and forest degradation. The National Thematic Working Groups (WG) serve as national platforms that engage stakeholders in scientific discussions, plan and organise research, collect data and serve as a platform for providing the National Steering Committee (NSC) on REDD+ with validated data and information for its decisions. Pakistan's National Forest Policy 2015 (GoP, 2015), approved by the Council of Common Interest under the chairmanship of the Prime Minister of Pakistan in November 2016, also gives provisions for mainstreaming REDD+ as a tool to curb deforestation and enhance forest cover and forest carbon stocks. The coordination functions of the National REDD+ Office are to be taken over by the Pakistan Climate Change Authority established under Section 5 of the Climate Change Act, 2017.

1.2 General Approach

The UNFCCC invites parties to submit information and rationale on the development of their FREL and/or FRL, including details of the national circumstances, and if adjusted, including details on how the national circumstances were considered in accordance with the guidelines contained in annex to decision 12/CP.17. Paragraph (b) of the annex to decision 12/CP.17 enquires parties to provide transparent, complete, consistent and accurate information, including methodological information used at the time of construction of FREL and/or FRL, including, inter alia, as appropriate, a description of data sets, approaches, methods, models and assumptions used, descriptions of relevant policies and plans, and descriptions of changes from previously submitted information. Further guidance was provided in Decision 13/CP.19 which requires country parties to provide description of relevant policies and plans (Paragraphs d & e) to include assumptions about the future changes to domestic policies in construction of the FREL and/or FRL (Paragraph h).

FREL/FRLs are guided as benchmarks for assessing REDD+ performance by modalities contained in UNFCCC Conference of Parties (CoP) decisions, most notably decision 12/CP.17 and its annex. These modalities state that when establishing FREL/FRLs, parties should do that transparently considering historic data and adjust them for national circumstances. A stepwise approach is allowed that enables parties to improve the FREL/FRLs by incorporating

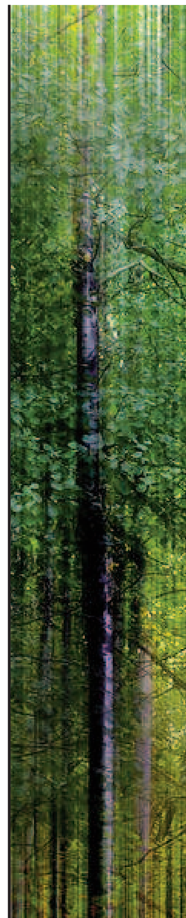


Table 1: **Pakistan's FREL Compliance Concerning the Relevant UNFCCC COP Decisions**

UNFCCC Reference	Description	Pakistan's FREL
Decision 12/CP. 17 II. Paragraph 9	Submission of information and rationale on the development of forest FRL/FRELs, about the details of national circumstances and their consideration	- The methodological details included in the FREL technical document and its annexes.
Decision 12/CP.17 II Paragraph 10	Stepwise approach	- Developing FREL following a gain-loss approach for Tier 2 emission factors (EF) derived with sub-national data sets. - The first submission with available data and its subsequent analysis supporting selection of relevant activities and pools.
Decision 12/CP. 17 Annex II. Paragraph 9	The information contents guided by the most recent IPCC guidance and guidelines Submission of information and rationale on the development of forest FRL/FRELs, about the details of national circumstances and their consideration	- 2006 IPCC Guidelines have been adopted to guide the development besides the UNFCCC decisions. - The methodological details included in the proposed FREL technical document and in its annexes.
Decision 12/CP.17 Annex, paragraph I	Activities	- Inclusion of deforestation.
Decision 12/CP.17 Annex, paragraph (c)	Pools and gases	- CO2 emissions from above-ground (AGB) and below-ground biomass (BGB) pools.
Decision 12/CP.17 Annex, paragraph (d)	Forest definition applied in the GHG inventories	- Forest definition notified in September 2017 - Tier 2 emission factors produced by the main forest types.

better data, improved methodologies and, where appropriate, additional carbon pools. A FREL/FRL must maintain consistency with a country's greenhouse gas inventory (according to 12/CP.17, Paragraph 8).

A summary of Pakistan's FREL compliance with these UNFCCC decision modalities is given in Table 1.

1.3 The Objectives of this Submission

The first objective is to present a national FREL figure for REDD+ implementation in Pakistan and to assess effectiveness of Policies and Measures (PAMs) through clear, transparent, accurate, complete and consistent estimates of carbon emissions from the forestry sector.

The second objective is to fulfil a global responsibility to report the national contribution to the mitigation of climate change

A final objective is to access results based REDD+ Finance for reducing emissions

1.4 Process of FREL Establishment

In scope of the REDD+ readiness, Pakistan has started proceeding stepwise by developing the first national FREL for the establishment of FREL with support of an international consulting firm Arbonaut Oy in joint venture with WWF-Pakistan. The consultant worked in collaboration with the Ministry and other REDD+ stakeholders including provincial forest departments, REDD+ working groups, and provincial REDD+ focal points, etc. The following stepwise process was adopted:

Step 1: Establishment of National Standards

1.4.1 Definition of Forest

The national definition of forest complies with the following definition:

"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 definition for Pakistan."

The minimum threshold values for land area and canopy cover were selected as per national forest definition finalised in consultation with provincial forestry departments. This threshold has been fixed keeping in view the fact that the dominant species in scrubs and thorns in Pakistan, i.e. Acacias and Olives, have potential to reach 2 m at maturity and considering the spatial resolution of Landsat satellite data with wide coverage.

1.4.2 Deforestation

The direct human induced conversion of forest to non-forest (UNFCCC) or the permanent reduction of the tree canopy cover below the minimum 10% threshold (FAO, 2015). For this submission, deforestation and emission estimates are only based on changes in natural forests and exclude irrigated plantations; though the notified forest definition includes irrigated plantations as one of the forest types. A minimum mapping unit of 0.5ha has been applied for the deforestation mapping.

1.4.3 Activity Data

The data on the magnitude of human activities resulting in emissions or removals taking place during a given period of time (UNREDD 2013).

1.4.4 Emission Factors

Emission factors for deforestation represent average net carbon dioxide (CO_2) emissions per hectare of land when forest land has been converted to non-forest.

1.4.5 FREL / FRLs

FRELs and / or FRLs are benchmarks for assessing a country's performance on REDD+. Though the UNFCCC does not explicitly specify the difference between a FREL and a FRL, the most common understanding is that a FREL includes only emissions from deforestation and degradation, whereas a FRL includes both emissions by sources and removals by sinks, thus it also includes enhancement of forest carbon stocks.

FREL refers to average gross annual emissions as CO_2-equivalent tons per year. This average is calculated using activity data and emission factors for each forest stratum separately with the following formula:

FREL (tons CO_2 in average per year) = Annual deforestation (hectares in average per year) X EF (tons CO_2-e of average emissions per hectare)

1.4.6 Forest Stratification

The forest stratification has been adapted from the classification scheme published and revised by Champion et al. (1965) (Figures 1a and 1b). As part of the FREL development process, a spatial information layer has been generated primarily with help of the global spatial data available for altitude, range, slope, orientation, weather data (average annual temperature/rainfall) and geographic distribution annotations by Champion et al. (1965) (Table 2).

Figure 1a: Zonal Map of Forest Types of Pakistan

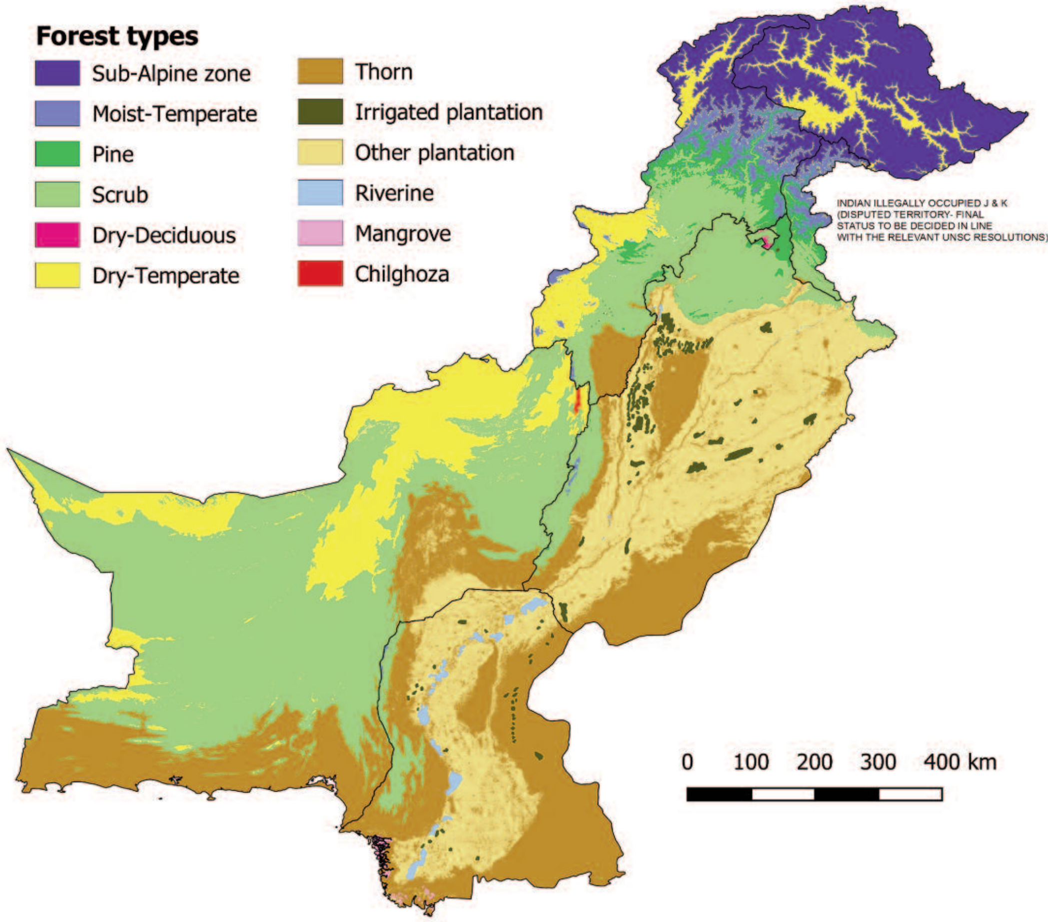


Figure 1b: Forest Stratification

Climate Zone	Main Forest Stratum	Sub-Stratum
1. Tropical	1.1 Littoral and swamp forest	1.1.1 Mangroves
	1.2 Dry deciduous	
	1.3 Thorn forest	
	1.4 Riverain forests	
2. Sub-Tropical	2.1 Broad- leaved evergreen Scrub forests	2.1.1 Montane sub-tropical scrub
		2.1.2 Sub-tropical broad-leaved evergreen
	2.2 Chir Pine forests	
3.Temperate	3.1 Moist Temperate Forests	
	3.2 Dry Temperate Forests	3.2.1 Montane Dry Temperate Coniferous
		3.2.2 Dry temperate Juniper and Chilghoza
		3.2.3 Dry Temperate Broad-leaved
4. Alpine	4.1 Sub-Alpine Forests	
5. Plantations	5.1 Linear	5.1.1 Road side plantations
		5.1.2 Railway side plantations
		5.1.3 Canal side plantations
	5.2 Irrigated Plantations	

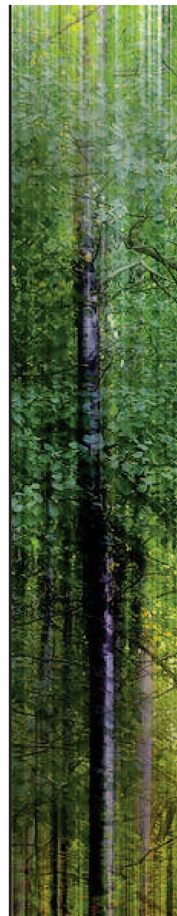


Table 2: Forest Strata, Altitude Range, Mean Rainfall and Temperatures (Adapted from Champion et al., 1965)

Forest Stratum	Altitude range (Nothern/ Southerrn Aspect)	Mean annual rainfall	Mean minumum temperature
Littoral and Swamp (Mangroves)	Max 3 m	16-23 cm	16 °C
Thorn	3-385 m	5-49 cm	10 °C
Dry deciduous	253-510 m	83-107 cm	10 °C
Scrub	457-1524 m	12-98 cm	7 °C
Pine	914-1676/2134 m	77-162 cm	13 °C
Moist temperate	1524-3048 m	64-152 cm	2 °C
Dry temperate	1524-3353/3658 m	14-74 cm	-4 °C
Sub-Alpine	3353-3810/3962 m	< 66 cm	-13 °C

Step 2: Field and Satellite Based Inventories

Field and satellite based data was acquired and assessed for a period from 1992 to 2012. Land use, land cover classification and time-series analysis has been conducted using 55 historical Landsat satellite image scenes acquired for each reference year.

Forest inventory data for Khyber Pakhtunkhwa and Gilgit Baltistan was used as existing data, whereas, field data for Punjab, Sindh, Balochistan and AJK (Disputed Territory) was collected by a two-phased sampling approach. After careful assessments and consultation with stakeholders, the data points of 2004 onwards were considered reliable due to lack of reference data before 2004.

2 FREL ESTABLISHMENT (AREA, ACTIVITIES AND POOLS COVERED)

2.1 Area Covered

The official country territory, as reported and published by the Survey of Pakistan (SOP), is 796,096 km^2. For the FREL development purposes, the national and provincial boundaries have been digitised from the administrative boundary map originating from the SOP. The national FREL also covers the territories of GB (69,713 km^2) and AJK (Disputed Territory) (13,297 km^2) according to the area extent references provided by the respective sub-national units. The mangrove forest patches and estuaries with vegetation in the Southern coastal regions in BN and SD have been included. The total FREL area sums up to 879,106 km^2 including the provinces and states as the sub-national units.

It should be noted that the SOP map has been used as the national boundary reference (digitised from the rectified raster map in scale 1:3,000,000) except in case of AJK and Southern coastline due to low resolution. The mapped area statistics are scaled to correspond to the official territory area.

2.2 REDD+ Activities

Deforestation refers to the activity when forest land is directly converted to non-forest land due to anthropogenic means. Deforestation has been identified as the key activity category for developing FREL, therefore, considering the resources and time constraints, the first submission of Pakistan's FREL only contains deforestation at a national scale.

The definition of '**Forest degradation**' was worked upon during the sixth Working Groups' meeting of REDD+, however, further deliberations are required. The emission factors and activity data for forests land remaining as forests land activity category could not be accounted for due to lack of reliable multi-temporal ground measurements at national level or even for surrogate data (proxy measures). Currently, a nationally representative data of coverage for forest growth, wood removal and disturbance is being prepared to produce reliable estimates for annual forest degradation rate under additional funding activities of the Readiness Preparation Proposal (R-PP).

When non-forest land is converted to forest land, tree vegetation is restored through either afforestation, reforestation or natural regeneration sub-activities, and is considered in the third activity category. **Carbon stock enhancement** takes place through forest restoration (afforestation, reforestation and natural regeneration) and forest growth, but there is very limited growth research and modelling base for accounting for emission removals through these activities.

The **Sustainable forest management** and **Conservation of forest carbon stock** are included in scope of future FRL, but potential emissions are reported as part of the deforestation activity. Reporting sustainable forest management and conservation activities separately would require including them as additional strata for collecting carbon-stock inventory time-series data and aggregating harvesting statistics at forest management and conservation unit level consistently throughout the country.

2.3 Carbon Pools and Gases

The Readiness Preparation Proposal (R-PP, 2013) declares that carbon pools included in the FREL/FRLs are to be limited initially to above-ground biomass. As more information becomes available, for instance from field assessments stored in the NFMS, other carbon pools may be incorporated, possibly stratified by forest type, as FREL/FRLs are periodically updated and as suggested in Decision 12/CP.17, paragraph 10.

The aboveground, belowground and soil carbon pools form 93-99 % of the total forest carbon stock in Pakistan according to the pilot national forestry inventory (NFI) data. There is an immediate change in above-ground and belowground carbon stocks after a forest is harvested, as a significant part of them is converted to timber and deadwood pools.

The Soil Organic Carbon (SOC) change dynamics are largely dependent on the kind of land management applied and the gradual change is accounted over a period of 20 years in scope of the GHG-I accounting (IPCC, 2006). During the pilot NFI campaign, it was found that in some forest areas, the SOC content was even higher outside the forestland depending on the applied land management. Monitoring and modelling soil carbon changes also requires implementing permanent soil monitoring design under different forest management regimes. Due to limitations, soil carbon is excluded from this submission and may be an area for future improvement.

Based on pilot NFI results, the litter and deadwood were found insignificant; hence, they are excluded from this submission.

The terrestrial carbon pools, included in the first FREL submission, are above-ground and belowground biomass.

The greenhouse gases accounted from the selected forest pools cover carbon dioxide (CO_2) only.

In the context of national greenhouse gas inventories, it is mandatory for Non-Annex-I countries to report the CO_2, CH_4 (Methane) and N_2O (Nitrous oxide) emissions. Carbon dioxide must always be included in REDD+ accounting. The CH_4 emissions are normally emitted from the forests growing in wet organic soils. Conversion of these forests through drainage is not an acceptable practice in scope of REDD+. Nitrous oxide emissions take place when biomass is burned, fertilizer is applied or nitrogen fixing trees are planted in the forest, but those activities are rare in Pakistan. There are no certain prospects that these activities would get more widely promoted in the forestry sector. If their importance increases as emission sources, they can be included following a stepwise approach in the future FREL/FRL submissions.

Furthermore, there is no significant forest fire issue causing deforestation in Pakistan. MODIS active fire archive data shows that 80% of the yearly fire alerts in Pakistan during 2004-2012 have happened in Sindh and Punjab. Of these, only 6% have occurred in forest areas during the years 2004, 2008 and 2012. Therefore, emissions from forest fires are not accounted for in this submission.

3 DATA, METHODOLOGY AND PROCEDURE

Pakistan follows a development approach based on the historical average of emissions from deforestation. Activity data is accounted for periods of 2004-2008 and 2008-2012. The two periods for temporal change assessments are considered as a reliable basis to create a projection for predicting the future business as usual trends. The past trends in gross deforestation are assessed through activity data mapping. Modelling historic emissions relies on the activity data produced with the documented Satellite Land Monitoring System (SLMS) methodology and time-series analysis.

For the Forest Stratification (as referred to in section 1.4.6) the spatial reference layer has been complemented with land cover / use classification and map reference data received from the provincial FDs regarding irrigated plantations and riverine forests. The existing statistics have been referred for the total irrigated plantation, riverine forest land cover and linear plantations, wherever the specific forest cover class was difficult to assess. The mangrove forest land area reference extent is sourced from the remote sensing study published by Abbas et al. (2013).

The recent pilot National Forest Inventory (NFI) plot data (2017/2018) has been used to validate the resulting spatial information layer by comparing the classified forest areas to indicator tree species information. The geographical distribution limits, structural characteristics and indicator species composition are summarised for each forest type in the following paragraphs using Champion et al. (1965) as the principal reference source.

The nationally harmonised emission factors have been developed with a reference to the previous forest carbon stock inventories. The pilot national forest inventory (NFI) measurements were conducted from October 2017–April 2018 covering all the main forest types in AJK (Disputed Territory), PB, SD, BN and FATA. A provincial forest carbon inventory campaign was also conducted from 2013-2016 providing above-ground and belowground carbon data coverage in KP (Ali, 2017). Another provincial carbon inventory was also completed in Gilgit-Baltistan including above-ground and belowground carbon pools in 2015-2016 (Ali et al., 2017). The total carbon densities for different forest strata and other land uses are used to derive emission factors (EF)[1].

All the emission calculations are conducted by the main forest types and then aggregated as national level estimates. It is assumed that sustainable forest management is implemented in the government owned irrigated plantations, so that there are no permanent deforestation events inside their boundaries, and they are carbon neutral in terms of emissions.

1. The harmonised national carbon densities by forest types have been used for developing the national emission factors found in Annex 4.

3.1 Data Collection

3.1.1 Mapping for Activity Data for Deforestation

Activity data mapping is based on the LULC classification using Landsat imagery (5/7/8) for each of the reference years of 2004, 2008 and 2012. The workflow is based on Free and Open Source Software (FOSS) tools and data available free of cost. The FOSS tools used are Quantum GIS, Orfeo Toolbox, SAGA processing tool QGIS and FAO Open Foris Collect Earth. The adopted Satellite Land Monitoring System (SLMS) workflow is illustrated in Figure 3. The SLMS manual provides the detailed process of how the one-time maps have been produced for each point of time under interest.

3.1.2 Emission Factors for Deforestation

i. Biomass and Carbon Stock Data

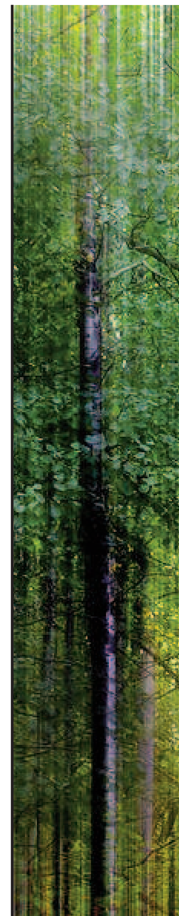
The forest inventory calculation process produces carbon density value (C ton/ha) at sample plot-level by aggregating biomass estimates relying on bio-physical tree measurements. Tree height has very high biomass prediction power in allometric equations but measuring heights for every tally tree is time consuming to measure accurately in field. For that reason, every 5th tally tree has been measured for its height during the pilot NFI campaign. Allometry is utilised to develop a height-diameter regression model and estimate tree heights. The height-diameter models by species and species groups have been assigned with plot wise model parameters. Tree-level above-ground biomass has been estimated using allometric models (Chave et al. 2014). The applied wood densities are listed in Annex 3. The tree-level above-ground biomass values have been aggregated using the sample plot data to represent biomass density per hectare. The belowground biomass for plot is calculated using the default IPCC root-shoot ratios. The root shoot ratios used were adjusted for AGB at plot level. The default IPCC fraction (0.47) is applied to convert biomass to carbon.

For ensuring transparency and robustness of estimates of carbon stocks, Quality Assurance (QA) and Quality Control (QC) procedures were implemented as detailed in Annex-7.

ii. Emission Factor Development

The emission factors represent emissions per hectare of land which has been converted to other land use. The national emission factors have been computed by forest strata using the recently collected pilot NFI and provincial carbon stock inventory results:

The sampling design was based on 307 clustered plots, each consisting of 5 sub-plots. The sampling was optimised for forest land: All clusters with the central sub-plot located inside the forest were visited in the field and measured. The measurements were then taken from all 5 sub-plots, regardless if some of them were outside the forest. Therefore, biomass data from plots is also available for "other land uses" than forest. The field observed plots during the pilot inventory are summarised by the provinces in the statistics below (1 = Forest land, 2 = Cropland, 3 = Grassland, 4 = Settlement, 5 = Wetland, 6 = Other land). It should be noted that the emission factors for these land uses



refer only to tree and bush biomass. Annual and perennial crops have been excluded to avoid destructive sampling, thus, their biomass has not been considered (or rather assumed as zero) in the emission factor development. Details are as under:

Table 3: Count of Sub-plot ID

Row Labels	Count of Sub-plot ID
AJK	61
1	52
2	6
3	3
Balochistan	65
1	54
3	3
6	8
FATA	25
1	23
3	2
Punjab	102
1	77
2	11
3	13
6	1
Sindh	54
1	35
2	6
3	10
6	3
Grand Total	307

Existing Carbon Stock Inventories:

Sub-alpine forest reference data, as well as carbon density data for the remaining provinces, is sourced from the KP and GB carbon stock inventories (Ali, 2017; Ali et al., 2017). The national unified densities and emission factors (Tier 2) are calculated by applying forest type areas mapped by provinces as weights to average the pilot NFI and provincial carbon inventory estimates. The mean carbon densities are also calculated for other land use classes and aggregated as national level averages by the climatic zones (Details available in Annex-4).

Figure 2: Forest Inventory Measurement

3.1.3 Land Cover Change Analysis

Land cover change analysis uses supervised machine learning to classify land use based on satellite images. After image acquisition, a teaching set is created by systematic sampling of plots to be visually interpreted in terms of land use and land use change. After this, an appropriate training set is defined and a Random Forests algorithm created to classify land use. The produced land use land cover (LULC) Map is then post-processed for noise removal. Based on the polished map, final LULC maps are compiled, their accuracy estimated and appropriate provincial FREL statistics computed.

The main steps involved are conducted technically, as follows:

Process 1: Satellite Imagery Acquisition and Processing
Activity data mapping is based on the LULC classification using Landsat imagery (5/7/8) for each of the reference years. Terrain corrected Level 1 (L1T) satellite imagery products[2] have been used. Top of Atmosphere (TOA) correction has been carried out using Dark Object Subtraction (DOS) algorithm to convert at-sensor radiance to Top-of-Atmosphere Reflectance. Atmospherically (and topographically) corrected image bands are stacked (concatenated) to generated composites (natural colour, VNIR, SWIR) for further analysis. Individual image scenes are stitched together (mosaicked) to cover one province or territory.

Process 2: Systematic Sampling Design and LULC Interpretation
Very High-Resolution (VHR) satellite imagery available on Google Earth is used as reference data when producing LULC maps and verifying their accuracies with visually interpreted and multi-temporal systematic plots using Open Foris Collect. Total 12,532 visual squared plots with 50x50-meter dimensions have been sampled and visually interpreted as subsets of 10’, 5’, 2.5’ and 1.25’ (arcminute) systematic grid as needed to get better representation for all the major land use and cover types.

Denser sampling grids have been applied for the smaller provinces, AJK and FATA, and the Islamabad Capital Territory, to ensure a sufficient number of plots over all the main land use and cover categories. Because of its large area, Balochistan province was sampled with the lowest density. In addition, a set of randomly sampled plots was generated within the detected (post-processed) deforestation areas to be able to assess their accuracy, because too few of the systematically sampled plots fell in those areas.

Many operators have been involved in the original interpretation process for different years of assessment, and interpretation results were cross-checked by other interpreters. All the conflicting observations between the different years were harmonised by a supervisor. For example, in case of KP province, provincial forest department staff members verified the visually assessed plot data for confirmation of accuracy assessment.

2. USGS Glovis (https://glovis.usgs.gov/next/#)
EarthExplorer (https://earthexplorer.usgs.gov/)
USGS Landsat Look (https://landsatlook.usgs.gov/viewer.html)

Process 3: Designing Sample Set for Image Training

Satellite image classification has been carried out using the Orfeo Toolbox classifier tool. A representative training set sample with regions of interest (ROI) has been selected by the operators for training image pixels for LULC classification.

Process 4: Image Classification

Image classification has been conducted using machine learning algorithm Random Forests. Random Forests is a non-parametric regression model capable of using continuous and categorical data.

Process 5: Post Classification Processing

Post classification processing has been applied to remove noises such as 'salt and pepper' effects of individual classified pixels. This is often done by "sieving" isolated pixels and replacing them with the classification of surrounding majority class pixels. Threshold for sieving is defined as 0.5 ha, which is the minimum continuous forest area threshold. The same threshold is applied for deforestation areas before accuracy assessment and area estimation.

Process 6: Accuracy Assessment and Area Estimation

Accuracy assessment and area estimation of the LULC map classes have been conducted using the sample of reference observations of the study area. The basic assumption is that the mapped areas of land cover are biased because of image classification errors, which are identified by comparing the map to a sample of reference observations. Area estimates and accuracy are then inferred by analysing the samples (Olofsson et al., 2014).

To operationalise the 2 meter height threshold, particularly in differentiating Scrubs and Thorns as forest land (have dominant trees potential to grow to reach 2 m at maturity) or not forest land, it was based on crown cover from the satellite assessment and environmental conditions (soil condition and climate zone) validated with support of the field forestry officers having good knowledge of ground conditions.

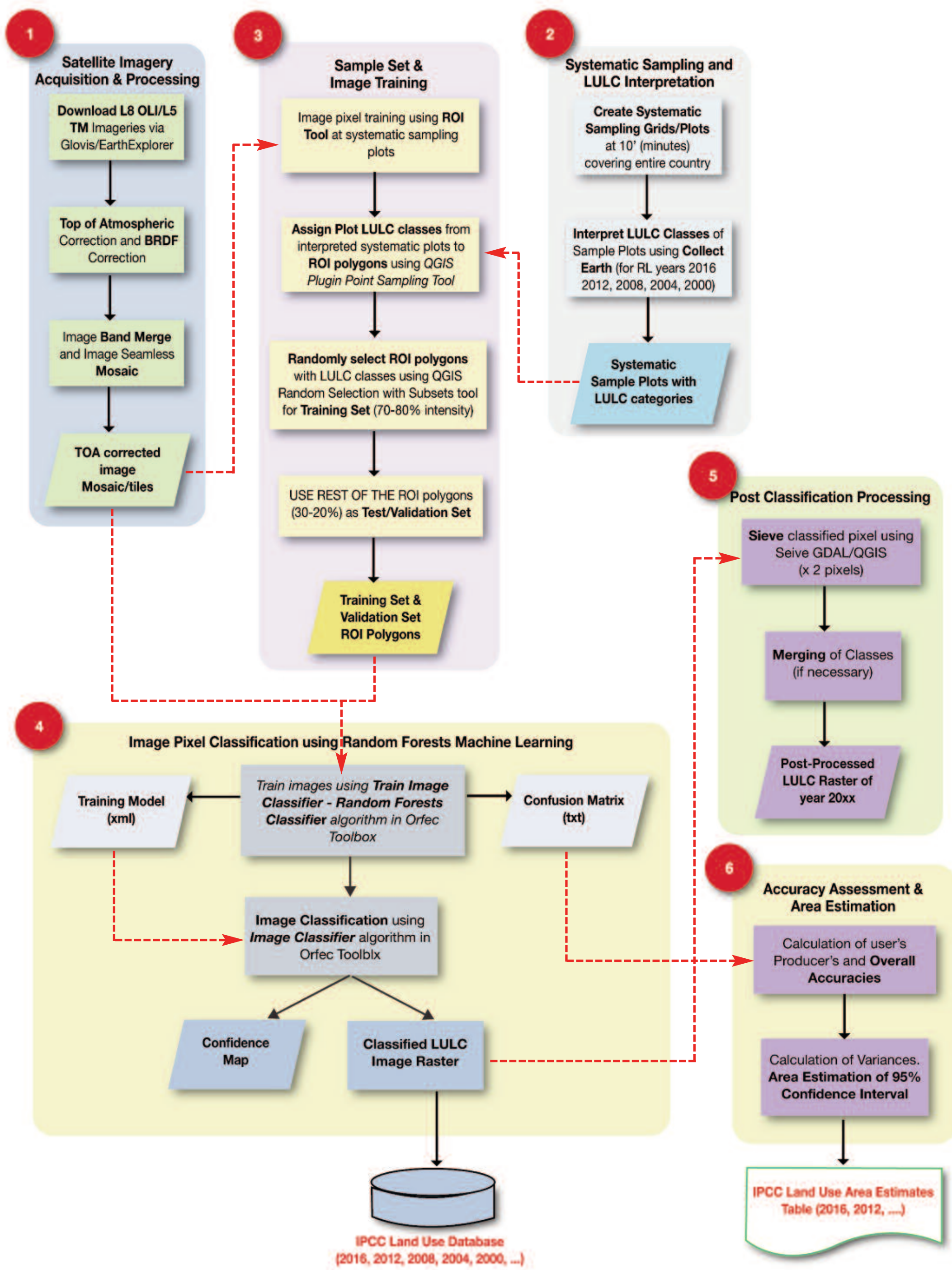
For assessment of deforestation in mangroves over the 2004-2012 period, the sea mask layer used in Abbas et al (2013) was applied because it was more detailed compared to the SOP reference map (scale 1:3,000,000).

Process 7: Land Use Change Assessment

Deforestation activity data generation is based on the visual plots interpreted for the LULC statistics and analysed with GIS raster analysis operations. A hotspot layer, indicating the potential locations for deforestation, is produced in order to calculate statistics on how much area changes there have been from forest to other land use categories. The area-adjusted statistics concerning deforestation area have been acquired by applying the error adjustment with the LULC systematic visual plot observations (over 12,500 plots) and some additional randomly sampled visual interpretation plots (566 plots) over the deforestation hotspot areas. The error-adjusted deforestation estimates are calculated following methodological guidance and formulas by Olofsson et al. (2014). The deforestation area proportions (percentages) by forest types have been derived by using the hotspot map and forest stratification.

For accuracy assessment and permanence check, the final maps were interpreted/checked with support of experienced provincial forestry field officials having good ground knowledge, who were able to judge if the forest cover loss was permanent. Moreover, a permanence verification procedure (consistency check) was applied to exclude temporary loss of tree cover from the mapped deforestation. Only if the detected deforestation remained until the following reference year (e.g. 2012 in case of the reference period 2004-2008, and 2016 in case of 2008-2012), the area was considered permanently deforested.

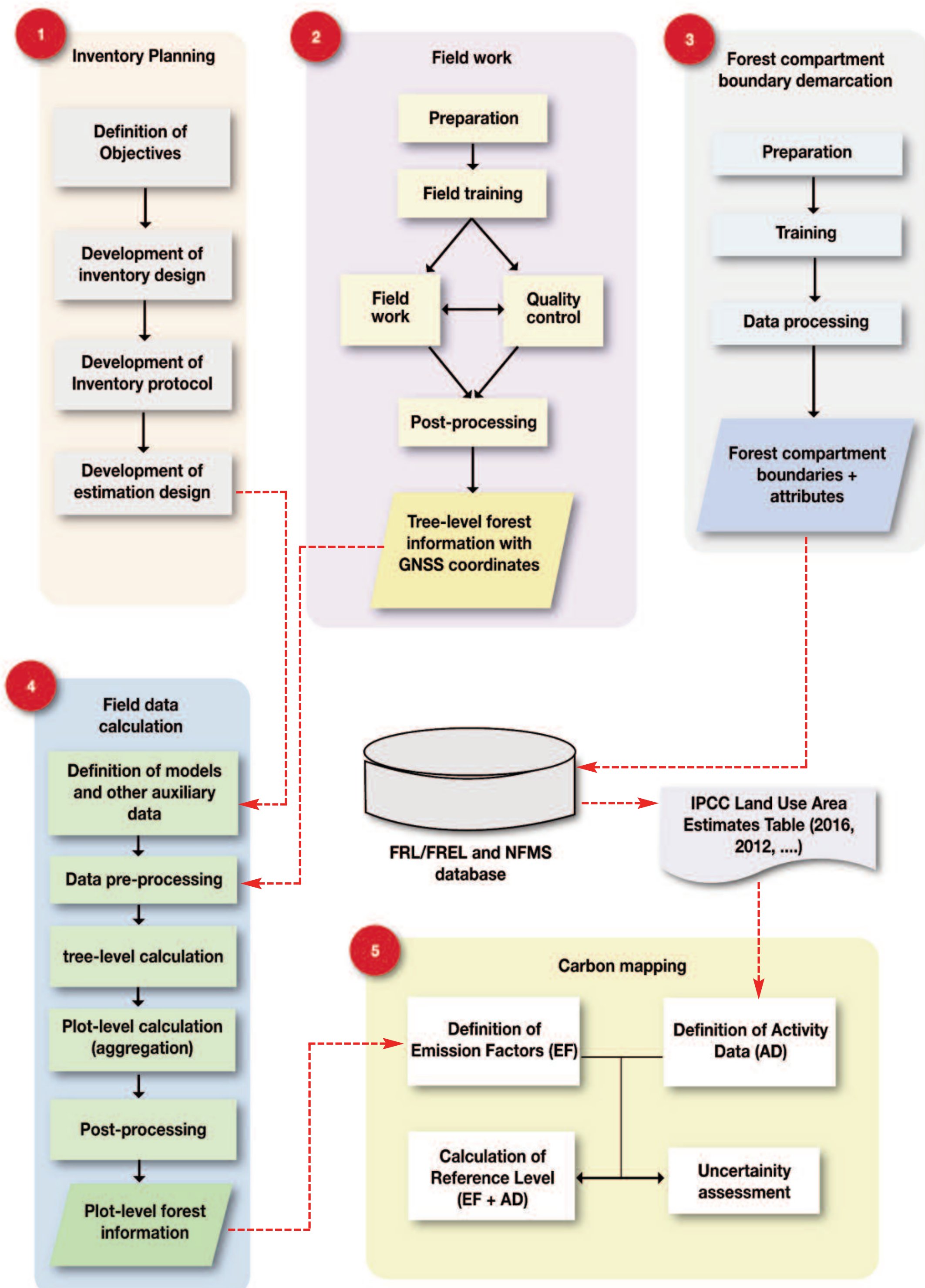
Figure 3: Design of Operationalised System for Forest Land Assessment



3.1.4 Reference Period

The national FREL for Pakistan is developed by producing land use and cover maps with time-series analysis for 2004-2012 due to the limited reference data available for accuracy assessment and error-adjustment before the year 2004.

Figure 4: Design of Operationalised System for Emission Calculation



3.1.5 Reference Emission Calculation

The sample plot-based forest carbon stock assessment process involves a modelling chain with the following critical steps and potential error sources:

1) Field measurements and data entries;
2) Height modelling for individual trees;
3) Allometric biomass modelling of AGB for individual trees; and,
4) Applying default root-shoot ratios to estimate BGB

3.1.6 Emission Calculation from Deforestation

Deforestation converts forest land into another land use category. The emission factors represent emissions per hectare of land which has been converted to other land use. The national emission factors have been computed by forest strata using the recently collected pilot NFI and provincial carbon stock inventory results. Table 4 indicates the formulas that have been used to derive the emission factors by forest strata. Sub-alpine forest reference data, as well as carbon density data for the remaining provinces, is sourced from the KP and GB carbon stock inventories (Ali, 2017; Ali et al., 2017).

Table 4: Emission Factor Calculation Formulas for Deforestation

	Term	Variable definition / Formula
Forest converted to other land	A	Forest carbon density, mean AGC+BGC, (ton C/ha)
	B	Other land carbon density, mean AGC+BGC (ton C/ha)
	E_{FN}	(A – B) x 44/12
	E_{FN}	Emission factor (ton CO2-e/ha)

The national unified densities and emission factors (Tier 2) are calculated by applying forest type areas mapped by provinces as weights to average the pilot NFI and provincial carbon inventory estimates. The mean carbon densities are also calculated for other land use classes and aggregated as national level averages by the forest types as per Table 2. More details on carbon stocks and emission factor development are provided in Annex 4.

Considering the coarse average values provided by IPCC, it was considered as a more unbiased approach to use the locally derived values. Using Tier 1 EF values would have required applying EF weights by non-forest types as well. The non-forest plots are located close to the forest edges, so they give a reliable indication what carbon stocks could be some years after a deforestation event over different landscapes in Pakistan.

A two-stage averaging was applied: Average of biomass in all non-forest classes at the cluster level (resulting in 27 averaged values of non-forest biomass), and then averaging the cluster-level averages at the level of climatic regions and farm plantation category.

Forest Type	Clusters
Other land (tropical)	12
Other land (sub-tropical)	6
Other land (temperate and alpine)	5
Other land (farm plantation)	4

Non-tree crop species were not sampled destructively on the plots and thus were not considered in emission factor development.

The total emission uncertainties have been derived combining the provincial activity data and emission factor uncertainties following the error propagation method over the periods of 2004-2008 and 2008-2012. The methodology is described in GFOI, 2016.

Table 5: National Unified Densities and Emission Factors (Tier 2)

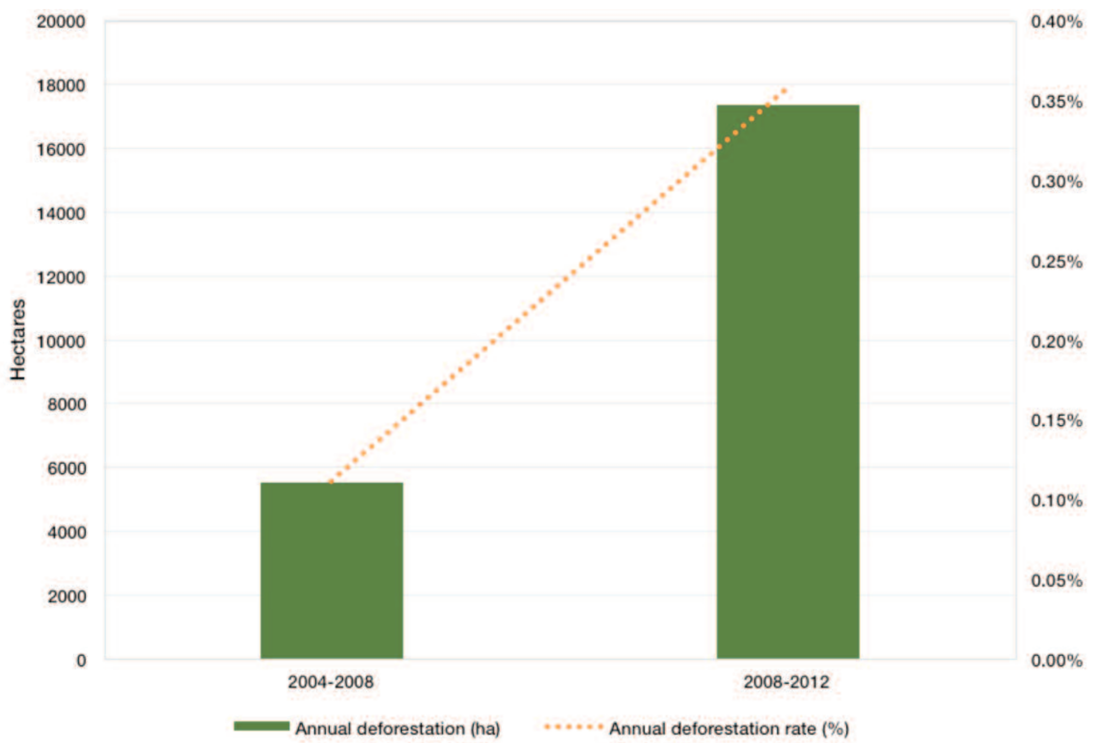
Forest Type	Mean Carbon Density (C ton/ha)	Emission Factor, Deforestation (CO2-e ton/ha)
Littoral and Swamp Forest (Mangroves)	5.2	14
Thorn	7.8	23
Riverine	19.0	65
Scrub	12.8	36
Pine	31.6	105
Moist Temperate	99.5	359
Dry Temperate	41.6	147
Sub-Alpine	29.1	101
Irrigated Plantation	20.8	71
Other Land (Tropical)	1.4	-
Other Land (Sub-tropical)	3.0	-
Other Land (Temperate and Alpine)	1.6	-
Other Land (Farm Plantation)	10.5	-

4 RESULTS OF THE CONSTRUCTION OF FOREST REFERENCE EMISSION LEVEL (FREL)

4.1 Estimates of Deforestation

Due to limited reference data availability, the deforestation has been assessed from 2004 onward. The average annual deforestation has been estimated up to about 11,000 hectares, while the total deforestation has been assessed up to 92,000 hectares over the entire period of 2004-2012. **(Figure 5)**. The overall national land use map of the year 2012 is available in Annex 2.

Figure 5: Annual Deforestation Rates in 2004-2012



Deforestation has had the highest average annual rates in riverine (34%), scrub (20%), dry temperate (19%), pine (13%) and thorn forests (9%) (**Figure 6**).

The highest rate of deforestation is noticeable in the riverine forest of Sindh due to the fact that Forest Land Lease Policy was introduced in 2004 which resulted in significant clearance of riverine forests for agricultural purposes.

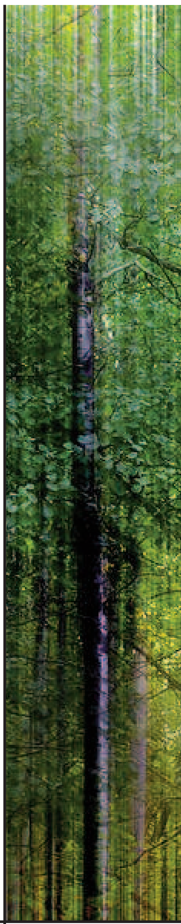
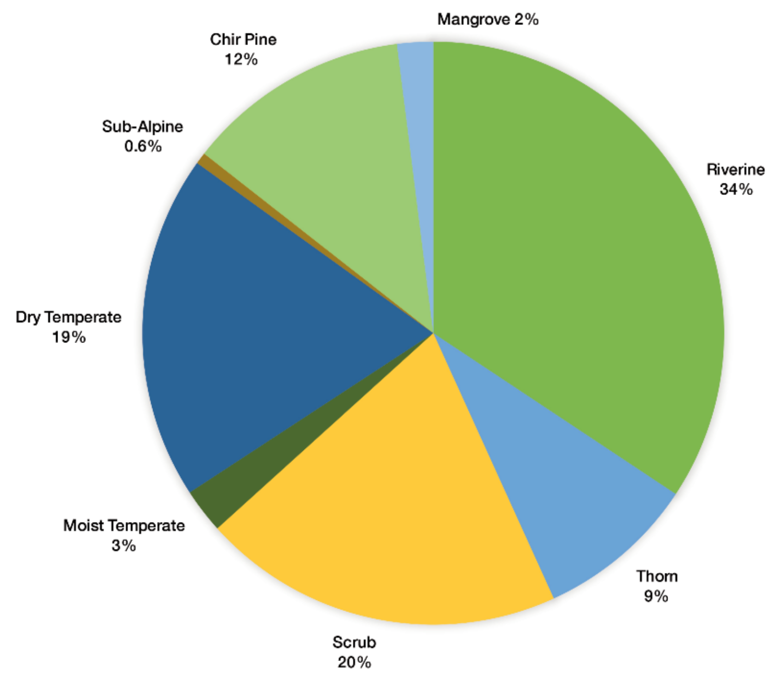


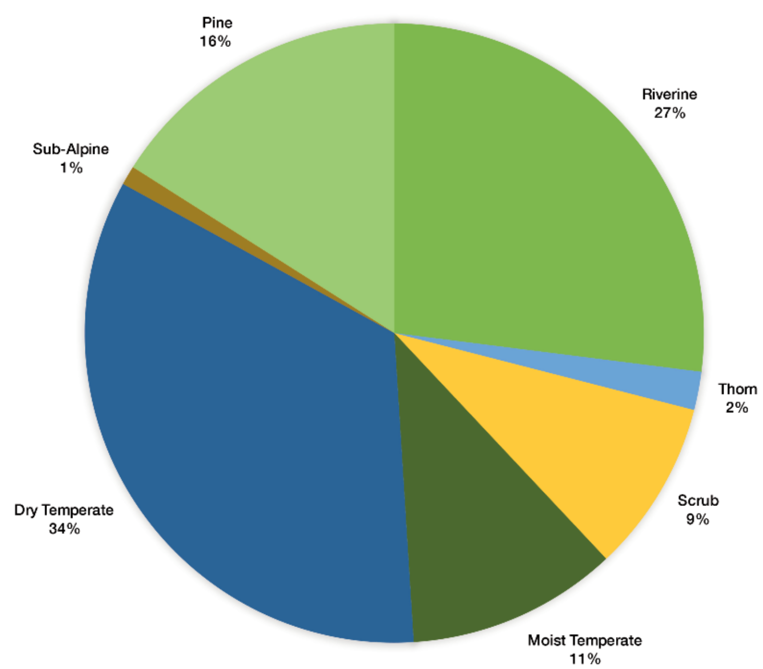
Figure 6: Deforestation Proportion by Main Forest Strata (2004-2012)



4.2 Emissions from Deforestation

The mean annual emissions from deforestation were reaching up to 1.0 Million tons of CO_2-e between 2004 and 2012 with the increasing emission trend from deforestation. The largest share of CO_2 emissions originates from dry temperate (34%), riverine (27%), pine (16%) and moist temperate forests (11%), followed by scrub (9%) and thorn (3%) forests in 2004-2012.

Figure 7: Emission Proportion by Main Forest Strata (2004-2012)



The deforestation hotspot areas have been derived with the time-series analysis of two consecutive reference years. The consistency verification procedure assists in reducing false detections due to the different image radiometric and geometric properties between two sets of satellite image mosaics. Besides some omission and commission errors may still occur with deforestation observations. VHR reference images are not always available with constant good quality to allow observing canopy cover changes and producing error-adjusted area estimates with the maximum confidence.

4.3 Uncertainty Analysis

The key sources of uncertainty have been identified for both activity data and emission factors. There is some uncertainty which originates from the fact that there is no consistent carbon stock inventory data available to model the temporal variation in emissions during the different reference periods. The future projections always involve uncertainties, but it is given less weight as no FREL adjustments have been proposed.

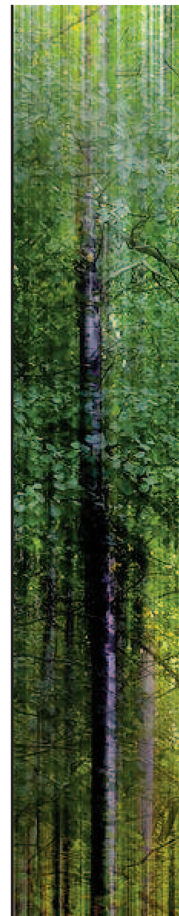
For activity data, the main sources of error are related to quality of the satellite images, temporal coverage and acquisition time (seasonality), sampling error (fragmented forest patch distribution in some areas) and random errors associated with the individual visual interpretations.

Satellite imagery temporal availability and properties determine the LULC classification output quality. In case of historical Landsat data, the input image radiometric properties have been harmonised and cloud cover minimised by selecting image scenes from the post-monsoon months whenever available. Still the radiometric properties and terrain shadows are affected by the prevailing sun angle and topographic relief in that moment when images are captured. Also, due to limited image availability, the coverage must be augmented by accepting data with ± 2-year temporal difference in relation to a respective reference year.

In tabular form, national level uncertainty analysis of Activity Data can be summarized as follows:

Table 6: **Uncertainties of Activity Data at National Level**

Uncertainty Estimates 2004-2008 & 2008-2012		
	Deforestation (ha), 2004-2008	Deforestation (ha), 2008-2012
Province	**95% CI**	**95% CI**
AJK	116	54
BN	1718	34303
FATA	711	4535
KP	11494	695
GB	7684	1055
ICT	113	1186
PB	2045	23464
SD	15315	26464



Total emissions for deforestation were 2.38 ± 1.15[3] Million CO_2-e tons over the period of 2004-2008 and 5.20 ± 1.99[4] Million CO_2-e tons over the period of 2008-2012 (Table 7).

Table 7: **Uncertainties of Total Emissions at National Level**

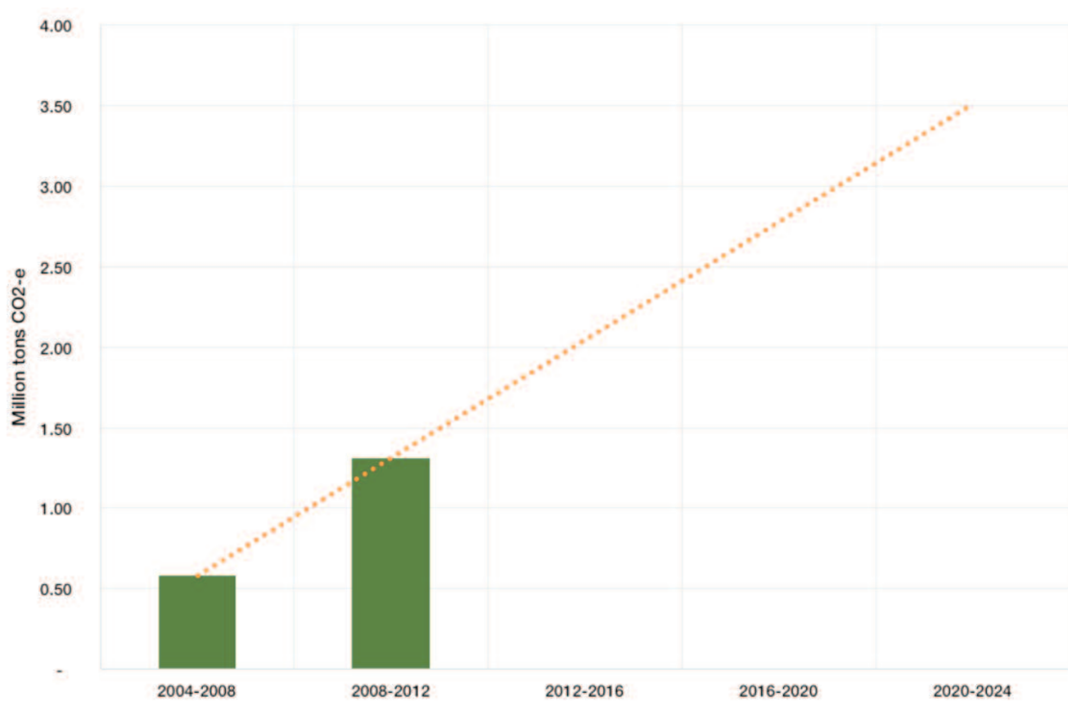
	Total Emissions, Tonnes of CO_2-e		Uncertainty, 95 % Confidence Interval, ± Tonnes of CO_2-e	
Period	**2004-2008**	**2008-2012**	**2004-2008**	**2008-2012**
TOTAL	2319994	5253229	2555962	4372938

4.4 Constructed National Forest Reference Emissions Level

The proposed FREL is 946653 Tonnes CO_2e after the assessment of national circumstances and development scenarios that can potentially impact the future forest carbon emissions. The effects of future changes in national circumstances are well captured by the projections for 2012-2022 and all the upward adjustment justification criteria are not complied. The largest share of CO_2 emissions originates from dry temperate (34 %), riverine (27 %) and pine forests (16 %) followed by moist temperate (11 %), scrub (9 %) and thorn (3 %) forests in 2004-2012 (Figure 8).

A comprehensive description of the national circumstances can be found from Annex 6.

Figure 8: **Mean Annual Emissions (Mt CO_2-e) from Deforestation (2004-2012) and Projection (2012-2024) at National Level**



3. 95-% confidence interval
4. 95-% condidence interval

5 OPPORTUNITIES FOR IMPROVEMENT

REDD+ is a relatively new concept and the participating countries are encouraged to adopt a step-wise approach in developing and strengthening REDD+ systems. Being a relatively new entrant in the REDD+ Programme, Pakistan lacks the capacity and resources and hence, intends to adopt a step-wise approach to further strengthen and expand the scope of REDD+ activities, improving forest reference data and monitoring and assessing other pools of gases as the areas for future improvement, as summarised in Table 8 below.

5.1 Improvement of Activity Data

In terms of spatial and spectral resolutions, there are several alternatives to Landsat 8 datasets for continuous monitoring applications. However, in terms of consistency in data coverage, availability (both current and future) and free/low cost accessibility, only Sentinel-2 (Multispectral Instrument) can be considered as a viable option. The following alternative VHR image options could be considered to provide data for accuracy assessment and area adjustment purposes:

- The recently launched (on 9 July 2018) Pakistan's own PRSS-1 Earth Observation Satellite with optical sensor capable of 1 m (3 foot) spatial resolution[24] has service lifespan of 7 years and was launched to provide data for China-Pakistan Economic Corridor (CPEC). However, the details of the mission and the availability of its imagery products are not known yet.

- Several commercial high-resolution imagery products are available to cover the territory of Pakistan. SUPARCO has been providing Spot 4/5[25] images and derived products to the users in Pakistan at lower costs. For future monitoring, options like Spot 6/7 (1.5 m resolution) may be acquired through SUPARCO in subsidised cost to the provinces to implement SLMS monitoring.

- For real/near real time monitoring of smaller forest areas, SUAVs (Small Unmanned Aerial Vehicles), commonly known as drones, (flying at heights of less than 200 m) can be used to take nadir photographs of the monitoring area to create true colour ortho-mosaics to assess the changes in forest coverage as well as canopy structure to monitor degradation. Commercial multi-rotor SUAVs have lower endurance, flying up to 30 mins in a mission, covering about 2-5 square kilometres. While fixed winged SUAVs have endurance of 60-120 mins covering 10-20 square kilometres to acquire single run image data of very high resolution (20 cm).

- Advanced active remote sensing techniques, such as LIDAR (Light Detection and Ranging) based airborne remote sensing in model-based inventories can assist in accurate collection of tree height and density information, which provides indication for the level of forest degradation over larger areas more cost-efficiently than drone systems.

As a co-benefit, LIDAR can be used for producing accurate terrain height models and inventory data for forest management planning.

In the present submission, Pakistan adopted approach 1 of land representation (IPCC 2006 guidelines); which do not require preparation of transition matrix, thus, changes were tracked from forest land to non-forest land only without tracking such changes to specific non-forest land use classes, e.g. crop land or settlement, etc. This is planned to be an area for future technical improvement to apply approach 2 (or 3) for tracking land use change and knowing correctly the proportion of different uses of land post deforestation to further improve the accuracy of estimates to represent the impact of deforestation.

The consistency of sampling approach and application of stratification is planned to be an area for future technical improvement of the FREL.

The boundary data was digitised from the rectified raster map of Survey of Pakistan available in scale 1:3,000,000. The data therefore lacks accuracy in AJK and coastal areas, which needs to be improved in the future.

5.2 Improvement of Forest Emission Factors

The second phase sampling units have been visited in the field to measure above- and belowground carbon stock, among other variables, using the developed NFI field measurement protocol as reference. These same plots are recommended to be measured as permanent sample plots with 3-year intervals to assess growth, regeneration and disturbance rates. The NFI plot network should be amended to provide better statistical representation for all the major and forest sub-strata in the future. The same systematic reference grid layout and methodology should be followed in KP and GB, as well.

There should be continued efforts for more systematic and intensive collection of permanent NFI sample plot data for growth data and biomass yield models to cover the most prevailing forest type. There is already a representative selection of allometric biomass models existing for the temperate forests, but it is recommended to develop biomass models for the most common tree species in other forest strata. The recently collected carbon stock inventory datasets provide guidance in prioritising the target species. To achieve the Tier 3 targets, allometric models can be improved potentially without intensive destructive sampling campaigns, e.g. by applying the terrestrial LIDAR measurement systems to determine volume of stems and canopies of the representative standing trees.

More localized Tier 3 methods rely on local models and data, adopting a systematic carbon stock and regular disturbance monitoring conducted at the lowest forest management level of natural and plantation forest compartments. The systematic data collection efforts through the NFMS and corresponding provincial systems are also required to have consistent timber, fuelwood harvesting and disturbance records from the forest compartments and REDD+ project areas in the future. Once parameter data is available, simulation models can be used as a supporting approach to model the carbon stocks and fluxes in forest biomass, soil organic content, and wood product chains.

As the combined uncertainty of activity data and emission factors remains with relatively high emission confidence intervals, it is highly recommended to collect more sample data and apply Monte Carlo methodology to lower the overall uncertainty associated with emission estimates.

5.3 Inclusion/Exclusion of other REDD+ Activities, Carbon Pools and Gases

Forest degradation requires the emission factors for forests remaining as forests, which cannot be accounted for without reliable multi-temporal measurements.

Also, currently, there is no full nationwide coverage for forest growth, wood removal and disturbance data to produce reliable estimates for annual forest degradation rate to assess the levels of degradation and carbon stock enhancement. Carbon stock enhancement takes place through forest restoration (afforestation, reforestation and natural regeneration) and forest growth, but there is very limited growth research and modelling base for accounting for emission removals from these activities.

As such, afforestation removals have been excluded from this FREL submission due to non-availability of authentic data and spatial layers and is planned to be targeted under future areas of improvement.

Moreover, the additional carbon pools such as soil carbon, especially in mangroves, are also planned to be targeted under future areas of improvement.

Table 8: **The Step-wise Plan for FREL/FRL Improvement**

Current Status (Phase 1)	Short-Term Objective (Phase 2)	Long-Term Objective (Phase 3)
Pilot NFI data available for the key category analysis over major forest types. Unified National emission factors (Tier 2) have been developed for the major forest types.	Key category assessment for carbon pools completed for major forest types. Province/territory wise Emission factors developed by major forest types.	Key category assessment for all carbon pools completed for all forest types. Province/territory wise Emission factors developed for all land types (eg. Crop land, farm plantations, etc.)
Carbon stock inventory data is available for Tier-2 for the main forest types over all the provinces and territories. Carbon stock estimation has been conducted at the national level.	Carbon stock estimation using Tier-2 and 3 where data supports it.	Carbon stock estimation using Tier-3 in all forests and assessment against applicable FREL or FRL to establish performance.

Current Status (Phase 1)	Short-Term Objective (Phase 2)	Long-Term Objective (Phase 3)
Activity data derived for deforestation only. The estimated activity statistics by the forest types are available. Activity data reported based on approach 1.	Activity data derived for deforestation, forest degradation and enhancement. The estimated activity statistics by forest types are available. Activity data reported based on land use categorisation using approach 2 with Landuse Transition matrix.	Activity Data derived for all activities. Activity data reported based on land use categorisation using approach 3 (spatially explicit data).
FREL based on deforestation, above and below ground biomass and CO_2 gas is available	FREL based on deforestation, forest degradation and enhancement is available using above, below ground biomass and Soil OM in Mangroves.	FREL based on all potential activities, pools and gases is available

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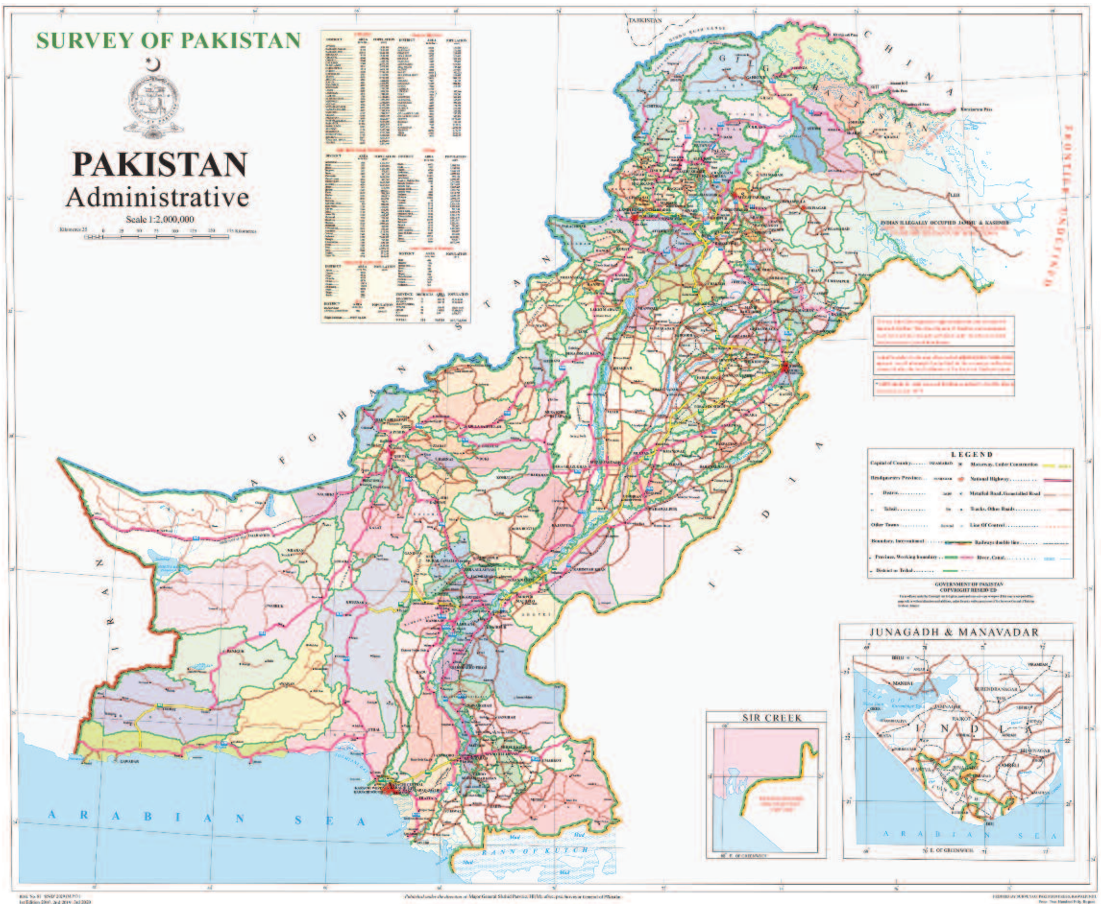
ANNEXES

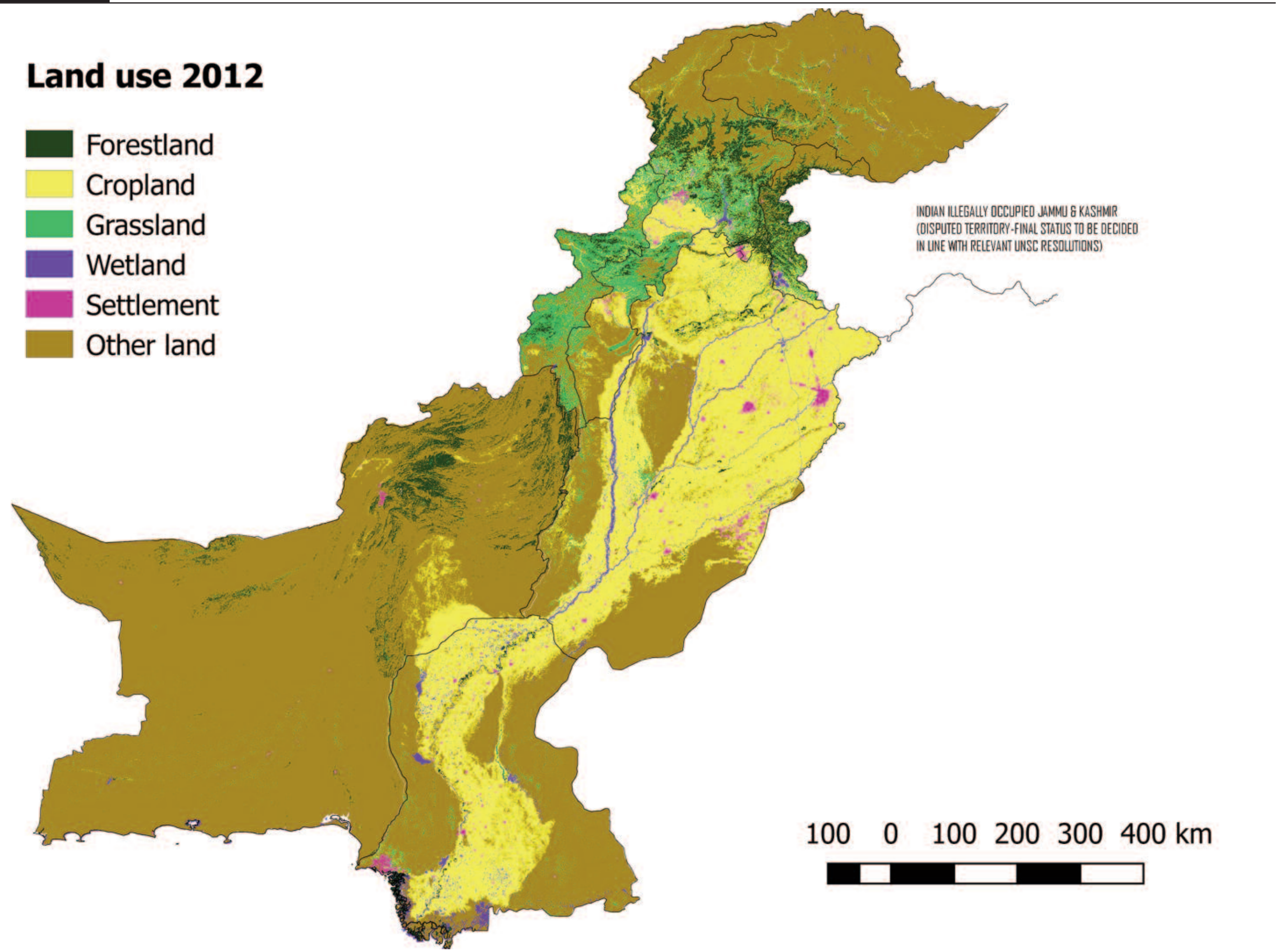
Annex 1: Administrative Boundary Map

Figure 9: Administrative Map of Pakistan, Source: SoP 2020



Annex 2: Land Use and Cover Map 2012 of Pakistan

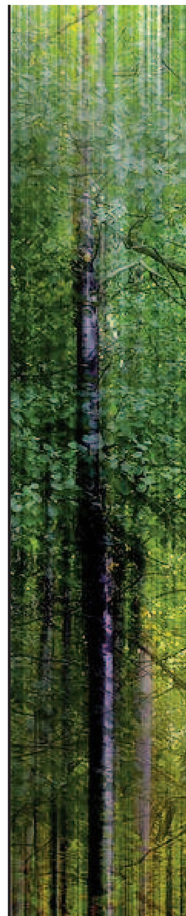
Figure 10: Land Use / Land Cover in Pakistan 2012



Annex 3: Wood Densities by Species

Applied Wood Densities. Sources: Zanne et al., 2009; ICRAF, 2018.

Species	Wood Density (ton/m3)	Species	Wood Density (ton/m3)
Abies pindrow	0.420	Juniperus excelsa	0.504
Acacia catechu	0.801	Leucaena leucocephala	0.450
Acacia modesta	0.835	Mallotus philippinensis	0.676
Acacia nilotica	0.689	Malus domestica	0.610
Aesculus indica	0.465	Melia azedarach	0.451
Ailanthus altissima	0.536	Millingtonia hortensis	0.640
Albizia lebbeck	0.596	Monotheca buxifolia	0.851
Albizia procera	0.587	Morus alba	0.578
Alnus nitida	0.370	Olea ferruginea	0.887
Armenian plum	0.675	Picea smithiana	0.430
Avicennia marina	0.650	Pinus gerardiana	0.500
Azadirachta indica	0.620	Pinus roxburghii	0.327
Betula utilis	0.500	Pinus wallichiana	0.430
Bombax cieba	0.350	Pongamia pinnata	0.640
Capparis decidua	0.691	Populus caspica	0.370
Cedrela serrata	0.390	Populus deltoides	0.417
Cedrus deodara	0.430	Prosopis cineraria	0.663
Celtis australis	0.550	Prosopis juliflora	0.800
Celtis eriocarpa	0.549	Prunus bokharensis	0.548
Ceriops tagal	0.758	Prunus spp.	0.606
Cordia myxa	0.330	Punica granatum	0.771
Dalbergia sissoo	0.760	Pyrus pashia	0.643
Diospyros lotus	0.706	Quercus incana	0.635
Dodonaea viscosa	0.840	Rhizophora mucronata	0.820
Ehretia acuminata	0.526	Robinia robesta	0.610
Ehretia spp.	0.526	Salix acmophylla	0.424
Eucalyptus camaldulensis	0.570	Salix tetrasperma	0.340
Eucalyptus citriodora	0.830	Salvadora oleoides	0.594
Ficus religiosa	0.443	Schinus molle	0.525
Ficus sp.	0.443	Syzygium cumini	0.760
Gmelina arborea	0.560	Tamarix aphylla	0.640
Grewia optiva	0.646	Tecomella undulata	0.500
Juglans regia	0.533	Ulmus wallichiana	0.440
		Zizyphus mauritiana	0.583



Annex 4: Forest Carbon Density and Emission Factors

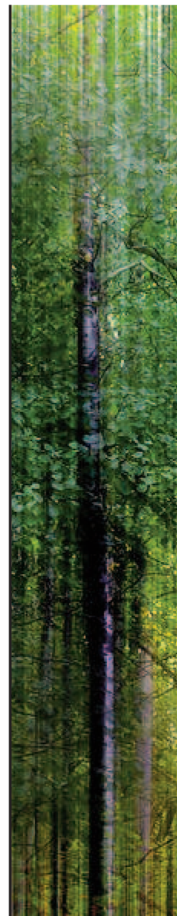
Pilot NFI			
Forest type	**No. of Clusters**	**Mean Carbon Density (C ton/ha)**	**Emission Factor, Deforestation (CO_2-e ton/ha)**
Littoral and swamp forest (Mangroves)	11	5.2	14
Thorn	14	7.8	23
Riverine	3	19.0	65
Scrub	16	13.8	40
Pine	4	30.3	100
Moist Temperate	8	88.0	317
Dry Temperate	9	23.2	79
Irrigated Plantation	9	20.8	71
Other Land (Tropical)	12	1.4	-
Other Land (Sub-tropical)	6	3.0	-
Other Land (Temperate and Alpine)	5	1.6	-
Other Land (Farm Plantation)	4	10.5	-
Gilgit-Baltistan			
	No. of Single Plots	**Mean Carbon Density (C ton/ha)**	**Emission Factor, Deforestation (CO_2-e ton/ha)**
Dry Temperate	439	90.6	326
Sub-Alpine	98	20.1	68
Khyber Pakhtunkhwa			
Forest Type	**No. of Clusters**	**Mean Carbon Density (C ton/ha)**	**Emission Factor, Deforestation (CO_2-e ton/ha)**
Thorn	-	5.7	16
Scrub	22	5.7	10
Pine	99	32.7	109
Moist Temperate	146	104.6	378
Dry Temperate	90	122.3	443
Sub-Alpine	-	45.2	160

National Unified Densities and Emission Factors (Tier 2)

Forest Type	Mean Carbon Density (C ton/ha)	Emission Factor, Deforestation (CO_2-e ton/ha)
Littoral and swamp forest (Mangroves)	5.2	14
Thorn	7.8	23
Riverine	19.0	65
Scrub	12.8	36
Pine	31.6	105
Moist Temperate	99.5	359
Dry Temperate	41.6	147
Sub-Alpine	29.1	101
Irrigated Plantation	20.8	71
Other Land (Tropical)	1.4	-
Other Land (Sub-tropical)	3.0	-
Other Land (Temperate and Alpine)	1.6	-
Other Land (Farm Plantation)	10.5	-

The applied surface area weights to calculate the unified values are as following:

	KP	GB	Other Provinces / Territories
Riverine	0 %	0 %	100 %
Thorn	0 %	0 %	100 %
Dry-Deciduous	0 %	0 %	100 %
Scrub	12 %	0 %	88 %
Moist Temperate	69 %	0 %	31 %
Dry Temperate	8 %	16 %	76 %
Sub-Alpine	22 %	68 %	10 %
Pine	45 %	0 %	55 %
Mangrove	0 %	0 %	100 %
Irrigated Plantation	0 %	0 %	100 %
Chilgoza	0 %	0 %	100 %



Annex 5: Average Forest Carbon Stock (2004-2012)

Forest Type	Area (ha)	Proportional Area (%)	Carbon Density (C ton/ha)	Carbon Stock Mt C
Riverine	213,777	4%	19.0	4
Thorn	125,837	3%	7.8	1
Dry-Deciduous	1,946	0.04%	12.8	0.025
Scrub	928,667	19%	12.8	12
Moist Temperate	741,207	15%	99.5	74
Dry Temperate	1,767,847	36%	41.6	74
Sub-Alpine	107,676	2%	29.1	3
Pine	639,174	13%	31.6	20
Mangrove	160,602	3%	5.2	1
Irrigated Plantation	173,449	4%	20.8	4
Chilgoza	15,235	1%	31.0	0.5
Average 2004-2012	**4,875,417**	**100%**	**39.5**	**192**

Annex 6: National Circumstances

1. Forest Governance in Pakistan

Pakistan, a federated country of four provinces and two territories (GB and AJK), has an extensive set of regulations regarding natural resources, land tenure and institutional arrangements.

Legislative and executive powers are divided between the Federation and the Provinces by the Constitution of Pakistan, 1973. AJK and GB, although not de jure provinces of Pakistan are under the de facto administrative control of the Federation with legislative and executive functions between them and the Federation being regulated by the Azad Jammu and Kashmir Interim Constitution Act, 1974 (AJK Interim Constitution) and the Gilgit-Baltistan (Empowerment and Self Governance) Order, 2009 (GB Order) respectively.

In respect of the territories of AJK and GB, the forests of AJK are within the exclusive legislative domain of the Legislative Assembly of AJK and the executive domain of the AJK Government as per the AJK Interim Constitution whereas under the GB Order the forests of GB are within the exclusive legislative and executive domain of the Gilgit-Baltistan Council with the Prime Minister of Pakistan as its Chairman, who may exercise the executive authority vested in the Council directly or through the Secretariat of the Council.

2. Policy Intervention to Reduce Emissions

Pakistan has taken various actions to mainstream climate change in its policies, programmes and planning to safeguard sustainable development progress with due respect to international commitments and national development priorities.

In November 2016, the first ever National Forest Policy of Pakistan was approved by the Council of Common Interest, chaired by the Prime Minister of Pakistan (GoP, 2015).The goal of the policy is “expansion of national coverage of forests, protected areas, natural habitats and green areas for restoration of ecological functions and maximising economic benefits while meeting Pakistan’s obligations to international agreements related to forests.” The forest policy gives provision for mainstreaming REDD+ as a tool to enhance forest cover, preserve forest carbon stocks and control deforestation.

The National Climate Change Policy (NCCP) was approved in 2012. It provides an inclusive framework for policy vision, goals, targets and actions to mainstream climate change, particularly, in those sectors of the economy which are socially and economically vulnerable, including the forestry sector. The NCCP identifies the need to restore and enhance Pakistan’s forest cover to withstand present and possible future impacts of climate change. It also recognises the importance of retrieving climate finance through international windows to reduce emissions and build resilience by setting afforestation and reforestation targets and curbing illegal deforestation. However, these actions are contingent upon provision of international climate finance, affordability, capacity building and transfer of technology. There is a provision in NCCP “to prepare the framework for a national REDD+ strategy on priority basis and ensure its implementation in accordance with international conventions /

processes," and "to develop the legal and institutional framework for improved forest management, investment clearly specifying rights to REDD+ credits".

The Government of Khyber Pakhtunkhwa commenced the "Green Growth Initiative (GGI)" in 2012 through which the "Billion Tree Afforestation Project" was initiated and one billion trees were successfully planted in the province by end of 2017. Pakistan also became party to the Paris Agreement and submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015. Emission reduction targets are not clearly specified in the INDC document.

One important development is the formulation of Pakistan Climate Change Act (2016). The Act envisages an over-arching Pakistan Climate Change Council headed by the Prime Minister of Pakistan, with representation of the sub-national governments at the Chief Ministerial level. It also envisages establishment of a high-powered Pakistan Climate Change Authority and Pakistan Climate Change Fund to mobilise resources from both domestic and international sources to support mitigation and adaptation initiatives in the country.

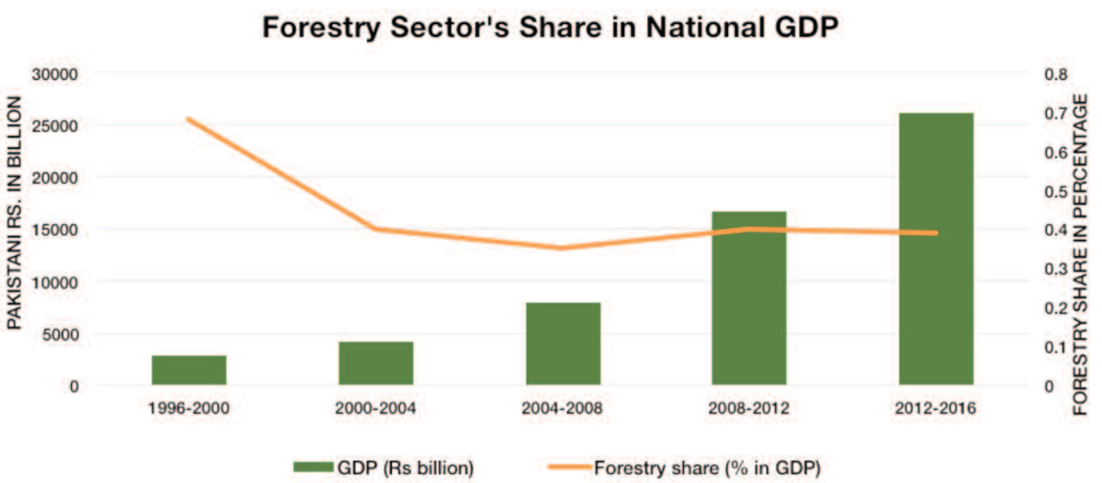
Pakistan's Vision 2025 is a major policy document which provides a roadmap for national development until the year 2025. The above-mentioned policies and programmes are in sync with Pakistan's Vision 2025. Vision 2025 rests on seven pillars for driving growth and development to transform Pakistan into a vibrant and prosperous nation. Pak-INDC (Pakistan's Intended Nationally Determined Contribution) is engrained in the state's strategic plan 'Vision 2025'. It is lined up with the respective policies, plans and sectoral growth targets planned by various ministries and other government entities. Contributions to economic growth, partly due to China-Pakistan Economic Corridor (CPEC), have been taken into consideration. Though considerable efforts are being made for the revival of forestry, aiming to expand the forest cover through mega tree plantation programmes and strengthening the regulatory and forest protection policy mechanism, but still future emissions are expected to increase. This is due to the ambitious plans of the present government to spark economic activity through large-scale investments in energy, communication and industrial infrastructure through China Pakistan Economic Corridor (CPEC). The forecasted economic growth is historically unprecedented and unmatched. Accordingly, the future emissions of the country will increase manifold. Consistent with historical trends, significant increase in emissions, due to increased pressure, is also expected from forestry sector like other sectors such as energy, agriculture, industrial processes and wastes.

3. Socio-Economic Context

Pakistan's overall developing economy has shown a significant rise since last six to seven years. Major economic changes are also expected in macro-economic outline of the country due to the current and future development targets with due consideration to global economic growth models. The Government aims for a significant reduction in poverty by the year 2025 and eliminating extreme poverty before 2030 under its vision 2025 and SDGs target. Keeping in view these fundamentals, GDP growth rate of 7 % is forecast in pre-2020 period with further 1.5 % rise by 2025 (GoP, 2018). GDP continued to grow above 5 % in each of the last 2 years reaching 5.79 %, the highest in 13 years in the outgoing fiscal year 2018 and 4 percent in each of the three preceding years. As a major development, Pakistan has ranked No. 1 in South Asia in private infrastructure investment, thus becoming one of the world's top five destinations for private participation in infrastructure investment (GoP, 2018).

The forest sector's share in national GDP is fractional as shown in Figure 11. Rather the contribution of forestry sector in GDP has been decreasing. However, these figures are not illustrative of factual contribution of forestry sector in the national economy since many forest products and almost all forest services; agriculture, water, tourism, soil conservation, carbon sequestration, and biodiversity etc. remain unaccounted for. Instead, only the marketed goods from state-managed forests are accounted for. About 95 % of timber and 99 % of fuel wood demands are met from farmlands (Maanics Int., 2004). The forest products of farmlands are either sold in the local market or used at farm level. Mechanisms to value these products for GDP calculations do not exist.

Figure 11: **Share of Forestry in GDP of Pakistan (1996-97 to 2015-16). Data Source: Ministry of Finance's Economic Survey Reports**

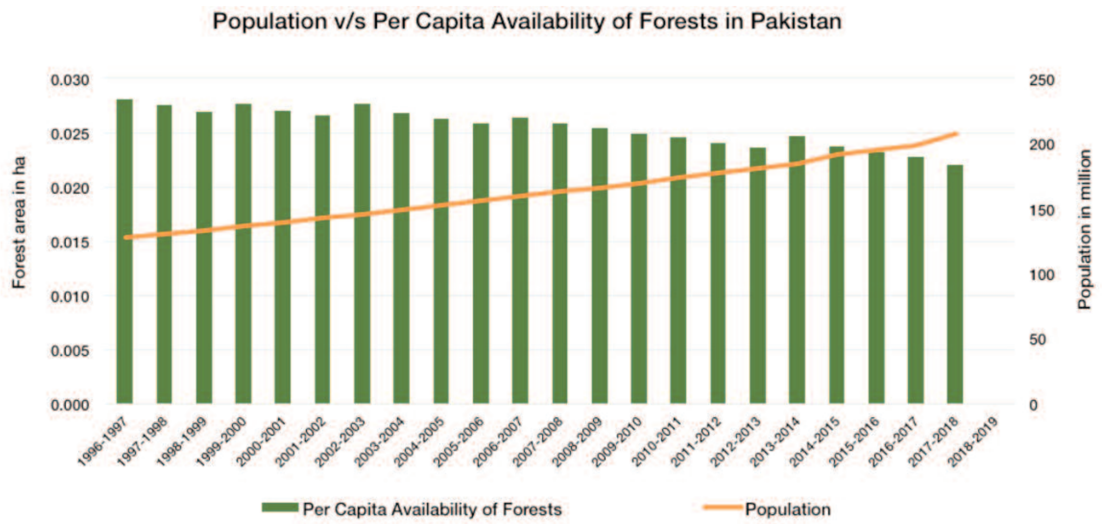


If long term sustainable forest management plans for commercial harvesting, including timber logging, are developed, continued and implemented, the share of forestry sector in GDP is likely to increase. It is also expected that the revenues from carbon credits under REDD+ would also increase by avoiding carbon emissions due to illegal and unsustainable forest cuttings. If serious efforts are made to explore and utilise non-conventional non-timber forest products (NTFP), medicinal, aromatic and other economic plants, the share of the forest sector would increase in the GDP in the coming decades.

Population Dynamics and per Capita Availability of Forests

The latest census (2017) has estimated population of about 207.7 million in 2017 representing a 57 percent increase in 19 years with average annual growth rate of 2.4 %. Out of this, 63.6 % are in rural areas and 36.4 % in urban centres. Population is expected to reach the figure of 211 to 213 Million in 2020 with annual population growth rate of 2.4 %. National Population Vision, 2030 predicts that Pakistan will become the fifth country from top by 2030, with a population ranging between 230 and 260 million people, 60 % of whom will live in urban areas. Further addition of 50 million people by 2030 will certainly put further pressure on the forest resources. Currently, with only 0.023 ha of forest per capita against the world average of 1.0 ha, Pakistan is comparatively forest poor. The high population growth rate is pushing the figure further down and, at present, despite the government's efforts, it is not possible to enlarge public forest area at a high enough rate to keep up with the demand for forest products. Due to limited availability of resources, rural population (63.6 %) is experiencing higher level of poverty than the urban population, both on economic and social indicators. The rural population has high dependence on forestry sector resources for their livelihoods. There is a big gap between supply and demand due to mismatched forest resource base and continuously increasing population growth. The supply has only steadily increased from the farm trees whereas pressure on natural forests has continued to increase significantly. Forest cover per capita is declining due to increase in human population as well as deforestation (Figure 12).

Figure 12: **Historical Trends in Population Dynamics and Per Capita Availability of Forests (1996-2019). Data Source: Ministry of Finance's Economic Survey Reports.**



4. Agriculture Intensification

Agriculture is a major land use in Pakistan. The cultivable area is 23.67 million ha i.e. 27.7 % of the total area (GoP's Economic Survey Report, 2018). The population, directly and indirectly associated with the agriculture sector, currently stands at 42.3 %, whereas contribution of the sector to the overall GDP is around 18.9 % (GoP, 2018). According to INDC 2016, the forecasted economic growth rate, duly adjusted, shows a faster agriculture sector growth as compared to its average historical trend of about 3 % per annum. The minimum agriculture growth rate of 4 % has been determined by the government to improve food security and ensure minimum nutritional value for the growing population. With expected healthy rise in GDP and sizeable impacts of the China-Pakistan Economic Corridor (CPEC) interventions, this growth is likely to be well over 4 % per annum (INDC, 2016).

5. Poverty

Pakistan is facing huge energy crises, including power and fuel. About 63.6 % of the total population in Pakistan is still living in rural areas and depends on firewood for domestic needs of energy. Many households in urban areas also use firewood due to lack of alternative sources of energy. The connection between forestry systems and integrated family health in the rural areas of KP and GB shows that poverty is one of the major factors of deforestation. Studies submit that the prevailing poverty situation in rural areas is compelling the people to resort to cutting trees as a source of income as well as consuming natural resources for subsistence. Due to lack of the provision of electricity, gas, access and availability of renewable energy sources at reasonable rates, wood becomes the only choice as an energy source for communities in hilly areas.

High dependency on forests, due to poverty and lack of alternative livelihoods further aggravates the forest devastation. The draft National REDD+ Strategy of Pakistan has also highlighted the poverty nexus with forestry resources. According to REDD+ strategy, one of the major drivers of deforestation and forest degradation in rural areas, in particular the hilly areas, is the unsustainable harvesting of wood due to lack of compensating mechanisms for forest communities by the Government for not using their legal or traditional rights of harvesting beyond sustainable limits. Notwithstanding additional supply of fuel wood from farmland trees, the forests and other sources of fuel woods fail to meet the continuously increasing demand for fuel wood on a sustainable basis. Subsequently, the demand is encountered through over utilisation of natural forest resources to the degree of being the foremost factor for deforestation and degradation of forests. This tendency, if it remains unimpeded, will have radical insinuations in the form of irreparable loss of forest resources at an exceptional pace.

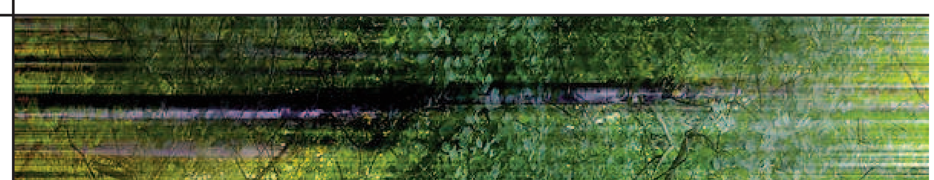
6. Emissions from Consumption of Timber and Fuelwood

Based on per capita consumption of wood and population growth at national level in 2003-04, the supply and demand survey by the government of Pakistan 2003, compiled and projected wood consumption by provinces for 15 years, i.e. 2003-2018 (Maanics Int., 2004). Using these statistics, the national and provincial emissions in terms of million tons of carbon dioxide equivalents (Mt CO_2-e) with average annual change rates for different time periods are calculated and given in Table 9.

Table 9: National and Provincial Level Emissions (million tCO_2-e) due to Wood Consumption (projected from 2003 to 2018).

Province / Sector	Emissions (million tons of CO_2 equivalent)				Annual Change Rates (million tons of CO_2 equivalent per year)					
	2003	2008	2013	2018	2003-2008		2008-2013		2013-2018	
					Mt CO_2 -e/ year	%	Mt CO_2 -e/ year	%	Mt CO_2 -e/ year	%
KP										
Industrial timber	1.25	1.38	1.52	1.67	0.03	2.01	0.03	2.02	0.03	2.02
Industrial fuelwood	0.48	0.53	0.58	0.64	0.01	2.03	0.01	2.01	0.01	2.01
Commercial fuelwood	0.20	0.22	0.24	0.27	0.00	2.05	0.00	1.98	0.00	2.02
Domestic fuelwood	4.53	4.99	5.49	6.04	0.09	2.02	0.10	2.02	0.11	2.02
Total volume	**6.46**	**7.11**	**7.83**	**8.62**	**0.13**	**2.02**	**0.14**	**2.02**	**0.16**	**2.02**
Punjab										
Industrial timber	4.39	4.83	5.32	5.86	0.09	2.02	0.10	2.02	0.11	2.02
Industrial fuelwood	1.69	1.86	2.05	2.25	0.03	2.01	0.04	2.02	0.04	2.02
Commercial fuelwood	0.27	0.29	0.32	0.36	0.01	2.02	0.01	2.01	0.01	2.03
Domestic fuelwood	7.82	8.61	9.48	10.43	0.16	2.02	0.17	2.02	0.19	2.02
Total volume	**14.17**	**15.60**	**17.17**	**18.90**	**0.29**	**2.02**	**0.31**	**2.02**	**0.35**	**2.02**
Sindh										
Industrial timber	1.80	1.98	2.18	2.39	0.04	2.02	0.04	2.01	0.04	2.02
Industrial fuelwood	0.69	0.76	0.84	0.92	0.01	2.01	0.02	2.03	0.02	2.00
Commercial fuelwood	0.12	0.13	0.15	0.16	0.00	2.05	0.00	1.96	0.00	2.05
Domestic fuelwood	2.23	2.45	2.70	2.97	0.04	2.02	0.05	2.02	0.05	2.02
Total volume	**4.84**	**5.32**	**5.86**	**6.45**	**0.10**	**2.02**	**0.11**	**2.02**	**0.12**	**2.01**
Balochistan										
Industrial timber	0.39	0.43	0.47	0.52	0.01	2.02	0.01	2.02	0.01	2.00
Industrial fuelwood	0.15	0.17	0.18	0.20	0.00	2.11	0.00	1.90	0.00	2.03
Commercial fuelwood	0.04	0.05	0.05	0.06	0.00	1.88	0.00	2.29	0.00	1.79

Province / Sector	Emissions (million tons of CO_2 equivalent)				Annual Change Rates (million tons of CO_2 equivalent per year)					
	2003	2008	2013	2018	2003-2008		2008-2013		2013-2018	
					Mt CO_2 -e/ year	%	Mt CO_2 -e/ year	%	Mt CO_2 -e/ year	%
Domestic fuelwood	1.27	1.40	1.54	1.69	0.03	2.01	0.03	2.02	0.03	2.02
Total volume	**1.85**	**2.04**	**2.25**	**2.47**	**0.04**	**2.02**	**0.04**	**2.02**	**0.05**	**2.01**
AJK										
Industrial timber	0.17	0.19	0.21	0.23	0.00	2.05	0.00	1.99	0.00	2.00
Industrial fuelwood	0.07	0.07	0.08	0.09	0.00	1.96	0.00	1.96	0.00	2.11
Commercial fuelwood	0.02	0.02	0.02	0.02	0.00	2.22	0.00	2.00	0.00	1.82
Domestic fuelwood	0.57	0.63	0.69	0.76	0.01	2.02	0.01	2.02	0.01	2.01
Total volume	**0.83**	**0.91**	**1.00**	**1.10**	**0.02**	**2.02**	**0.02**	**2.01**	**0.02**	**2.01**
GB										
Industrial timber	0.06	0.06	0.07	0.08	0.00	2.05	0.00	2.06	0.00	1.87
Industrial fuelwood	0.02	0.02	0.03	0.03	0.00	1.76	0.00	2.16	0.00	1.95
Commercial fuelwood	0.04	0.04	0.05	0.05	0.00	1.97	0.00	2.09	0.00	2.16
Domestic fuelwood	0.57	0.62	0.69	0.76	0.01	2.03	0.01	2.01	0.01	2.02
Total volume	**0.69**	**0.76**	**0.83**	**0.92**	**0.01**	**2.02**	**0.02**	**2.02**	**0.02**	**2.01**
National Total										
Industrial timber	8.06	8.88	9.77	10.76	0.16	2.02	0.18	2.02	0.20	2.02
Industrial fuelwood	3.10	3.41	3.75	4.13	0.06	2.02	0.07	2.02	0.08	2.02
Commercial fuelwood	0.69	0.76	0.84	0.92	0.01	2.03	0.02	2.01	0.02	2.00
Domestic fuelwood	16.98	18.69	20.58	22.65	0.34	2.02	0.38	2.02	0.42	2.02
Total volume	**28.83**	**31.74**	**34.94**	**38.44**	**0.58**	**2.02**	**0.64**	**2.02**	**0.70**	**2.00**



The average per capita emissions due to timber and fuel wood consumption in 2003 were 0.188 tCO_2-e per capita and projected as 0.185 tCO_2-e per capita for a population of 207.7 million in 2018. The per capita emissions varies from province to province; highest in GB (0.484 tCO_2-e per capita for a current population of 1.9 million) followed by KP (0.282 tCO_2-e per capita for a current population of 30.52 million), AJK (0.272 tCO_2-e per capita for a current population of 4.04 million), Balochistan (0.200 tCO_2-e per capita for a current population of 12.34 million), Punjab (0.171 tCO_2-e per capita for a current population of 110 million) and Sindh (0.135 tCO_2-e per capita for a current population of 47.89 million) in a descending order. The average annual increase in emissions from 2003 to 2018 due to wood consumption (is 2.02 %. The wood consumption mentioned here includes major share from farmland trees and industrial consumption (Table 9-10) and also includes degradation in natural forests which is to be assessed as part of future improvement plan.

The above figures are also compared with average annual timber and fuel wood consumption per capita (m3/capita) calculated in 2002-03 for the current population of 207.7 million (Population Census 2017). The results show almost similar statistics regarding over all emissions (million tCO_2-e) due to timber and fuelwood consumption for the current year, i.e. 2018 (Table 10).

The study of consumption by urban and rural split at domestic scale (Table 11) has reinforced the common belief that the use of biomass as fuel is highest in rural areas as compared to urban areas. The consumption at provincial level revealed that the domestic sector in the province of Balochistan has typically consumed fuelwood due to extreme cold in winters and lack of alternative fuels. Punjab mostly consumes crop residues due to larger farm area. High level of urbanisation is attributed to the use of electricity as energy source in Sindh. In KP, FATA, GB and AJK, where majority of the forest resources exist, most of the fuelwood is being consumed at household level, attributed to lack of alternate biomass fuels in these areas.

Table 10: Average Annual Timber and Fuelwood Consumption and Associated Emissions (tons of CO_2-e) for Pakistan

Consumption Wood	Average Per Capita Cons. (m^3)[vi]	Total Country Population	Total Cons (Million m^3)	Total Cons (Mt)	Total Cons	Total Emission (Mt CO_2-e)	Percent Share[v] (million tCO_2-e)		
							State Forest	Farm-lands	Imports
	A	B	A*B	C = (A*B)/1.309[i]	D = C*0.5[ii]*0.47[iii]	D*3.67[iv]	T = 3.34 F.W. = 0.20	T = F.W. = 91.8	T = 5.22 F.W.= 0.00
Industrial Wood Timber	0.0796	207.7	16.53292	12.6301	2.9680	10.8929	0.3638	9.9604	0.0048
Fuelwood (domestic + commercial + industrial)	0.205	207.7	42.5785	32.5270	7.6439	28.0533	0.0561	25.7529	0.0000
Total	**0.2846**		**59.1114**	**45.1577**	**10.6120**	**38.9462**	**0.4199**	**35.7134**	**0.0048**

i Conversion factor i.e. 1 ton = 1.309 m^3 (GoP, 2003)

ii Conversion factor from wet weight to dry weight (IPCC, 2006)

iii Dry mass to carbon conversion factor (IPCC, 2006).

iv 1 ton of carbon equals 3.67 tons of CO_2 Eq. (IPCC, 2006)

v Assuming percent shares of 2003 (GoP, 2003) for current year

vi Source: Supply and Demand Survey, Government of Pakistan, 2003

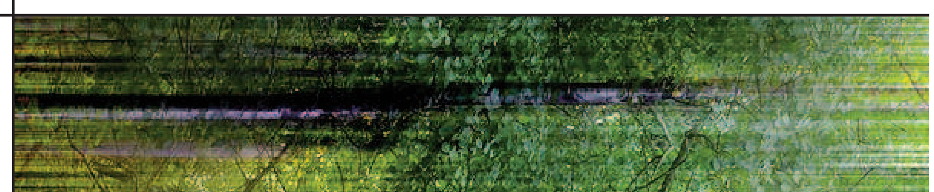


Table 11: Province Wise Fuelwood Consumption and Associated Emissions by Household Sector

Province	Per Capita Consumption (mounds)/ year[i]		Population (million)[ii]		Total Consumption (Million maunds)		Total Cons- (mill. maunds)	Total Cons. (mill. tons)[iii]	Total (million tons C)[iv]	Total (million tCO_2 -e)[v]	Sources[vi] (million tCO_2-e)		
	Rural	Urban	Rural	Urban	Rural	Urban					Own Lands (61%)	Markets (34%)	Others (5%)[vii]
	A	B	C	D	E = (A*C)	F = (B*D)	G = (E+F)	H = G*40 kg)/1000	I = H*0.5* 0.47	J = I*3.67	61%*J	34%*J	5%*J
KP	1.126	0.748	25.13	5.39	28.30	4.03	32.33	1.29	0.304	1.115	0.680	0.379	0.056
PB	0.614	0.11	69.62	40.38	42.75	4.44	47.19	1.89	0.444	1.628	0.993	0.553	0.081
SD	0.591	0.028	22.99	24.9	13.59	0.70	14.28	0.57	0.134	0.493	0.301	0.168	0.025
BN	0.924	0.526	8.94	3.4	8.26	1.79	10.05	0.40	0.094	0.347	0.211	0.118	0.017
AJK	0.907	0.268	3.54	0.5	3.21	0.13	3.34	0.13	0.031	0.115	0.070	0.039	0.005
GB	2.503	1.2	1.57	0.33	3.92	0.40	4.32	0.17	0.040	0.149	0.090	0.051	0.007
	Total		**131.79**	**74.90**	**100.02**	**11.49**	**111.52**	**4.46**	**1.048**	**3.847**	**2.347**	**1.308**	**0.192**

i Source: Supply and Demand Survey, Government of Pakistan, 2003
ii Source: Pakistan Bureau of Statistics, Government of Pakistan, 2017
iii Conversion Factors i.e. 1 maund = 40 kg; 1 ton = 1000 kgs (Supply and Demand Survey, Government of Pakistan, 2003)
iv Conversion factor (0.5) from wet weight to dry weight; Dry mass to carbon conversion factor i.e. 0.47 (IPCC, 2006).
v 1 ton of carbon equals 3.67 tons of CO_2 Eq. (IPCC, 2006)
vi Source of Percent Shares: Supply and Demand Survey, Government of Pakistan, 2003
vii Assuming this as contribution from state forests

Annex 7: Quality Assurance and Quality Control in NFI

The following sub-section presents the SOP for each of these procedures implemented for developing FREL/FRL and MRV for REDD+ in Pakistan.

1. QA/QC for Field Measurements

This "Forest Inventory and Field Surveying Manual" is developed as a comprehensive '**Standard Operating Procedure (SOP)'** document containing the details of all the steps to be taken in field inventory and measurements. Proper implementation of this SOP ensures measurements executed by different teams or at different times are consistent and comparable. This SOP covers all the aspects of field measurement along with detailed instructions for navigating to the inventory plot, laying out of the Primary and Secondary Sampling Units (PSU and SSUs), recording the locations of the plots, measurement of trees, classifying deadwood and delineating litter from mineral soils along with the measurements of these, recording of measurements in field tally sheets, entering the recorded data into the database. Field crews should be extensively trained in all the procedures of field data collection as accurately as possible. During every field mission, a document should be prepared and filed, which records and verifies that all the steps from the SOP have been followed and lists all the deviations from the SOP, if any. The SOP should be updated if significant deviations and issues from the procedure are encountered during the inventory.

An audit programme for field measurement should be established. Typically, the audit programme is conducted by a National Technical Team and consists of two levels of checks. In the first check, auditors observe members of field crew during data collection on a field plot. Mistakes in procedural errors are corrected in the field and the field crew are re-oriented in the field. This is done as a part of the training. A second type of field evaluation involves complete re-measurement of certain sample plots by the auditors after the completion of field works. About 10-20% of the clusters/plots (12 clusters in current NFI throughout Pakistan) are re-measured independently by an experienced National Technical Team. Field data collected at this stage is compared with the original data to calculate measurement variances. Any errors found should be corrected and recorded, and could be expressed as a percentage of all the plots that have been rechecked to provide an estimate of the measurement error.

Measurement error (in %) for all the verified plots can be calculated as:

```
Measurement error (%) = (biomass before corrections – biomass after
corrections) x 100/biomass after corrections
```

2. QA/QC for Sample Preparation and Laboratory Measurements

Similarly, procedure described in the SOP for sample preparation (for litter, soil organic carbon) should be rigorously followed for sample preparation and lab analysis. Laboratory measurement should also follow a standard/accredited procedure. If a commercial/external

laboratory performs the analysis, record of the procedure should be obtained, ensuring an accepted standardised procedure is followed.

For QC, all combustion instruments for measuring carbon should be calibrated using commercially available certified carbon standards. Similarly, all balances for measuring dry weights should be periodically calibrated against known weights. Fine-scale balances should be calibrated by the manufacturer and calibration certification made available. Where possible, 10-20% of the soil samples should be reanalysed/reweighted to produce an error estimate. Similar procedure should be applied to litter material. Measurement error is estimated using this equation:

```
Measurement error (%) = (number of errors among checked sample +
total number of samples checked) x 100
```

If the calculated measurement error is greater than 10%, all the analysis needs to be rerun.

3. QA/QC for Data Entry

Field data is either collected directly on electronic devices (field computers, tablets, PDAs, etc.) using specialised/customised data entry software or written down in field sheets. In the latter case of manual entry on field sheets, data is digitised into spreadsheet or data entry software upon completion of inventory day/mission. In both the cases, errors in field data entry can occur and efforts should be made to check the entry step. In the field, clear communication between all the personnel involved in measuring and entering the data is critical to eradicate apparent anomalies in data entry. Typical mistakes are confusion between diameters or circumferences of trees measured, or the length unit (mm, cm, and inches). All the measurements to be entered in the field sheet/data software must have 'units' clearly indicated. Errors can be reduced by:

- spot checks of the entered data by independent personnel,
- range checks - outliers can be identified by checking whether each value is within an expected range

If during spot checks or range checks, a significant error is found, all data must be rechecked by independent personnel. To check data entry errors, an independent person should enter 10-15% of the field sheets into the data entry software. These two data sets can then be compared to check for errors. Any errors detected should be corrected in the master file. The errors in data entry can be estimated as:

```
Measurement error (%) = (number of errors among checked sample +
total number of samples checked) x 100
```

If the calculated measurement error is greater than 10%, data must be re-entered.

Customised data entry/analysis software could be developed such that there are data validations and checks built into the system to highlight the potential error in entry. For instance, such checks or data validation could include tests to check if the diameter limits for given nested plot is within the limit set.

Further, expert's knowledge and sometimes common sense needs to be used when reviewing the results of data analysis to make sure the results are realistic. Errors can be reduced if the entered data are reviewed using expert judgment and, if necessary, through comparison with independent data.

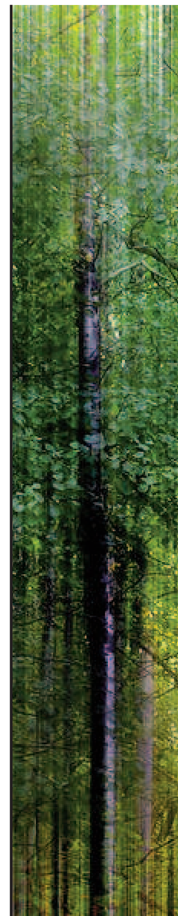
4. QA/QC for Data Archiving

Proper management of inventory data and archiving is very important for future references and its timely use in analysis. Due to relatively long-term nature of forest inventory works, data archiving and storage is also important in an inventory project. Following procedure is recommended for proper data archiving:

- Original copies of the field measurement (data sheets or electronic files) and laboratory data should be maintained in original form, placed on electronic media, and stored in a secure location. Mobile cameras can be used efficiently to scan/photograph the paper field sheets and electronically store in the device and/or email to office/cloud storage[5] for archiving.

- Copies of all data analyses, models, the final estimates, GIS products, and a copy of the measuring and monitoring reports also should all be stored in a secure location (preferably offsite). It is recommended that a centralised database be used to store and archive all the data and results. Various enterprise free and open source and commercial database systems are available such as PostgreSQL, MySQL, MSSQL, Oracle, etc. for data archiving and administration. Preferably, open source database systems such as PostgreSQL can be used to store both data and spatial datasets in a single database with a common interface in GIS applications such as QGIS, ArcGIS, etc.

- Given the period for reporting and the pace of production of updated versions of software and new hardware for storing data, electronic copies of the data and reports should be updated periodically or converted to a format that can be accessed by new or updated software. Open data formats and web accessible standard interchangeable formats are recommended instead of proprietary formats.



5. Google Drive, Dropbox, OneDrive, Mega, Box etc. offer limited (5-50 GB) free storage service.