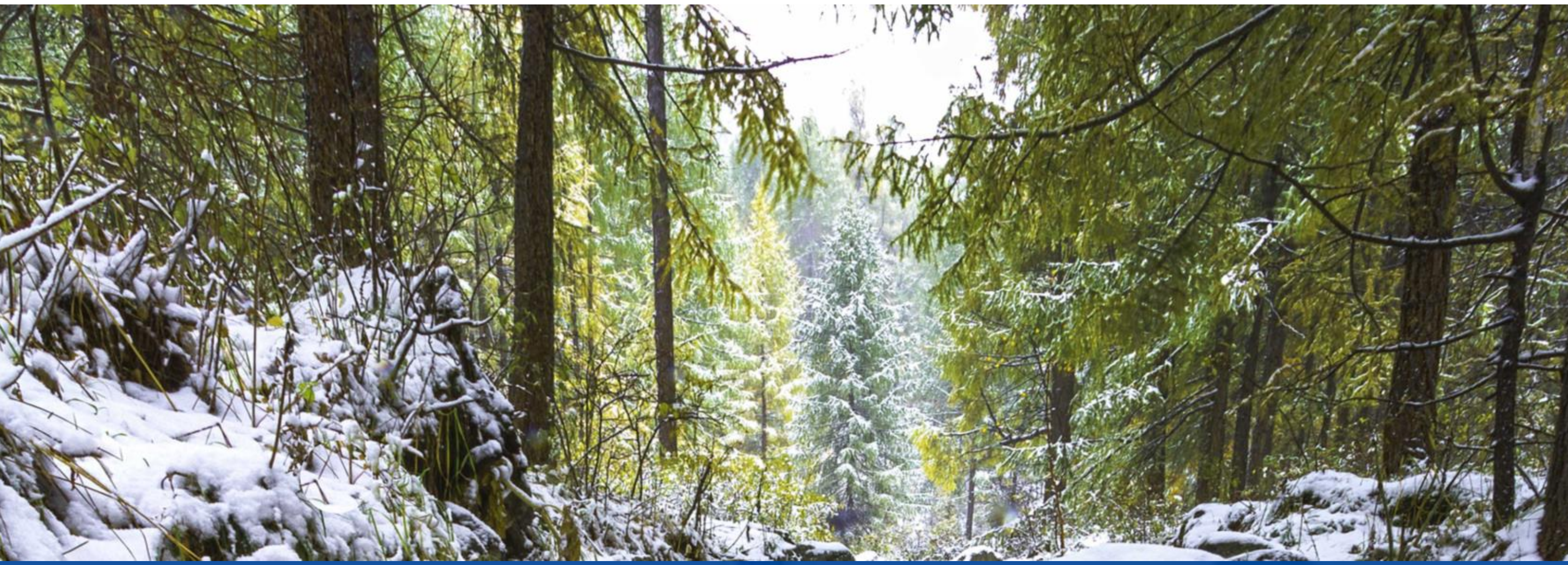
MINISTRY OF ENVIRONMENT AND TOURISM

REDD+ MONGOLIA
Building resilience, livelihoods and economy



Mongolia's Forest Reference Level submission to the UNFCCC

Modified Submission: June 2018

Date: 6/22/2018

UN-REDD PROGRAMME

Food and Agriculture Organization of the United Nations

UNDP Empowered lives. Resilient nations.

UNEP

Citation

Government of Mongolia. 2018. Mongolia's Forest Reference Level submission to the United Nations Framework Convention on Climate Change. UN-REDD Mongolia National Programme, Ministry of Environment and Tourism, Ulaanbaatar.

List of contributing authors:

CCPIU
Sanaa Enkhtaivan, Dorjzodov Nyamsuren and Zolbayar Purevjav

FRDC
Khosbayar Battuvshin, Altangadas Janchivdorj and Michid Khaltar

UN-REDD Mongolia National Programme
Khongor Tsogt, Bat-Ulzii Chultem and Yeseul Byun

Technical Experts:
Abu Mahmood, Remote Sensing and Land Cover Assessment Expert, FAO Bangkok
Mathieu Van Rijin, Forestry Officer, FAO, Bangkok
Marieke Sandker, Forestry Officer, FAO Rome
Ben Vickers, Regional REDD+ Programme Officer, FAO Bangkok

Acknowledgement
The Government of Mongolia would like to thank the REDD+ Mongolia technical partners for provision of support for the development of this submission. In particular, we would like to acknowledge technical support from the UN-REDD National Program, and the three partner agencies, FAO, UNDP and UN Environment; the Mongolia GIZ Program, especially for support to the Multi-purpose National Forest Inventory. The Government of Mongolia also would like to thank the active support from Mongolia's University and Research Institutions, especially those members of the Technical Working Group on Forest Reference Level and National Forest Monitoring Systems, including Department of Forest Policy and Coordination, Forest Research Development Centre, and Climate Change Project Implementing Unit of MET.

Should readers wish for more information, they are encouraged to get in touch via:

The UN-REDD Mongolia National Programme Management Unit
Tel: +976-71117750
E-mail: info@unredd.mn
Web site: www.reddplus.mn

Contents

Figures

Tables

Acronyms and Abbreviations

AD	Activity Data
AFOLU	Agriculture Forests and Other Land Use
AGB	Above-ground Biomass
ALAMGC	Agency for Land Administration and Management, Geodesy and Cartography
BAU	Business as usual
BCEF	Biomass conversion and expension factor
BGB	Below Ground Biomass
IBUR	Initial Biennial Update Report
C	Carbon stock in forest biomass
CE	Collect Earth
CBD	Convention on Biodiversity
CCPIU	Climate Change Project Implementing Unit
CI	Confidence Interval
COP	Conference of Parties
CSO	Civil Society Organization
DBH	Diameter at breast height
DW	Deadwood
EF	Emission Factor
EIC	Environmental Information Centre
ERISC	Environmental Research and Information Study Center
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resource Assessment
FRDC	Forest Research and Development Centre
FRL	Forest Reference Level
FREL	Forest Reference Level
FUG	Forest user group
GASI	General Agency for Specialized Inspection
GCF	Green Climate Fund
GCM	Global Climate Model
GDP	Gross domestic product
GFW	Global Forest Watch
GHG	Greenhouse gas
GHGI	Greenhouse Gas inventory
GIZ	Technical Cooperation Agency of the German Government
GPG	Good practice guidance
IGEB	Institute of General and Experimental Biology, Mongolian Academy of Sciences
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change and Forestry
MET	Ministry of Environment and Tourism
MPNFI	Multi-purpose National Forest Inventory
MRV	Measurement Reporting and Verification
NDC	Nationally Determined Contribution
NFI	National forest inventory

NFMS	National Forest Monitoring System
PAM's	Policies and Measures
QGIS	Quantum GIS
RBP	Results-based payments
RCP	Representative GHG concentration pathway
REDD+	Reduced emission from deforestation and forest degradation, Conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks
SDG	Sustainable Development Goal
SIS	Safeguard Information System
SLMS	Satellite Land Monitoring System
SoI	Summary of Information
Stdev	Standard deviation
tCO2e	Tonnes of carbon dioxide equivalent
TCC	Tree crown cover
TFI	Taxation Forest Inventory
TWG	Technical Working Group
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	United Nations REDD Programme

SUMMARY

This report is Mongolia's first Forest Reference Level (FRL), one of the four main elements of REDD+, which enables the measurement of performance of REDD+ measures associated with the implementation of the national REDD+ strategy for Mongolia. It is based on the United Nations Framework Convention on Climate Change (UNFCCC) decisions, technical documentations, and a review of available tools and methodologies, through national Technical Working Group meetings. Mongolia's FRL is at national scale reflecting the historical reference period 2005-2015. Greenhouse Gas (GHG) emissions from deforestation and forest degradation are estimated, from 4 different drivers[1] - fire/pest, grazing, soil erosion, logging, as well as GHG removals from enhancement through afforestation and/or reforestation activities.

The TWG made recommendations of the elements needed to construct a FRL and convened a FRL core group which has revisited all interim technical decisions to reach national consensus and developed nationally-available data and information necessary to construct a national FRL. Activity data were derived from the assessment of systematic samples to cover the entire country using FAO's Open Foris Tool Kit, Collect Earth and through visual interpretation of high-spatial resolution reference data available from various sources. Emission factors are mostly derived from the data of the National Forest Inventory executed in 2014-2016 and biomass models developed by the Mongolian academy of science (IGEB). A total of 52,660 ha, 1,394,810 ha and 3,038 ha were estimated to have undergone forest loss (deforestation and forest degradation) and forest gain respectively between 2005 and 2015.

Mongolia's annual GHG emissions and removals from the forestry sector were estimated as 3,551,439 tCO_2e at 95 % confidence interval (2,928,271 tCO_2e, 4,174,606 tCO_2e) and -74,055 tCO_2e at 95% confidence interval (-133,303 tCO_2e, -14,806 tCO_2e), respectively, during the reference period 2005-15.

[1] Fire and Pest were not separately considered in Activity Data

1. INTRODUCTION

Mongolia is a landlocked country geographically located between China and Russia. The climate is characterized by high fluctuations and extremes in temperature and precipitation. The annual mean temperature ranges from -8ºC to 6ºC across regions and the annual precipitation varies from 50 mm in the Gobi Desert to 400 mm in the northern mountainous area. It is an immense area of 156 million ha, largely consisting of grasslands which have traditionally supported nomadic herding lifestyles for thousands of years.

The country supports two major forest biomes, boreal forests in the north accounting for 14.2 million ha (87 %), dominated by larch and birch; and 2.0 million ha of saxaul forests (13%), a dryland woodland ecosystem in the southern arid regions of Mongolia that is considered under national definitions as 'forest' (CCPIU, 2018) (Figure 1.1). The boreal forest comprises deciduous and coniferous forests growing in the forest steppe, boreal forest and mountain zones. Boreal forest is dominated by six main conifer species: larch (*Larix sibirica*), birch (*Betula platyphylla*), Siberian pine (*Pinus sibirica*), Scots pine (*Pinus sylvestris*), aspen (*Populus tremula*) and spruce (*Picea obovata*), with much of the forests being dominated by larch (FRDC, 2016). The broad-leaved trees found here are mainly birch (*Betula platyphylla*), aspen (*Populus tremula*) or poplar (*Populus diversifolia*). Northern boreal forests are part of the transitional zone between the Siberian taiga forest to the north and the grasslands to the south. They typically grow on mountain slopes between 800 m and 2500 m above mean sea level. According to the forest taxation inventories conducted by the Forest Research and Development Center (FRDC), larch, birch and saxaul trees account for more than 60%, 10% and 15% of forest areas, respectively. In terms of growing stock, larch contributes close to 80%, while all other trees are below 10%. The boreal forest average growing stock is estimated 114 m^3/ha, excluding saxaul forest (MET, 2016).

The reduced emissions from deforestation and forest degradation, conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks (REDD+) readiness process commenced in June 2011 when Mongolia became a partner country of the UN-REDD programme and the implementation plan of its REDD+ Readiness Roadmap was developed afterwards. Mongolia officially adopted its national REDD+ Readiness Roadmap in 2014, followed by the UN-REDD National Programme being launched in 2016 to support Mongolia's REDD+ readiness process. A comprehensive process of engagement with stakeholders has been undertaken and the readiness process is expected to be completed in December 2018 with completion of the "Warsaw Framework" elements for REDD+.

A Forest Reference Level (FRL) or a Forest Reference Emission Level (FREL) is one of the four elements of REDD+ according to the Cancun Agreement: Decision 1/CP.16 of the United Nations Framework Convention on Climate Change (UNFCCC) at the 16th Conference of Parties (COP) in 2010. The Cancun Agreement defined a FRL/FREL as a benchmark for assessing the performance of each country in implementing a REDD+ strategy. In addition to the Cancun Agreement, decisions relating to the rules and modalities for FRL/FREL development can be found from COP 15 in Copenhagen (Decision 4), COP 17 in Durban (Decision 12) and COP 19 in Warsaw (Decision 13, of the 'Warsaw Framework for REDD+'). The methodological guidance for FREL/FRLs contained in these decisions included, for example, the importance of consistency and tranparency of data; the recommendation for a step-wise approach to development; and the process for Technical Assessment (TA) by UNFCCC experts in the context of result-based payments (RBPs) for REDD+. Since Mongolia included Greenhouse Gas (GHG) removal estimates from carbon stock enhancement activities, as well as GHG emission reduction estimates from deforestation and forest degradation, this submission is for a FRL instead of a FREL, which is understood to deal with emission reduction estimates only.

Figure 1.1. Forest habitat types in Mongolia. Clockwise from top left to right: Deciduous forest – birch (*Betula platyphylla*); Coniferous forest – larch (*Larix sibirica*); Mixed deciduous and conifer forest and saxaul forest.

1.1. Objective of FRL development

Mongolia's national stakeholders have come to an agreement on the objectives of FRL development as follows:

1) to access RBPs under the REDD+ initiative,
2) to assess the contributions that the forest sector makes toward the Nationally Determined Contributions (NDC) to the Paris Agreement of 2015, and
3) to assess the impacts of REDD+ policies and measures taken to mitigate and adapt to climate change in the Agriculture, Forest and Land Use (AFOLU) sector.

1.2. Underlying causes of forest change

Deforestation is defined as the permanent conversion of forest cover to another type of land cover, while forest degradation is the reduction of biomass in an area of forest which, while still remaining as forest, reduces the functionality of the forest ecosystem. Drivers of deforestation and forest degradation are often a complex set of interactions between direct and indirect factors, often attributing the cause to one clear driver is not possible. Table 1.1 shows the main direct and indirect drivers of deforestation and degradation in Mongolia (UN-REDD, 2016a).

Table 1-1. Direct and indirect drivers of deforestation and forest degradation in Mongolia (UN-REDD, 2016a)

<table>
<tr><th colspan="2">Deforestation drivers</th><th colspan="3">Degradation drivers</th></tr>
<tr><td colspan="2">Permanent land use change from forests to other land use</td><td colspan="3">Persistent reduction in forest ecosystem function, or in the case of REDD+, in carbon stock and canopy cover, but the predominant land use remains as forest.</td></tr>
<tr><th colspan="5">Direct drivers</th></tr>
<tr><td colspan="2">Mining and land use change
Deforestation through continued degradation</td><td colspan="3">Forest Fire
Unsustainable logging and subsequent degradation
Minor damage from pest outbreaks
Grazing
Fuelwood collection</td></tr>
<tr><th colspan="5">Indirect drivers and underlying causes</th></tr>
<tr><td>Demographic Factors</td><td>Socio-Economic Factors</td><td>Institutional & Governance Factors</td><td>Environmental Factors</td><td>Policy and Legal Issues</td></tr>
</table>

1.2.1. Direct drivers of deforestation/forest degradation

Mongolian forests are slow in growth, and are vulnerable to disturbance from drought, fire and pests. Therefore forests could easily lose their ecological balance following a disturbance and they have a relatively less natural regrowth afterwards, partly due to the biophysical environment in the northern hemisphere's harsh continental climate, which significantly limits vegetative growth and soil moisture content.

The long-term compounded effect from several drivers, such as forest fire, followed by pest infestation and grazing, often exacerbated by loss of moisture content in soil, which may lead to permanent deforestation. Once disturbed, forests increasingly degrade and ultimately, they could turn into steppe with few trees or shrubs. Since several factors are compounded in deforestation, it is difficult to identify a single factor of the major cause, therefore they should be treated as a group of factors. It is due to the long-term compounded effect of forest fires, pest damage, often triggered by improper unsustainable logging practice, and exacerbated by uncontrolled grazing and recurrent burning inhibiting regeneration (Tsogtbaatar, 2013). Once disturbed, the resilience of a forest ecosystem declines, and a combination of pressures from unsustainable logging practice, livestock grazing, fires and pests occur together. Any of these drivers can provide an entry point to a process of increasing forest degradation, both in spatial extent and in severity. Independent to the specific driver that triggered degradation, forests increasingly degrade and ultimately turn into steppe with few trees or shrubs.

Mining

Mining can also cause deforestation when mining operations remove the top soil and open pits. To date, 2,736 mining licenses have been issued covering 11 million ha (7.0 % of the total national territory). These include 1.1 million ha of exploitation licenses and 9.9 million ha of exploration licenses (MET, 2015). In 2009, the total area under exploration and mining licenses is estimated to be between 2 % and 14 % of forest areas within the forest provinces. Further collection of detailed datasets from the Ministry of Mining needs to be undertaken. Mine-site restoration is insufficient on much of the mining areas. Technical reclamation refers to closing the mining pit; whereas biological restoration refers to re-establishing vegetation cover by sowing of perennial plants and planting trees.

The absence of grown soil makes biological reclamation difficult and often establishment of vegetation cover is unsatisfactory. A mining moratorium on new areas, declared in 2010, has drastically reduced the forest land areas affected by mining activities.

Forest Fire

Forest fires affect large areas in Mongolia, generally about 95 % of these are regarded as caused by human activities, only 5 % are due to natural factors, mainly lightning (MET, 2017b). Fires most likely occur during the spring and autumn period, the highest fire risk season, when activities such as timber harvesting, use of non-timber forest products, hunting may cause forest fires.[2] Forest fires burn large amounts of herbaceous plants, and parts of the soil, that can contain humus layer, moss, peat, tree crowns, shrubs, and trees on the surface of the forest soil. There can be surface, ground and crown fires depending on environmental conditions and the amount of fuel in the forest ecosystem, with crown fires resulting in effects that are more deleterious and may lead to many tree deaths. Once burnt, forests are more susceptible to damage from pests, and are more accessible for logging, specifically for deadwood collection and grazing, as the resulting opening of crown cover will benefit grass and therefore attract grazing animals, and may lead to the deforesting through continued degradation that is described above. The effects of fire also result in increased oxidization of organic matter in soils leading to emissions several years after the forest fire incident. Recurrent burning often compounded with grazing suppresses natural regeneration that would occur in natural forests. The potential of drier summers and increased temperature, as observed in other northern hemisphere countries, may increase the risk of forest fire.

Forest Pests

Insect damage is caused by a complex interaction of factors that are only partly human induced. Beneficial and detrimental insects in any forests live in harmony with the ecosystem, with outbreaks often being part of the natural ecological cycles. However, the ecological balance can be lost and provide suitable conditions for pest outbreak due to weakened forest tree health because of forest fire, logging, competition for water. After fire, there is high risk of pest infestation and logged-over forests tend to attract pests. Damage can be severe, but most commonly the forest will become degraded rather than undergo a land use change. Increasing aridity because of climate change has also been said to favor mass proliferation of harmful insects (Dorjsuren, 2014); climate change has also been reported to lower the abundance of insect parasites which may ultimately cause increased abundance of insect pests. Minor pest outbreaks will only slow growth for one season and these tend to lead to forest degradation, herewith classified as minor pest damage. If there is no further pest outbreak, or other cause of degradation, it is expected that in following years the forests will gradually recover. Pest damage is also one of the contributing factors of forest degradation (combined with fire, environmental change, logging) which eventually leads to deforestation through continued forest degradation.

[2] Nyamjav, Goldammer, and Uibrig 2007

Unsustainable logging and fuelwood collection

Many logging practices in Mongolia are unsustainable and consequently lead to long-term forest degradation. Logging companies do not follow best logging practices and do not follow reduced impact logging practices. Though Codes of Practice are available in Mongolia, logging safeguards are usually not implemented to reduce the subsequent effects of increased fire, pest damage, and grazing following timber extraction. Unsustainable logging compromises the forests' capacity for regeneration, by increasing the risk of soil compaction, forest fire, and grazing damage.

However, it should be noted that large areas of Mongolia's forests need to be placed under a sustainable forest harvesting regime to increase ecosystem health and resilience to pests and fire, and to provide economic incentives and benefits for communities and enterprises.

Grazing

Mongolia has a long tradition of raising livestock, with pastoral nomadism the prevailing form of land use and an important way of life for many communities living in forested areas. Currently around one third of Mongolia's population lives as nomads from livestock husbandry. Grazing is not a driver of forest change, but works together with several other factors contributing to deforestation through continued degradation and directly affecting areas that are assigned for carbon stock enhancement. The complexity of factors is described in the section on deforestation through continued degradation. Grazing within forests is widespread in degraded or edge forests and an important factor inhibiting regeneration; animals eat young trees and it suppresses regeneration. Well-stocked forests' with low intensity grazing have been observed to occur high seedling density compared with forests' having low-stocking along with high intensity grazing (MET, 2017). Grazing is therefore a contributing factor to the degradation of already disturbed forest; it also is an inhibiting factor for any natural regeneration or plantations on degraded areas.

1.2.2. Indirect drivers of deforestation

Underlying causes of forest change include demographic, economic, technological, policy & institutional, cultural & socio-political, and environmental factors (Chapter 6 of UN-REDD, 2016). In Mongolia, technical capacity development, regulation and policy strengthening, awareness raising, and direct funding of activities for maintaining and enhancing forest carbon stocks, and sustainable forest management have promise for addressing the drivers of forest change. These broad types of policies and measures will emerge from examining the interactions between drivers' underlying the causes. All drivers provide entry points for designing useful interventions to address them.

Demographic Factors

Growing population has increased the general activity levels in forest areas; and small-scale rural activities result in fires and pervasive pressure placed upon forest resources. Population growth is compounded by urbanization and urban expansion creates a need for wood products and construction areas.

Socio-economic factors

Fast economic growth in recent years resulted in more government funds available for activities enhancing forest carbon stocks, such as tree planting and pest control; though this funding has been subsequently reduced because of Mongolia's economic downturn caused by a downturn in the mining industry. Prior to the economic expansion, there was higher demand for wood products leading to an increase in unsustainable logging and subsequent degradation. Lingering rural poverty continues to drive unsustainable forest management, overgrazing, forest fires (or grassland fires which impact nearby forests), illegal logging and ultimately deforestation by continued degradation.

Institutional factors

Low technical capacity for forest management exacerbates forest fires and unsustainable logging and subsequent degradation; it compromises the effectiveness of pest control and tree planting. Forest skills and capacity would benefit from updating and experience from other countries facing similar issues in North America and Scandinavia. The lack of firefighting equipment is widespread, but more importantly, forest fire management techniques are outdated. *Weak governance and poor transparency around the allocation of mining permits may result in deforestation. Poor* compliance with applicable environmental regulations in mining can increase deforestation, reduce restoration and cause other environmental and social impacts, including possibility of communities being relocated. The lack of transparency in public procurement for services such as tree planting, may result in the selection of ineffective service providers and lack of tree care and maintenance, which significantly compromises success rates.

Environmental Factors

Climate change has led to increasing occurrence of pests and compromised forests' regenerative capacity. Reduced rainfall and the increased occurrence of droughts have created unfavorable conditions for tree plantings, led to more forest fires and increased pest occurrence. The potential change in climate in Mongolia with predicted rainfall change, permafrost thaws, seasonal temperature change, including extreme winters, has the potential to increase the vulnerability of the forests to snow and ice damage, forest fire risk, pest infestation, and places inordinate ecological pressure, especially through competition for water in dense forest stands, through reduced soil moisture from reduced rainfall and lost permafrost. Both thawing peatland permafrost as well as drying and degrading peatlands result in increased greenhouse gas emission from peat soils. Mongolia is estimated to host one of the largest peatland areas in the world, potentially covering more than 1.7 percent of the country's surface (Minayeva et al. 2016). It is important to note that due to lack of data, especially soil sampling for reliable peatland mapping, the emissions from soil organic carbon are not considered herewith.

Policy and Legal Factors

The regulatory environment and law enforcement capabilities are insufficient for fire prevention, illegal logging, grazing and mining. The insufficient regulatory environment is compounded by a low capacity for law enforcement and fire prevention, which promotes unsustainable illegal logging, fails to curtail grazing activities and leads to environmentally damaging mining practices in forest areas. *The political environment has overemphasized forest protection at the expense of development of a sustainable wood industry, this can be restrictive and counter-productive preventing the legalized sustainable harvesting and resource use which would ensure better management of the forest resources.* The low harvest rates prevent an effective forest sector from developing, yet wood processing factories still demand timber, this is either imported or comes from illegal sources within Mongolia. Most government funding is allocated to tree planting and to pest control rather than being directed to investment in more effective forest management. Forest planting has not been successful despite receiving large budgets and should be reserved for selected areas with natural regeneration processes being the focus of forest establishment.

1.3. Extent of FRL components

1.3.1. Scale

Boreal forests in the northern part of the steppe and taiga zone take up most of the forested area in Mongolia. Saxaul (*Haloxylon ammodendron*) trees in the southern part of the desert zone form wooded land (Enkhsaikhan, 2017). It is also considered as forest land in Mongolia (FRDC, 2017).

Mongolia's FRL is at national-scale, that takes into account for changes in all types of forest.

1.3.2. Scope: activities, pools and gases

REDD+ activities in the FRL

The FRL includes the REDD+ activities: deforestation, forest degradation and enhancement of forest carbon stocks (afforestation/reforestation).

Deforestation and *forest degradation* are the significant contributors of GHG emissions from forest land and therefore have been included in the emission calculation. Fire, pest outbreaks, logging and mining are the key drivers of deforestation and forest degradation in Mongolia.

Forest areas where tree canopy cover has been reduced to below 10 % by the drivers are defined as deforestation. The forest areas converted for settlement and agricultural purposes are also considered as deforestation even if the minimum threshold of 10 % canopy cover is reached.

Forest areas with a canopy cover equal to, or above, 10 % but in which canopy cover has been reduced due to fire, pest or logging activities were considered as degraded forest.

Removals from reforestation/afforestation are included as *enhancement of forest carbon stocks* in the FRL calculation.

Furthermore, removals in forest land remaining forest land are also observed as enhancement of forest carbon stocks. Mongolia included these removals in order to be complete and for consistency with the GHG inventory. Growth in stable forest land, however, is not expected to be very different in the results reporting period so even though these concern large amount of removals, they are not expected to contribute to the results reporting. Even more, considering that under the current calculation the growth rate is considered stable in the stable forest area, where growth is happening, decreases slightly, the inclusion of removals in forest land remaining forest land has an expected minor negative impact on REDD+ results.

No separate calculation has been considered for GHG emissions or removals due to conservation of forest carbon stocks and sustainable forest management. However, the impacts of these the two 'REDD+ activities' are considered to be covered by the measurement of emissions due to deforestation and forest degradation and by the measurement of removals due to forest carbon stock enhancement.

Carbon pools in the FRL

Above-ground biomass (AGB), below-ground biomass (BGB), deadwood (DW), and litter pools were included in the FRL, excluding Soil Organic Carbon (SOC). For AGB and DW, data from the NFI was used, and for BGB default estimate (root-shoot ratio) from IPCC guidance was used.

In its initial FRL submission, Mongolia had included the soil carbon pool but assessed the emissions from soil at zero following a Tier 1 calculation suggested by IPCC (2006). This assumption is correct considering the default stock change factors for land-use systems (F_{LU}), management regimes (F_{MG}) and input of organic matter (F_I) in equation 2.25 if all deforestation would happen on mineral soils. However, a map-based inventory demonstrated that as much as 272 000 km^2 (approximately 1.7 percent of Mongolia's land area) might consist of peatlands (Minayeva et al., 2016), bound to foothills and mountains within forest steppe, taiga, and mountain tundra. Joosten (2010) suggests Mongolia is among the 10 world's largest peatland emitters though the study does not specify whether these emissions are from forest lands or outside. Other sources suggest the peatland areas in Mongolia to be much smaller (e.g. Xu et al 2018) based on an analysis using the Harmonized World Soil Database yet the accuracy of this database for peatland (or 'histosols') is disputed.

In absence of reliable information on spatial distribution, EFs or RFs from soil organic carbon pool (SOC) in forested peatland areas, this FRL does not include SOC pool in the emissions and removals calculations.

Gases in the FRL

CO_2 released from all four carbon pools was included in the FRL. Other GHGs believed to be significant in terms of emissions from the forest sector include N_2O, from forest fire, and CH_4 from permafrost melt. Work has begun on the development of emissions of these two gases, but is currently incomplete at the time of this modified submission.

1.3.3. Forest definition

Since 1958 Mongolia has implemented a Taxation Forest Inventory (TFI) which was designed for management planning purposes. The TFI uses a minimum relative stocking density threshold value of 0.3 within an area of 1 ha to qualify land as forest. The estimate based on the TFI has been used to report to the FRA. In 2014, the first National Forest Inventory (NFI) was initiated and data collection has been made over the period of 2014-2016 based on a forest definition designed to fit in Mongolian boreal forest context. To ensure consistency between the FRL and the recently completed NFI, this FRL has adopted the same forest definition for boreal forest, as used in the NFI (2016, page 17).

Based on the review of TFI, FRA and NFI, the decision to adopt the forest definition for boreal forest was made by the Technical Working Group (TWG) for National Forest Monitoring System (NFMS) and

FRL development (UN-REDD, 2016b). Revisions have been made by the TWG for the minimum height, from 5 m to 2 m, and for the minimum area, from 0.5 ha to 1 ha, thresholds compared with the FRA definition. These revisions were taken to include some forest tree species such as birch (*Betula exilis, B. Humilis*) and dwarf pine (*Pinus pumila*), which do not reach 5 m in height.

The definition of 'forest' for Mongolia's boreal areas can be summarized as follows: "***all land spanning of at least 1 ha covered by trees with a height of at least 2 m and with a canopy cover of at least 10 percent***". This definition will be used in future national and international communication.

Forest definition for saxaul forest was adopted from the publication of Jalbaa and Enkhsaikhan (1991). A standard table in the study provides that minimum height class is 1 m and minimum crown cover is 4.65 %. For this FRL, a 4% area threshold was used for Saxaul forest.

1.3.4. Historical reference period

For the national GHG inventory in the IBUR, Mongolia compiled a LULUCF assessment for 30 years, covering the time period from 1986 to 2016. The proposed reference period for the FRL is the 10-years period from 2005 to 2015.

1.4. Consistency with greenhouse gas inventory reporting

Both IBUR and FRL reports followed the six IPCC land use categories (IPCC, 2006). Mongolia reported emissions and removals from both boreal and saxaul forests in the IBUR (MET, 2017a). In the IBUR, it was estimated that of the total forest area, about 75 % is under boreal forest cover while remaining 25 % is saxaul type, based on data from the Agency for Land Administration and Management, Geodesy and Cartography (ALAMGC).

ALAMGC data does not contain spatially explicit information on forest change, therefore the estimates of changes in the FRL cannot be compared directly with the IBUR. Forest area change estimates are based on the systematic dot-grid sampling which provides uncertainty estimates for forest/non-forest areas as well as change areas. The IBUR indicated the use sample-based approach using openforis collect earth (CE) as the main source of Activity Data (AD) for the LULUCF sector for subsequent submissions of BUR in terms of LULUCF area estimates and changes (MET, 2017c, Chapter 6.1.7). The carbon fraction (0.51) from biomass and root-shoot ratios are taken from the table 4.4 of IPCC GL (2006), similar to the IBUR.

2. MATERIALS AND METHODS

2.1. Activity data

2.1.1. Rationale for data selection

Mongolia has both spatially explicit wall-to-wall maps and dot-grid systematic sample-based data available for estimating forest cover changes. Those datasets were reviewed for their reliability, suitability, and accuracy in the context of construction of the FRL to ensure transparency and consistency.

1. The Collect and Collect Earth system of FAO's openforis were used to assess 123,577 systematically gridded sample points covering the entire country. Ten percent randomly chosen sample points were independently assessed to determine the operators assessment uncertainties (CCPIU, 2017). By using dot-grid sampling to assess forest area and its change from satellite imagery, the need for time consuming and vast territorial area coverage of Mongolia's image processing workload was substantially reduced. Dot-grid sampling is conceptually simple, but appropriate sample design and dot intensity are essential to ensure estimations that are both accurate and precise.

2. The Environmental Research Information and Study Center (ERISC) has been producing Mongolian forest cover maps using a Moderate Resolution Imaging Spectroradiometer (MODIS) -derived NDVI value of 0.65 threshold since the year 2000 based on 30 m-Landsat imagery. To date ERISC has produced sixteen annualized forest/non-forest maps from 2000 to 2015 (Ariunzul et al., 2017). Figure 2.1 shows the 2005 forest map from ERISC. These annualized forest/non-forest maps could potentially be a useful database to generate activity data. The ERISC mapping however do not comply with the forest definition adopted in the FRL. The wall-to-wall ERISC maps do not provide information on degraded forest and also on forest gain. Moreover, the maps have not been tested for a robust accuracy assessment to generate uncertainty estimates. ERISC maps are therefore of limited use as a source of AD for the FRL.

To develop historical data on forest cover change at the national-scale, which had not previously been done, the TWG decided to follow sample-based approach and to use FAO's openforis Collect Earth (CE) system for the assessment of samples. The analysis was conducted using high to medium spatial resolution Earth Observation data accessible through Google Earth, Google Earth Engine (GEE), and Bing Maps. A sample plot was determined to be forest land when ≥10% tree cover was estimated using the dot grid within a sample.

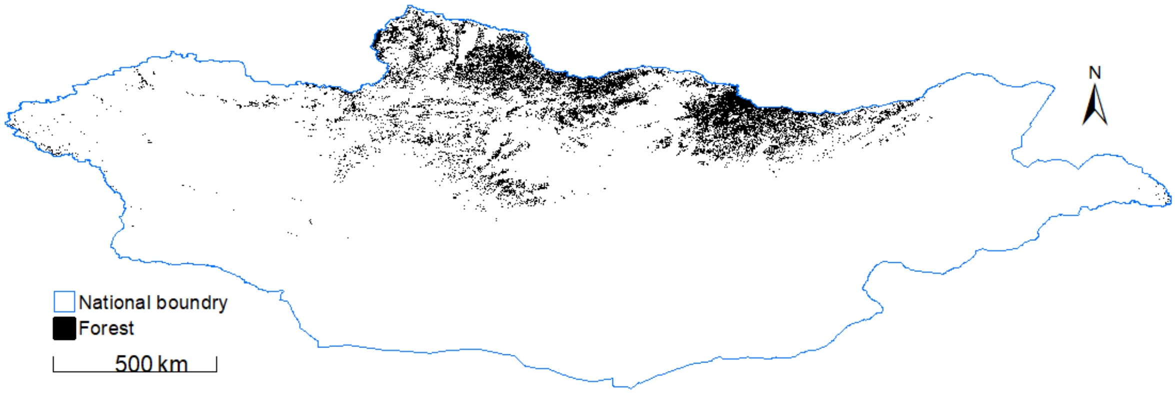


Figure 2.1. Forest cover map of the year 2005 from ERISC

2.1.2. Sample Density

The CE study required the selection of an optimum density of sample points that captures maximum changes of the activities within the forest, that are statistically sound, and that ensures unbiased forest change estimates. This study was used to develop forest and land use change estimates for Mongolia, not only for the FRL.

The study first examined the annual spatial changes in forests that are reported in the Global Forest Watch[3] (GFW) datasets and then investigated how accurately the annual area changes in GFW are captured using systematic grids at different sampling densities. The theory is that there should be an optimum sample density that serves three purposes. First, the optimum sampling density should minimise the errors in estimates. Second, the time required for analysis should be minimised. Third, it should result in an acceptable level of accuracy in estimates.

Figure 2.2 shows how the annual changes in the GFW data were actually estimated in relation to different grid point densities. It can be seen that, as might be expected, the error as expressed by the variance (the deviation from the value of 1, the ratio of estimated area to observed area) reduces as the number of points in the design increases. In the case of a country like Mongolia, with relatively small annual changes in land cover, the point at which the error is largely eliminated was shown to be a systematic grid with spacing between 1 km and 2 km. Analysis of this range suggested that, theoretically, about 99% of the changes could be captured at a systematic grid spacing between 1 km and 2 km (without consideration of operator's error) (Figure 2.2). It was concluded that a target sample grid of 2 km by 2 km would be sufficient to capture annual forest changes in Mongolia.

The NFI conducted between 2014 and 2016 used a national sampling grid of 9 km by 9 km (MET, 2016). In order to enable consistency of the CE analysis with current and future NFI exercises, it was decided that the grid design for CE should be compatible with this national sampling density, hence a distance of 2.25 km between sample points was selected, as both compatible with the results of the analysis described above, and with existing national datasets.

[3] http://www.globalforestwatch.org/

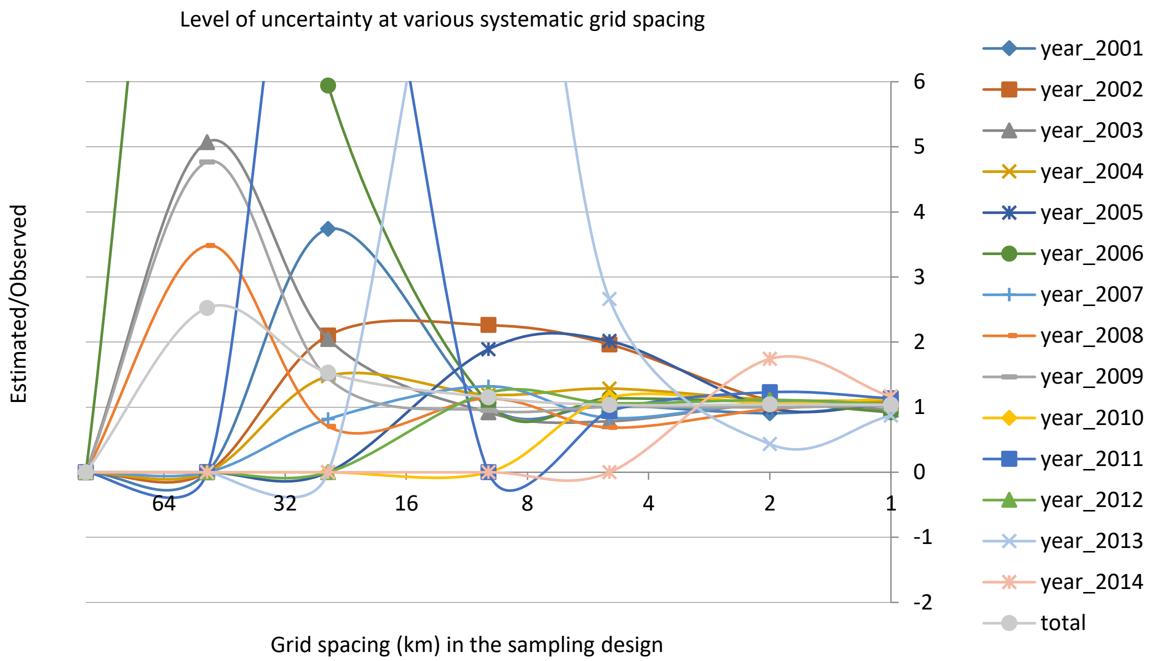


Figure 2.2. Error associated with grid density and the ability of the sample grid to estimate the area of annual forest changes as recorded in the Global Forest Watch dataset for Mongolia (one sample every km means 4096 times more samples than one sample every 64 km).

Mongolia's total land area is 156,411,556 hectares (ALAMGC, 2016). In order to assess land use and land-use change, over 123,577 regularly-distributed sample points were created and assessed across the territory of the entire country. The Climate Change Project Implementation Unit (CCPIU), under the Ministry of Environment and Tourism (MET) led the AD collection and analysis for the FRL between the years of 2005 and 2015 (Bey et al., 2015; CCPIU, 2018).

Considering the national GHGi reporting has been conducted on a two-year cycle, it was further concluded that a grid of 2 km by 2 km (one quarter of the point density) would capture the cumulative changes taking place over a two year period with the same accuracy (Figure 2.2).

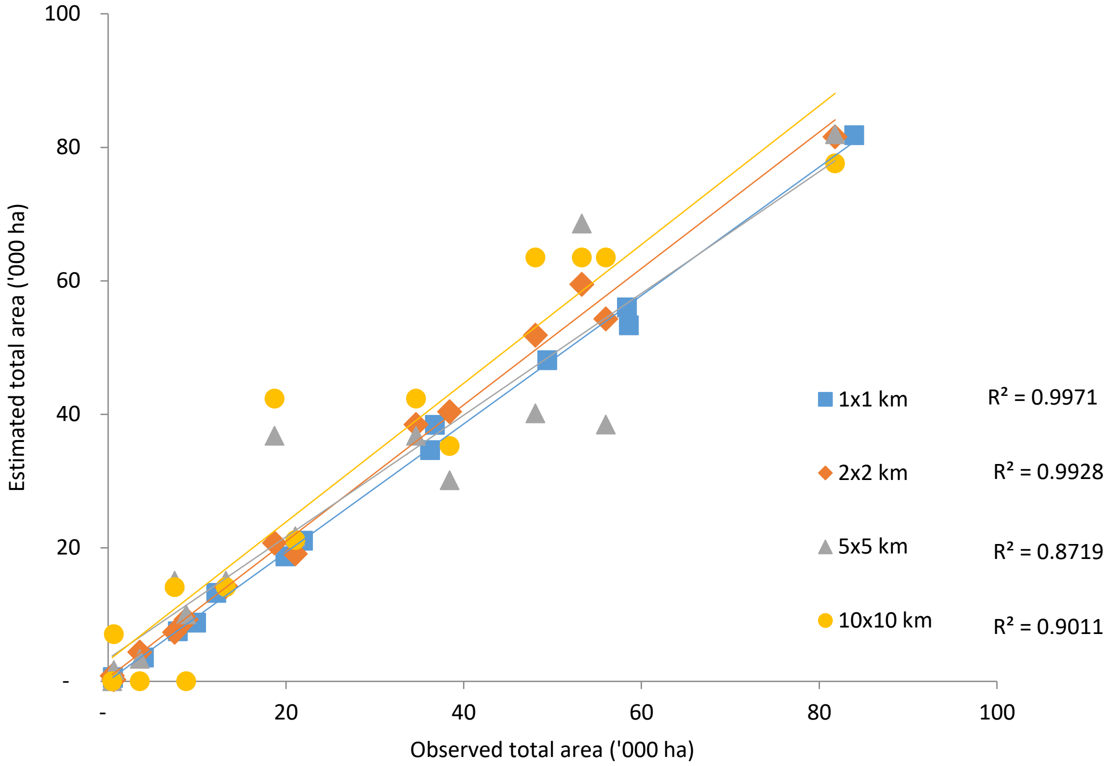


Figure 2.2. Analysis for optimal grid spacing design. Relationship between grid spacing and size of area change when compared to Global Forest Watch data as wall-to-wall information for Mongolian forest cover change.

2.1.3. Stratification

The sample design was stratified into boreal forest zone and the rest of the country (including Saxaul forest as well as all non-forest zones). Most of the observable changes between forest and non-forest over time occur in the boreal forest zone, so the sampling density for non-boreal areas does not need to be as high.

For boreal forest areas, therefore, a 2.25 km by 2.25 km grid (as described above) was used to locate sample points and for other areas a 9 km by 9 km grid was used, with the intention that this will be consistent for all subsequent reporting of FRL and IBUR. This results in a total of 123,669 sample points across the entire country. The grids have been chosen on a nested basis so that if the country decided to change density of the assessment points, the different density grids will always be coincident for any amended spacing between points. (Figure 2.3 and Figure 2.4), i.e. if the forest mask is adjusted in future, no new sample points will need to be created for non-forest areas, and new sample points for forest areas will be consistent with the existing grid.

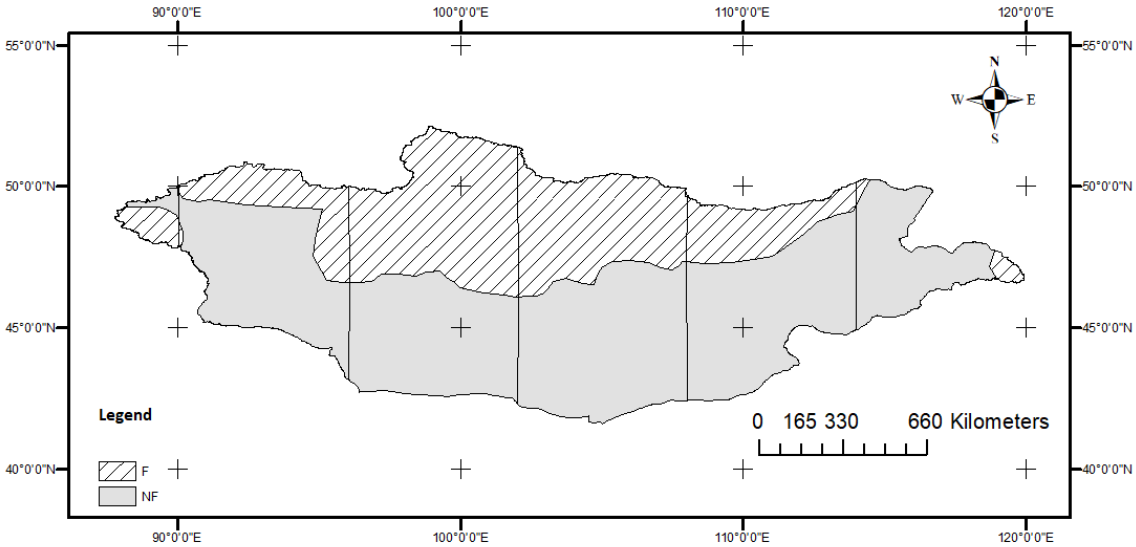


Figure 2.3. Forest (F) and non-forest (NF) strata have been used to determine the optimum density range of a systematic grid. The boundary of the forest (F) stratum (*diagonal stripped*) was chosen to include all NFI points as well as the forest mask 2013. The highlighted area in Gray is non-forest (NF).

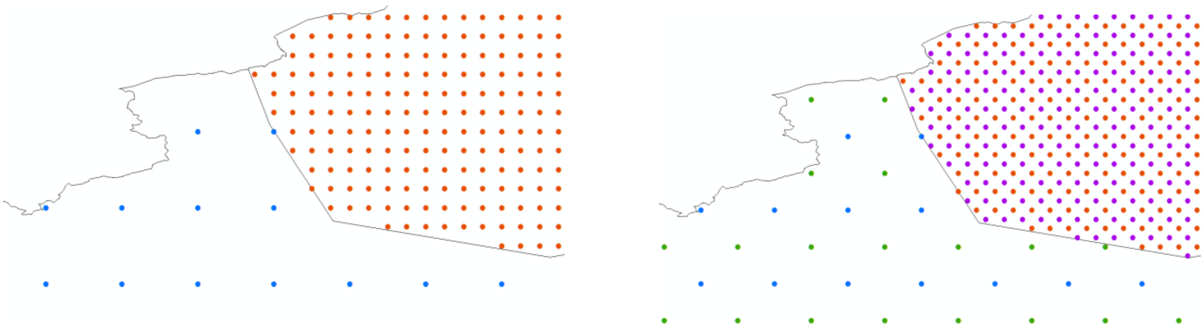


Figure 2.4 Coarse grids for forest 4.5 km x 4.5km and non-forest 18 km x 18 km samples (*left*) and current denser grid for forest 2.25 km x 2.25 km and non-forest 9 km x 9 km (*right*).

2.1.4. Sample point generation

It was decided that an equal distance sample grid would be constructed based upon the six Universal Transverse Mercator (UTM) projection zones that cover Mongolia. The alternative would be to use a grid based upon equal angular units in a geographic coordinate system (latitude/longitude), for which a single grid could be constructed for each stratum. However, in northern latitudes as in Mongolia, this results in a variable grid size and the need for a unique expansion factor for each grid point. It also creates a potential bias, in terms of the grid density (more dense in the north) and directionality of the grid (greater density in the east/west direction than north/south) which is considered undesirable.

A systematic sample design was chosen for the study. QGIS 2.14 was used to automatically generate a rectangular array of points over each zone (using a grid generator), then spatial query was used to select points from the array that falls within the stratum and UTM zone. Expansion factor for each zone is multiplied by total number of the plots to estimate total area of the polygon area (see Table 2-1.). Detailed process of creating the sampling grids is provided in annex Collect Earth user manual (Daniel et al., 2015).

Table 2-1. Expansion factor for each UTM zone

Strata	UTM zones	No. of points	Area (ha)	Expansion factor (ha)	Square grid spacing
Forest (boreal zone)	45	3,660	1,850,126	505.50	2.25 km by 2.25 km
	46	14,752	7,471,554	506.44	
	47	43,231	21,881,587	506.16	
	48	33,251	16,833,385	506.25	
	49	14,646	7,417,686	506.47	
	50	1,714	868,568	506.75	
	sub total	111,254	56,322,906		
Non-forest (including Saxaul)	45	68	579,301	8,519.13	9 km by 9 km
	46	2,362	19,170,923	8,119.83	
	47	2,555	20,747,694	8,120.43	
	48	3,151	25,613,817	8,128.79	
	49	2,771	22,473,093	8,110.10	
	50	1,416	11,454,767	8,089.53	
	Sub total	12,323	100,039,595		
	Total	123,577	156,362,501		

2.1.5. Survey design

The Survey Form was designed using *openforis-Collect* tool to gather information in a manner consistent with the IPCC guidelines, thus enabling Mongolia to use the resulting data to address some of its data needs for reporting to the UNFCCC. Figure 2.5 shows an example of a data collection form used in this Collect Earth Land Assessment (CELA) project for collecting data on LULUCF. As shown in the figures, the CELA project used square-shaped plots of one hectare which again contains 49 sub-plots or grid-points. Each of the 49 sub-plots or grid-points, therefore, represents to approximately 2 % of a 1-ha square sample plot. Data has been analyzed at the plot level while the sampling points have been used to quantify and to characterize a land cover type.

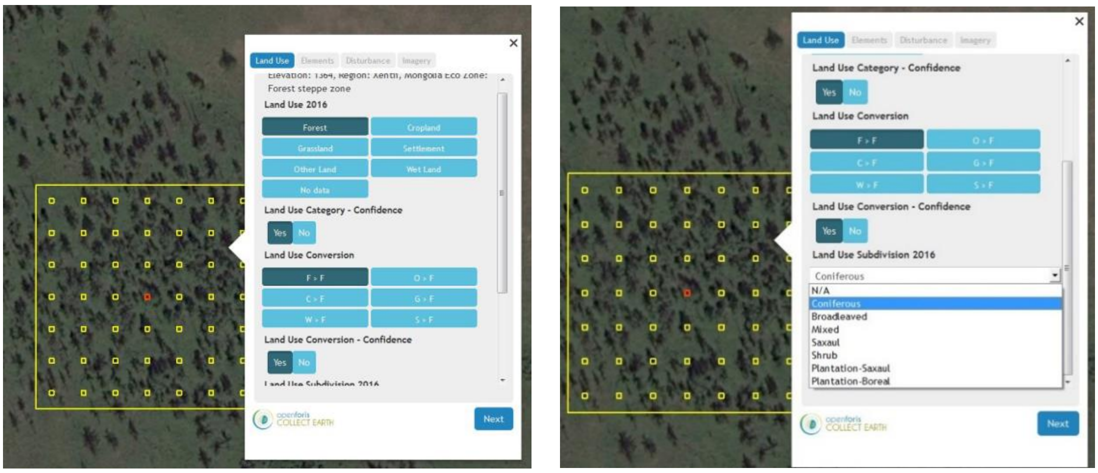


Figure 2.5. Collect Earth land assessment form for land use and land-use change information collection.

2.1.6. *Land-use types and use of hierarchical rules*

Land use assessment follows certain rules in terms of reducing subjective effects on the result, as described in Table 2-2. For the historical assessment, the level of disturbance is associated with the different land use categories as a result of human impact, i.e., fire/pest, logging, grazing, soil and soil erosion. The degree of disturbance impact is determined by the operators's own interpretation. As for the land use change, the operator has to use Google Earth Engine with different time series of Landsat imagery to determine the actual year of change from one land use conversion to another.

Table 2-2. Land use assessment hierarchy and land cover thresholds

	Land use categories	Classification rule, %
1	Settlement	14
2	Cropland	14
3	Forest *Boreal* *Saxaul*	 *10* *4*
4	Grassland	14
5	Wetland	14
6	Otherland	14
	No data	Omitted

2.1.7. *Response design*

The desired goal of this validation was to derive a statistically robust, quantitative assessment of the uncertainties associated with the forest area change estimates. Several factors potentially impact on the quality of forest mapping (GOFC GOLD, 2015), namely

The spatial, spectral and temporal resolution of the imagery

The radiometric and geometric pre-processing of the imagery

The automated and manual procedures used to interpret the forest map category

Thematic standards (i.e. minimum mapping unit and land use definitions)

The availability of field reference data for evaluation of the results.

Approaches were used in the case of Mongolia's FRL to minimize these sources of error following IPCC and GOFC-GOLD good practice guidelines, as appropriate. However, the representativeness of reference data and sample selection of the accuracy assessment of change area were slightly compromised by the restricted availability of high spatial resolution imagery in Google Earth, in GEE and in Bing Maps across Mongolia.

Through a collect survey design form (see Figure 2.5), using *Open Foris Collect*, the six Land cover types were assessed within each sample through an expert image interpretation of medium (15-m pan-sharpened Landsat) to very high (sub-meter) spatial resolution aerial imagery and satellite data. The reference datasets were used in the accuracy assessment are listed in Table 2-3 and have sufficient temporal representation consistent with the reference period: 2005-2015. The *Collect* survey design form has been designed to allow a confidence-level specified by an interpreter.

Table 2-3. Validation datasets used for sample assessment

Data types	Spatial resolution	Source
High-resolution RGB imagery from various satellite sensors, such as SPOT, GeoEye-1, WorldView-1/2/3, Digital Globe, IKONOS, etc.	10-m to 30-cm	Google Earth Pro/ Bing Maps
Landsat time series archive: 2005-2015	30-m (15-m pan-sharpened)	Google Earth Engine Landsat/Sentinel MSI 2 Archive

2.1.8. Analysis design

Appendix 1 shows the analysis design for six IPCC land cover/use categories and also for forest/non-forest categories, respectively. Appendix 2 illustrates the calculation of estimators for a systematic random sampling design, following GFOI (2016) guidelines. The samples were analyzed and the sample-based estimates were derived through using the *survey package* (Lumley, 2004 and 2014) available within the statistical package R Core Team (2014). The *survey package* uses the standard formulae for estimation of means and variances.

2.2. Emission and removal factors

2.2.1. National Forest Inventory

The NFI (2014-2016) also followed a pre-stratified systematic design, with different sampling intensity in different regions, to survey a representative fraction of the forests in order to derive information on quantitative and qualitative conditions of forest. A national-level sampling grid was prepared with the objective of generating NFI results with satisfactory precision at national-level, i.e. statistics reflecting the average boreal forest in Mongolia. This national sampling grid covers the entire boreal forest area (with a few exceptions) with a grid spacing of 9 km North and 9 km East. In order to generate NFI statistics with satisfactory precision also at the regional level, further intensified sampling grids were added in the main forest inventory regions. In the *Khangai*, *Khuvsgul* and *Khentii* regions grids with spacing 4 km north and 4 km East were added. In the Altai region a denser grid with spacing 1.5 km North and 1.5 km East was added, to better capture the relatively small forest area.

The NFI field inventory sampling design was developed to generate per-hectare based forest statistics. A total of 4,284 sampling units were inventoried (see Figure 2.6) of which 1,007 sample units for national square-grid (9 km by 9 km) and 3,277 units for intensified grid. Each sampling unit is a cluster of 3 sample plots, in order to cover the variety in the forest characteristics in the tract (forest site). Therefore, the total of 12,216 sample plots were measured during the NFI inventory. The centers of sample plots are distanced 100-112 m of each other in a triangle. A sample plot is composed by nested circles with radii of 20 m, 12 m, 6 m, 2 m; on which different measurements and assessments were carried out as specified in Table 2-4. Appendix 3 illustrates the sampling unit design and design of the nested plots within a sampling unit.

Table 2-4. Plot size and corresponding measurements and observations carried out in the NFI field inventory

Plot radius	Measurements and observations
2 meter	Regeneration
6 meter	Standing trees with diameter at breast height (dbh) – 6 cm -14.99 cm Deadwood Soil assessment
12 meter	Standing trees with dbh of 15 cm – 29.9 cm
20 meter	Standing trees with dbh ≥ 30 cm Stand structure, fire, grazing, erosion, protection status, etc.

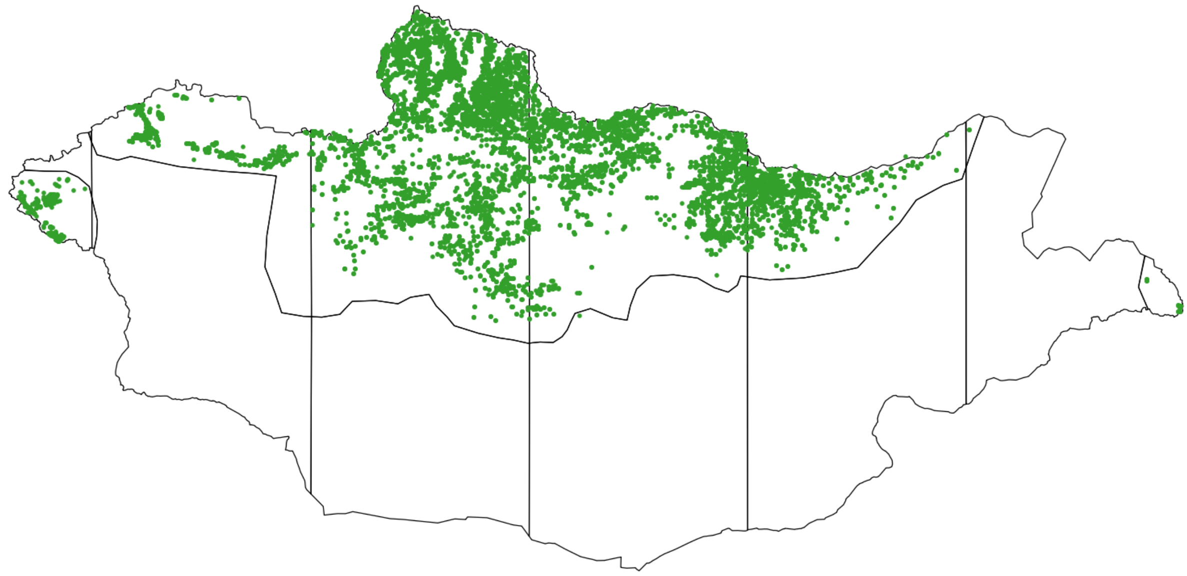


Figure 2.6. NFI plots locations (green dots) over boreal forest distributional area. Vertical lines represents 6 UTM zones from 45 to 50 over Mongolian territory.

EFs and/or RFs for ABG, DW, and Littler were derived from NFI (MET, 2016) inventory plots data. The NFI sample locations were selected using a Forest Mask 2013/2015 covering only the dominant well stocked forest areas in the Boreal forest zone, with approximately 66 % canopy cover or more. There was, therefore, a lack of information regarding EFs from low-stocked boreal forests. To be consistent with the national forest definition, where the canopy cover threshold is 10 %, additional NFI plots were needed to be surveyed to cover low-stocked forest areas.

According to the drivers study (UN-REDD, 2016a), *direct and indirect impacts of wildfire, pest outbreak and logging leads to deforestation and degradation. In order to estimate EFs for the change classes within forest area,* additional data collection for low-stocked forest inventory was organized by the Mongolia UN-REDD National Programme, with 156 new NFI clusters measured in 2017 following same methodology of NFI (MET, 2016), representing 1,583,492 ha low-stocked Boreal forest area (Figure 2.7 and Figure 2.8).

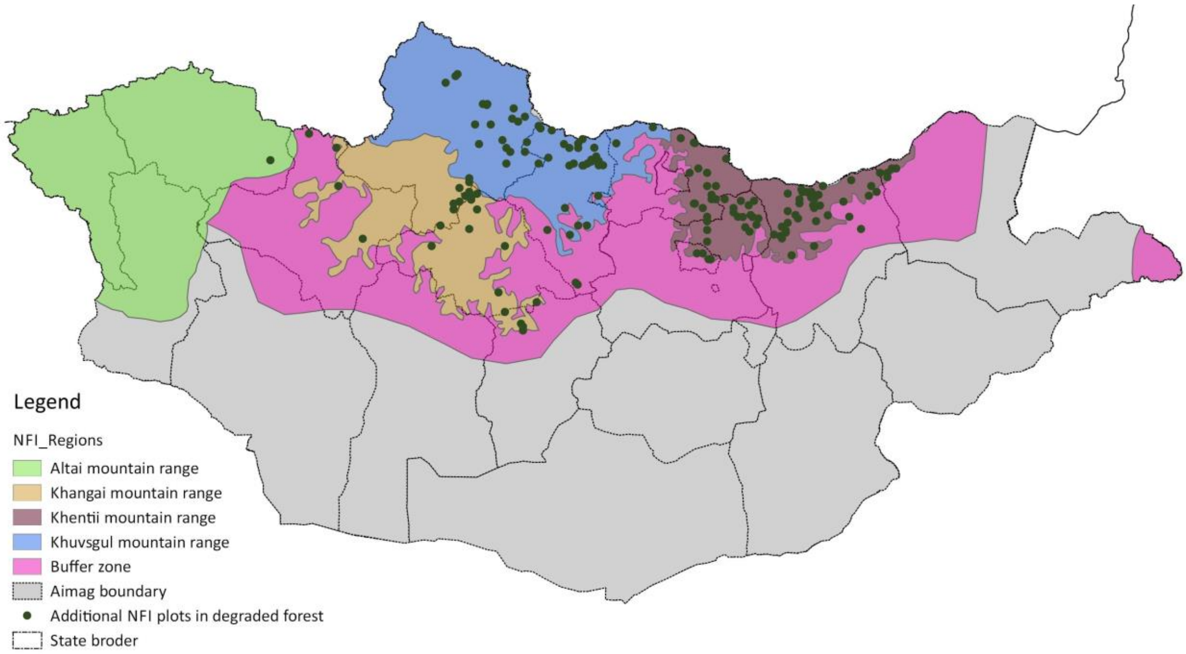


Figure 2.7. Distributions of additional field inventory plots that are degraded by fire, pest and logging activities and sparse trees.

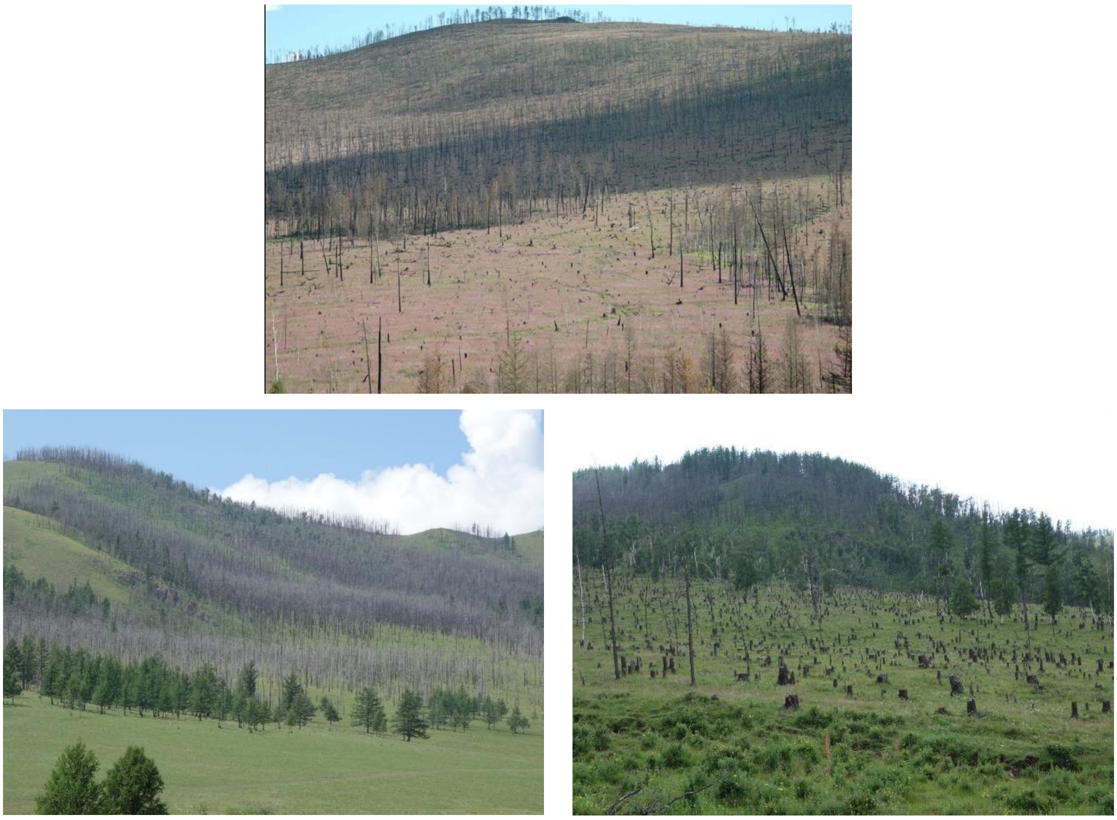


Figure 2.8. Burnt forest area (top), Pest affected forest (left) and logged forest (right). During the vegetation period in 2017, Mongolia conducted field inventory on additional 156 plots located in degraded forests which represents area of 1.58 million ha temporally un-stocked or low-stocked forest area.

2.2.2. Estimating biomass/carbon

Above-ground biomass (AGB)

The Institute of General and Experimental Biology (IGEB) of the Mongolian Academy of Science (MAS) has carried out a field survey of biomass of main tree species of Mongolia (Dorjsuren, 2017). The field surveys were carried out in most typical forest stands. A total of 23 circular samples of 20 m radius were established. All the plots were inventoried following the NFI (MET, 2016) plot measurement methods.

A total of 192 selected trees were harvested and measured for tree volume and biomass (Table 2-5) following methods of Picard et al. (2012). Tree biomass measurement was organized with seven different operations: site preparation and felling; measurement of felled trees – stem profile; cross-cutting into logs and disks; weighting of logs and brushwood; sampling of branches; and sample weighing. Each model tree was divided into three different sections: trunk wood, crown wood (top, middle, bottom section), and branches and foliage. Standard oven dry methods were used to derive dry biomass of the samples.

The allometric models (Eq. 1) were derived based on the relationship between AGB and diameter at breast height (DBH) and total height of tree (H_{tot}) measurements.

$$AGB = a * DBH^b \times H_{tot}^c \qquad \text{Eq.1}$$

Where:

AGB = Above-ground live Biomass (tonnes), (= *dry biomass of stem incl. bark, branch and leaves*)

DBH = Tree stem diameter (m) at breast height (1,3m)

H_{tot} = Tree total height/length (m)

a = Species specific factor

b = Species specific DBH exponential factor

c = Species specific H_{tot} exponential factor

The species specific coefficients are provided in Table 2-5.

Above ground carbon calculated by following equation:

$$Above - ground\ carbon = AGB \times 0.51 \qquad \text{Eq. 2}$$

Table 2-5. National species-specific coefficients for biomass models

	Scientific name	Common name	Species specific factors		
			a	b	c
1	*Larix sibirica*	Siberian Larch	0.0534	2.03321	0.5996
2	*Pinus sylvestris*	Scotch Pine	0.037	2.2875	0.4418
3	*Pinus sibirica*	Siberian Pine	0.0677	1.9944	0.5774
4	*Picea obovata*	Siberian Spruce	0.0313	1.5339	1.3435
5	*Abies sibirica*	Siberian Fir	0.1212	0.4343	1.9744
6	*Betula platyphylla*	Asian White Birch	0.0735	2.19502	0.4053
7	*Betula humilis*	Shrubby Birch	0.0735	2.19502	0.4053
8	*Betula rotundifolia / B. nana*	Dwarf Birch	0.0735	2.19502	0.4053
9	*Populus laurifolia*	Laurel poplar	0.1396	2.5168	-0.3862
10	*Populus balsamifera var. Suaveolens*	Mongolian poplar (Siberian poplar)	0.1396	2.5168	-0.3862

	Scientific name	Common name	Species specific factors		
			a	b	c
11	*Populus tremula*	Aspen	0.0579	2.01676	0.5845
12	*Ulmus pumila*	Siberian Elm	0.0735	2.19502	0.4053
13	*Haloxylon ammodendron*	Saxaul	0.0735	2.19502	0.4053
14	*Populus diversifolia / P. Euphratica*	Desert poplar	0.0735	2.19502	0.4053
15	*Salix berberifolia*	Willow	0.0735	2.19502	0.4053
16	*Salix glauca*	Gray willow	0.0735	2.19502	0.4053
17	*Salix reticulata*	Net-leaved willow	0.0735	2.19502	0.4053
18	*Padus asiatica*	Black Cherry	0.0735	2.19502	0.4053
19	*Sorbus sibirica*	Service Tree	0.0735	2.19502	0.4053
100	not specified	not specified	0.0534	2.03321	0.5996

Below-ground biomass (BGB)

BGB was estimated from IPCC GL (2006) default value of root-shoot ratio for boreal forest (Eq. 3) with a criteria of equal to or above 75 tonnes of dry AGB per ha (Table 2-6).

$$BGB = AGB * RSR \qquad \text{Eq. 3}$$

Where:

RSR = Root-Shoot ratio for Boreal forest from IPCC GL (2006)

Table 2-6. Below-ground living tree biomass as proportion of above-ground living tree biomass

BGB/AGB Root-Shoot ratio for Boreal forest	
AGB<75	AGB≥75
0.39	0.24

Below-ground carbon calculated by following equation:

$$Below - ground\ carbon = BGB \times 0.51 \qquad \text{Eq. 4}$$

Litter (L)

Baatarbileg et al. (2016) conducted the first study in Mongolia on forest litter C stock estimation, based on an analysis of litter samples collected from 210 quality control sampling units in the NFI that includes all forest regions in boreal forests (MET, 2016).

The IPCC guidelines define litter an organic horizon (all leaves, twigs, small branches, fruits, flowers, roots, and bark) on the soil surface (IPCC 2006), although the term litter differs in soil science, where its meaning is restricted to fallen dead leaves. However, in this study, litter was defined as an organic horizon (O horizon) that is divided into four litter types: fine woody debris, which includes fallen boles, branches, twigs (<5 cm maximum diameter), strobilus, and bark; fresh leaves; the fermentation layer and the humus layer. We defined the humus layer as continuously stocked humus ≥5 cm in depth.

All samples were collected by NFI quality control team according to the manual developed during the assessment of MPNFI in 2014. At each point, a sample of litter was taken from each plot centre with cylindrical core with surface area of 117.81cm^2.

All samples were kept in the cold storage until the laboratory procedures were started. Process of estimating carbon stock of litter samples were completed step by step in order to estimate C stock of litter samples based on loss on ignition methods developed by Walkley-Black (Craft et al., 1991; Takahashi et al., 2010)

Deadwood (DW)

In the NFI (MET, 2016) deadwood organic matter was calculated as the sum of three types of organic matter: standing above-ground deadwood, on-the-ground deadwood (branch ≥ 5cm DBH), and below-ground deadwood (Eq. 5). The three types of deadwood were calculated separately (Eq. 6-8).

$$DW_{total} = DW_{ground} + DW_{standing} + DW_{BG} \qquad \text{Eq. 5}$$

Where:
DW_{ground} = Deadwood on-the-ground and stump (based on mid-log diameter, log length and decay)
$DW_{standing}$ = Standing deadwood (*only stem*)
DW_{BG} = Below-ground deadwood (based on stump/tree DBH and decay)

$$DW_{ground} = {D_m}^2 * \frac{\pi}{4} * L * (100 - Bd) \qquad \text{Eq. 6}$$

Where:
D_m = Diameter at middle length of a log
L = Log length
Bd = decay as percentage

$$DW_{standing} = a * DBH^b * Htot^c * (100 - Bd)/100 \qquad \text{Eq. 7}$$

$$DW_{BG} = AGB * RSR \qquad \text{Eq. 8}$$

2.2.3. Emission and removal factors

Land use change – Deforestation and Re/Afforestation

Forest converted to other land was considered to lose 100 % of four carbon pools: AGB, BGB, DW and Litter. Non-forest land converted to forest land was calculated as 100 % gain of four carbon pools: AGB, BGB, DW and Litter.

None of the NFI plots were located in Saxaul forest and Shrub and country-specific biomass or EF data are lacking for those two forest types. Therefore, this FRL has not considered Saxaul forest and Shrub in emission factor calculations and this is an area for future improvement. The Saxaul forest and Shrub cover has been stable since 2005 (see Table 3-2.), hence the lack of EF data for those two forest types has no impact on the Forest Reference Level emission and removal estimates.

Forest remaining forest – changes of carbon stock due to disturbances

Mongolia's forests are major sinks, capturing carbon from the atmosphere as they grow. All forest land remaining forest land removes carbon through growth. Mongolia has included natural growth as gain in the calculation of removals in the FRL for both intact and degraded forests to increase consistency with the GHG reporting. Forest land remaining forest land where forests are disturbed by fire, pests or logging activities are included in the FRL under the REDD+ activity "forest degradation".

To correlate activity data with emission factors we have studied forest disturbance years over the NFI plots using the CE tool to determine whether the plots have been affected by fire/pest and logging disturbances. This resulted in two different biomass estimates for intact and degraded forest areas respectively (Table 2-7). In total, 4276 first sample plots out of 4284 sampling units were assessed using the CE tool for fire/pest and logging disturbances, which are the key drivers of deforestation and degradation. 8 samples were excluded from the LULUCF assessment due to missing and/or incorrect geospatial information.

Table 2-7. Collect Earth disturbance study and number of plots which reached forest threshold

	Crown cover < 10 %	Crown cover ≥ 10 %	Total
Disturbance recorded	3	843	846
No disturbance recorded	193	3237	3430
Total	196	4080	4276

4080 sample plots with crown cover of more than or equal to 10 % were used for emission factor development out of 4276 sample plots. It was difficult to separately identify fire distributed and pest affected area by using a visual assessment on Collect Earth, so all plots that were fire and pest disturbed were classified into the same disturbance category.

Due to the limited number of samples for broadleaved and mixed forests during the CE study, it was not possible to develop specific EFs for different forest categories. Therefore, the EF estimates for both intact and degraded forests are assumed to be similar for all Boreal forest types.

EFs for forest degradation due to forest fire/pest and logging disturbances were assessed by the difference in mean carbon values for both intact and degraded forests. Associated confidence interval ranges around the mean carbon values were also calculated. Estimates for AGB, BGB and DW carbon pools were calculated for intact forest and degraded forest seperately. For litter, a single carbon stock estimate was used for both intact and degraded forests.

The estimation of carbon in living biomass and in DW is estimated by converting the corresponding biomass pools to carbon with IPCC 2006 recommended carbon fraction for boreal coniferous trees, 0.51 tonnes carbon per tonne dry biomass. The carbon content per hectare values for litter is adopted from the NFI (MET, 2016).

2.2.4. Removal factor - estimating annual increase in biomass carbon stocks

Annual gain in biomass (ΔC_G) is a product of mean annual biomass increment (G_{TOTAL}), area of land (A) and carbon fraction of dry matter (CF); Equation 9 (IPCC, 2006).

$$\Delta C_G = \Sigma(A * G_{TOTAL} * CF) \qquad \text{Eq. 9}$$

Where:

ΔC_G = annual increase in biomass carbon stocks due to biomass growth in forest (boreal) land remaining in the same land-use category, tonnes C yr^{-1}

A = area of forest (boreal) land remaining in the same land-use category, ha
G_{TOTAL}= mean annual biomass growth of boreal forest, tonnes d. m. ha^{-1} yr^{-1}
CF = carbon fraction of dry matter, tonne C (tonne d.m.)$^{-1}$

G_{TOTAL} is calculated using Equation 2.10 of IPCC (2006) for given values of annual AGB growth (GW), BGB to AGB ratio (R), and default data tables in Section 4.5 of IPCC (2006).

For the Mongolia,
GW = 1.0 tonnes d.m. ha^{-1} yr^{-1} (Table 4.9 of IPCC, 2006);
R = 0.3 tonne d.m. (tonne d.m.)$^{-1}$ (Table 4.4 of IPCC, 2006);
G_{TOTAL} = 1.0 tonnes dm.$ha^{-1}yr^{-1}$ × (1 + 0.3) = 1.3 tonnes d.m. ha^{-1} yr^{-1} (see Equation 2.10 IPCC, 2006);
CF = 0.51 tonne C (tonne d.m.)$^{-1}$ (Table 4.3 of IPCC, 2006).

A removal factor of forest growth determined Tier 1 of IPCC (2006) guideline and were used for calculating annual increase of AGB growth rates as 1 tonnes d.m. ha^{-1} yr^{-1} and ratio of BGB were 0.3 for both intact and degraded forests, based on IBUR Annex in MET (2017). No annual growth calculated for Saxaul and Shrub forest types. Annual forest change matrices were produced in order to calculate annual forest growth related emission (Appendix 4).

2.2.5. Estimating emission and removal

Carbon stocks were calculated following the general guidelines of IPCC (2006) on the gain-loss method (Eq. 10).

$$\Delta \boldsymbol{C} = \Delta \boldsymbol{C_G} - \Delta \boldsymbol{C_L} \qquad \text{Eq. 10}$$

Where:
ΔC = annual carbon stock change in the pool, tonnes C per yr ΔC_G = annual gain of carbon, tonnes Cper yr
ΔC_L = annual loss of carbon, tonnes C per yr

Overall, carbon stock changes within a forest stratum are estimated by adding up the changes in all carbon pools as in Eq. 11.

$$\Delta \boldsymbol{C_{LU_i}} = \Delta \boldsymbol{C_{AGB}} + \Delta \boldsymbol{C_{BGB}} + \Delta \boldsymbol{C_{DW}} + \Delta \boldsymbol{C_{LI}} \qquad \text{Eq. 11}$$

Where:
ΔC_{LU_i}= carbon stock changes for a stratum of a forest land-use category
i = denotes a specific stratum or subdivision within the land-use category
AGB – above-ground biomass, BGB – below-ground biomass, DW – deadwood, LI – litter
The following equation (12) is used to calculate the FRL in tonnes of carbon dioxide equivalent (t CO_2e):

$$\boldsymbol{FRL_{Def\&Af}} = \frac{\boldsymbol{\Sigma_t \Delta C_{B_{t,Def}} + \Sigma_t \Delta C_{B_{t,Af}}}}{\boldsymbol{p}} * \frac{\boldsymbol{44}}{\boldsymbol{12}} \qquad \text{Eq. 12}$$

Where:
$FRL_{Def\&Af}$ = annual mean losses of carbon stocks from forest land during the reference period, in tonnes of CO_2e $year^{-1}$
$\Delta C_{B_{t,Def}}$ = change in carbon stocks in forest land converted to non-forest land, and in forest land which has undergone degradation, in year t of the reference period, in tonnes of C. Reference is made to the reservoirs included below.
$\Delta C_{B_{t,Af}}$ = change in carbon stocks in non-forest land converted to forest land in year t of the reference period, in tonnes of C.
p = years in the reference period, 10 years (2005-2015)

$\frac{44}{12}$ = factor for converting carbon to CO_2 equivalent, t CO_2e

2.3. Combined uncertainty

The definition of *good practice* requires that inventories should be accurate in the sense that they are neither over- nor underestimated as far as can be judged, and that uncertainties are reduced as far as practicable.

In the *GPG2000*, the percentage uncertainty is defined as:

$$\% \, uncertainty = \frac{{}^{1}/_{2}(95\% \, Confidence \, Interval \, width)}{\mu} \times 100 \qquad \text{Eq. 13}$$

Where:
μ = the mean of the distribution

The uncertainty of the overall estimates for activity data and emission/removal factors was calculated by error propagation with the following equation,

$$U_{total}{}^{4} = \frac{\sqrt{(U_1 * x_1)^2 + (U_2 * x_2)^2 + \cdots + (U_n * x_n)^2}}{x_1 + x_2 + \cdots + x_n} \qquad \text{Eq. 14}$$

Where:
U_{total}= the percentage uncertainty in the sum of the quantities

x_n *and* U_n are the uncertain quantities and the percentage uncertainties associated with them, respectively.

[4] Table 6.1: Tier 1 Uncertainty Calculation and Reporting under IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventory

3. RESULTS

3.1. Activity data

3.1.1. Area estimate

Table 3-1 shows the total area estimates along with 95% confidence interval (CI) under the six IPCC land cover classes during 2005-2015, derived from the 123,472[5] systematic random samples. The area estimates (156,309,341 ha) are the sum of the expansion factors of the samples identified under each IPCC land cover class. During the reference period, the most dominant land use category is grassland, which covers approximately 80 % of the country. Forest land is the second major land use in Mongolia, which covers approximately 10 % of the total land area. The forest area was 15.5 million ha in the year 2005, with standard error (SE) of 0.1 million ha; at 95 % CI the forest cover was between 15.2 and 15.8 million ha. In 2015, the forest cover declined to 15.4 million ha, with SE of 0.1 million ha, and between 15.1 - 15.8 million ha at 95 % CI (see Table 3-1). Contrary to the forest cover trend, land area under settlements has expanded by approximately 53,700 ha during 2005-2015. The remaining land cover classes have remained relatively stable during the reference period.

Table 3-1. Sample-based area estimates (ha) in Mongolia under the six IPCC land cover classes in 2005, 2010, and 2015.

IPCC categories	Total area	Standard error (SE)	95% Confidence Interval	
			Lower-2.5%	Upper-97.5%
Year 2005		Hectare (ha)		
Cropland	1,392,327.0	51,543.6	1,291,304.0	1,493,350.0
Forest	15,513,267.0	154,972.7	15,209,526.0	15,817,008.0
Grassland	124,336,515.0	764450.3	122,838,220.0	125.834,810.0
Other land	12,187,411.0	297,604.0	11,604,117.0	12,770,705.0
Settlement	1,333,698.0	83,456.0	1,170,128.0	1,497,269.0
Wetland	1,546,122.0	71,710.0	1,405,571.0	1,686,673.0
Year 2010				
Cropland	1,383,711.0	50,901.0	1,283,947.0	1,483,475.0
Forest	15,469,215.0	154,936.5	15,165,545.0	15,772,885.0
Grassland	124,357,252.0	764389.3	122,859,076.0	125,855,427.0
Other land	12,187,411.0	297,604.5	11,604,117.0	12,770,705.0
Settlement	1,364,112.0	84,280.2	1,198,926.0	1,529,298.0
Wetland	1,547,640.0	71,716.0	1,407,080.0	1,688,201.0
Year 2015				
Cropland	1,389,283.0	50,927.5	1,289,466.0	1,489,099.0
Forest	15,463,645.0	154,932.0	15,159,984.0	15,767,306.0
Grassland	124,341,548.0	764,404.7	122,843,343.0	125,839,754.0
Other land	12,187,411.0	297,605.0	11,604,117.0	12,770,705.0
Settlement	1,387,428.0	84,713.3	1,221,392.0	1,553,463.0
Wetland	1,540,027.0	71,258.3	1,400,363.0	1,679,690.0

[5] Of the 123,577 samples, 105 samples were omitted due to cloud cover. Assessment area sum is less than the country's total territory by 53,160 ha.

3.1.2. Rate of change

Three land cover change matrices were produced from the samples for 2005-2010, 2010-2015 and 2005-2015 for IPCC land cover classes (Appendix 5) and annual forest/non-forest classes (Appendix 4). About 51,647 ha, (at SE 5,109 ha, 95% CI (41,632 ha, 61,662 ha)) of forest has been converted into grassland during 2005-2015, and this conversion into grassland was a major cause of forest loss during the reference period (see Appendix 6). A similar amount of grassland - 52,717 ha, (at SE 14,566 ha, 95% CI (24,173 ha, 81,261 ha)) - has been converted to settlements during the same period, reflecting a period of accelerated urban expansion.

Between forest and non-forest land cover types, the analysis shows that deforestation occurred in 104 samples (out of 123,472 total), while only 6 samples showed forest gain during 2005-2015 (see Appendix 7). Therefore, loss outstripped forest gain during the reference period. The area under Saxaul forest cover has been relatively stable since 2005, but further analysis is required to obtain accurate AD for Saxaul.

Table 3-2 shows sample-based estimates of forest changes in Mongolia from 2005 to 2015. 11.9 million ha of forest has remained intact during 2005-2015. 1.4 million ha of intact forest has been degraded during this period due to fire, repeated burning, logging and other activities. 52,660 ha of intact forest has been completely lost during the reference period. Examples of forest loss (deforestation) detected in the Collect Earth-based sample assessment are illustrated in Figure 3.1, while Figure 3.2 shows an example of forest gain, identified using high-spatial resolution Google Earth imagery.

Table 3-2. Change in area (ha) between forest and non-forest cover types over the reference period 2005-2015**.**

Year of assessments		Mean	Std. Eror.	95% Confidence Interval		
2005	2015			2.50%	97.50%	±(%)
Stable classes				Area estimates in ha		
Intact forest	Intact forest	11,902,880.0	85,783.6	11,734,740.0	12,071,010.0	1.4
Degraded forest	Degraded forest	110,867.7	7,482.2	96,202.9	125,532.4	13.2
Saxaul forest	Saxaul forest	2,048,003.0	128,498.3	1,796,151.0	2,299,855.0	12.3
Shrub	Shrub	766,739.7	38,646.9	690,993.1	842,486.3	9.8
Non-forest	Non-forest	140,030,300.0	808,637.4	138,445,400.0	141,615,200.0	1.1
Change classes						
Intact forest	Degraded forest	1,394,810.0	28,504.0	1,338,943.0	1,450,676.0	4.0
Intact forest	Non-forest	52,659.7	5,159.5	42,547.3	62,772.2	19.2
Non-forest	Degraded forest	506.5	506.3	-485.8	1,498.7	200.0
Non-forest	Intact forest	2,531.2	1,131.5	313.5	4,748.9	87.6

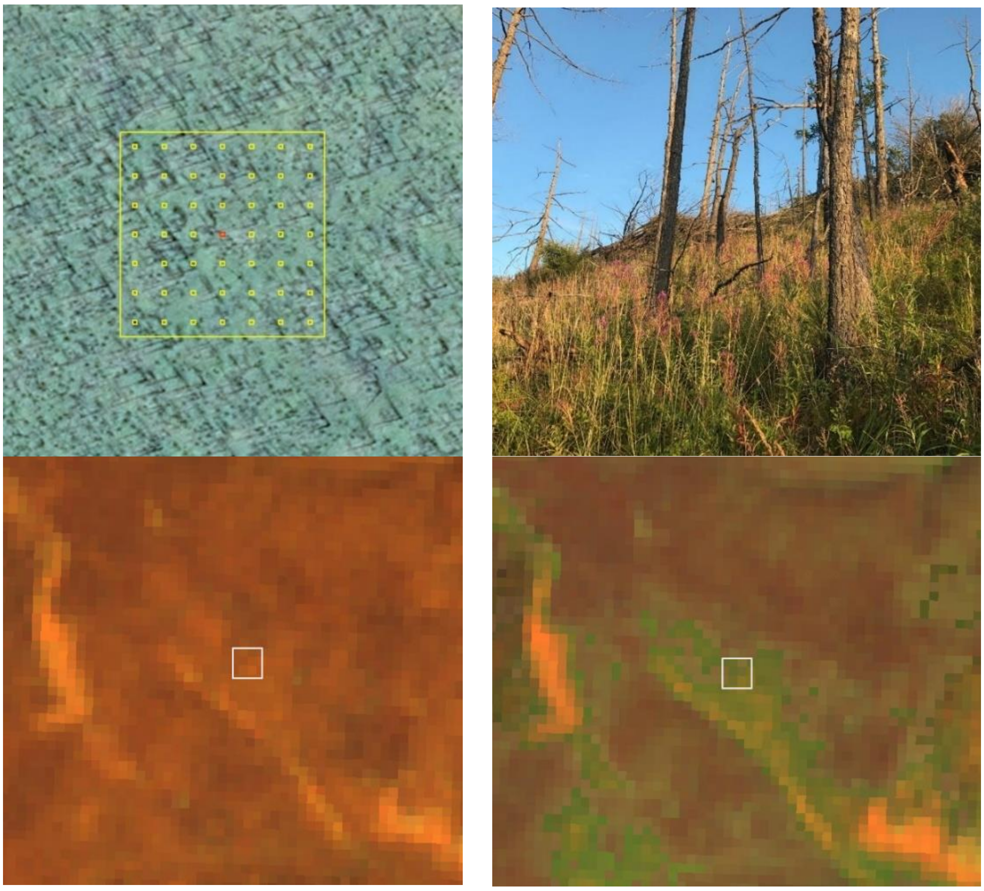


Figure 3.1. Forest land in 2008 converted into grassland (Set17, id: 80832) in 2009. High spatial resolution Google earth imagery (*top-left*), burnt forest photo (*top-right*) illustrates the type of land cover as a validation data for Landsat. Annual Greenest-Pixel top of atmospheric (TOA) Reflectance Composites for years 2008 (*bottom-left*) and 2009 (*bottom-right*) are displayed in false color composite (NIR_SWIR1_Red in RGB channels). The 1ha sample plot in the 2008 Landsat 30-m image shows forest cover (dark brown) while the 2009 image indicates grassland (green) cover.

2001 2005 2012

Figure 3.2. Non forest converted to forest land (Set42, id: 106298, G>F 100 m * 100 m or 1-ha plot) identified using high-spatial resolution Google Earth imagery in 2001 (*left*), in 2005 (*middle*) and in 2012 (*right*). The high-spatial resolution imagery in Google Earth (left), shows afforestation which probably occurred prior to 2001, identifiable through some scattered crowns. Therefore, an operator assessed the plot as non-forest (Grassland) in 2005, according to the dominant land cover type, but then as Forest land in 2012, due to ⩾ 10 % tree canopy cover.

Figure 3.3 shows the amount of sample-based forest loss and/or gain estimated per year from 2006 to 2015 where year 1 means forest change (loss/gain) estimated during 2005-2006 and so on. Most of the forest loss has been reported during 2005-2010 with a very insignificant amount of forest enhancement. The greatest amount of deforestation was recorded in year 3 (2007-2008) during the reference period, with 18,700 ha converted due to numerous incidence of severe forest fire. Compared with deforestation, gain in forest area was relatively scarce, as it was detected only in 3rd, 5th and 6th years of the reference period.

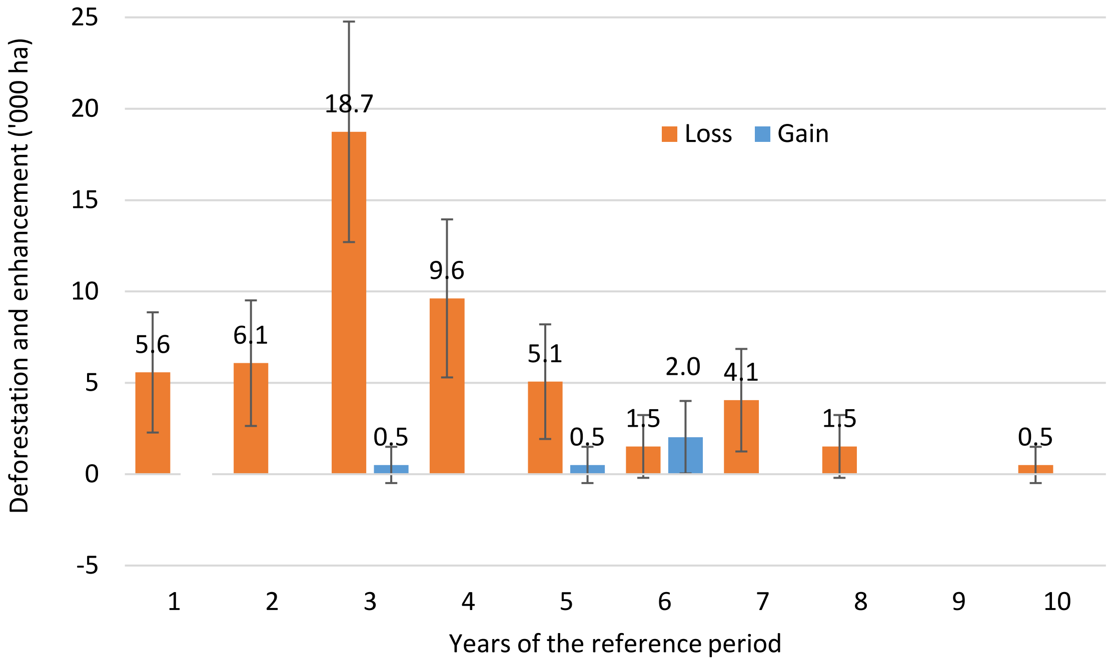


Figure 3.3. Annualized sample-based forest loss (deforestation) and forest gain (enhancement) estimates over the reference period: 2005-2015. The error-bar showing lower and upper limit of forest change estimates for corresponding year at 95 % confidence interval.

Over the period 2005-2015, forests have been converted to non-forest land at an average annual rate of 5,266 ha. Conversely, 304 ha of forest per year have been gained, based on the assessment of 123,457 samples during the reference period: 2005-2015. These figures are not consistent with the FRA report on forest change during 1990-2015 (FAO, 2015), which used forest cover data derived from the TFI. The TFI estimates forest cover over a 10 year period rather than an annualized forest data, through visiting the same area at 10-year intervals. In addition, the TFI estimates forest cover based on ocular methods and defines forest based on relative stem density at equal to or higher than 0.3. Therefore, the change estimates from TFI are less reliable compared with the CE sample-based assessment used for this FRL submission, which was also aligned with data from the 2014-2016 NFI and is therefore considered more accurate.

3.2. Emission and removal factors

Table 3-3 shows the biomass values for above-ground, below-ground and deadwood carbon pools estimated from the 4,080 NFI plots which were aligned with the CE study. Detailed deadwood biomass estimates for standing, below-ground and on-the-ground deadwood are provided in Appendix 8. The dry carbon content (tC per ha) of all four carbon pools are presented in Table 3-4. Boreal forests both intact and degraded classes contain 67.2 tC per ha and 62.8 tC per ha, respectively. The difference between the intact forest and degraded forest categories was because of the differences in AGB, BGB and DW pools.

Table 3-3. Biomass estimates (tons per ha) for above-ground, below-ground and deadwood carbon pools in the intact and degraded Boreal plots, respectively.

Variables	Observations	Mean	Std. Err.	[95% Confidence Interval] Lower-2.5%	Upper- 97.5%	CI range (%)
Degraded forest plots	Number	Biomass (t. ha^{-1})				
Above-ground	843	52.6	1.5	49.6	55.6	5.7
Below-ground	843	15.9	0.4	15.2	16.7	4.7
Deadwood	843	23.5	1.0	21.5	25.4	8.1
Intact forest plots						
Above-ground	3,237	67.7	0.8	66.1	69.3	2.4
Below-ground	3,237	19.6	0.2	19.3	20.0	1.9
Deadwood	3,237	13.3	0.4	12.6	14.0	5.5

Table 3-4. Estimation of organic carbon content (tC per ha) in four different carbon pools for intact and degraded Boreal forests plots, respectively.

Variables	Observations	Mean	Std. Err.	[95% Confidence Interval] Lower-2.5%	Upper- 97.5%	CI range (%)
Degraded forest plots	Number	Carbon (tC. ha^{-1})				
Above-ground	843	26.8	0.8	25.3	28.4	5.7
Below-ground	843	8.1	0.2	7.7	8.5	4.7
Deadwood	843	4.7	0.3	4.1	5.3	8.1
Litter	196	15.9	1.1	13.7	18.1	13.8
Total		62.8	1.0	60.9	64.8	3.1
Intact forest plots						
Above-ground	3,237	34.5	0.4	33.7	35.4	2.4
Below-ground	3,237	10.0	0.1	9.8	10.2	1.9
Deadwood	3,237	6.8	0.2	6.4	7.2	5.5
Litter	196	15.9	1.1	13.7	18.1	13.8
Total		67.2	1.1	66.1	68.3	1.6

Table 3-5 shows EFs from four change classes: from intact forest to degraded forest (4.4 tC per ha, ±25.0 % at 95 % CI), intact forest to non-forest (67.2 tC per ha, ±1.6 % at 95 % CI), non-forest to degraded forest -62.8 tC per ha, ±3.1 % at 95 % CI) and non-forest to intact forest (-67.2 tC per ha, ±1.6 % at 95 % CI). Although the EF from deforestation (intact forest > non-forest) is about eight times higher than that for degraded forest, a significantly larger area of intact forest (1.4 million ha) has been converted to degraded forest during the reference period than has been subject to deforestation. 63 % of the emissions are originated from degraded forest. Compared with degraded forest, deforestation resulted in approximately 37 % of annual CO_2 emissions from forests.

Table 3-5. REDD+ emission and removal factors (tC per ha) from four different conversions during the reference period 2005-2015 in Mongolia.

Year 2005	Year 2015	Mean	Std. Err.	95% Confidence Interval		
				Lower 2.5%	Upper 97.5%	CI range (%)
Boreal forest cover types				$tC.ha^{-1}$		
Intact forest	Non-forest	67.2	0.6	66.1	68.3	1.6
Intact forest	Degraded forest	4.4	0.6	3.3	5.5	25.0
Non-forest	Intact forest	-67.2	0.6	-68.3	-66.1	1.6
Non-forest	Degraded forest	-62.8	1.0	-64.8	-60.9	3.1

Note: (-) indicates removals and no sign indicates emissions.

3.3. Removals from annual forest growth

Total CO_2 removals from intact forest, forest degradation and carbon stock enhancement during the historical reference period from 2005 to 2015 are calculated as -301,246,610.0 tCO_2e, -25,101,861.1 tCO_2e and -7,384.5 tCO_2e, respectively. Figure 3.4 shows annual forest growth related removals from the three different activities.

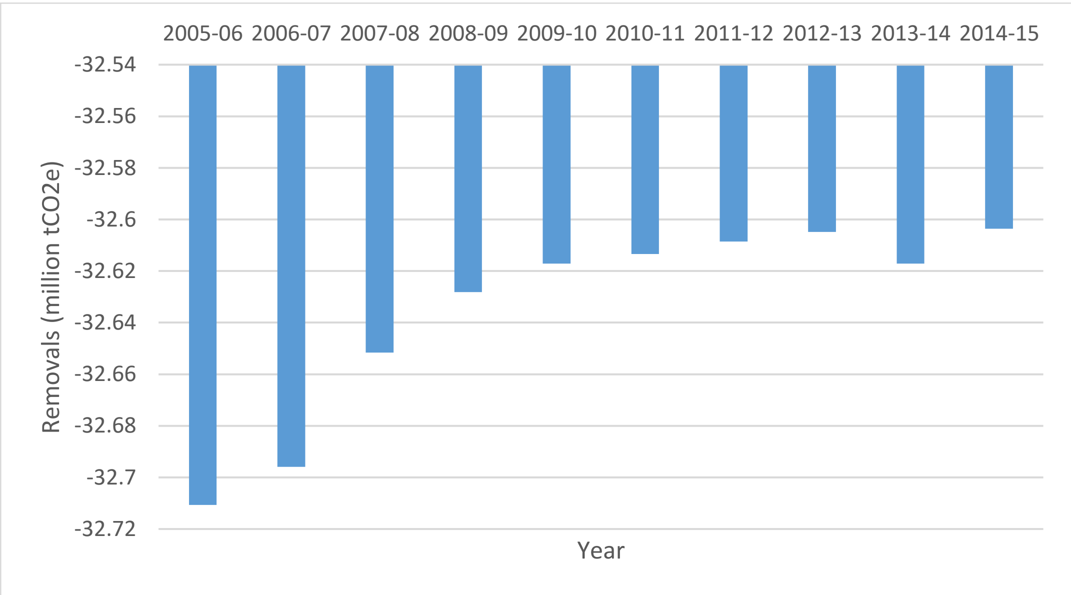


Figure 3.4. Mongolia's annual CO_2 removals from forest growth during the reference period 2005-2015.

3.4. The Forest Reference Level

Total CO_2 emissions from deforestation and forest degradation, and removals from carbon enhancement, from areas within forests during the historical reference period from 2005 to 2015 are presented in Table 3-6. During the reference period, CO_2 emissions and removals of the three REDD+ activities do not show any clear trend (see Figure 3.5). Mongolia's annual CO_2 emissions and removals from the forestry sector were estimated as 3,551,438.6 tCO_2e and -74,054.5 tCO_2e, respectively, during the reference period 2005-2015 (see Table 3-7).

Table 3-6. Carbon emissions and removals in Mongolia during the reference period: 2005-2015 from various change areas as a result of various drivers of change classes.

Reference period: 2005-2015	Area (ha)	Carbon emissions (tC.ha^{-1})	C emissions/ removals (tC)	CO_2e (tCO_2)	CO_2e ($tCO_2.yr^{-1}$)	U (%)
Change	AD	EF/RF	AD*EF	[AD*EF] * [44/12]		
Intact forest > Non-forest	52,659.7	67.2	3,539,859.6	12,979,485.3	1,297,948.5	19.3
Intact forest > Degraded forest	1,394,810.0	4.4	6,145,882.1	22,534,901.1	2,253,490.1	25.3
Non-forest > Intact forest	2,531.2	-67.2	-170,150.8	-623,886.4	-62,388.6	87.6
Non-forest > Degraded forest	506.5	-62.8	-31,815.9	-116,658.2	-11,665.8	195.9

Note: (-) indicates removals and no sign indicates emissions.

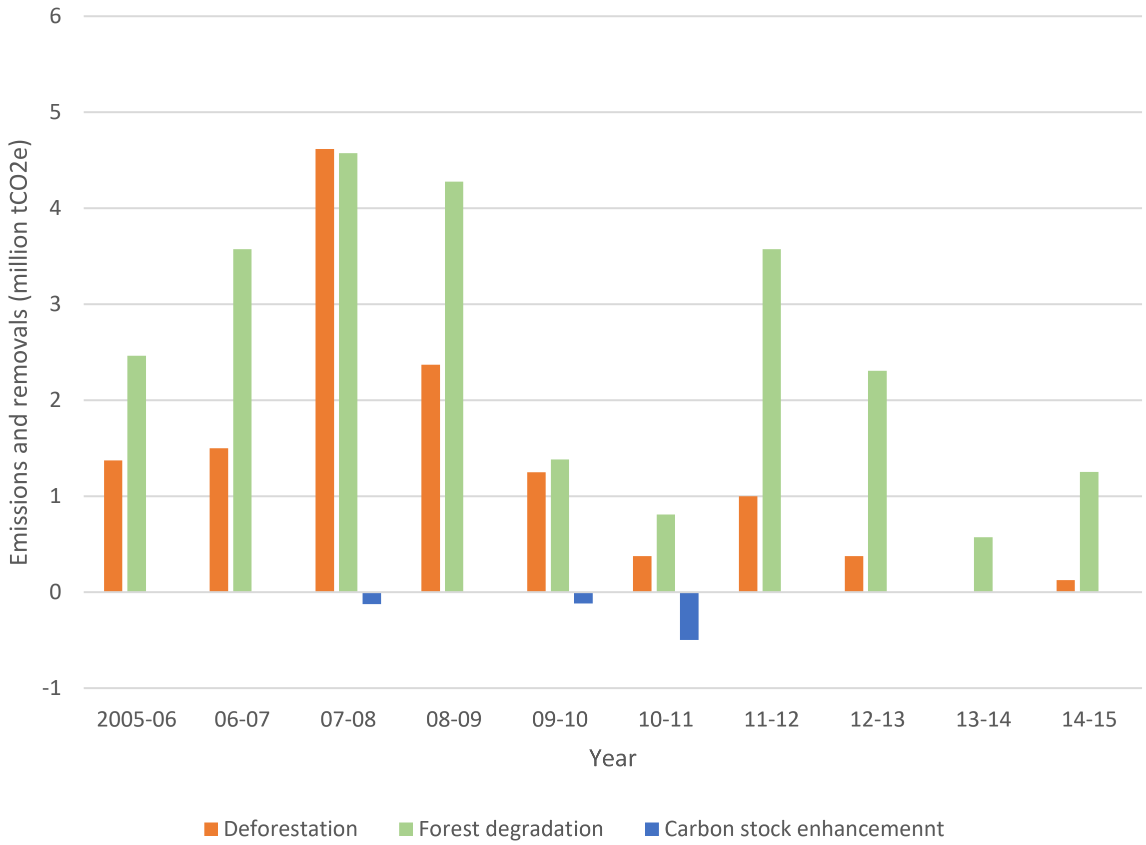


Figure 3.5. Mongolia's annual CO_2 emissions from deforestation and forest degradation and removals through afforestation activities during 2005-2015.

Therefore, the annual average emissions from deforestation and forest degradation are **3,477,384.2 tCO_2e,** without considering natural growth on forest land remaining forest land. And annual average removals from enhancement of forest carbon stocks are **-29,158,201.4 tCO_2e** when including natural growth on forest land remaining forest (see Figure 3.6).

However, since growth in stable forest land is not expected to be very different in the results reporting period (See Section 1.3.2 on Scope: activities, pools and gases) even though these concern very large removals, they are not expected to contribute to the results reporting and the figures without considering natural growth on forest land remaining forest land should be used for Mongolia's FRL.

Figure 3.6. Mongolia's annual CO_2 emissions from various change areas and removals through natural growth during 2005-2015.

Table 3-7. Combined uncertainty estimates for Activity data and Emission factors

Reference period: 2005-2015	Mean Annual CO_2e	95% Confidence Interval		
		Lower 2.5%	Upper 97.5%	CI range (%)
Change		($tCO_2.yr^{-1}$)		
Emissions Intact forest > Non-forest Intact forest > Degraded forest	3,551,438.6	2,928,271.0	4,174,606.2	17.5
Removals Non-forest > Intact forest Non-forest > Degraded forest	-74,054.5	-133,302.6	-14,806.3	80.0
Net emissions	3,477,384.2	2,851,406.4	4,103,362.0	18.0

3.5. Uncertainty analysis for activity data and emission factors

A total of 123,577 sample plots were used to assess Mongolia's land use and land use changes. Among the total number of sample plots, 105 plots were not used for uncertainty assessment due to no data. Accuracy assessment of different operators was done using a 10 % random sample of the total sample plots. Samples were randomly selected and independently re-assessed by the most experienced operators among the team (CCPIU, 2018). Results show a 93 % consistency between the operators and the independent re-assessors of the six IPCC land use categories. A field quality control measurement was undertaken in different types of land use and disturbance factors. Results show that 11 % of differences occurred in forest land when counting tree elements.

In terms of activity data and emissions factors, the sampling error and associated uncertainties were estimated by using systematic random sample design estimators. The uncertainty of each IPCC land use category was assessed. Uncertainty analysis in various conversions among the forest, degraded forest and non-forest classes occurred during the reference period were conducted and the results were reported in the previous sections.

Uncertainties for removals due to non-forest to forest conversion were very high due to the few numbers of non-forest to forest conversion occurrences, Appendix 5, compared to total number of observations, 123,472. During the reference period an area of 2,531.2 ha was converted from from non-forest with an assessed uncertainty of 87.6 %, and an area of 506.5 ha was converted from non-forest to degraded forest with a 195.9 % uncertainty (Table 3-6). Net emission calculations resulted in a 18 % uncertainty (see Table 3-7) when combining AD and EFs.

Mongolia used single growth increment default value (1 tonnes d.m. ha^{-1} yr^{-1} for aboveground net biomass) for the reference period without differentiating forests by degradation status, change type, and age categories. Therefore, Mongolia did not considered growth associated uncertainty into combined uncertainty analysis.

4. NATIONAL CIRCUMSTANCES

National circumstances in Mongolia are different from most other REDD+ countries as the major drivers of deforestation and degradation are a complex mixture of anthropogenic and natural impacts, compounded by poor forest management which has increased the forests' vulnerability. These drivers can aggravate forest vulnerability when combined with ongoing climate change, which is already 3 times more serious than the global average, in terms of mean temperature change (Chapter 6.6 Environmental Factors of UN-REDD, 2016b; Chapter 1.2 Natural Resources of MET, 2017b). Impacts include increased severity of winters, prolonged dry season, modified rainfall pattern, glacier and permafrost thawing, which may in turn lead to changes in vegetative growth pattern and forest health. It is therefore important for the establishment of the FRL, and for the medium-term prediction of GHG emissions over the next 20-30 years, to extrapolate what the effect of these already expected changes will be on predictions of land cover change. Although this first FRL submission does not suggest an adjustment to take these national circumstances into account, the extent to which future emissions can effectively be reduced through climate change related policies and measures should be investigated in the next cycle of FRL submission.

Mongolia has already developed and adopted several policies which are supportive of the REDD+ strategic objectives. These include the Green Development Policy (2014), State Policy on Forests (2015), National Biodiversity Program 2015-2025 (2015), Sustainable Development Vision (2016) and National Action Plan for the State Forest Policy (2017). These provide a supportive framework for the policies and measures which will be proposed within Mongolia's REDD+ strategy, conservation and sustainable forest management entrenched within these laws, and other regulations.

One of the strategies for increasing resilience of the boreal forests is to implement more effective sustainable forest management (SFM), particularly through improved thinning and harvesting regimes. These can ensure forests are healthier, through reduction of competition for light, water and resources, and as such generate more resilience to pest infestation and less deadwood matter which can fuel fires.

In terms of monitoring of the results, Mongolia considers SFM and conservation of forest implementation activities that result in reduced emissions from deforestation and degradation and the enhancement of forest carbon stocks. Therefore, even we may define them they are not separately measured to prevent over-complications of the FRL.

Sustainable Forest Management as part of a REDD+ strategy can also contribute to substantial socio-economic development and poverty alleviation benefits for local communities, private sector and enterprises. Community-based forest resource management covers 3.1 million hectares of boreal forests, about 20% of the forest area, these should be managed effectively and livelihood opportunities enhanced to ensure resilience is developed in forest edge dependent communities. Carbon stock enhancement strategies in Mongolia need to consider changes in climate and ecological conditions, and depend on maintaining genetic diversity, improved planting strategies and participatory land use management to eliminate grazing pressure.

The forests on peatlands are often degrading first: given their location in valleys, they are most easily cut and grazed compared to forests in highlands. Peatland degradation in Mongolia is followed by the thawing of the permafrost layer – the largest storage of fresh water in Mongolia. When peatlands degrade after their hydrology is altered, they lose their capacity to retain water and provide ecosystem services, such as carbon storage. Peatland degradation causes a reduction of habitats and losses in biodiversity. Peatlands are also called organic soils, and extremely rich in carbon content. Degraded, oxidizing peatlands therefore are significant sources of greenhouse gases.

5. FUTURE IMPROVEMENT

5.1. Improvement in quality of the Saxaul NFI

Saxaul Forest data inclusion in the modification process of FRL or the next submission is now being considered. The following actions are proposed to construct emission factors and estimate emissions and removals from Saxaul forest areas by setting Permanent Sampling Plots and configuring Saxaul population area:

1. Identify CE samples with saxaul forest
2. Check the distribution of the CE samples with saxaul forest in the digital elevation model
3. Check with ecoregions and soil type maps/information
4. Review various published studies/reports on saxaul forest to understand the ecology of this forest types
5. Develop methods for mapping, EF and monitoring saxaul forest.

5.2. Diversifying carbon pools

Mongolia collected soil and litter samples which represent degraded and low stocked forests during the additional NFI in 2017 (MET, In Prep). Therefore, soil and litter layer carbon contents will be analyzed for the additional samples and modified calculations will be complete for these two carbon pools.

The availability of spatial information on peatlands in Mongolia is a clear gap, which should be filled together with the introduction of spatial information, including soil sampling based on land management systems at the aimag and suom levels. Recognizing the urgent need to address the issue of peatland degradation and loss , and build capacity for peatland management in a systematic way, Mongolia will include emissions or removals from SOC especially in peatland areas as one of the areas for future improvement.

5.3. Uncertainty analysis

A comprehensive uncertainty analysis using Monte Carlo approach is expected in the future FRL submissions.

5.4. Fraction of biomass loss from disturbance

The proportion of biomass loss from each disturbance event can be defined to reflect level of decaying or oxidization in trees.

5.5. Inclusion of non-CO_2 GHGs

Initial studies have been carried out on the relative importance of non-CO_2 GHGs, including CH_4 from the impact of deforestation and degraded forest on the permafrost layer, and NO_2 from degraded forest caused by forest fire. These studies indicate that further work is required to develop data with a view to including these two gases in future FRL submissions.

6. REFERENCES

Adia B., Sanchez-Paus Diaz A., Pekkarinen A., Patriarca C., Maniatis D., Weil D., Mollicone D., Marchi G., Niskala J., Rezende M., and Ricci S. (2015). *Collect Earth User Manual: A guide to monitoring land use change and deforestation with free and open-source software.* Rome, Italy: Open Foris Initiative, Food and Agriculture Organization of the United Nations.

ALAMGC (2009). *Rules for conducting registration for integrated land fund.* Ulaanbaatar, Mongolia: Administration of Land Affairs, Geodesy and Cartography.

ALAGAC (2016). Integrated land fund annual report. Ulaanbaatar, Mongolia

Ariunzul Y., Batchuluun T., Undram G., Bayanmunkh N., Batchimeg B., Gunjargal B., and Erdenechimeg E. (2017). *Mongolian forest cover change*. Ulaanbaatar, Mongolia :Environmental Research Information and Study Center, Division of the Information and Research Institute of Meteorology, Hydrology and Environment.

Baatarbileg *et. al*., (2015). *National multipurpose forest resources control inventory.* Ulaanbaatar, Mongolia: National University of Mongolia

Baatarbileg N., Byambagerel S., Gerelbaatar S., Narmandakh G. and Bayarbaatar S. (2016). *Carbon stocks of litter, and soil in the forest areas of Mongolia: Preliminary results of Multipurpose National Forest Inventory in 2015.* Ulaanbaatar, Mongolia National University of Mongolia

Bat-Ulzii Ch., (2017). *Methodology for selection of additional NFI plots in degraded forest. Ulaanbaatar.* Ulaanbaatar, Mongolia : UN-REDD Mongolia National Programme

Breiman L., (2001). *Random Forests*. Machine Learning: 5-32.

CCPIU, (2018). *Forestry land use, land use change assessment report 1986-2016.* Ulaanbaatar, Mongolia : Climate Change Project Implementing Unit under Environment and Climate Fund of the Ministry of Environment and Tourism.

Craft, C. B., Seneca, E. D., & Broome, S. W. (1991). Loss on ignition and Kjeldahl digestion for estimating organic carbon and total nitrogen in estuarine marsh soils: calibration with dry combustion. *Estuaries*, *14*(2), 175–179.

Crump, J. (Ed.) 2017. Smoke on Water – Countering Global Threats from Peatland Loss and Degradation. A UNEP Rapid Response Assessment. United Nations Environment Programme and GRID-Arendal, Nairobi and Arendal.

Dorjsuren C., Dugarjav C., Tsogt Z., Tsedendash G., and Chuluunbaatar T. (2012). *Forest Mensuration Handbook of Mongolia.* Ulaanbaatar, Mongolia. Bembi San Printing. 262pp.

Dorjsuren Ch. (2014). "Forest Ecosystems." In Mongolia Second Assessment Report on Climate Change 2014, eds. Damdin Dagvadorj, Zamba Batjargal, and Luvsan Natsagdorj. Ulaanbaatar, Mongolia: Ministry of Environment and Green Development (MEGD), 94–99.

Dorjsuren, C. (2017). *Estimation of aboveground biomass and carbon stock in Mongolian Boreal forest*. Ulanbantaar, Mongolia: GIZ.

Dulamsuren, C., Klinge, D., Degener, J., Khishigjargal, M., Chenlemuge, T., Bat-Enerel, B., Yeruult, Y., Saindovdon, D., Ganbaatar, K., Tsogbaatar, J., Leuschner, C., Hauck, M., (2016) *Carbon pool densities and a first estimate of the total carbon pool in the Mongolian forest steppe*. Global Change Biology 22(2): 830-44

Enkhsaikhan, D. (2017). *Mongolian trees and shrubs*. Ulaanbaatar, p234.

Environmental Research Information and Study Center (2017). *Mongolian forest cover change*. Ulaanbaatar, Mongolia: Environmental Research Information and Study Center

ERISC (2017). *Mongolian forest cover change.* Ulaanbaatar, Mongolia.

FAO (2012). *Forest Resource Assessment 2015 - Terms and Definitions.* Rome, Italy: Food and Agriculture Organization of the United Nations

FAO (2014). *Forest Resource Assessment 2015 – Country Report, Mongolia*. Rome, Italy: Food and Agriculture Organization of the United Nations.

Forest Agency (2009). *Guideline to implement forest inventory.* Ulaanbaar, Mongolia: Forest Department of Government Agency of Mongolia.

Forest Agency (2012). *Handbook for forest specialists.* Ulaanbaar, Mongolia: Forest Department of Government Agency of Mongolia. 109-150p.

FRDC (2016). *Forest Resource of Mongolia – 2015.* Ulaanbaatar, Mongolia: Forest Research and Development Center State Owned Enterprise, Ministry of Environment and Tourism

FRDC (2017). *Forest Resource of Mongolia – 2016*. Ulaanbaatar, Mongolia: Forest Research and Development Center State Owned Enterprise, Ministry of Environment and Tourism

GFOI (2016). *Integration of remote-sensing and ground-based observations for estimation of emissions and removals of greenhouse gases*. In forests: Methods and Guidance from the Global Forest Observations Initiative, Edition 2.0. Rome, Italy: Food and Agriculture Organization.

GIZ, (2017). *Training on National counterpart in the validation and improvement of forest mask 2013.* Ulaanbaatar, Mongolia: GIZ Report.

Global Forest Watch, (2014). World Resources Institute. Accessed on 1.Dec.2017. www.globalforestwatch.org.

GOFC GOLD (2015). A sourcebook book of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals associated with deforestation, gains and losses of carbon stocks in forests remaining forests, and deforestation. GOFC-GOLD Report version COP22-1, GOFC-GOLD Land Cover Project Office, Wageningen University, The Netherlands.

Guo Zhang and Xi Li., (2014). A spectral index for highlighting forest cover from remotely sensed imagery. *Land Surface Remote Sensing II*, 92601L, Beijing, China, Vol:9260

IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

Jalbaa K., Enkhsaikhan D. (1991). *Saxaul (In Mongolian)*. Ulaanbaatar, Mongolia.

Joosten H. (2010). The Global Peatland CO2 Picture: Peatland status and drainage related emissions in all countries of the world. Wetlands International report

Ludwig R. (2014). *Multipurpose Forest Resources Inventory of Mongolia: Database Set-up and Quality Assurance Possibilities*. Ulaanbaatar, Mongolia: GIZ Report

MET (2015) *Report on the Environmental State of Mongolia 2013-2014.* Ulaanbaatar, Mongolia: Ministry of Environment, Green Development and Tourism.

MET (2016). *Mongolian Multipurpose National Forest Inventory 2014-2016 1st Ed.,* Ulaanbaatar, Mongolia: Ministry of Environment and Tourism.

MET (2017a). *Mongolia's Initial Biennial update report under the United Nations Framework Convention on Climate Change*. Ulaanbaatar, Mongolia: Ministry of Environment and Tourism.

MET (2017b). *Mongolia's Third National Communication under the United Nations Framework Convention on Climate Change.* Ulaanbaatar, Mongolia: Ministry of Environment and Tourism.

MET (2017c). *Mongolian Multipurpose national Forest Inventory 2014-2016 1st Ed.,* Ulaanbaatar, Mongolia: Ministry of Environment and Tourism.

MET (In Prep.) *Mongolian Multipurpose national Forest Inventory 2014-2018 2nd Ed.* Ulaanbaatar, Mongolia: Ministry of Environment and Tourism.

Minayeva, T., Gunin', P., Sirin, A., Dugardzhav, C. & Bazha, S. 2004. Peatlands in Mongolia: The typical and disappearing landscape. Peatlands International, 2004-2: 44-47.

Mongolian Law on Forest (2015). Ulaanbaatar, Mongolia

Mongolian Law on Land (2002). Ulaanbaatar, Mongolia

Nyamjav, B, J G Goldammer, and H. Uibrig. (2007). *The Forest Fire Situation in Mongolia.* International Forest Fire News (IFFN) 36: 46–66.

Schumacher F.X. and Hall F.S., (1993). Logarithmic expression of timber tree volume. *J. Agric. Res.* vol. 47 (pg. 719-734).

Semechkin I.V., Tetenkin A.E., (1980). Northern Mongolian forest structure characteristics. Forest of People Republic of Mongolia (Industrial use only). Bulletin V 12, Science, Moscov, p66-116. (in Russian)

Takahashi, M., Ishizuka, S., Ugawa, S., Sakai, Y., Sakai, H., Ono, K., … Morisada, K. (2010). Carbon stock in litter, deadwood and soil in Japan's forest sector and its comparison with carbon stock in agricultural soils. *Soil Science & Plant Nutrition*, *56*(1), 19–30.

Tsogtbaatar, J., (2012). Deforestation and Reforestation of Degraded Forestland in Mongolia. In: Yamamura N., Fujita N., Maekawa A. (eds) The Mongolian Ecosystem Network. Ecological Research Monographs. Springer, Tokyo

UN-REDD, (2016a). *Technical Working Group meeting report on reviewing Forest Reference Level decisions.* Ulaanbaatar, Mongolia: UN-REDD Mongolia National Programme, Ministry of Environment and Toruism.

UN-REDD, (2016b). *Preliminary Assessment of the Drivers of Forest Change in Mongolia.* Ulaanbaatar, Mongolia: UN-REDD Mongolia National Programme, Ministry of Environment and Toruism.

UN-REDD, (2017). *Meeting minutes for TWG meeting to review Forest Reference Level Calculations*. Ulaanbaatar, Mongolia: UN-REDD Mongolia National Programme, Ministry of Environment and Tourism.

UN-REDD, (2017). *Technical assessment of the National Forest Inventory*. Ulaanbaatar, Mongolia: UN-REDD Mongolia National Programme, Ministry of Environment and Tourism.

Vries P.G., (1986). Sampling Theory for Forest Inventory. Springer-Verlag Berlin Heidelberg. doi: 10.1007/978-3-642-71581-5

Xu J., Morris P.J., Liu J., Holden J., (2018) PEATMAP: Refining estimates of global peatland distribution based on a meta-analysis. *CATENA 160*: 134-140. doi.org/10.1016/j.catena.2017.09.010

APPENDIXES

Appendix 1

Structure of change sample assessment matrix for Forest/Non-forest cover classes

		Time 2						Total
	IPCC land cover types	Cropland	Forest	Grassland	Other land	Settlements	Wetland	
Time 1	Cropland	p_{11}	p_{12}	p_{13}	p_{14}	p_{15}	p_{16}	$p_{1.}$
	Forest	p_{21}	p_{22}	p_{23}	p_{24}	p_{25}	p_{26}	$p_{2.}$
	Grassland	p_{31}	p_{32}	p_{33}	p_{34}	p_{35}	p_{36}	$p_{3.}$
	Other land	p_{41}	p_{42}	p_{43}	p_{44}	p_{45}	p_{46}	$p_{1.}$
	Settlements	p_{51}	p_{52}	p_{53}	p_{54}	p_{55}	p_{56}	$p_{2.}$
	Wetland	p_{61}	p_{62}	p_{63}	p_{64}	p_{65}	p_{66}	$p_{3.}$
	Total	$p_{.1}$	$p_{.2}$	$p_{.3}$	$p_{.4}$	$p_{.5}$	$p_{.6}$	123,577

Structure of change sample assessment matrix for Forest/Non-forest cover classes

Period: Time1 to Time 2	Types of land cover	Time 2		Total
		Forest	Non-forest	
Time 1	Forest	Stable forest (p_{11})	Loss (p_{12})	($p_{1.}$)
	Non-forest	Gain (p_{21})	Stable non-forest (p_{22})	($p_{2.}$)
Total		($p_{.1}$)	($p_{.2}$)	123,577

Appendix 2

Estimating the population mean

The population means (μ) is estimated with $\hat{\mu} = \frac{\sum_{i=1}^{n} y_i}{n}$

Where y_i is the value for each unit in the sample and n is the number of units in the sample.
The population variance σ^2 is estimated with the sample variance s^2 which has an unbiased estimator:

$$s^2 = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}$$

Variance of the estimate $\hat{\mu}$ is: $v\hat{a}r(\hat{\mu}) = (\frac{N-n}{N})\frac{s^2}{n}$

The standard error of the estimate is the square root of variance of the estimate, which as always is t he standard deviation of the sampling distribution of the estimate. Standard error is a useful gauge of how precisely a parameter has been estimated for a population size N.

Standard error of $\hat{\mu}$ is $SE(\hat{\mu}) = \sqrt{(\frac{N-n}{N})\frac{s^2}{n}}$

Estimating the population total

The population total τ is estimated with $\hat{\tau} = N\hat{\mu} = \frac{N}{n}\sum_{i=1}^{n} y_i$

Variance of the estimate $\hat{\tau}$ is: $(\hat{\tau}) = N^2\, v\hat{a}r(\hat{\mu}) = N^2\,(\frac{N-n}{N})(\frac{s^2}{n})$

Standard error of $\hat{\tau}$ is: $v\hat{a}r(\hat{\tau}) = \sqrt{N^2\,(\frac{N-n}{N})(\frac{s^2}{n})}$

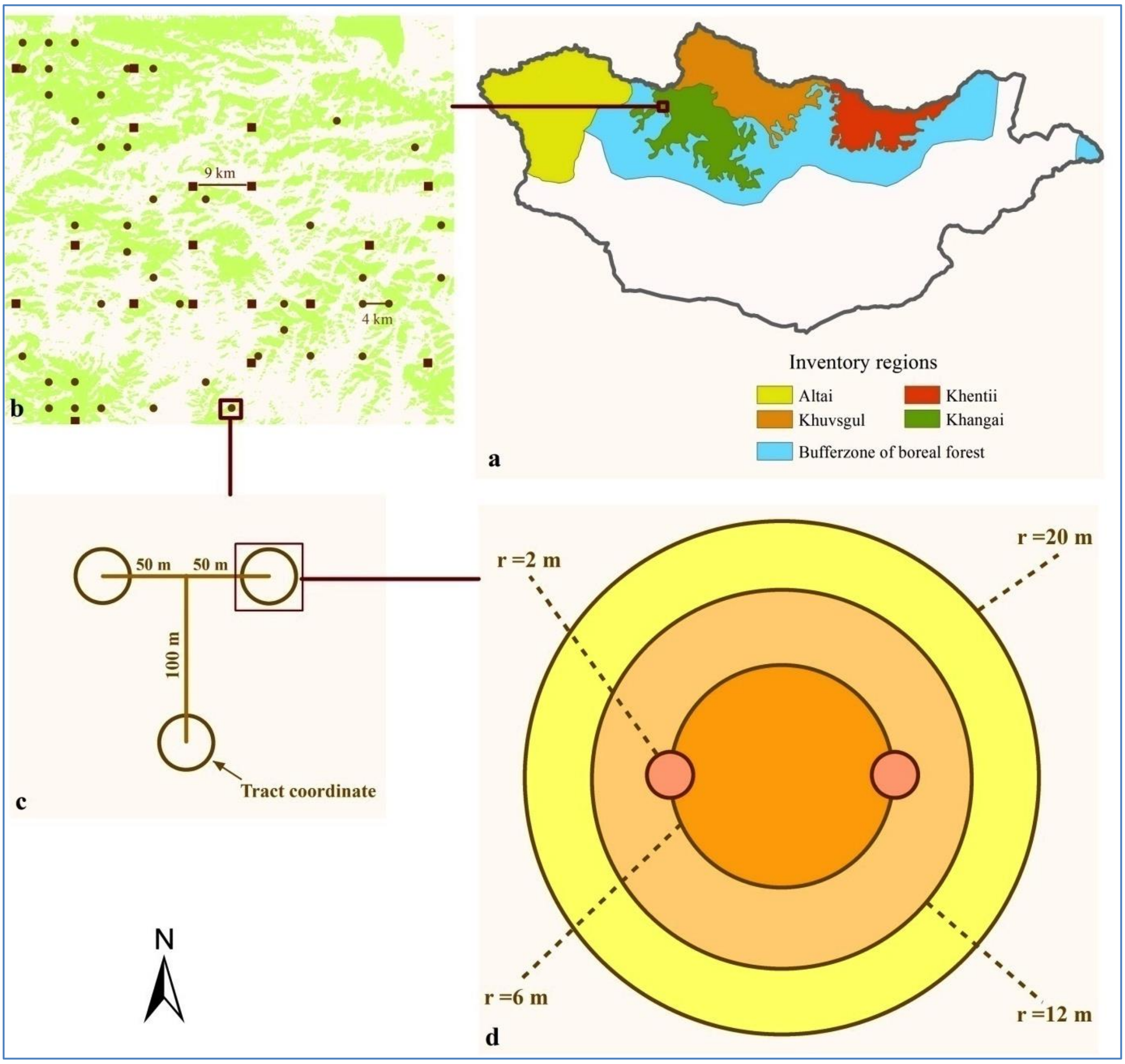
Confidence limits:

$$\hat{\mu} \pm SE(\hat{\mu}).t_{df,\ \alpha/2}$$

Appendix 3

Sampling unit design

Each sampling unit is a cluster of 3 sample plots, in order to cover the variety in the forest characteristics in the tract (forest site). The centres of sample plots are distanced 100-112 m each other in a triangle (see c). The layout of the sampling unit is presented in the following figure.



Layout of sampling unit. a) NFI inventory regions over the Mongolian boreal forest. b) Spacing of sampling units in forest area. c) Sampling unit - cluster of sample plots. d) Sample plot design – nested circular plots

Appendix 4

Annualized forest cover change matrices during the reference period 2005-2015

Annual forest change area (ha) matrix during 2005-2006.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2006
Degraded forest	110,867.7					110,867.7
Intact forest	150,863.2	13,193,914.2	5,569.2			13,350,346.7
Non-forest			140,033,384.5			140,033,384.5
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2005	**261,730.9**	**13,193,914.2**	**140,038,953.7**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2006-2007.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2007
Degraded forest	261,730.9					261,730.9
Intact forest	217,713.9	12,970,124.1	6,076.2			13,193,914.2
Non-forest			140,038,953.7			140,038,953.7
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2006	**479,444.8**	**12,970,124.1**	**140,045,029.9**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2007-2008.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2008
Degraded forest	479,444.8					479,444.8
Intact forest	262,288.6	12,689,099.8	18,735.7			12,970,124.1
Non-forest	506.5		140,044,523.4			140,045,029.9
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2007	**742,239.9**	**12,689,099.8**	**140,063,259.1**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2008-2009.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2009
Degraded forest	742,239.9					742,239.9
Intact forest	243,531.3	12,435,948.2	9,620.3			12,689,099.8
Non-forest			140,063,259.1			140,063,259.1
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2008	**985,771.1**	**12,435,948.2**	**140,072,879.4**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2009-2010.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2010
Degraded forest	985,771.1					985,771.1
Intact forest	72,394.9	12,358,490.2	5,063.1			12,435,948.2
Non-forest		506.2	140,072,373.3			140,072,879.4
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2009	**1,058,166.0**	**12,358,996.3**	**140,077,436.4**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2010-2011.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2011
Degraded forest	1,058,166.0					1,058,166.0
Intact forest	41,006.0	12,316,471.3	1,519.0			12,358,996.3
Non-forest		2,025.0	140,075,411.4			140,077,436.4
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2010	**1,099,172.0**	**12,318,496.3**	**140,076,930.4**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2011-2012.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2012
Degraded forest	1,099,172.0					1,099,172.0
Intact forest	209,063.3	12,105,382.9	4,050.1			12,318,496.3
Non-forest			140,076,930.4			140,076,930.4
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2011	**1,308,235.4**	**12,105,382.9**	**140,080,980.4**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2012-2013.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2013
Degraded forest	1,308,235.4					1,308,235.4
Intact forest	119,984.9	11,983,878.4	1,519.7			12,105,382.9
Non-forest			140,080,980.4			140,080,980.4
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2012	**1,428,220.3**	**11,983,878.4**	**140,082,500.1**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2013-2014.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2014
Degraded forest	1,428,220.3					1,428,220.3
Intact forest	28,856.9	11,960,085.2				11,988,942.1
Non-forest			140,077,436.4			140,077,436.4
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2013	**1,457,077.1**	**11,960,085.2**	**140,077,436.4**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Annual forest change area (ha) matrix during 2014-2015.

Types of land cover	Degraded forest	Intact forest	Non-forest	Saxaul forest	Shrub	Grand Total in 2015
Degraded forest	1,457,077.1					1,457,077.1
Intact forest	49,106.5	11,905,408.5	506.5			11,955,021.5
Non-forest			140,082,500.1			140,082,500.1
Saxaul forest				2,048,003.0		2,048,003.0
Shrub					766,739.7	766,739.7
Grand Total in 2014	**1,506,183.7**	**11,905,408.5**	**140,083,006.6**	**2,048,003.0**	**766,739.7**	**156,309,341.4**

Appendix 5

Sample-based IPCC land cover change matrices in three different temporal estimates: 2005, 2010 and 2015 in Mongolia.

	IPCC land cover types	Year 2010 Cropland	Forest	Grassland	Other land	Settlements	Wetland	Total
Year 2005	Cropland	2,254	0	16	0	0	0	2,270
	Forest	0	26,146	87	0	2	0	26,235
	Grassland	14	2	88,102	0	29	3	88,150
	Other land	0	0	0	3,730	0	0	3,730
	Settlements	0	0	1	0	1,099	0	1,100
	Wetland	0	0	0	0	0	1,987	1,987
Total		2,268	26,148	88,206	3,730	1,130	1,990	**123,472**

	IPCC land cover types	Year 2015 Cropland	Forest	Grassland	Other land	Settlements	Wetland	Total
Year 2010	Cropland	2,262	0	5	0	1	0	2,268
	Forest	0	26,133	15	0	0	0	26,148
	Grassland	17	4	88,154	0	30	1	88,206
	Other land	0	0	0	3,730	0	0	3,730
	Settlements	0	0	0	0	1,130	0	1,130
	Wetland	0	0	1	0	0	1,989	1,990
Total		2,279	26,137	88,175	3,730	1,161	1,990	**123,472**

	IPCC land cover types	Year 2015 Cropland	Forest	Grassland	Other land	Settlements	Wetland	Total
Year 2005	Cropland	2,248	0	21	0	1	0	2,270
	Forest	0	26,131	102	0	2	0	26,235
	Grassland	31	6	88,050	0	59	4	88,150
	Other land	0	0	0	3,730	0	0	3,730
	Settlements	0	0	1	0	1,099	0	1,100
	Wetland	0	0	1	0	0	1,986	1,987
Total		2,279	26,137	87,421	3,730	1,161	1,990	**123,472**

Appendix 6

Land cover changes during the reference period 2005-2015

Land cover change: 2005-2010	Total area	Standard error (SE)	Confidence Interval	
			Lower- 2.5%	Upper- 97.5%
Stable classes	Hectare (ha)	Hectare (ha)	Hectare (ha)	Hectare (ha)
Stable cropland	1,376,623.0	50,867.4	1,276,925.0	1,476,321.0
Stable forest	15,468,200.0	154,935.6	15,164,530.0	15,771,870.0
Stable grassland	124,297,000.0	764,408.4	122,798,800.0	125,795,200.0
Stable settlements	1,333,192.0	83,454.5	1,169,624.0	1,496,760.0
Stable other land	12,187,410.0	297,604.5	11,604,120.0	12,770,700.0
Stable wetland	1,546,122.0	71,710.9	1,405,571.0	1,686,673.0
Change classes				
Forest to Non-forest (Forest Loss)	45,064.6	4,773.3	35,709.1	54,420.1
Forest > Grassland	*44,052.1*	*4,719.4*	*34,802.2*	*53,302.0*
Forest > Settlement	*1,012.5*	*715.7*	*-390.2*	*2,415.2*
Non-forest to Forest (Forest Gain)	1,012.6	715.8	-390.2	2,415.5
Grassland > Forest	1,012.6	715.8	-390.2	2,415.5
Grassland > Cropland	7,087.9	1,893.5	3,376.7	10,799.0
Cropland > Grassland	15,704.2	8,340.5	-642.8	32,051.2
Grassland > Settlements	29,907.3	11,775.3	6,828.1	52,986.4
Grassland > Wetland	1,518.5	876.3	-199.1	3,236.1
Settlement > Grassland	506.3	506.1	-485.6	1,498.1

Land cover change: 2010-2015	Total area	Standard error (SE)	Confidence Interval	
			Lower-2.5%	Upper-97.5%
Stable classes	Hectare (ha)	Hectare (ha)	Hectare (ha)	Hectare (ha)
Stable cropland	1,380,673.0	50,887.0	1,280,937.0	1,480,410.0
Stable forest	15,461,620.0	154,930.2	15,157,960.0	15,765,280.0
Stable grassland	124,323,300.0	764,382.3	122,825,100.0	125,821,500.0
Stable settlements	1,364,112.0	84,280.2	1,198,926.0	1,529,298.0
Stable other land	12,187,410.0	297,604.5	11,604,120.0	12,770,700.0
Stable wetland	1,539,520.0	71,256.6	1,399,860.0	1,679,181.0
Change classes				
Forest to Non-forest (Forest Loss)	7,595.1	1,960.2	3,753.2	11,437.0
Forest > Grassland	7,595.1	1,960.2	3,753.2	11,437.0
Non-forest to Forest (Forest Gain)	2,025.0	1,012.1	41.3	4,008.7
Grassland > Forest	2,025.0	1,012.1	41.3	4,008.7
Grassland > Cropland	8,609.2	2,087.1	4,518.6	12,699.8
Cropland > Grassland	2,531.4	1,131.6	313.5	4,749.3
Grassland > Settlements	22,809.5	8,570.2	6,012.2	39,606.9
Grassland > Wetland	506.2	506.0	-485.5	1,497.8
Cropland > Settlements	506.2	506.0	-485.5	1,497.8
Wetland > Grassland	8,119.8	8,116.7	-7,788.6	24,028.3

Land cover change: 2005-2015	Total area	Standard error (SE)	Confidence Interval	
			Lower- 2.5%	Upper- 97.5%
Stable classes		Hectare (ha)		
Stable cropland	1,373,586.0	50,853.0	1,273,916.0	1,473,255.0
Stable forest	15,460,610.0	154,929.3	15,156,950.0	15,764,260.0
Stable grassland	124,263,000.0	764,401.3	122,764,800.0	125,761,200.0
Stable settlements	1,333,192.0	83,454.5	1,169,624.0	1,496,760.0
Stable other land	12,187,410.0	297,604.5	11,604,120.0	12,770,700.0
Stable wetland	1,538,002.0	71,251.5	1,398,352.0	1,677,652.0
Change classes				
Forest to Non-forest (Forest Loss)	52,659.7	5,159.6	42,547.2	62,772.3
Forest > Grassland	51,647.2	5,109.8	41,632.3	61,662.2
Forest > Settlements	1,012.5	715.7	-390.2	2,415.2
Non-forest to Forest (Forest Gain)	3,037.6	1,239.6	608.1	5,467.2
Grassland > Forest	3,037.6	1,239.6	608.1	5,467.2
Grassland > Cropland	15,697.0	2,817.8	10,174.2	21,219.9
Settlements > Grassland	506.3	506.1	-485.6	1,498.1
Cropland > Grassland	18,235.5	8,416.8	1,738.8	34,732.2
Grassland > Settlements	52,716.8	14,563.3	24,173.1	81,260.4
Grassland > Wetland	2,024.6	1,011.9	41.3	4,007.9
Cropland > Settlements	506.2	506.0	-485.5	1,497.8
Wetland > Grassland	8,119.8	8,116.6	-7,788.5	24,028.1

Appendix 7

Forest and non-forest change matrices during 2005-2010, 2010-2015, and 2005-2015, respectively.

2005-2010	Types of land cover	Year 2010		Total
		Forest	Non-forest	
Year 2005	Forest	26,876	89	25,965
	Non-forest	2	99,505	97,507
Total		26,878	97,594	123,472

2010-2015	Types of land cover	Year 2015		Total
		Forest	Non-forest	
Year 2010	Forest	25,863	15	25,878
	Non-forest	4	97,590	97,594
Total		25,867	97,605	123,472

2005-2015	Types of land cover	Year 2015		Total
		Forest	Non-forest	
Year 2005	Forest	25,861	104	25,965
	Non-forest	6	97,501	97,507
Total		25,867	96,605	123,472

Appendix 8

Deadwood biomass estimates (tons per ha) for standing, below-ground and on-the-ground deadwoods in the intact and degraded Boreal plots, respectively.

Variables	Observations	Mean	Std. Err.	[95% Confidence Interval]		CI range (%)
				Lower-2.5%	Upper- 97.5%	
Degraded forest plots	Number	Biomass (t. ha^{-1})				
Standing deadwood	843	10.4	0.5	9.4	11.4	9.7
Below-ground deadwood	843	3.8	0.2	3.4	4.2	10.2
On-the-ground deadwood	843	9.2	0.6	8.1	10.4	12.2
Total deadwood	843	23.5	1.0	21.5	25.4	8.1
Intact forest plots						
Standing deadwood	3237	5.6	0.2	5.3	5.9	8.1
Below-ground deadwood	3237	1.8	0.1	1.7	2.0	8.1
On-the-ground deadwood	3237	5.9	0.3	5.3	6.4	8.1
Total deadwood	3237	13.3	0.4	12.6	14.0	5.5

Appendix 9

Estimate of forest and non-forest cover types during the reference period 2005-2015.

Estimate of forest and Non-forest cover types in the year 2005

Land cover	Total area (ha)	Standard error (SE)	Confidence Interval	
			Lower- 2.5%	Upper- 97.5%
Degraded forest	110,867.7	7,482.2	96,203.0	125,532.4
Intact forest	13,350,346.6	88,982.5	13,175,944.0	13,524,749.1
Non-forest	140,033,383.8	808,634.1	138,448,490.0	141,618,277.5
Saxaul forest	2,048,002.9	128,498.3	1,796,151.0	2,299,855.0
Shrub	766,739.7	38,647.0	690,993.0	842,486.3

Estimate of forest and Non-forest cover types in the year 2010

Land cover	Total area (ha)	Standard error (SE)	Confidence Interval	
			Lower- 2.5%	Upper- 97.5%
Degraded forest	1,058,166.0	25,473.0	1,008,240.0	1,108,092.2
Intact forest	12,358,996.3	86,602.6	12,189,258.4	12,528,734.1
Non-forest	140,077,435.8	808,586.1	138,492,636.1	141,662,235.4
Saxaul forest	2,048,002.9	128,498.3	1,796,151.0	2,299,855.0
Shrub	766,739.7	38,647.0	690,993.1	842,486.3

Estimage of forest and non-forest cover types in the year 2015

Land cover	Total area (ha)	Standard error (SE)	Confidence Interval	
			Lower- 2.5%	Upper- 97.5%
Degraded forest	1,506,183.7	29,431.3	1,448,499.4	1,563,868.0
Intact forest	11,905,408.5	85,788.3	11,737,266.6	12,073,550.4
Non-forest	140,083,005.9	808,580.1	138,498,218.1	141,667,793.7
Saxaul forest	2,048,002.9	128,498.3	1,796,151.0	2,299,855.0
Shrub	766,739.7	38,647.0	690,993.1	842,486.3

MINISTRY OF ENVIRONMENT AND TOURISM

REDD+ MONGOLIA

UN-REDD PROGRAMME

Food and Agriculture Organization of the United Nations

UNDP

UNEP

The UN-REDD Programme / Mongolia
Address: Government Building II, United Nations Street 5/2, Chingeltei District, Ulaanbaatar 15160, Mongolia
Tel: +976-7711-7750
Email: info@unredd.mn
Web site: www.reddplus.mn