Drivers of Deforestation and Forest Degradation in Bhutan

Watershed Management Division
Department of Forests and Park Services
Ministry of Agriculture and Forests
Bhutan
March 2017

Report Edition

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Special thanks are due to Mrs. Gabrielle Kissinger and Mr. Matthias Seebauer (international consultants) for collecting, consolidating and analyzing the available data and for preparing this document, and Mr. K.B. Samal (national consultant) for providing the national context and supporting the international consultants.

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List of Acronyms

ACC	Anti-Corruption Commission
AEZ	Agro-ecological Zone
AAC	Annual Allowable Cut
ADB	Asian Development Bank
CF	Community Forest
CFMG	Community Forest Management Group
CFO	Chief Forestry Officer
DGPC	Druk Green Power Corporation
DoFPS	Department of Forests and Park Services
EDP	Economic Development Policy
EIA	Environment Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
FAOEMR	Forest areas outside existing management regimes
FMU	Forest Management Unit
FNCRR	Forest and Nature Conservation Rules and Regulations
FIMS	Forest Information Management System
FMU	Forest Management Unit
FREL	Forest Reference Emissions Level
FYP	Five Year Plan
GHG	Greenhouse gas
GNH	Gross National Happiness
GNHC	Gross National Happiness Commission
GPG	Good Practice Guidance
GRF	Government Reserve Forest land (now State Reserve Forest Land)
ICIMOD	International Centre for Integrated Mountain Development
INDC	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
LULC	Land Use Land Cover change
MCDA	Multi-criteria decision analysis
MoAF	Ministry of Agriculture and Forests
MoEA	Ministry of Economic Affairs
LCMP	Land Cover Mapping Project
LPG	Liquefied petroleum gas
MW	Mega Watt
NEC	National Environment Commission
NFI	National Forest Inventory
NLC	National Land Commission
NRDCL	Natural Resources Development Corporation Limited
NWFP	Non Wood Forest Produce
PA	Protected Area
PAM	Policy and measure
PES	Payments for Ecosystem Services
PF	Private Forest
REDD+	Reducing emissions from deforestation and forest degradation in developing countries, and conservation, sustainable management of forests and enhancement of forest carbon stocks.
RGoB	Royal Government of Bhutan
R-PP	RED+ Readiness Preparation Proposal

SRFL	State Reserved Forest Land
tCO2	Tonnes carbon dioxide equivalent
WMD	Watershed Management Division
WS	Working Scheme
UNFCCC	United Nations Framework Convention on Climate Change

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ROYAL GOVERNMENT OF BHUTAN
Ministry of Agriculture and Forests
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ཟུར་ཆེན།
SECRETARY

PREFACE

Bhutan's strong commitment to its forests stems directly from the Constitution of the Kingdom of Bhutan. At the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009, Bhutan declared to remain carbon neutral. In 2015, Bhutan's Intended Nationally Determined Contribution (INDC) was submitted to the UNFCCC as part of the historic Paris Agreement on climate change. The INDC emphasizes the importance of adaptation and mitigation for Bhutan's forests, given future climate change impacts to its mountain ecosystems. The forest component of the INDC can be well achieved through Bhutan's on-going pursuit of REDD+ (Reducing Emissions from Deforestation and Forest Degradation in developing countries, and the role of conservation, sustainable management of forest and enhancement of forest carbon stocks). REDD+ is a mechanism under the UN Framework Convention for Climate Change (UNFCCC), which the Department of Forests & Park Services (DoFPS) committed to adopt in 2013, with the support of the UN-REDD Programme and the World Bank Forest Carbon Partnership Facility.

This study on *Drivers of Deforestation and Forest Degradation* is the first step towards development of Bhutan's REDD+ National Strategy. By elucidating the various direct and underlying drivers of forest cover change and forest degradation, this report provides a guide to identify the various response interventions (policies and measures) that can be pursued by all relevant stakeholders to improve our forest carbon stocks and achieve co-benefits.

I am pleased that the Department of Forests and Park Services, through its REDD+ secretariat within the Watershed Management Division, has commissioned this study and will incorporate its findings into development of the REDD+ National Strategy. The report makes recommendations on priorities for improved alignment among various sectors that depend on or impact forests, such as energy, agriculture, and others. Therefore, the cross-sectoral nature of these findings can provide useful inputs to various sector plans which will be defined in the 12th Five Year Plan.

I would like to commend the Watershed Management Division and the team for guiding this crucial study. I am confident that the findings and recommendations from this study will provide the required guidance for the Department of Forests and Park Services and other agencies to meaningfully pursue actions to support the country in its efforts to maintain the high quality of its forests, support sustainable development, as well as contribute to global efforts to mitigate the adverse effects of climate change.

obtain support from the international community to achieve positive outcomes.

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Royal Government of Bhutan
Ministry of Agriculture and Forests
Department of Forests and Park Services
Thimphu

FOREWORD

With 70.46% of its total land area under forest cover, and rich forest biodiversity, the Kingdom of Bhutan is recognized as a leader in environmental stewardship. Our decision to pursue REDD+ and to develop a REDD+ National Strategy is part of our on-going commitment to high-quality management of Bhutan's forests. To this end, we welcome support from international donors such as the World Bank Forest Carbon Partnership Facility (FCPF) to achieve these goals.

This study on the Drivers of Deforestation and Forest Degradation in Bhutan provides a timely window through which we assess our forests at the national level. First, the report finds that while our forest cover is increasing, our forests are actually degrading. Forest carbon stocks can be a proxy measurement of overall forest health, but clearly there are other values to be accounted for, including the distribution of species-rich forest types, biodiversity values, watershed values, climate adaptation functions, cultural values and others. While net deforestation is not a major concern, future driver pressures, particularly from other sectors, will impact forests. We can anticipate these pressures on forests and work with other agencies and local governments to ensure our State Reserve Forest Land allotment decisions are sound over the long-term. These are some of the recommendations from this report that DoFPS will further refine with stakeholders during the development of the REDD+ National Strategy.

This study applied spatial, statistical and policy analysis to identify the full range of deforestation and forest degradation factors affecting forests, identified the underlying drivers that influence those, and projected the trends into the future. These analyses formed the basis for the policy and measure recommendations, which were vetted by a broad set of experts and stakeholders.

I would like to acknowledge the hard work by the Watershed Management Division, Forest Resources Management Division, members of REDD+ Taskforce and the Technical Working Groups for their valuable contribution to this study. The support from the World Bank FCPF made this report possible. I look forward to continue working with other ministries, agencies and stakeholders to carry these insights and recommendations forward through subsequent planning and implementation processes.

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EXECUTIVE SUMMARY

Bhutan declared to remain carbon neutral at the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 in Copenhagen, Denmark. In addition, the Intended Nationally Determined Contribution (INDC) submitted in September 2015 towards finalization of the Paris Agreement further re-iterated Bhutan's pledge to remain carbon neutral. Bhutan's INDC emphasizes the importance of adaptation and mitigation, given future climate change impacts to its mountain ecosystems. The Department of Forests & Park Services (DoFPS) is implementing three programs in the 11th Five Year Plan (sustainable Management of State Reserve Forests (SRFL), sustainable management of forest landscapes and conservation of biodiversity, and integrated watershed management) to ensure sustainable environmental service delivery, and REDD+ activities cut across all three programs.

The identification of drivers of deforestation and forest degradation is a critical first step towards the National REDD+ Strategy. This analysis of the drivers of deforestation and forest degradation in Bhutan, including barriers to sustainable management, conservation and enhancement of forests (the 'driver analysis'), frames historical patterns as well as estimates future pressures on forests, based on projections for growth and development. In this way, the driver analysis should provide the basis for understanding what policies and measures can affect driver pressures into the future, at various scales, in order to guide growth and development that is compatible with Bhutan's forest heritage. This is the first kind of study undertaken to measure deforestation and forest degradation in the country and it paves the way forward for further works under the REDD+ Readiness process. Further analysis on deforestation and forest degradation will also be undertaken under the Forest Reference Emission Level (FREL) work. Therefore, the figure on deforestation and forest degradation presented in the study will be validated by the FREL work.

1. Land use/land cover change analysis

A land use/land cover change analyses (LULC) was undertaken for Bhutan based on existing maps as well as on a new classification for the year 2015 in close cooperation with the ongoing Land Use Land Cover (LULC) mapping, 2016 DoFPS, Ministry of Agriculture and Forests. An ICIMOD dataset produced in the frame of a decadal land cover change study (1990 – 2010) for Bhutan (ICIMOD 2015; Hamad et al, 2015) was used as reference for the years 2000 and 2010. In addition, a new classification was done for the year 2015 using Landsat 8 images from USGS. Finally, this led to a land use/land cover change analysis for the period 2000-2015 in the frame of this study.

Areas with crown cover above 10% and minimum area of 0.5 ha were classified as forest in this study, as per the definition of forest in Bhutan. Any land with crown cover below 10% (whether classified as State Reserve Forest Land (SRFL) or not) was not included as forest in this analysis. The forest area was further stratified into conifer forests, broadleaf forests and mixed forests based on the ICIMOD dataset. Forest types in this study were aligned with the LULC 2016 and National Forest Inventory forest types. In addition, a second layer of analysis was done for the same time period in order to assess potential forest degradation, using three crown cover classes:

- 50% crown cover – medium to dense forests, representing natural or near-natural forest conditions;
- 30-50% crown cover – semi-disturbed forests, representing typically forests which supply timber and other resources for rural households; and
- 10-30% crown cover – open forests, representing severely disturbed forests.

Results – Deforestation

On a national level, this study finds the forest area increased from 2.63 million ha in 2000, to 2.65 million ha in 2010, and 2.70 million ha in 2015. This results in a total forest cover of 70.6% in 2015 which is in line with the forest cover of the LULC project 2016 (70.8%). Hence, deforestation is not a discernible land use trend in Bhutan from a land use/land cover change perspective.

Over the 15-year period (2000-2015), 64,111 ha have been deforested while 140,819 ha of forest area were gained. This results in a total net forest area change of 76,708 ha, or an annual increase of 5,114 ha over this period. 36,298 ha of the deforestation can be attributed to the conversion of forest to agriculture. There are two districts where the forest area has decreased compared to the year 2000 - Mongar had a reduction of 3,922 ha, and Punakha had a reduction of 162 ha. In all other districts the forest area has increased.

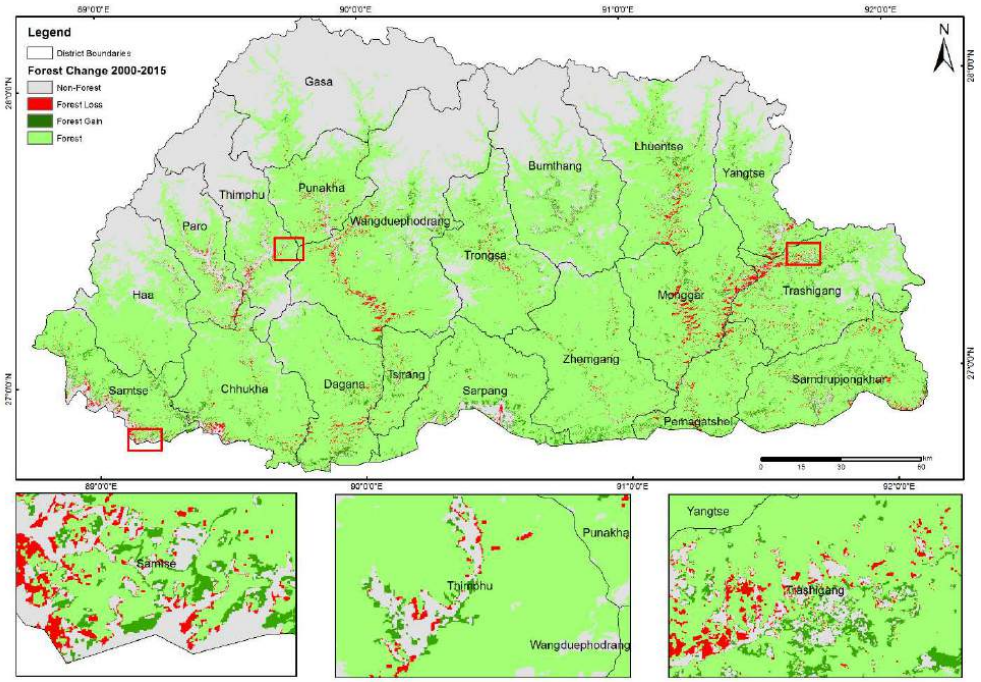


Figure: Forest loss and gain 2000-2015

The assessment of deforestation patterns between 2000-2015 yields the following observations: 75% of the deforestation occurred within broadleaf forest, while mixed forests had 13% and 12% in conifer forests. 40% of the deforestation occurred in elevations in the range of 1,000 to 2,000 meters, while 31% was in areas lower than 1,000 meters, and 28% above 2,000 meters. Deforestation is fairly evenly distributed across slope classes. 58% of forest loss occurred within 1 km of the nearest road, and 67% of deforestation occurred within 1 km of a settlement. 65% of forest loss occurred within the temperate zones of Bhutan, 19% in tropical/ sub-tropical zone and 17% in

cool temperate zones. Deforestation largely occurred in forest areas outside existing management regimes (FAOEMR). However, 17% of deforestation occurred within protected areas.

Drivers of deforestation

In Bhutan, there are a number of human activities or immediate actions that directly impact forest cover and loss of forest carbon. In order to consolidate the information in this report into a compact summary, this section combines the future driver projections into the driver summaries.

Allotment of State Reserve Forest Land (SRFL) for various purposes: According to Ministry of Agriculture and Forests statistics, a total of 12,674 ha of SRFL have been allotted for various purposes between 2008 and 2014, translating into an annual average of 1,923 ha. Allotments for lease constitute slightly over half of all SRFL allotments between 2008-2014, followed by allotments for satshab/ land substitution, government institutions, and other SRFL allotment, i.e., allotment for various unspecified purposes. The statistics do not allow for differentiation between how much SRFL allotted had forest on it, and how much was not covered by forest. By definition, SRFL is largely forest, but a forest may include a water body and/or non-vegetated land cover class. This driver has to be considered differently from the subsequent deforestation drivers since some categories of allotment (e.g. other SRFL allotment, land lease, etc.) most likely include land allotments for the drivers mentioned below, particularly agriculture. The allotment statistics for roads and transmission lines are specifically excluded under this driver. Future trends/projections: Assuming the historical average of forest area lost due to all allotments between 2008-2014, the average deforestation predicted to occur between now and 2030 due to RGoB allotments of SRFL for various purposes is roughly 28,800 ha.

Hydropower projects: About 99.5% of electricity in Bhutan is estimated to be generated from hydropower – with the remaining portion generated from diesel power. Roughly 75% of electricity generated in Bhutan is exported to India, and this is expected to increase given the hydropower sector development plans. Based on the hydropower projects developed so far 2,276 ha of forest were affected, which averages out to around 272 ha per hydropower project. Based on those estimates, 1 to 3 hectares of forest are lost for every megawatt (MW) generation capacity, or on average, 2 ha of forest for every MW generation capacity. Associated use of SRFL for transmission lines and road access related to hydropower development is related, and covered in the next two driver categories. Future trends/projections: Extrapolating into the future based on known development plans, and assuming an average of 2 ha of deforestation for every MW generation capacity developed, we estimate that 18,380 MW may generally impact about 39,760 hectares of forest, or an annual average of 1,880 ha. Actual impacts will vary based on hydropower development plans.

Roads: About 5,770 ha of SRFL was allotted to road construction between 2008-2014, or an annual average of 820 ha. The density of roads has been estimated to have doubled from about 1.5 km/km^2 in 2005 to 3 km/km^2 in 2011. Future trends/projections: Assuming the average forest area lost due to road construction in the period 2008-2014, the average deforestation due to roads is predicted to be about 4,100 ha between now and 2020, and up to 12,300 ha by 2030. It is important to note that increased road development in remote and forested areas may increase access for illegal resource extraction.

Agriculture: The spatial analysis of this study showed that a total of 36,298 ha were converted to agriculture between 2000-2015. This conversion can be further classified into Chhuzhing (wet land agriculture) – 8,303 ha; Kamzhing (dry land) – 25,690 ha; and Orchards – 2,304 ha. 86% of this conversion was located within the tropical and temperate AEZs of this study. During the same time, 24,631 ha have been converted from agriculture back to forests. This results in a net loss of 11,667 ha of forests to agriculture, or 778 ha annually. Future trends/projections: Assuming the average forest area lost due to conversion to agriculture assessed with the spatial analysis 2000-2015 (as well as taking into account the area converted back to forests), the average deforestation would be predicted at about 3,890 ha between now and 2020, and up to 11,670 ha by 2030. Agricultural projection is changing, given increasing interest in leasing for cardamom and other uses. But there are also increasing concerns over urbanization spreading into paddy lands, given their suitability for development with so few flat areas in the country.

Mines and quarries: Roughly 3,800 ha were leased for mining between 2008-2014. Future trends/projections: Assuming an average annual forest area loss of 633 ha due to mines and quarries in the period 2008-2014, the average deforestation would be predicted at about 3,165 ha between now and 2020, and up to 9,495 ha by 2030. Mining is one of the fastest growing industries of the country (revenues in mining and quarrying increased 20.86% in 2014 compared to the year before) and mining is a strong priority for the government to pursue economic development.

Power lines: A total of 3,791ha of forest were lost to make way for power lines between 2008-2014, which converts to an annual average of 542 ha. Future trends/projections: Historical statistics indicate that SRFL allotted to this driver declined in the 2008-2014 period, though this does not correspond to the impact expected to result from increasing number of hydropower projects being developed in the country. Assuming the average forest area lost due to construction of power lines in the period 2008-2014, the average deforestation would be predicted at about 2,710 ha between now and 2020, and up to 8,130 ha by 2030.

The table below summarizes and compares the statistical records of forest loss attributed to the different drivers identified above against the spatial analysis of forest loss. Figures are presented as an annual average area of deforestation.

Table: statistical records of deforestation 2000-2015 attributed to the different drivers

Driver	Statistical records of annual deforestation (ha/year)	Spatial analysis of annual deforestation (ha/year)
SRF land allotment for various purposes (excl. roads & transmission lines)	1,923	
Hydropower projects	1,880	3,496
Roads	820	
Mines and Quarry.	633	
Power lines	542	
Agriculture	No records	778
Total annual deforestation	5,798	4,274

The total annual deforestation of the statistical records of all drivers is 5,798 ha compared to 4,274 ha of total annual deforestation based on the spatial analysis. Taking into account that the driver 'allotment for various purposes' significantly overlaps with the annual deforestation areas in particular for agriculture and hydropower, the comparison of spatial and statistical records of forest loss is well aligned.

The ranking of drivers of deforestation is presented below, based on the extent of forest areas estimated to be affected annually by the drivers which were identified in the previous table. In addition, the annual GHG emissions are estimated based on the average carbon stock density estimated in this study.

Driver	Area affected annually (ha/ year)	Annual GHG emissions as a result of forest area loss (tCO2 e/ year)	Ranking in extent of deforestation
SRF land allotment for various purposes	1,923	604,852	1st
Hydropower projects	1,880	591,327	2nd
Roads	820	257,919	3rd
Agriculture	778	244,709	4th
Mines and quarries	633	199,101	5th
Power lines	542	170,478	6th

Stakeholder consultation workshops were organized for the three different regions in Bhutan, i.e. South Central, East and West. Representatives from different sectors were invited from each region to identify and rank their regional drivers of deforestation and degradation. Stakeholders ranked the No 1 direct driver of deforestation as roads, followed by hydropower projects, and power lines. The allotment of SRFL, identified as No 1 driver in this study, is ranked only fourth by the stakeholders. Assessing the ranking of the same drivers in the future, however, identified allotment of SRFL as well as agriculture as the highest ranking drivers. This was justified by the future development of commercial agriculture leading to higher risk of deforestation.

Results - forest degradation

In contrast to the results from deforestation in Bhutan which shows a forest cover increase, the findings of this degradation study suggest that forest degradation is occurring to some extent. Using crown cover changes as the proxy indicator for degradation, 667,680 ha of forests have been degraded (crown cover decrease) in the 15-year assessment period while 456,794 ha have improved (crown cover increase). 32% of the area identified as degrading saw crown cover shift from dense to medium dense forests. 42% and 27% of the forest area under degradation represent degradation from medium-dense to open and dense to open forests respectively. However, the share of dense forests remains remarkably high and is more than 50% of the total forest area. Significant changes have taken place in the other two crown cover classes. The area under medium dense forests (30-50% crown cover) has decreased from 40% in 2000 to only 26% in 2015 while the open, degraded forest class (10-30% crown cover) has increased from 10% to as much as 24% in 2015. District-level degradation patterns vary significantly. Generally the majority of districts flagged with degradation from

dense to open forests are located in the southern tropical or warm temperate zones dominated by broadleaf forests.

The following maps summarize the qualitative change of forests in Bhutan.

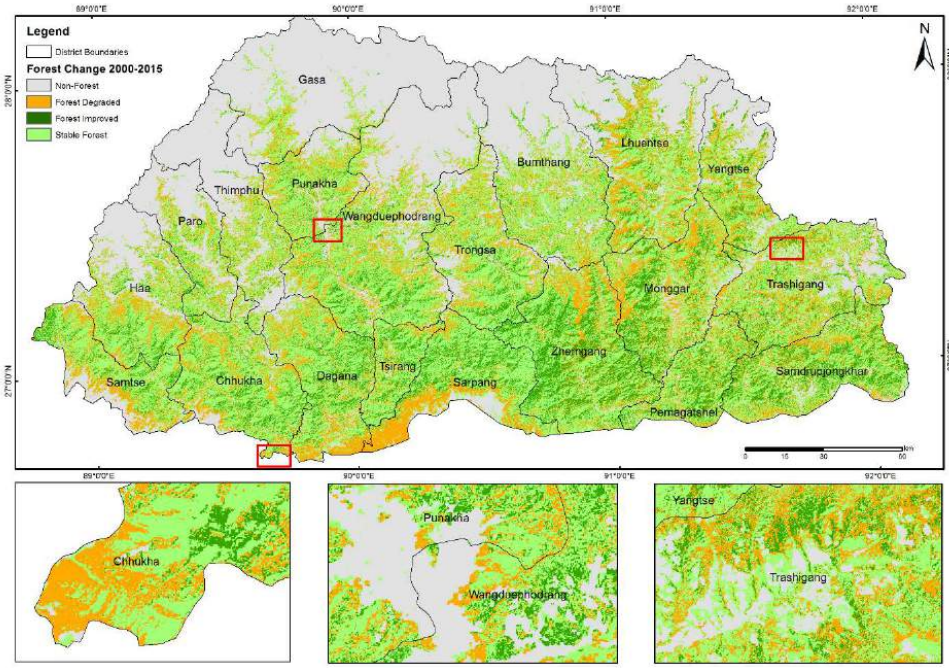


Figure: Forest degradation and improvement 2000-2015

Findings indicate that 34% of the total degradation occurred in altitudes ranging from 2000-3000 meters, 31% in areas above 3,000 meters, 17% within zones between 1,000 and 2,000 meters, and 19% of degradation occurred in forest areas below 1,000 meters. Degradation is fairly evenly distributed across various slope gradients. 32% of forest degradation occurred in areas beyond 5 km of the nearest road, 28% within 2-5 km of a road, 14% within 1-2 km, and 25% of degradation in less than 1 km from the nearest road. 50% of forest degradation occurred more than 2 km from settlements, while 33% of degradation occurred within 1 km of a settlement. 66% of degradation occurred within the temperate zones, 17% in the tropical/sub-tropical zone, and 19% in cool temperate zones.

Degradation patterns vary according to the different forest management regimes in Bhutan. Findings indicate that **most of the degradation occurred in forest areas outside of the existing management regimes (FAOEMR), in particular the degradation from medium dense and dense forest to open forest conditions is significant. Also, 40% of the total forest degradation occurred within forest areas in protected areas** (PAs). This could be attributed to the rural timber entitlements to the community residing within the protected areas. In protected areas, degradation of the dense to medium dense forests occurred along with an improvement from open to medium dense forests.

22% of forest within FMU areas experienced degradation with the forest cover changing from dense to medium dense. However, this opening of the forest cover most likely is a result of the logging activities using group felling and cable yarding systems and must

not be considered as degradation as the harvesting is planned and executed along principles of sustainable forest management (AAC). These degraded areas in FMUs should recoup during the stages of the working cycle and regain canopy closure.

Community management areas showed a balance between degradation and improvement. Finally, all management regimes (e.g. FAOEMR, FMU, CF, PA) contain roughly 40% of persistent dense forest.

Drivers of forest degradation

Timber harvesting: National statistics indicate 72% of the timber extracted in the period between 2009 to 2015 has been supplied as subsidized timber, followed by commercial timber (27%), and Royalty free timber (1%). According to national statistics, the amount of timber (excluding firewood) extracted from the country's forests between 2008-2015 amounts to 1,127,059 m^3 or an annual average of 161,008 m^3 over the same period. These figures do not include unauthorised/illegal extraction. This is equivalent to about 19% of the estimated sustainable annual yield in the country. There is no systematic evaluation of the impact of different types of timber allotments on forest degradation. However, it is estimated that only a small percentage (14%, including community forests) of forest area in the country is suitable for commercial timber production without compromising the principle of sustainable forest management. Future trends/projections: Predicted to continue to exert degradation pressure on the forests. Assuming the annual average of 161,008 m^3, the impact on forests would be predicted at about 805,042 m^3 between now and 2020, and up to 2,415,125 m^3 by 2030. The concentration of timber extraction in the few feasible areas might result in further forest degradation.

Firewood: Firewood accounted for 90% of Bhutan's energy demand in 2005 (MoEA, 2016), and yet the efficiency of firewood devices is only 10%–15%. However, increasingly, other types of firewood consumers become significant such as residents in urban areas; institutions such as hotels, restaurants, schools, monasteries; industries; and agriculture. Removal of trees as firewood occurs within and outside of FMU areas. According to national statistics, the amount of firewood extracted and supplied between 2009 and 2015 amounted to 594,552 m^3, or an annual average of 84,936 m^3, which is equivalent to about 10% of the estimated sustainable annual yield. Our analysis estimated total firewood consumption on a per capita basis and finds a much higher consumption rate. The total firewood consumption in 2014 was 637,231.66 tonnes (MoEA, 2016). Divided by the total population of Bhutan in 2014, 745,153 (NSB, 2014) the per capita firewood consumption was 855 kg / year. Using the weighted average wood density of 0.469 tonnes/m^3 (FAO 2015), this calculates as 298,862 m^3 for 2014. This estimate is about five 3.5 times higher than the estimates of firewood extracted and supplied, which are reported in the national statistics. This difference should simply highlight the difficulty of reliably estimating actual firewood extraction. Considering this alternative estimate, firewood extraction would equal to about 35 % of the estimated sustainable annual yield in the country. These different estimates highlight the difficulty of reliably estimating actual firewood extraction. Future trends/projections: Predicted to continue to exert a marginally reduced but still significant degradation pressure on the forests. Assuming the annual average of 84,936 m^3, the impact on forests would be predicted at about 424,680 m^3 between now and 2020, and up to 1,274,041 m^3 by 2030.

Forest fires: Each year, significant forest areas burn in Bhutan. Between 2009 and 2014, 334 fire incidences were recorded in the country, affecting 43,817 ha of forest areas, or an annual average of 6,260 ha. Fires are more prevalent in the eastern and central regions, due to pine and oak forests being more associated with fire incidences. Future trends/projections: Assuming a continuation of previous trends, one could predict that between now and 2030, about 93,800 ha of forest would be subject to fire across the country.

Livestock: The impact of livestock grazing on forest degradation is localised, and varies from place to place depending on the forest types and grazing intensities. Grazing is generally acknowledged to contribute to forest degradation, although insufficient data exists to accurately assess its impact. With a cattle population of 500,000, the grazing density is about 1 cow for every 5 ha of forest. Compared with the estimated carrying capacity of 0.54 Livestock Units/ ha in Nepal for temperate rangelands associated with oak, mixed broad leaf, or blue pine forests, the estimated grazing density in Bhutan on a national level is well below levels leading to significant degradation. However, there is anecdotal evidence that grazing can adversely impact regeneration in localized areas particularly following forest harvesting in FMUs. Future trends/projections: Decreasing trends.

The table below summarizes and compares the statistical records of forest degradation attributed to the different drivers identified above against the spatial analysis of this study. In order to compare degradation given in m^3 and areas, all areas degraded have been converted into corresponding volumes in m^3 using an average degradation rate of 7.4 m^3 per ha and year.

Table: Validation of the statistical records with spatial results for forest degradation

Driver	Statistical records of annual degradation (ha/year)	Spatial analysis of annual degradation (ha/year)	Degradation in corresponding m^3 (m^3/year)
Timber harvesting	Given in m^3	not available	161,008
Firewood	Given in m^3	not available	84,936
Forest fires	6,260 ha	not available	46,397
Livestock	not available	not available	not available
Total annual degradation spatial analysis		44,512 ha	329,911

Using the weighted average degradation rate, the degradation based on the spatial analysis of 44,512 ha of forests annually amounts to 329,911 m^3 per year. In comparison to this, the sum of annual degradation of the drivers in this study totals 292,342 m^3 per year. This results in a gap of an annual 37,569 m^3, which might be a combination of unrecorded firewood, non-extracted timber for instance from transmission lines, as well as unquantified degradation from livestock and pest and disease. It has to be noted, that these results are interpreted on a national level, and that degradation has to be further assessed on a regional (district) level.

The ranking of drivers of degradation is based on the extent of timber volumes estimated to be affected annually by each driver. In addition, the annual GHG emissions are estimated based on the average carbon stock density calculated in section 3.4 (Scenario 2, year 2000).

Table: Ranking of drivers of forest degradation

Driver	Annual degradation in corresponding (m^3 /ha)	Annual GHG emissions as a result of forest degradation (tCO2 e/ ha)	Ranking in extent of deforestation
Timber harvesting	163,009	117,394	1st
Firewood	84,936	61,168	2nd
Forest fires	111,969	88,560	3rd
Livestock	Not available	Not available	4th

With regards to the assessment of drivers of degradation during the stakeholder consultation workshops, the ranking by the stakeholders is similar to the findings of this study; timber harvesting and firewood extraction are ranked highest. In addition, illegal logging and livestock were ranked relatively high by the stakeholders.

Carbon stock change estimates

Estimations of carbon stock changes were calculated based on the difference in carbon stock density of different forest types and crown cover density, between 2000, 2010 and 2015. The methodology follows IPCC GPG guidance, with the objective of providing at least Tier 2 results. This analysis evaluated two scenarios to estimate carbon stock changes in the forest between 2000 and 2015. Scenario 1 derived stocking volumes from a database compiled from FMU management plans. Scenario 2 uses significantly higher stocking volumes from the NFI for each of the forest strata which results in overall higher total carbon budgets within the forest areas of Bhutan. Both scenarios used reported stocking volumes in the FAO FRA 2015 country report for Bhutan as a benchmark. Using the LFI data and soil carbon data, carbon stocks and changes will again be estimated as part of the FREL process and published in near future.

Findings:

- Scenario 1 results indicate that the total carbon budget within the forest areas of Bhutan has decreased from 841 million tCO2 to 836 million tCO2 which results in a decrease of 4,432,012 tCO2 for the 15-year period. The average annual decrease amounts to 295,467 tCO2/year which is remarkably similar to the sum of total annual degradation in tCO2 per year of the degradation drivers (295,544 tCO2, see Table above). In terms of the carbon density of tree biomass (above and below ground biomass) the area weighted carbon stock densities decreased from over 306 tCO2/ ha in 2000 to 296 tCO2/ ha in 2015. This represents a reduction of 0.7 tCO2 per ha per year.
- Scenario 2 results indicate overall higher total carbon budgets within the forest areas of Bhutan. Nevertheless, the carbon budget has decreased from 1,052 million tCO2 to 1,039 million tCO2 which results in a decrease of 13,889,641 tCO2 for the 15-year period. The average annual decrease in this scenario amounts to 925,976 tCO2/ year. Again comparing total annual degradation in tCO2 per year of the degradation drivers, a huge gap is identified according to this scenario as a result of the significant higher carbon stock densities and consequently higher stock changes. The area weighted carbon stock densities decreased from over 386 tCO2/ ha in 2000 to 370 tCO2/ ha in 2015. This represents a reduction of 1.1 tCO2 per ha per year.

As a comparison, the Tier 1 IPCC approach results in a total of 1,102 Million tCO2 for the year 2000, which reduces to 1,082 Million tCO2 in 2015. This corresponds to a reduction of 0.05 tCO2 per ha per year.

This analysis confirms the overall findings of this study that the total forest area has increased, while the quality of forest has decreased, which results in lower carbon densities as well as in decrease of the total forest carbon budget.

2. Actors, motivations and underlying drivers

Twenty-six actors play a role in or have a stake in Bhutan's deforestation and forest degradation. These actors are explored to identify their motivations and where opportunities may reside for positive engagement towards REDD+ activities. In defining policies and measures to address driver pressure, consideration will need to be given to how PAMs shift the motivations of actors and influence land use behaviour.

Through expert/stakeholder interviews, and the literature review, underlying drivers were identified in the topical areas of governance challenges and law enforcement; economic, social poverty and tenure aspects; and demographic factors.

Governance challenges and law enforcement

Land allotment decisions for various uses (e.g., agriculture, hydropower, transmission lines, and roads), are made at project levels, with input from line ministries and approval by local government, but l**acking guidance by policy, decision-criteria, and spatially-explicit sector master plans to guide decisions, particularly when there are potential trade-offs**. Decisions occur in a piecemeal manner, without the long-term national spatial planning policy. Numerous interviewees noted the scientific and technological limitations in these decision-making processes. Sectoral conflict appears to come from the Land Act defining the mode of decision making on land use, allowing for subdivision and leasing, without all the guidance that decision-makers feel is necessary. There are sector guidelines (such as the Forest and Nature Conservation Rules and Regulations of 2017), which support evaluation, but these are sector-based and do not provide a means to harmonise or align, or mitigate conflicts between sectors. Though information sharing mechanisms are not streamlined, which makes information access difficult, there is a willingness for more integrated planning and decision-making, if such information were available. While Environmental Impact Assessments (EIAs) are consistently applied, they sometimes occur after a major infrastructure agreement is already made, thus their utility in these cases is to mitigate affects of a project, but not evaluate systematic impacts (such as throughout a watershed). EIAs cannot be expected to replace sector policies, plans and guidelines.

Implications of expanding hydropower: Expansion of hydropower facilities will have increasing impacts on forests due to facility siting and related infrastructure. Government is trying to address forest loss due to hydropower projects by requiring compensatory plantations to be established, which will now be managed by the Green Bhutan Corporation, formed in 2017, in collaboration with DoFPS and local government. Government is also addressing the forest loss through establishment of a plough-back mechanism of 1% of royalties, to be paid to MoAF on an annual basis for sustainable management of watersheds, although this is yet to be operationalised.

There are plans for 18,380 MW of hydropower to be developed. The prioritization of hydropower development as the primary source of foreign exchange and economic development is clear. However, the financial commitment associated with hydropower expansion is a potent underlying driver that will put pressure on the country's forests.

Capacity constraints appear to occur on a range of levels. Interviews with DoFPS indicate that capacity in numbers of staff is adequate, but the enrichment of knowledge and capacity to implement policies on the ground are needed. Despite the existence of policies, effective management plans are lacking. Law enforcement and stemming illegal activity is an increasing challenge, though the majority of the forest offences appear to be small-scale and opportunistic.

Rural subsidized timber allotment: The overall resource base of forests in Bhutan for producing good quality construction timber is limited given the large extent of protected areas, the remote location and steep mountain terrain of many of the forest areas. Basically, only around 14% of the total forest area is considered capable of producing commercial timber. The amount of timber required to meet the allotment changes from year to year. There was a spike in 2015, but generally subsidised timber allotment accounts for 72% of overall timber harvested. The Rural Subsidised Timber Policy is increasingly viewed by interviewees as requiring a redesign. Housing requirements have changed as building materials are shifting away from reliance on wood, houses do not need to be repaired and rebuilt as often, and more people are living in suburban and urban areas than before. Further, the concept of entitlement is based on demand from beneficiaries, not what the forest can sustainably provide, and acts as a disincentive for local people to steward the forest around them. There is also concern that the entitlement competes with community forestry, which is a local forest governance approach that relies on local community management. The present allotment system has many loopholes that provide opportunities for diverting the rural subsidized timber to urban markets, basically relabeling it as commercial timber. This is incentivized by the price difference between the rural and commercial timber which has widened. Though changes to the Forest and Nature Conservation Rules and Regulations (2017) address the corrupt and illegal activity identified by the Anti-Corruption Commission in 2009, it does not comprise a redesign of the policy itself. However, one important change is that the allotments will be made on a volume basis, rather than a standing tree basis. There will need to be increased capacity to implement the proposed changes.

Climate change is not yet fully mainstreamed into development planning: There is clear recognition that climate change is having an impact on Bhutan's forests, and government is undertaking a range of actions. The policy and arrangements to address climate aspects are not refined yet, though the RNR Sector Adaptation Plan of Action 2016 provides an updated view on potential impacts and adaptation strategies. The INDC submitted to the UNFCCC notes that the priority mitigation and adaptation actions within the INDC will be considered and integrated in the preparation of the 12th Five Year Development Plan (2018-2023). There is a strong need to bring both biodiversity conservation and the management of forests as carbon sinks into the Forest Act. There is also a need to deliver on the enrichment of knowledge and capacity development on climate impacts, mitigation and adaptation all the way to the village level.

Economic, social, poverty and tenure aspects

The cycle of poverty in some regions and rural areas (and perhaps increasingly urban areas, too) in Bhutan is a noted underlying driver that is interconnected to land degradation and food security. Bhutan's poverty reduction in the last decade has been rapid, broad-based, and inclusive. Between 2007 and 2012, the poverty rate halved and Bhutan has almost ended extreme poverty. That said, the pressures to degrade forests are strong, both for economic and practical reasons.

Demographic factors:

By 2030, 50% of Bhutanese will be urban, according to UN population statistics. The Department of Agriculture has observed migration from the East and Central areas to Western areas, with farm abandonment occurring in areas experiencing outmigration, especially in economically depressed areas where people are not able to produce enough food on their farms. Many of the abandoned farmlands are former slash-and-burn cultivation lands, some of which are reverting back to shrubland (and then forest). Human wildlife conflict has also increased due in part to improving wildlife habitat close to agricultural lands which are increasingly being abandoned in certain areas. Nomadic herding is on the decline, and reduced grazing has resulted in the juniper forest expanding into old grazing lands, thereby increasing woody biomass.

Due to the Land Act of 2007 and resultant land reforms, issues related to forest land tenure and customary use rights (besides tsamdro and tseri use) were not identified in the expert interviews as key underlying drivers. Addressing changes to tenure arrangements to support REDD+ objectives and goals is therefore not a priority.

3. Opportunities for '+' activities

Bhutan has over 50% of its land area dedicated as protected areas, and other forest defined as Forest Management Units, Working Schemes, Local Forest Management areas, Community Forests, and there are also Watershed Management Plans and Wetland Management Plans. But within all of these areas, more attention could be paid to defining protection for high carbon stock/high conservation value forest, areas suitable for sustainable management, areas suitable for forest loss (or clearing , and areas suitable for increasing forest cover and carbon enhancement. For example, steep, ecologically sensitive areas could be dedicated to protection to conserve carbon stocks, while afforestation, reforestation and enrichment planting could be promoted in degraded and barren areas. The intensification of sustainable management for timber and NWFPs would be suitable in forests with higher production potential. Improved management in FAOEMR is recommended, as these are outside planned management regimes, and yet supply the bulk of the timber supply.

If the evaluation of the success of Community Forestry shifts from the number created to the impacts of CF management, this will improve stewardship, and likely carbon stocks.

Bhutan should also maintain its wood imports, including various products, in order to maintain or increase its forest carbon stocks and protect the biodiversity of its forests. One recent study found that prior to 2009, Bhutan's domestic wood product (excluding

firewood) demand was largely met by domestic supplies. However, after 2009, urban demand greatly outstripped supply, and imports increased, the majority of which was wood charcoal by 2011. Bhutan has imported increasing quantities of wood charcoal from India to process calcium carbide and ferrosilicon, which is then exported to India.

4. Regulatory and policy framework

Overarching policy and legislation: The basis for Bhutan's strong commitment to its forests stems from the **Constitution of the Kingdom of Bhutan**, mandating a minimum of 60% forest cover, and directing every Bhutanese person, as a trustee of the Kingdom's natural resources, to contribute to the protection of the natural environment, conservation of the rich biodiversity of Bhutan. The **Gross National Happiness** measure the aspects of life beyond material well-being, and includes the environment as a pillar, though there is a need for a better set of indicators to measure the health of the forest ecosystem, including a robust information management system. The **National Environmental Strategy, "the Middle Path,"** which sought to develop the economy while still maintaining the country's rich cultural heritage, traditional values, and natural resource base, and the **Bhutan 2020** blueprint for development continue to be relevant today. The **National Environmental Protection Act of Bhutan 2007** does not mention climate change explicitly, but the overarching framework implicitly encompasses considerations for addressing forest degradation. The **Environmental Assessment Act of Bhutan 2000** serves its purpose, though focuses on project-level proposals, and does not provide guidance on how to address multiple projects proposed in water catchments, for example.

Land: The preeminent law guiding land use is the **Land Act of 2007**. The Act defines the mode of decision making on land use, allowing for subdivision and leasing, and provides procedural guidance, but criteria for evaluating allotments or leases of SRFL sits with each sector. Thus, the Land Act does not provide policy or planning guidance to help reconcile trade-offs between sector goals. The **Local Government Act of 2009** promotes decentralized governance and defines the roles of Dzongkhag and Gewog level government in decisions. Local governments will benefit from having national perspectives and guidance based on national-level plans and zoning. The new **Economic Development Policy (June 2016)** identified these gaps and defines that the NLC should carry out zoning to outline optimal land use, SRFL should be allotted for strategic business activities, and indicates that a range of Acts should be reviewed and revised, including the Land Act, the National Environment Protection Act, and the Local Government Act.

Forestry: The **2011 National Forest Policy** defines the overarching goal of sustainable management of forest resources and biodiversity. The **Forest and Nature Conservation Act 1995** is the primary means of defining appropriate forest uses, and enabled community forestry and social forestry. It has separate chapters on soil conservation, community forestry, protected areas and protection of wildlife. The **Forest and Nature Conservation Rules and Regulations 2017** operationalise the Forest and Nature Conservation Act. They cover general aspects of managing State Reserved Forest Land (SRFL) as well as detailed management prescriptions for different categories of SRFL including Forest Management Units, Community Forests, Protected Areas and watersheds. They contain provisions for a plough-back mechanism of 1% of royalties from hydropower development, and the provision of funds for compensatory plantations

to offset the impacts of mega-projects and development projects.

Community and social forestry: The **Forest and Nature Conservation Act 1995** provided the legal basis for community forests, and the 2016 revisions to the **Forest and Nature Conservation Rules** maintain the commitment to allow designation of SRFL for community management. The **Land Act of Bhutan 2007** also affects community forestry. The **Local Government Act 2009** appoints the Gewog Tshogde as custodian of community land and forests. This act and the **Local Government Rules and Regulations 2012** clarify the roles and responsibilities of local governments for local development and the interface with community forests.

Climate change: Climate adaptation and mitigation are clearly defined in Bhutan's **Intended Nationally Determined Contribution**, submitted to the UNFCCC in 2015. The INDC identifies sustainable forest management goals for climate benefits, and the REDD+ National Strategy can further refine the mitigation components, if designed to do so. The INDC seeks to integrate priorities in the preparation of the 12th Five Year Development Plan (which begins in 2018) and subsequent five-year plans. The **Forest and Nature Conservation Act, 1995**, and associated **Forest and Nature Conservation Rules and Regulations of 2017** do not explicitly contain climate change priorities, though they can be inferred from other priorities such as watershed management. While the **National Forest Policy of 2011** includes mention of climate mitigation and adaptation in the 'production forest' category, it does not provide coherent guidance to decision-makers and managers on how to bring climate change considerations into forest management.

Biodiversity: The **Biodiversity Act of Bhutan, 2003** is the basis for defining biodiversity priorities. The **National Biodiversity Strategies and Action Plan of Bhutan 2014** is a comprehensive document to guide decisions related to biodiversity protection. Two national targets are of most relevance for REDD+: National Target 5: stating that by 2018, high-biodiversity value habitats are mapped, the rate of loss is accounted, trends monitored and overall loss and fragmentation reduced, and; National Target 7: Areas under agriculture and forestry, including rangelands are managed through the adoption of sustainable management practices, ensuring conservation of biological diversity.

Water: A range of legislative frameworks for watershed management exist (Article 5 of the Constitution, Bhutan 2020, the National Forest Policy, Forest and Nature Conservation Act of 1995, the Land Act of 2007, Bhutan Water Vision 2025, Bhutan's Water Policy of 2008 and Bhutan's Water Act of 2010). A "Roadmap" for Watershed Management (2011) provides guidance for the implementation of strategies aimed at improving the management of the country's watersheds. It included a strategy to focus watershed management planning initially on critical or degraded watersheds requiring urgent management interventions. This approach is codified in the new FNCRR of 2017. The challenge for the future is to facilitate the implementation of "climate smart" watershed management plans in degraded watersheds.

5. Criteria to prioritize strategic options

This driver assessment takes stock of the historical and future drivers of deforestation and forest degradation in Bhutan, in order to provide a stronger sense of what policies

and measures (PAMs) could be put in place today to anticipate pressures on the forest into the future. PAMs are a key part of a National REDD+ Strategy, and are the means by which countries address driver pressures from within and beyond the forestry sector.

This assessment explores a range of criteria and priorities to guide Bhutan's consideration of what interventions can be adopted to shift the pressures on forests.

Bhutan is developing, becoming more urban and less rural and the country's relationship to its forests is dynamic. Forest cover as a measure of forest health is not fit to the task, as degradation is clearly having larger impacts on the forest, its functions, and its biodiversity. Refreshing Bhutan's vision and commitment to its forests inherently entails a contemporary view of forests and projections into the future, to define interventions and actions that maintain the integrity of the forest, while allowing for future development that is compatible.

The National REDD+ Strategy should be the means to carry out the forest component of Bhutan's INDC. The pillars and domains of Gross National Happiness can help guide the direction for REDD+ to underpin and implement these values and goals. Bhutan should likely also filter PAM options against its objectives being developed for the 12th Five-Year Plan. The 12th Five-Year Plan may be a suitable vehicle in which to position cross-sectoral strategies, and these should also be reflected in amended sector plans or guidelines as much as possible.

A key methodological step in evaluating PAM options is to consider what counter-measures to address drivers are already in place, those that are in place but could be improved, and those that might have been identified already but not yet implemented.

Based on the direct and underlying drivers identified in this report, key observations to guide assessment of PAM selection criteria include:

1. Degradation should be prioritized over deforestation, as forest cover is slightly increasing, while the forest as a whole is degrading. Carbon stock assessment of the forest can be a proxy measurement of forest health, but clearly there are other values to be accounted for, including the rich species distribution of forest types, biodiversity values, watershed values, climate adaptation functions, cultural values and others.
2. The relative impact of the Subsidized Rural Timber Allotment Policy on the amount of timber harvested each year, and the inconsistency with principles of sustainable forest management, deserves a re-think that goes beyond amending the Forest and Nature Conservation Rules.
3. It is appropriate to acknowledge that future deforestation will happen, so it is advisable to prioritize the suitability of the loss of some forest areas under different scenarios which safeguard high conservation value and high carbon stock forests
4. Eco-regional distribution of forests is important, so evaluation of intervention options should make sure not to weight interventions for one forest-type at the expense of others.
5. Hydropower development and associated infrastructure development will have a

large impact on the forest.

6. Interventions that address trade-offs between sectors are important, and would address a current weakness in governance. A National Land Use Policy and spatial land use planning/zoning is an option to help this. Simply addressing needs from the forest sector perspective will not reconcile the conflicting priorities between sectors.

7. The cultural significance of forests in Bhutan must not be overlooked, and the NWFPs and traditional uses of the forest are important parts of culture and livelihoods.

8. The adaptation benefits and values of forests are crucial, and yet integration of climate considerations into current forest management and planning is not clear. This presents a large opportunity.

6. Initial policy and measure responses to address drivers

This section provides a comprehensive table, which summarizes each driver of deforestation and forest degradation, it's current and future projected impacts, what underlying drivers were identified that affect the direct drivers, and what recommended interventions could address the driver pressure. These recommendations would be further reviewed and considered in the National REDD+ Strategy development process.

	Underlying drivers that affect direct driver	Possible initial PAM options
Degradation drivers by rank		

Timber harvesting
About 161,008 m^3 harvested annually
72% of timber harvest serves subsidized rural timber allotments
Future projection: Based on historical trends, 805,042 m^3 between now and 2020, and up to 2,415,125 m^3 by 2030.
	• Subsidized rural timber based on entitlement may not be not sustainable:
	  • There has been no assessment of what the viable needs are for rural households (demand side)
	  • Entitlement has not allowed for an assessment of sustainable supply requirements, and concept of 'entitlement' may be outdated and does not serve the intended purpose
	  • Pre-existing households now in suburban areas still qualify as 'rural'
	  • Allotment policy skews the timber pricing structure
	• Illegal timber trading based on subsidized timber has been lucrative. The FNCRR 2017 states that surplus timber from rural house constructions can be sold upon payment of 25% of the existing NRPC rate, in order to legalise the usage of surplus timber and to deter the black market.
	• Community forestry - success largely judged by #'s of CFs, not necessarily by improved management.
	• the majority of wood products (excluding firewood) consumed in Bhutan was from India, the majority of which was wood charcoal. This suggests Bhutan should
		1. FNCRR 2017 has revised provisions for rural timber allotment, so it is unlikely there will be substantial changes in the near-term. Key operational task given to DoFPS in the Economic Devo Policy of 2016 is section 7.6.16 which states the need to 'rationalize timber subsidy to ensure optimal utilization of the timber resources.' Need to analyse the actual requirement rural timber, what the forest can supply and the gaps, and develop necessary analytics to inform the redesign. Identify how to correct pricing distortions (NRDCL and rural timber).
		2. Related to illegal pressures, oversight of allotment, transit offenses, need to build capacity and strengthen the ability of field level forest department staff (staff, equipment, knowledge, monitoring)
		3. Develop an Indicator of Forest Health, for use by GNHC.
		4. Community forestry: Capacity-building, better planning, and SME development potential. Ensure CF's are not also sourcing timber needs from allotment (it rationalizes use and builds sustainability within their own systems, and makes it easier to monitor as wood can only come from one source). When establishing CFs, ensure area and volume is appropriate to their needs.
		5. Manage forests to maintain high-carbon stocks in prioritized FAOEMR, FMU and CF areas, while defining

	maintain its level of imports of wood products from other countries to keep its natural forests (which are of high ecological value), though evaluation of impacts of sourcing wood products from other countries is recommended. • FAOEMR are not as well managed as FMUs • NRDCL is the most important stakeholder in the forest sector, however they are operating under constraints (strong regulation, pricing, capacity building needs) • FMU management to always done by plan (subsidy policy pulls timber) • There are underutilized species such as hardwoods, and efficiency of timber utilization and processing could be improved	other forest types as suitable to more intensified production: • FAOEMR comprise the major source of timber supply, are not as well-managed as FMUs. Stratification of management objectives based on goal of increasing carbon stocks and high-conservation-value forests (so that if forest area decreases, carbon stocks still increase). Refinement of the Rapid Resource Assessment – to provide more granularity on management objectives for different forest qualities • Manage based on forest carbon density and other attributes • Afforestation and reforestation on barren and degraded areas; can be for economically valuable species (commercial and export) or other purposes • Enrichment planting within open forests, also enrichment planting as compensatory activity rather than complete new reforestation • Develop web-based multiple use management information system (open-source MIS) supporting monitoring as well as planning and management of forest resources (possible for other land uses to be included). 6. Capacity-building for DoFPS to support FNCRR 2017 implementation, including at local levels, to calculate the 4000 cft limit or equivalent for rural timber allotment per household. Conduct further research to calculate how much cft is really needed for house construction- one and two storied. Monitoring, information, hardware components are also necessary. 7. Find ways to promote demand for lesser known broadleaf timber species. Develop regional forestry and timber supply chain clusters with the full range of actors, from planning, production, processing, marketing, markets. The goal is improved supply chain development for prioritized new product lines (including promotion of value-addition). 9. To address illegal timber trade, stronger timber tracking and chain of custody verification. The new rules on chainsaw registration and licensing could be effective, but very hard to monitor. Increased road checks recently put in place.
Firewood About 84,936 m^3 harvested annually (av. 2008-2014), equal to about 35% of the timber harvest amount (is additional to) Future projection: based on historical trends about 424,680 m^3 between now and 2020, and up to 1,274,041 m^3 by 2030.	• Key for household heating, not only cooking • Is > 90% of the residential sector's energy demand, yet efficiency of woodfuel burning devices is only 10%–15%. • Is the cheapest source of fuel and allotted free of royalty in rural areas • In future, as long as electricity access increases (and electricity prices are subsidized), households will switch fuels away from wood	• Plantations for woodfuel on cleared or degraded areas • How to increase efficiency in woodfuel devices, while supplying an alternative source for household heating? Or focus on fuel-switching for cook stoves? Upscaling of Min of Economic Affairs cookstove project • Need to address the institutional and urban demand for firewood • Changing entitlement system so that rural households don't depend on 2 trees, but use more lops and tops or salvage or scrap timber • Upscaling of briquette-making
Forest fires Annual average: 6,260 ha Future projection: 93,800 ha between now and 2030; ; or 231,985 m^3 between now and 2020, and up to 695,955 m^3 by 2030.	• Climate change impacts expected to increase fires • Almost all fires are human induced – either intentionally or unintentionally, and agriculture appears to be an	• Government already sees this as a risk factor, and a forest fire strategy is in place, but inadequate capacity to effectively carry this out (field division levels). Training and awareness raising. • Increase volunteer firefighting at Dzongkhag level

	important source (lemongrass distillation in East) • Pine forests more susceptible between November and April	
Livestock Average forest area affected annually: not available, on a national level insignificant Future projection: Decreasing trends.	• 500,000 head nationally, though numbers are declining • Redistribution of Tsamdo leasing so far having positive impacts for pasture management and socio-economic benefits • Grazing density is about 1 cow for every 5 ha of forest. • Practice of nomadic herding is on the decline	• Awareness that free-ranging of cattle has greater impacts on forests (carrying capacity assessments), but interconnectedness of livestock and grasslands/forests is strong. More research and awareness is needed to understand livestock browsing of regeneration after grazing (social and institutional aspects). • Encourage stall-feeding (intensification and reduced grazing)
Deforestation drivers by rank		
Allotment of SRFL for various purposes Average forest area affected annually: 1,923 ha Total area estimated to be affected by 2030: 28,845 ha	• Decisions made without sufficient policy and guidance, criteria to support decisions on use and locations, or spatially explicit long-term/master plans • Land Act and is the key policy guide, and FNCRR (2017), 'Interim Guidelines on Lease of GRF Land for Commercial Agriculture of 2011,' NLC Rules and Regulations 2009, also apply. • Policy/planning guidance which does exist does not include robust assessment of future challenges and needs, such as increased urbanization or climate change • No clear mechanism yet to address sectoral trade-offs (and devolving to local levels to sort trade-offs may not be best way to handle) • Lack of zoning (DoFPS is only agency to have done this, in forest areas falling within management regimes) • Lack of info sharing between ministries	• Pursue concept of a National Land Use Policy – find where is best to house this. In order to increase or maintain carbon stocks, land use planning will help to identify land suitable for development while reducing deforestation/degradation pressures. Must have high-level political engagement, as well as technical component • Phased process, with policy and zoning developing in tandem, but both need to be reinforcing of the other. • Zoning should include suitability and carrying capacity considerations. • Find how Land Use Plan can best enable compatible decisions at Dzongkhag and Gewog scales • Based on Land Use Policy, Plan and zoning, can have more detailed technical guidelines to inform allotment decisions.
Hydropower projects Average forest area affected annually: 1,880 ha Total area estimated to be affected by 2030: Based on hydropower development plans 39,760 ha Based on linear trend: 28,200 ha	• The prioritization of hydropower development as the primary source of foreign exchange and economic development is clear. The financial commitment associated with hydropower expansion is a potent underlying driver that will put pressure on the country's forests. • EIAs have occurred after the Umbrella Agreement with India (not before) and cumulative impacts of multiple projects within large watersheds has not systematically occurred • After the development clearance is given, and the DPR approved, and when it comes to the operational level, then detailed assessments are done (so aspect is mitigating impact of specific activities, rather than evaluating whole project). • DoFPS needs to holisticly assess the broader environmental impacts from hydropower development	• Jointly review hydropower expansion plans from a watershed and forest management perspective (basin-wide), strengthen capacity to carry out such reviews and share information with relevant agencies. • Explore trans-boundary PES mechanisms aimed at compensating upstream land managers in Bhutan for sustainably managing the landscape to produce high-quality water • Create a more refined assessment of ecosystem valuation (water/forests) • Account for timber harvested from hydropower and infrastructure development • Project proponent should report on the broader environmental impacts from hydropower development as a holistic package and not piecemeal (basin-wide- including power transmission lines and roads).
Roads	• Linked to government commitment to reach every village by road – critical for	• Consider de-emphasizing roads as a PAM intervention, as road build-out is a large priority for rural access, and much investment has already

1. Overview and context

Bhutan has a rich cultural diversity and intact natural environment that are closely intertwined. Forests are the cornerstone of Bhutan's commitment to remain carbon neutral, implement low emission development strategies, and maintain 60% forest cover over its land area, as enshrined in the Constitution of the Kingdom of Bhutan. Article 5 of the Constitution reflects the commitment to secure ecologically balanced sustainable development while promoting justifiable socio-economic development.

With 71% of Bhutan's land area under forest cover, forests dominate in all ecosystem types and across the country's varied geographies. More than half of the country (51.40%) is comprised of protected areas made up of the five national parks, four wildlife sanctuaries, strict nature reserve and biological corridors (RGoB, 2016a). The value of Bhutan's mountains and waters is appreciated far beyond its borders, as its forests contain the headwaters of many tributaries feeding the Brahmaputra River, home to at least 500 million people and part of the great Ganges-Brahmaputra-Meghna river complex.

The 11th Five Year Plan (2013- 2018) of Bhutan is developed on the concept of a 'green' plan creating a 'green' mind-set and attitude in order to prioritize environment management and reduction of greenhouse gas emissions (GHG) and pollution (RGoB, 2016a).

Bhutan declared to remain carbon neutral at the 15th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 in Copenhagen, Denmark. In addition, the Intended Nationally Determined Contribution (INDC) submitted in September 2015 towards finalization of the Paris Agreement further re-iterated Bhutan's pledge to remain carbon neutral (RGoB, 2016a). Bhutan's INDC emphasizes the importance of adaptation and mitigation, given future climate change impacts to its mountain ecosystems.

The Department of Forests & Park Services (DoFPS) is implementing three programs in the 11th Five Year Plan:

1. Sustainable Management of State Reserve Forests (SRFL)
2. Sustainable management of forest landscapes and conservation of biodiversity
3. Integrated watershed management to ensure sustainable environmental service delivery

REDD+ activities cut across all three programs of DoFPS and are explicitly mentioned in program 3 under output 1, which is titled "REDD+ Readiness activities initiated to implement climate change adaptation in watersheds."

At the COP 16 in 2010, Bhutan decided to adopt a phased program of implementing REDD+ in securing its ecological and economic benefits. In 2011, Bhutan was approved as a member of the UN-REDD program and has been receiving limited financial support from UN-REDD under its Targeted Support program. Several national level workshops were started from 2010 and local level consultations in the following years at the (dzongkhags) and block (gewog) level. Since then, stakeholder consultations,

creation of the REDD+ Taskforce and Technical Working Groups, and Anti-Corruption analyses, and other REDD+ institutional arrangements for the Readiness Phase have been convened and undertaken (Royal Government of Bhutan, 2014). Bhutan entered into an agreement with the World Bank Forest Carbon Partnership Facility in 2015 to support the country's readiness preparation activities.

To assist Bhutan in the transition from the REDD+ Readiness towards implementation, the creation of a National REDD+ Strategy will be pursued. **The identification of drivers of deforestation and forest degradation is a critical component of the National REDD+ Strategy, but also to inform broader natural resources management and sustainable development planning.** In the Cancún Agreements, developing countries are requested to address the drivers when developing and implementing their national strategies or action plans. Subsequent UNFCCC decisions affirm the complexities and importance of addressing the drivers, and encourage countries, international organizations and the private sector to continue working on this and share information via the UNFCCC web platform.

This analysis of the drivers of deforestation and forest degradation in Bhutan (the 'driver analysis'), including barriers to sustainable management, conservation and enhancement of forests, can frame historical patterns as well as estimate future pressures on forests, based on projections for growth and development. In this way, the driver analysis should provide the basis for understanding what policies and measures can affect driver pressures into the future, at various scales, in order to guide growth and development that is compatible with Bhutan's forest heritage.

The specific objectives identified for completion of this driver analysis were to:

i. Thoroughly identify and analyse all critical (both direct and indirect/underlying) drivers and agents of deforestation and forest degradation, and assess the emissions contributed by each driver with reference to key forest types;

ii. Identify the barriers (and agents) to forest conservation, forest enhancement and sustainable management, at the national and subnational level;

iii. Identify and prioritize strategic options and key interventions (REDD+ policies and measures) to address these causes and barriers (including through cost analysis);

iv. Evaluate the impact of drivers at all levels (local, regional, national), looking beyond the forest sector and in particular at sectors that impact on forests such as agriculture, energy, infrastructure and fast urbanization. Estimate the magnitude of current and potential future consumption of wood products (timber and fuel wood);

v. Assess the potential for increased carbon removals through natural regeneration, forest conservation, sustainable forest management and afforestation and reforestation.

The process of undertaking this study

Overview of Drivers study process:

DD study started in June 2016
Bilateral discussions with stakeholders in June 2016
Collection of data
Field visit to FMUs and other forest sites
Stakeholder Consultation workshop for Central region in Zhemgang
Mid-term report completed and reviewed by WMD and FRMD (GIS/RS experts) in October 2016
Draft DD report completed and reviewed by WMD and FRMD in November 2016
Consultation workshop for Eastern and South-central regions from November 28 to December 2, 2016
Bilateral consultations in December 5-8, 2016
Presentation to DoFPS on December 7, 2016
Consultations with local communities by Tarayana Foundation
Consultation workshop for Western region on December 27-28, 2016
First Review writeshop on December 29-30,2016
Second Review writeshop on January 13 & 16, 2017
National Validation workshop in February 2017

2. Analytical framework

The analytical framework underpinning this study is based on the following understanding of drivers of deforestation and forest degradation (and plus activities), causal factors, and intervention options that the public and private sector can have in response:

First, the definitions of deforestation and forest degradation are:

Deforestation is a process of clearing and converting forest land to another land use, such as for agriculture, mining, or development. In this regard, deforestation usually results in a change in land use. If the land is cleared of forest and then not maintained in the new land use, trees may grow back.

Forest degradation is understood as forest remaining predominantly forest, and not switched to a different land use, but the quality of the forest declines, and the carbon stocks of the forest are reduced.
The drivers of deforestation and forest degradation are the rationales and activities that cause change to forests. They can be human induced or naturally-occurring. Drivers of deforestation and forest degradation are caused by:

Direct (proximate) causes: human activities or immediate actions that directly impact forest cover and loss of carbon. Examples include:

Deforestation: commercial agriculture, subsistence agriculture, mining, infrastructure and urban expansion
Forest degradation: logging, fires, livestock grazing in forest, firewood collection and charcoal production

Underlying/indirect causes: complex interactions of fundamental social, economic, political, cultural and technological processes - often distant from their area of impact.

Source: Adapted and modified from Geist and Lambin (2002)

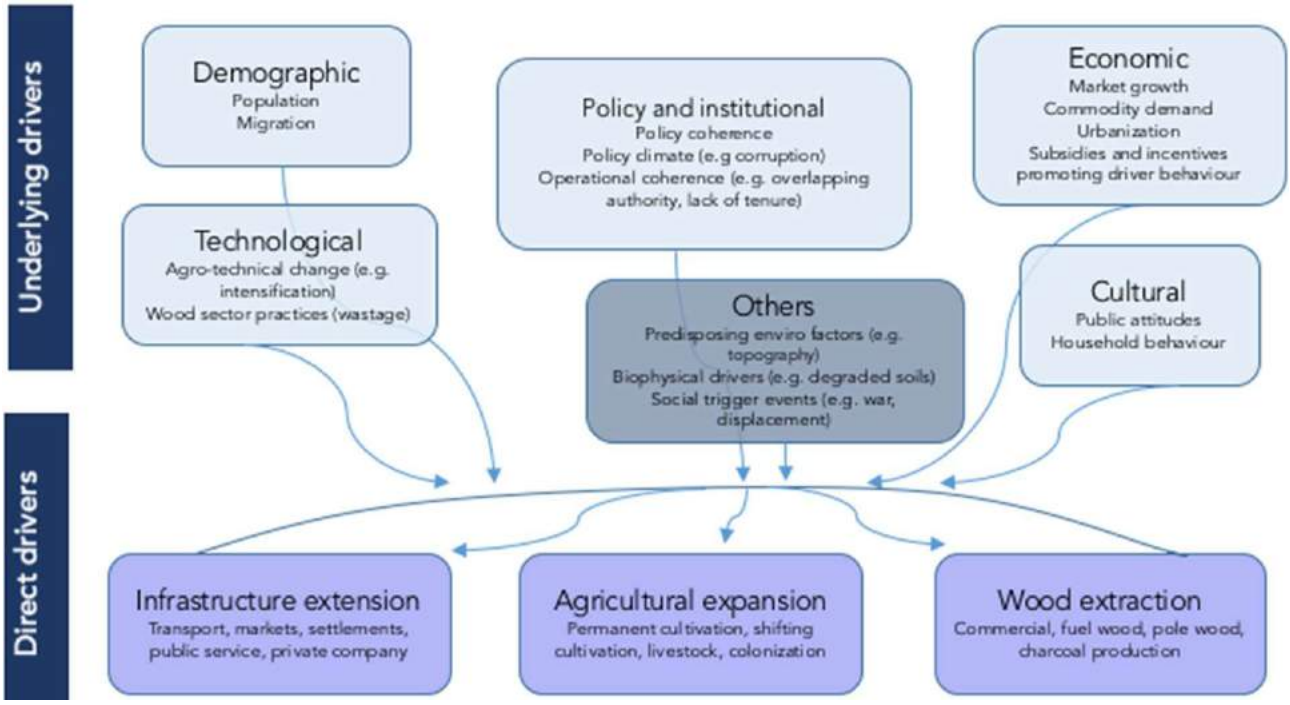


Figure 1: Relationship between underlying and direct drivers of deforestation and forest degradation

The UNFCCC Conference of the Parties have agreed through various decisions that drivers of deforestation and forest degradation are important, and developing countries are encouraged to identify them (Decision 4/CP.15) and address drivers in their national strategies or action plans (Decision 1/CP:16), and ensure that the responses to drivers are adapted to national circumstances (Decision 15/CP.19). The text of the three decisions mentioned can be found below:

Paragraph 1 of decision 4/CP.15:

> Requests developing country Parties, on the basis of work conducted on the methodological issues set out in decision 2/CP.13, paragraphs 7 and 11, to take the following guidance into account for activities relating to decision 2/CP.13, and without prejudging any further relevant decisions of the Conference of the Parties, in particular those relating to measurement and reporting:
> (a) To identify drivers of deforestation and forest degradation resulting in emissions and also the means to address these;

Paragraph 72 of decision 1/CP.16:

> Also requests developing country Parties, when developing and implementing their national strategies or action plans, to address, inter alia, drivers of deforestation and forest degradation, land tenure issues, forest governance issues, gender considerations and the safeguards identified in paragraph 2 of annex I to this decision, ensuring the full and effective participation of relevant stakeholders, inter alia, indigenous peoples and local communities;

Warsaw Framework decision on drivers (15/CP.19):

Also noting that livelihoods may be dependent on activities related to drivers of deforestation and forest degradation and that addressing these drivers may have an economic cost and implications for domestic resources,

1. Reaffirms the importance of addressing drivers of deforestation and forest degradation in the context of the development and implementation of national strategies and action plans by developing country Parties, as referred to in decision 1/CP.16, paragraphs 72 and 76;
2. Recognizes that drivers of deforestation and forest degradation have many causes, and that actions to address these drivers are unique to countries' national circumstances, capacities and capabilities.

Drivers of deforestation and forest degradation occur at all scales (global to local), and thus strategies to address drivers can occur at all scales. As this is a national study, the focus is primarily on national level interventions (policies and measures) that affect deforestation and degradation drivers. Interventions at international and local scales are also important in affecting drivers, and need to be considered when developing response options, and assessment of where interventions can best influence key actors should be considered. Defining what actions can best affect driver behaviour at the most appropriate scale is an important consideration by policy and decision-makers. Figure 2 provides a conceptual framework for how REDD+ driver interventions and actors relate at different scales. Enabling factors such as effective information systems to guide decisions, policies, institutional capacity, transparency and accountability, political will, and consultation with stakeholders underpin any strategy to affect drivers. For REDD+ to be successful, incentives, disincentives and enabling measures will need to reach the actors responsible for addressing the drivers of deforestation and forest degradation for shifting land use. These actors span all scales, from international commodity buyers to forest-dependent communities.

Source: Kissinger et al., 2012

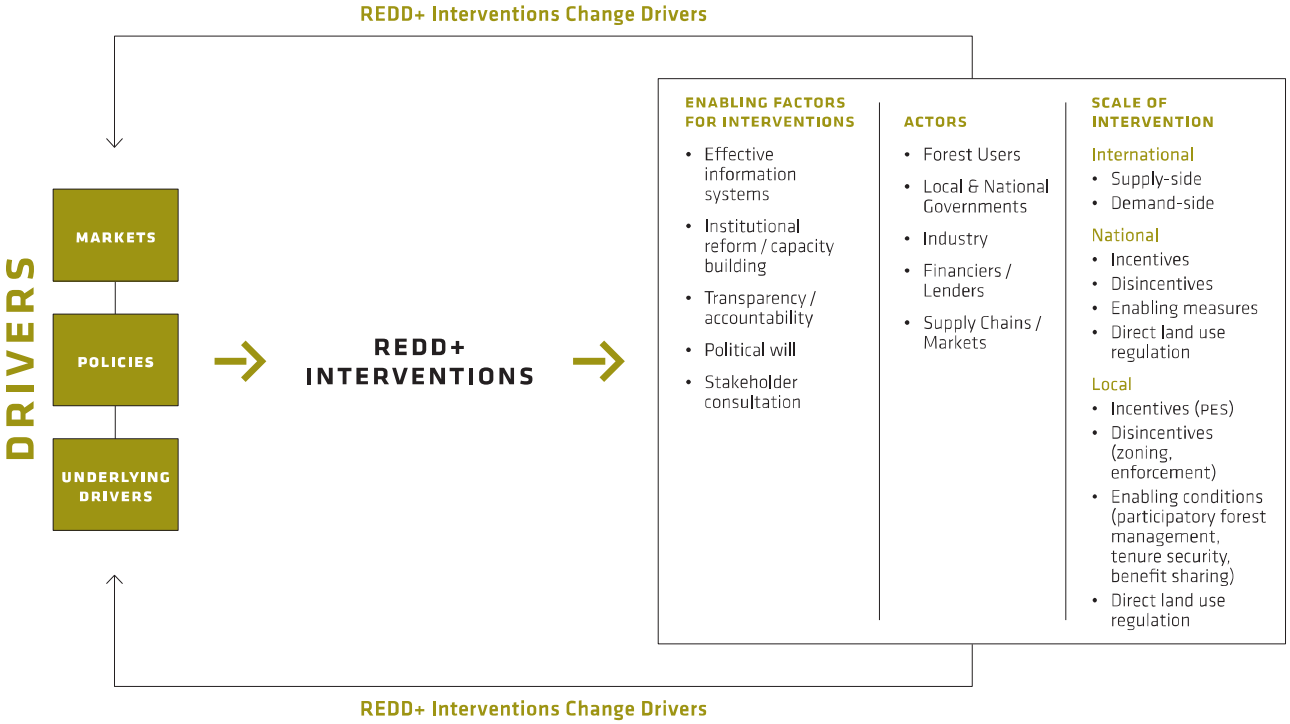


Figure 2: REDD+ driver interventions, actors and scales

At the very heart of this study resides an intention to provide solid and reliable information to help inform decisions on interventions on the country's forests to guide Bhutan's future development options while maintaining its social and natural capital.

3. Direct drivers of deforestation and forest degradation

3.1 Land Use Cover Change Analysis

3.1.1 Spatial analysis

A land use/cover change analysis (LULC) was undertaken for Bhutan based on existing maps as well as on a new classification for the year 2015 in close cooperation with the ongoing Land Use Land Cover (LULC) mapping, 2016 DoFPS, Ministry of Agriculture and Forests. An ICIMOD dataset produced in the frame of a decadal land cover change study (1990 – 2010) for Bhutan (ICIMOD 2015; Hamad et al, 2015) was used as reference for the years 2000 and 2010. In addition, a new classification was done for the year 2015 using Landsat 8 imageries from USGS. Finally, this lead to a land use/land cover change analysis for the period 2000-2015 in the frame of this study. The overall accuracy of the land cover mapping for 2015 reached 93%. Annex 4 provides a detailed working protocol of all GIS analytical steps performed.

Areas with crown cover above 10% and minimum area of 0.5 ha were classified as forest in this study, as per the definition of forest in Bhutan. All land (whether classified as forest land or not) with a crown cover below 10% was not included as forest in this analysis. The forest area was further stratified into conifer forests, broadleaf forests, and mixed forests based on the ICIMOD dataset. Forest types in this study were aligned with the LULC 2016 and National Forest Inventory forest types. In addition, a second layer of analysis was done for the same time period in order to assess potential forest degradation into three crown cover classes:

1. 50% crown cover – medium to dense forests, representing natural or near-natural forest conditions;
2. 30-50% crown cover – semi-disturbed forests, representing typically forests which supply timber and other resources for rural households; and
3. 10-30% crown cover – open forests, representing severely disturbed forests.

As an outcome of this spatial analysis a consistent spatial time-series dataset is now available for 2000, 2010 and 2015 showing land uses and forest types including crown cover classes.

Below are the first three land cover maps, which are followed by the forest crown cover maps.

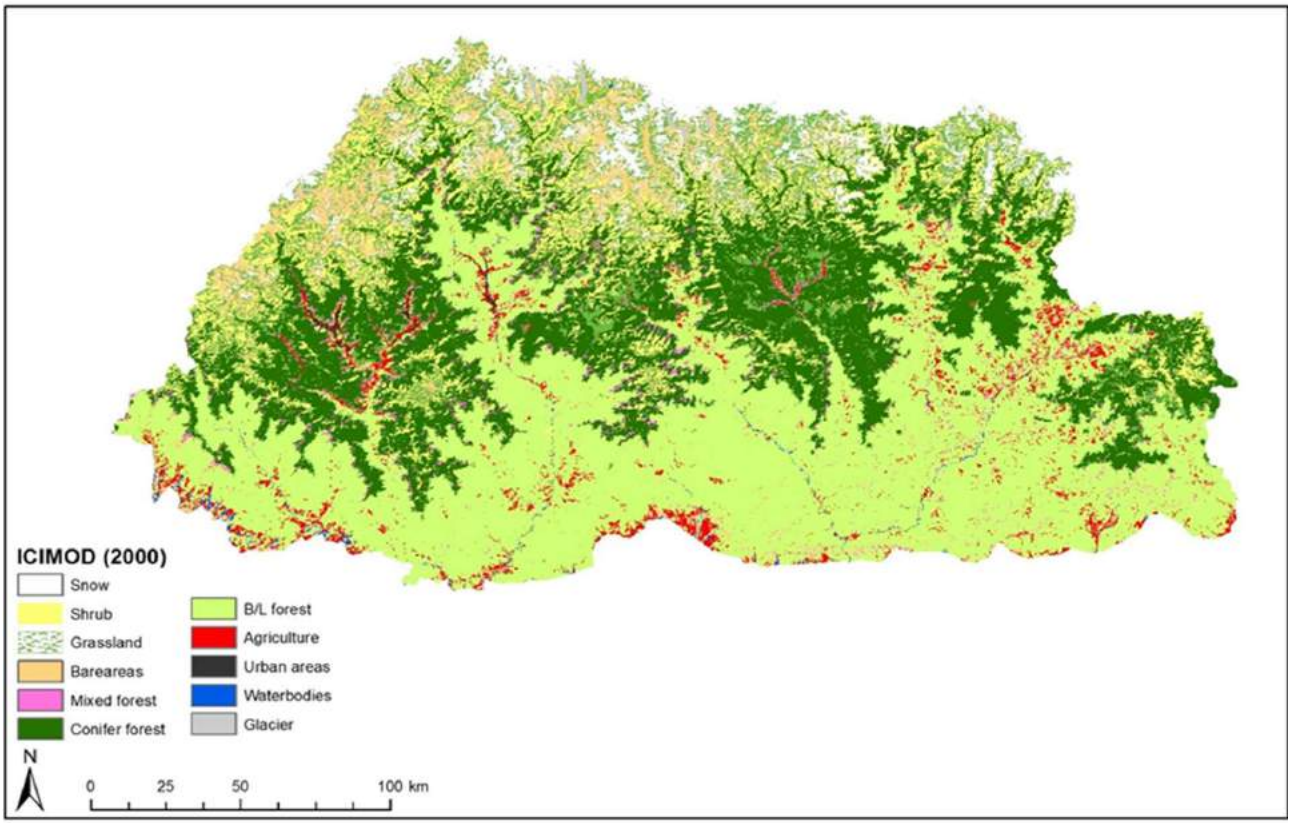


Figure 3: Land Use 2000

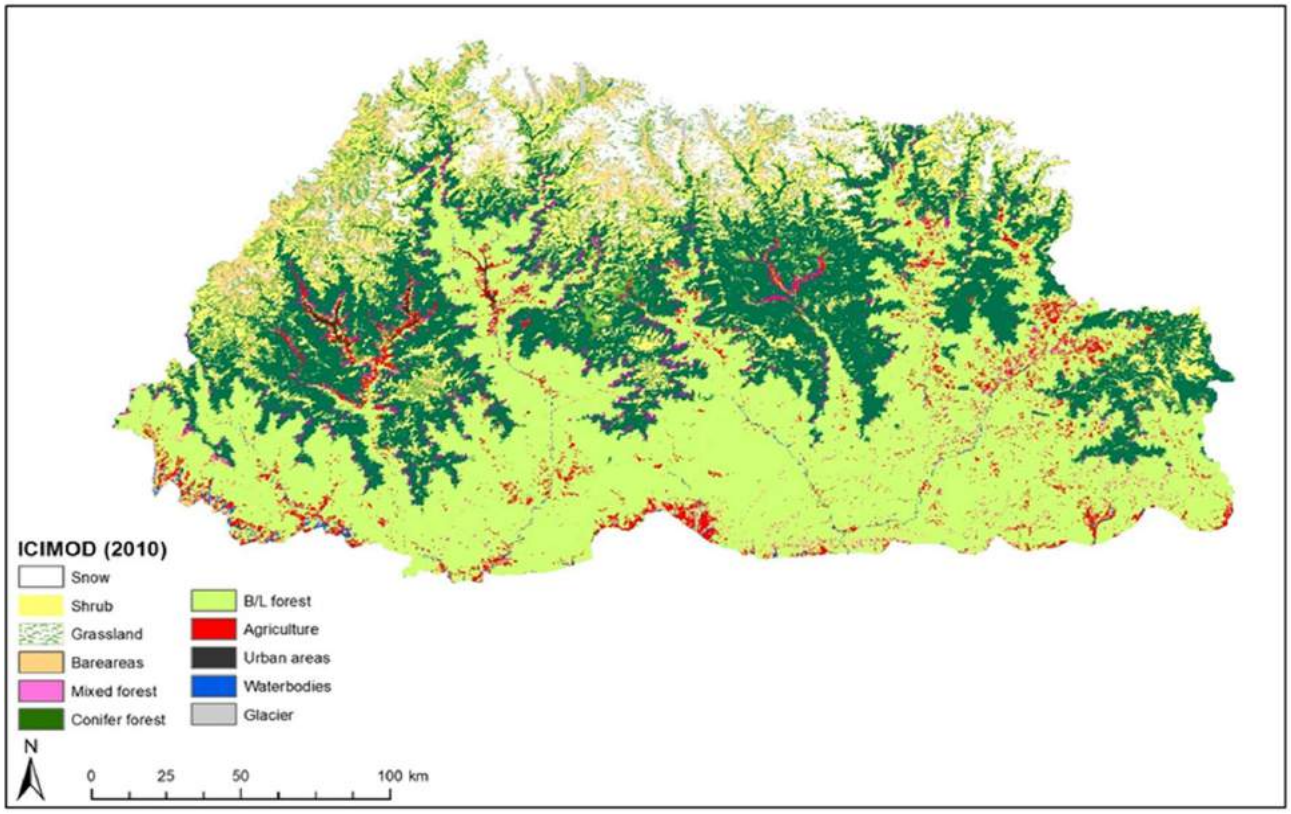


Figure 4: Land Use 2010

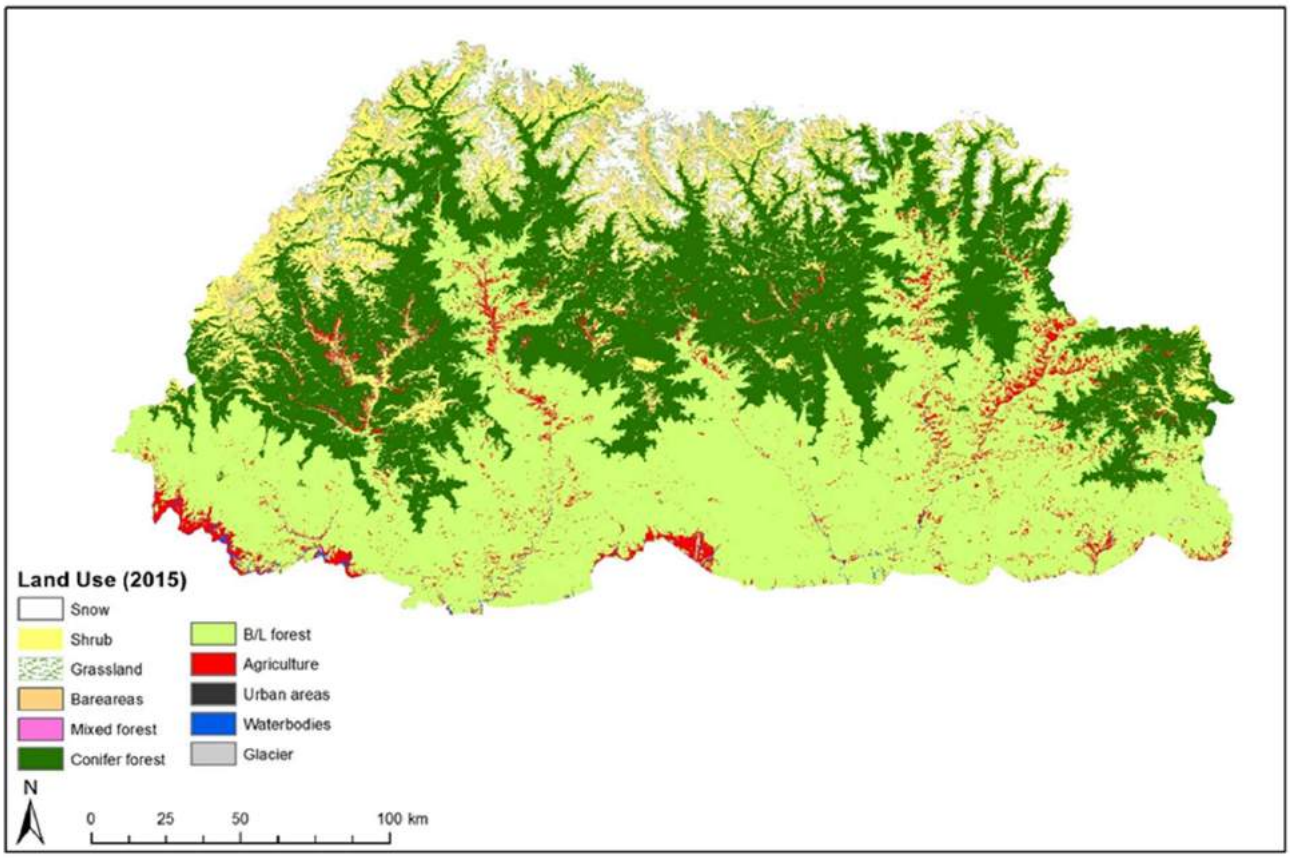


Figure 5: Land Use 2015

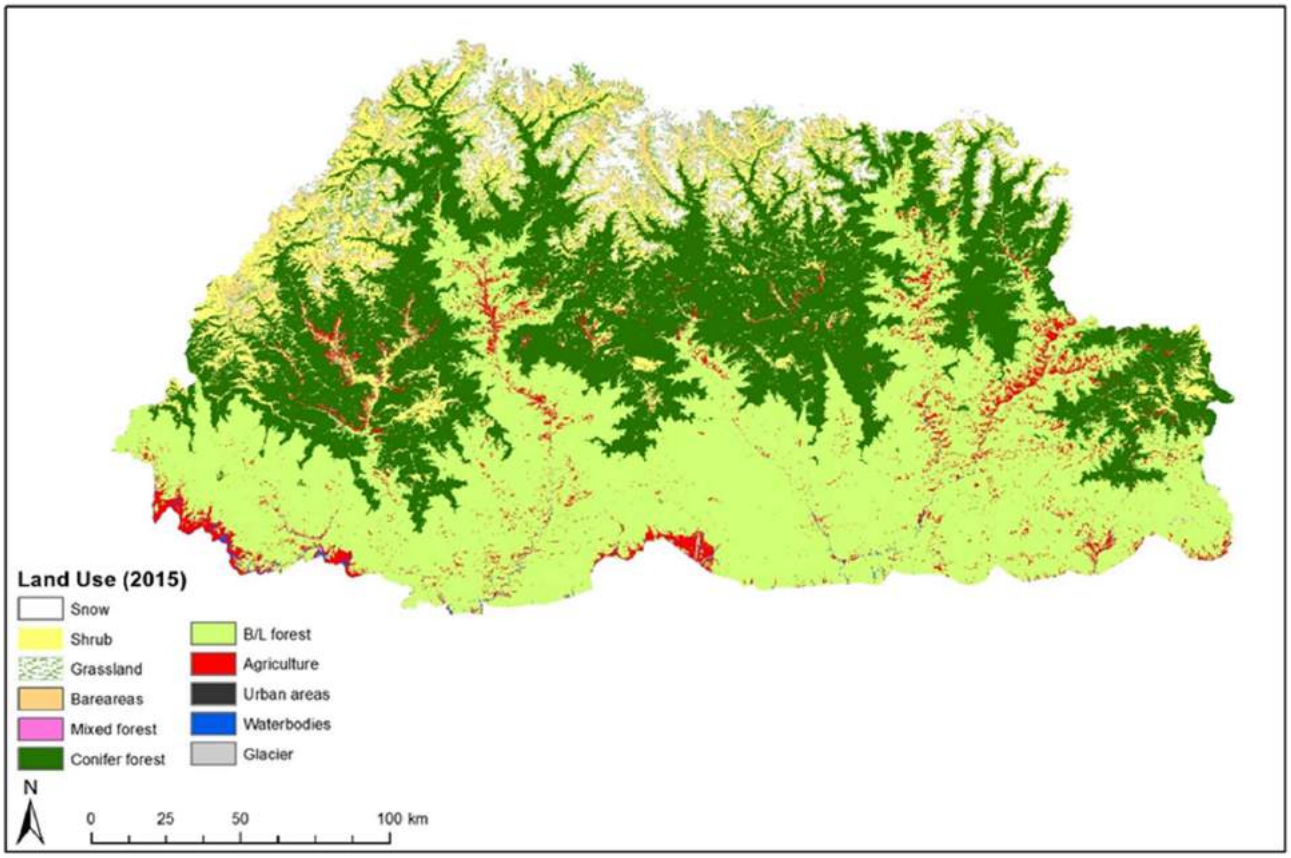


Figure 6: Crown cover 2000

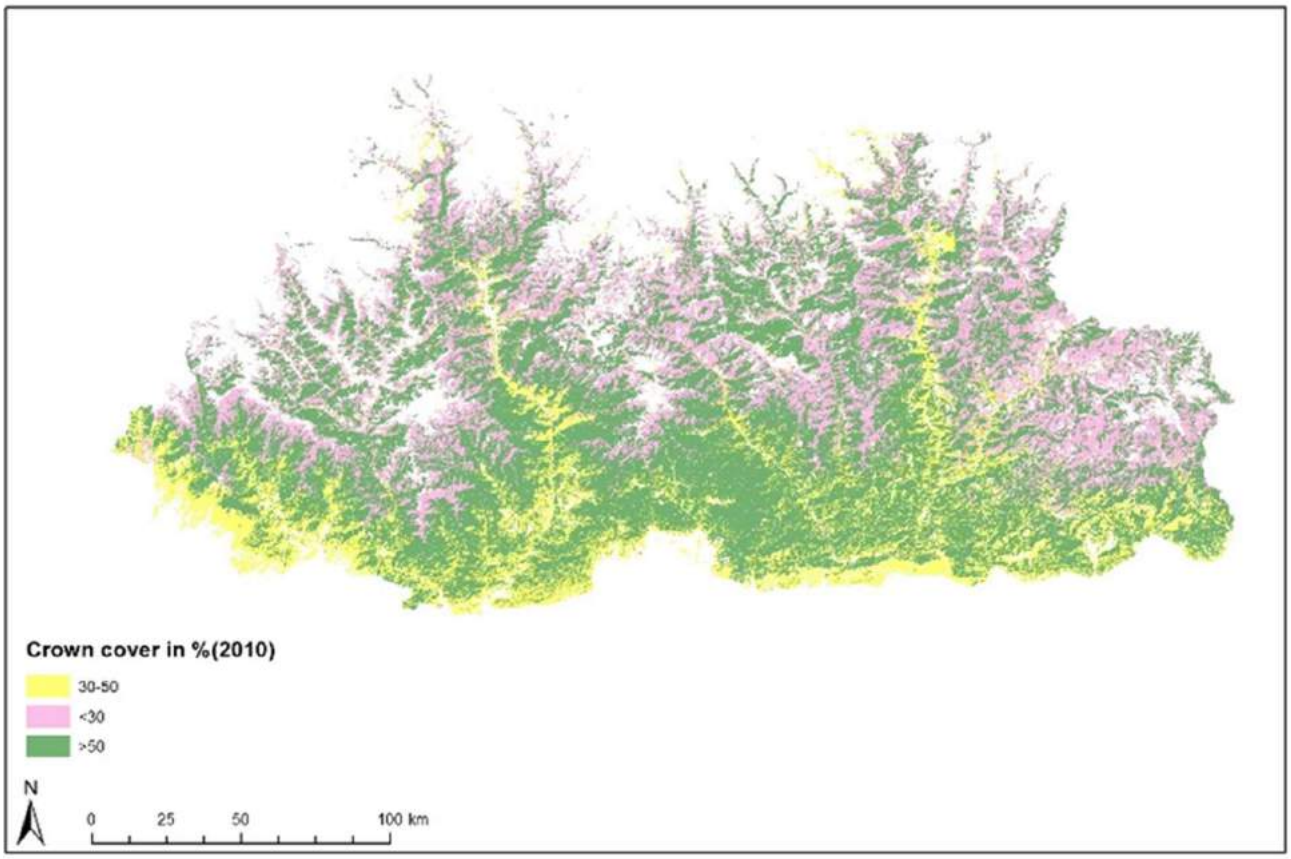


Figure 7: Crown cover 2010

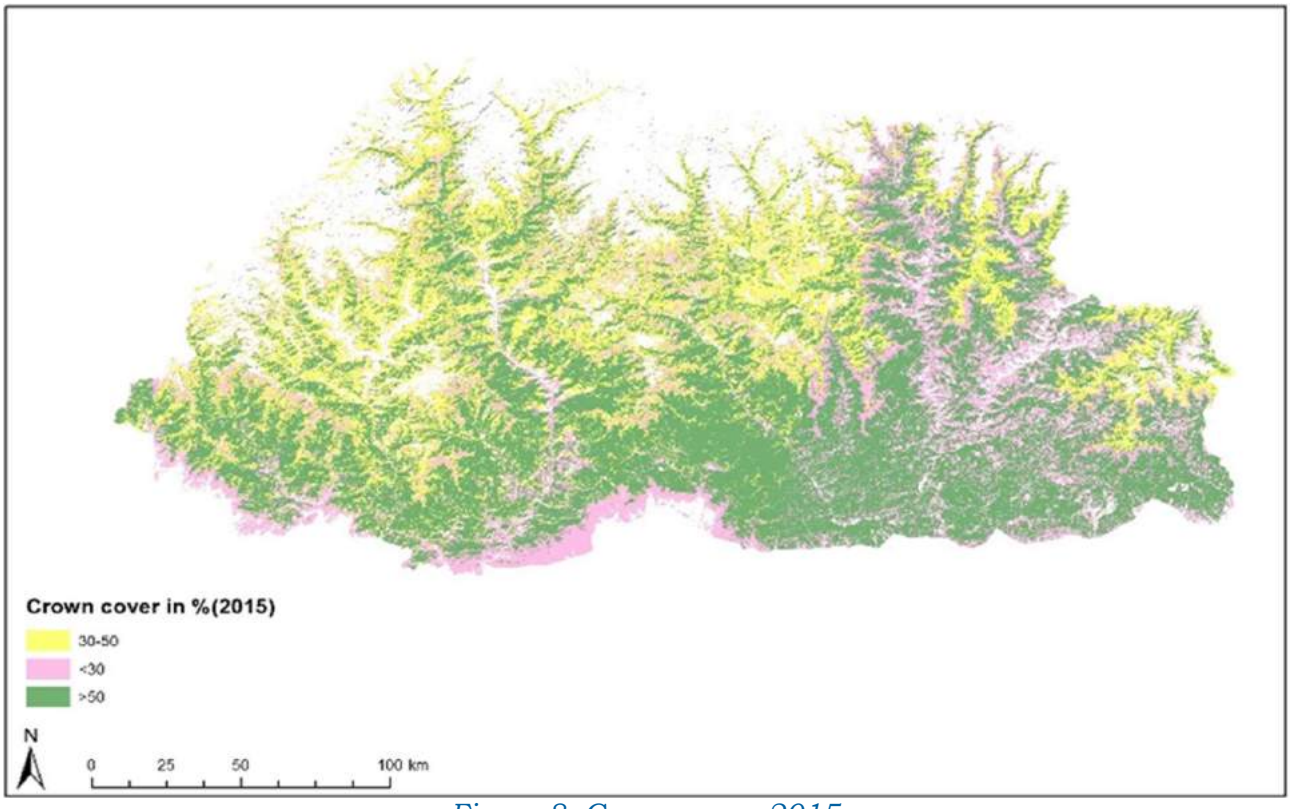


Figure 8: Crown cover 2015

The observed land use and crown cover changes were assessed against a set of variables in order to identify patterns related to drivers as well as certain hotspot areas. The selected and assessed variables include:

- 3 Forest types (1) coniferous forests; (2) broadleaf forests; and (3) mixed conifer and broadleaf forests (see note below)
- Elevation in meters
- Slope in degrees
- Distance to roads in km
- Distance to settlements in km
- Agro-ecological zones; the 18 AEZs of the Center for Sustainability and the Global Environment (SAGE) were used as reference to the IPCC climate zones. The 18 AEZs are defined by length of the growing period as well as climatic zones (Monfreda et al., 2007). The use of this global AEZ dataset was driven by the need to further stratify the three forest classes into more homogenous strata to understand forest stocking volumes and carbon stocks, for the purpose of a more accurate assessment of carbon stock changes during the assessment period. The process of alignment of these AEZs with the LULC 2016 and NFI 2016 datasets is presented below.
- Different forest management regimes under State Reserve Forest Land (SRFL):
    - Protected areas (PA);
    - Forest Management Units (FMU)
    - Community forests (CF), and
    - Forest areas outside existing management regimes (FAOEMR), such as FMUs, PAs, and CFs

Aligning forest types of this study with LULC 2016 and NFI forest types: The Land Use and Land Cover (2016) was finalized in early December 2016 and the results and findings were shared and discussed. The LULC map 2015 has classified the forests into the following types:

- Broadleaf
- Blue Pine
- Chir Pine
- Fir
- Mixed conifer

In addition, the first results of the National Forest Inventory (NFI) were shared with the consultant's team end of December 2016 with the following forest type classification for which stocking volumes were estimated based on the NFI sample plots:

- Subtropical forest
- Warm broadleaved forest
- Chir Pine forest
- Cool Broadleaved forest
- Evergreen Oak forest
- Blue Pine forest
- Spruce forest

- Hemlock forest
- Fir forest
- Juniper-Rhododendron Scrub forest
- Dry Alpine Scrub forest

The analysis in this study was done on the basis of the three forest types presented above, and then were stratified according to the different AEZs. To produce a higher Tier level carbon stock change assessment, the following procedure was applied to align the datasets of this study with the results of the LULC 2016 and NFI datasets.

- Based on the AEZ classification and the vegetation zoning graph presented in Chhetri (2011) the most dominant forest types used in the NFI classification were identified for each AEZ in this study
- For some forest types, the LULC 2016 dataset was used to spatially validate the identification of forest types, such as for Blue Pine, Chir Pine and Fir forests.

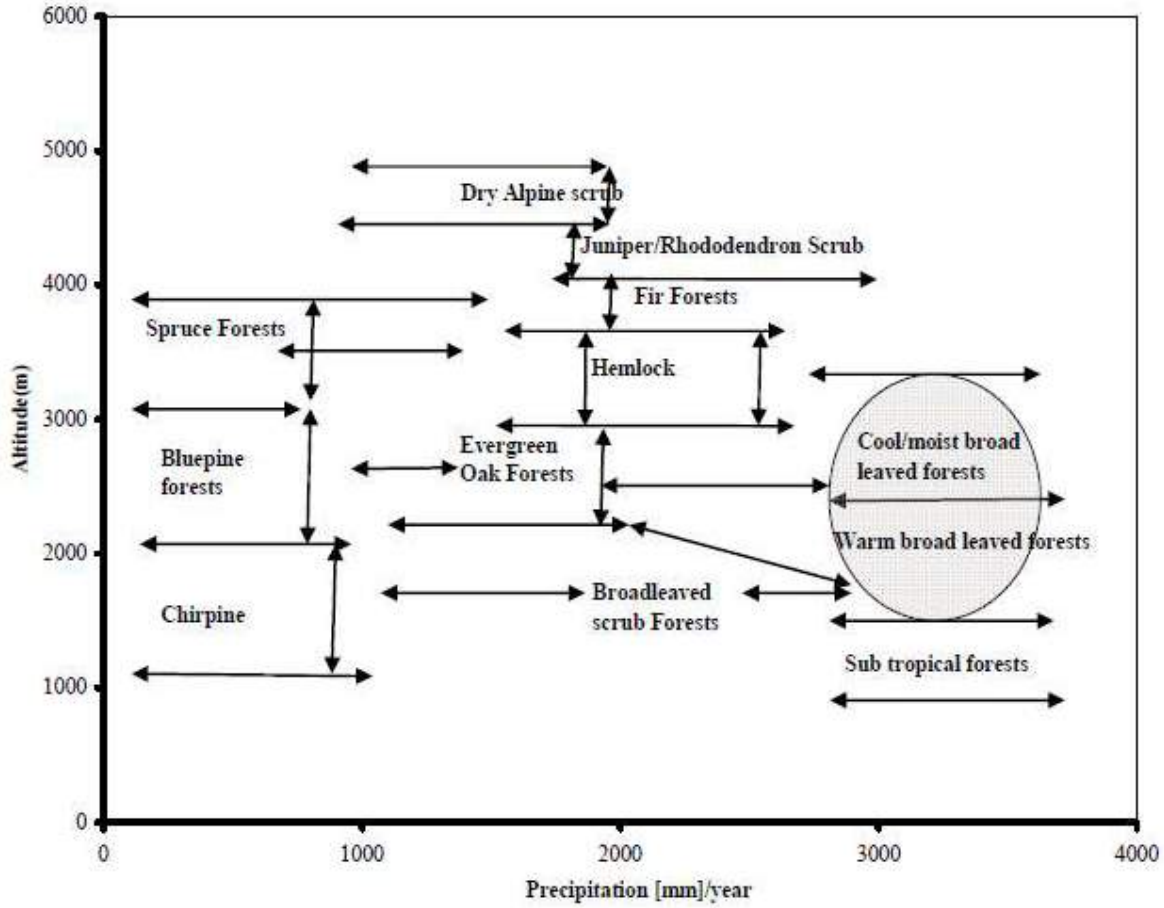


Figure 9: Vegetation zones of Bhutan based on the vegetation classification of Grierson and Long (1983), in relation to altitude and precipitation

The table below shows the allocation of forest types used in the NFI and LULC 2016 with the forest types and AEZs in this study.

Table 1: Allocation of forest types of this study with LULC and NFI forest types

Forest Types – LULC and NFI 2016	Dominant Forest Type – this study	AEZ – this study
Subtropical forest	Broadleaf Forest	Tropical humid
Warm broadleaved forest; Chirpine forest; Mixed conifer	Broadleaf Forest	Temperate humid all year
Cool broadleaved forest, Mixed conifer forest; Blue pine forest	Broadleaf Forest	Temperate humid
Hemlock forest; Fir forest; Juniper-Rhododendron Scrub forest; Evergreen Oak forest;	Conifer Forest	Boreal sub-humid
Spruce forest	Conifer Forest	Boreal moist semi-arid
Fir forest; Blue pine forest	Conifer Forest	Boreal semi-dry

Based on this allocation, weighted average stocking volumes are derived for the forest strata used to estimate carbon stock changes between the year 2000 and 2015.

In the following sections, the results are shown first for forest deforestation and then for forest degradation. Both of these two results sections are structured in the following way:

- Overall results on a national level
- District-wise assessment of deforestation and degradation impacts
- Display of overview maps
- Assessment of deforestation and degradation against the selected variables to identify certain patterns and presentation of results if significant
- Review of deforestation and degradation drivers based on statistical records
- Comparison of spatial results with statistical records of the selected drivers
- Ranking table of drivers based on statistical and spatial results including estimation of GHG emissions

In order to show standardized results, the following terminology is used for the five different categories of forest changes:

1. **Degradation** – this refers to crown cover loss used as proxy indicator for forest degradation
2. **Gain** – this refers to land use change from any non-forest land to forests, be it through plantation or natural regeneration, or restoration
3. **Improve** – This refers to increase of crown cover as a proxy for forest improvement
4. **Loss** – complete deforestation and transition to any other land use (forest to non-forest)
5. **Persist** – No change occurred, forest remained in the same status in terms of crown cover and area

These change categories are further refined into changes of crown cover classes, presented in the all graphs of this results section as illustrated in the following examples:

- Persist > 50 To > 50 – No change, forest remained in dense forest class
- Improve < 30 To 30 -50 – Increase of forest cover from open to medium dense forest
- Degradation > 50 To 30 -50 – Crown cover reduction from dense to medium dense forests
- Degradation 30 -50 To < 30 - Crown cover reduction from medium dense forests to open forests
- Gain 0 To < 30 – Forest gain from non-forest (zero crown cover) to forest
- Loss 30 -50 To 0 – Forest loss from medium dense forest to non-forest (zero crown cover)

Since this study is merely concerned about deforestation and degradation, less emphasis was placed on assessing forest improvement and forest area gains. However, the basic result of forest area gains are shown in the deforestation section and forest improvement are shown in the degradation section.

3.2 Results - Deforestation

3.2.1 Deforestation at the national level

On a national level, this study finds the forest area increased from 2.63 million ha in 2000, to 2.65 million ha in 2010, and 2.70 million ha in 2015. This results in a total forest cover of 70.6% in 2015 which is in line with the forest cover of the LULC project 2016 (70.8%).

Table 2 Total national forest area, deforestation and forest gain results 2000, 2010 and 2015

Year	Area in ha	Total forest cover in %
Forest area 2000	2,632,627	68.6%
Forest area 2010	2,650,306	69.0%
Forest area 2015	2,709,335	70.6%
Changes		
Forest area gain 2000-2015	140,819	
Forest area loss 2000-2015	64,111	
Net change 2000-2015	76,708	
Net annual change 2000-2015	5,114	

Over the 15-year period (2000-2015), 64,111 ha have been deforested while 140,819 ha of forest area were gained. This results in a total net forest area change of 76,708 ha, or an annual increase of 5,114 ha over this period. 36,298 ha of the deforestation can be attributed to the conversion of forest to agriculture. Based on this findings, the forest area in Bhutan has increased in the last 15 years.

3.2.2 Deforestation at District-levels

To identify regional differences in forest area changes in the assessment period, table 3 below displays the forest area gains and losses at the district level as well as the net area changes. The table is ranked according to total forest area losses.

Table 3: Forest area gains and losses at the district level

District	Forest area gain 2000-2015 (ha)	Forest area loss 2000-2015 (ha)	Net change 2000-2015 (ha)
Monggar	5,417	9,338	-3,922
Wangduephodrang	13,494	7,210	6,284
Trashigang	12,445	5,932	6,514
Samdrupjongkhar	11,023	4,752	6,271
Lhuentse	5,628	4,147	1,481
Chhukha	5,553	4,137	1,416
Samtse	8,682	3,963	4,718
Dagana	5,261	3,281	1,980
Paro	7,169	2,887	4,282
Pemagatshel	4,531	2,870	1,661
Punakha	1,851	2,013	-162
Yangtse	6,609	1,998	4,612
Thimphu	8,605	1,927	6,678
Zhemgang	6,508	1,907	4,601
Trongsa	5,709	1,831	3,878
Sarpang	8,286	1,474	6,812
Haa	5,172	1,373	3,799
Bumthang	9,433	1,311	8,122
Tsirang	2,028	1,041	987
Gasa	7,415	718	6,696
Total Bhutan	**140,819**	**64,111**	**76,708**

The three districts with the highest forest area losses are Monggar, Wangduephodrang and Trashigang, Monggar with a net reduction of -3,922 ha, and Punakha with a net reduction of -162 ha are the only two districts, however, where the forest area in total has decreased. In all other districts the forest area has increased

The following map summarizes the deforestation analysis in Bhutan.

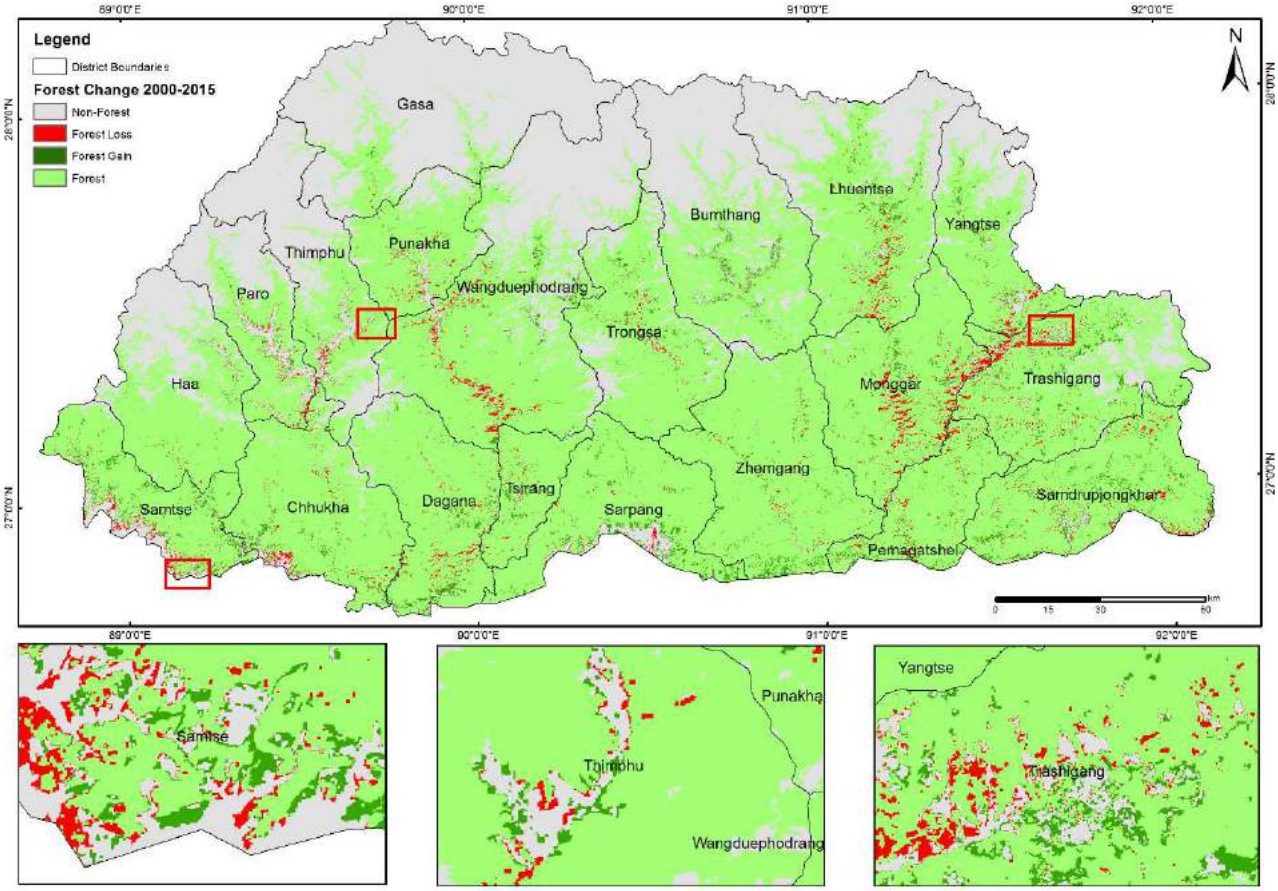


Figure 10: Forest loss and gain 2000-2015

3.2.3 Assessment of deforestation patterns

Assessing the total deforestation 64,111 ha between 2000 and 2015 against the variables defined above in the methodology section, the following conclusions can be drawn:

- Forest types: Between 2000-2015, 75% of the deforestation occurred within broadleaf forest, 13% in mixed forests and 12% in conifer forests, based of the stratification of forest area according to the three different forest types in Bhutan.
- Elevation: 31% of the deforestation occurred in elevations lower than 1,000 m, 40% in the range 1,000 and 2,000 m, and 28% above 2,000 m.
- Slope: 26% of deforestation occurred on land up to 20° slope, 26% deforestation on 20-30°; 25% on 30-40° and 23% on land with slopes >40°.
- Distance to roads: 58% of forest loss occurred within 1 km to the nearest road, 24% within 1-3 km to the road, and 18% of deforestation > 3 km from the nearest road
- Distance to settlements: 67% of the total deforestation occurred nearest to settlements within a buffer of 0-1 km, 17% within 1-2 km distance to settlements, and 18% > 2 km
- Agro-ecological zones: Stratifying forest loss according to the AEZs used in this study: 65% of the loss occurred within the temperate zones of Bhutan, 19% in

tropical/ sub-tropical zone and 17% in cool temperate (boreal) zones.

- Management regimes: Deforestation largely occurred in forest areas outside existing management regimes (FAOEMR). However, 17% of deforestation occurred within protected areas.

3.2.4 Drivers of deforestation

The spatial analysis above has assessed the forest loss in detail. Now, national documentation and statistics are used to identify a number of human activities or immediate actions in Bhutan that directly impact forest loss. They result in forest loss in particular locations, but their overall impact on forest cover on a national basis is muted due to increases in forest cover elsewhere in the country. **Hence, from a land use/land cover change analysis perspective, deforestation is not a discernible land use trend in Bhutan.** National statistics as well as the spatial analysis indicate that it is forest areas outside existing management regimes (such as FMU, CF and Pas) that experience higher deforestation due to conversion to other planned land uses/ activities. Hence, the deforestation in the country can be classified as primarily planned deforestation. The human activities or immediate actions (drivers) of deforestation in the country are discussed in the subsequent sections.

Allotment of State Reserve Forest Land (SRFL) for various purposes

As per the Forest and Nature Conservation Act of Bhutan, 1995, all forests were declared to be Government Reserve Forests (GRF) (National Assembly of Bhutan, 1995), however with the most recent Forest and Nature Conservation Rules and Regulations of 2017, GRF forest is now referred to as "State Reserved Forest Land (SRFL)" (RGoB, 2017). Following the enactment of the Land Act 2007, forests grown on private land are now legally private property. The Forest and Nature Conservation Act of Bhutan, 1995 further stipulates that the National Assembly or His Majesty The King may direct that any land ceases to be SRFL. In practice, the institution that actually allots land for different development purposes, e.g., infrastructure, agriculture, etc. is the National Land Commission. In addition, His Majesty The King can grant SRFL as "Kidu" (free land) to people, and such land can be registered as private lands. Community forests also legally fall under SRFL: the community forest management groups have resource management and use rights, but land ownership lies with the state. (RGoB, 2016c; RGoB, 2007a).

According to statistics reported in the Forest Facts and Figures of the Ministry of Agriculture and Forests (see Table 4), every year the government allots thousands of hectares of SRFL to various purposes/uses, resulting in substantial forest loss. The quantities and purposes of these allocations vary from year to year. Generally, the purposes are classified in the statistics as follows:

- **Lease:** SRFL allotted to large projects such as hydro power, private commercial farming, mining, quarrying etc.;
- **Government institutions and Municipality:** SRFL allotted to government institutions for various uses;
- **Satshab/land substitution:** SRFL allotted as compensation for private registered land acquired for developmental purpose;

- Religious institution: SRFL allotted to religious institutions for various uses;
- **Kidu land allotment:** SRFL allotted as a royal prerogative – usually to households for their own use;
- **Land exchange:** exchange of registered land with SRFL under circumstances such as: scattered land inside state reserve forests; land destroyed by natural calamities; secluded areas with crops exposed to damages by wild animals; and private registered land falling within critical watershed areas; and
- Other SRFL allotment: SRFL allotted for other various unspecified purposes.

The allotment statistics for roads and transmission lines have been excluded from this list and this driver assessment since these statistics are used specifically for the respective drivers 'roads' and 'transmission lines' (see below).

Table 4 presents estimates of SRFL allotments for different purposes in the period 2008 to 2014 derived from various national reports that present annual forest facts and figures. The statistics do not allow for differentiation between how much SRFL allotted had forest on it, and how much was not covered by forest. By definition SRFL is largely forest, but a forest may include a water body and/or non-vegetated land cover classes.

Table 4: Estimates of state reserve forestland allotted to various purposes in 2008 to 2014 (ha)

Purpose of allotment	2008	2009	2010	2011	2012	2013	2014	Total	% of total	Annual average
Lease	1,013	376	1,950	895	478	453	1,327	6,491	51.2%	927
Government institutions	333	317	178	465	212	81		1,586	12.5%	264
Lhakhang	11	8	6	3	4			33	0.3%	7
Satshab/land substitution	129	104	162	117	103	2,170	123	2,908	22.9%	415
Religious institution						44		44	0.3%	44
Kidu land allotment	19	14	21	26	129	11	24	245	1.9%	35
Land exchange	32	18	15	6	6			77	0.6%	15
Other SRFL allotment	136	101	137	192	228	496		1,290	10.2%	215
Annual total	1,674	938	2,470	1,705	1,158	3,254	1,474	12,674	100.0%	1,923

Sources: Katwal et al., 2011; Department of Forest and Park Services /Ministry of Agriculture and Forests, 2013; 2014; and 2015

**Values are in hectares. It is important to note that the classification of allotment purpose have not been exactly consistent throughout the years; hence, some purposes may not be correctly represented in the national statistics, e.g., they may be named differently or combined with others. Also it has not been possible to determine exactly if all SRFL allotted were vegetated forest land.*

According to the statistics in Table 4 above, a total of 12,674 ha of SRFL have been allotted for various purposes between 2008-2014, translating into an annual average of 1,923 ha. Allotments for lease constitute slightly over half of all SRFL allotments

between 2008-2014, followed by allotments for satshab/ land substitution, government institutions, and other SRFL allotment, i.e., allotment for various unspecified purposes, in that order.

This driver has to be considered slightly different compared to the subsequent deforestation drivers since some of the categories of allotment (e.g. other SRFL allotment, land lease, etc.) most likely include land allotments for the drivers mentioned below, in particular allotment for agriculture purposes or hydropower. As already mentioned the allotment statistics for roads and transmission lines are specifically excluded under this driver.

Agriculture

The spatial analysis of this study showed that 50,878 ha of forest has been converted to agriculture in the assessment period 2000 to 2015. To validate this figure this data was aligned with the LULC 2016 dataset in order to exclude any misclassification. After this process, a total of 36,298 ha are found to have been converted to agriculture between 2000-2015, with a highly significant trend in the last 5 years, as more than 90% of this conversion occurred between 2010 – 2015. This total conversion (2010-2015) from forest to agriculture can be further classified according to LULC 2016 dataset:

- Chhuzhing (wet land agriculture) – 8,303 ha
- Kamzhing (dry land) – 25,690 ha
- Orchard – 2,304 ha

86% of this conversion was located within the tropical and temperate AEZs of this study.

During the same time, 24,631 ha have been converted from agriculture back to forests. This results in a net loss of 11,667 ha forests to agriculture, or 778 ha annually. It has to be noted that the agriculture driver is overlapping with the driver 'allotment of State Reserve Forest Land for various purposes' since significant forest areas allotted are converted into agriculture.

Agricultural projection is changing, given increasing interest in leasing for cardamom and other uses. But there are also increasing concerns over urbanization spreading into paddy lands, given their suitability for development with so few flat areas in the country. These issues will be further discussed in the underlying driver section, as they will likely have greater impact in the future.

The National Action Program to Combat Land Degradation observed that unsustainable agriculture practices exist mainly in the form of imbalanced and prolonged use of inorganic fertilizers, farming on steep terrain without adequate soil and water conservation measures, and tseri cultivation with shortened fallow cycle. Construction of earthen irrigation canals in places where the soil is highly erodible, and poor maintenance and management of irrigation systems cause downward movement of slopes (NSSC, 2014).

Hydropower projects

Bhutan's energy mix consists primarily of firewood and hydropower. Both energy sources directly affect Bhutan's forests. Most projects constructed to date are run-of-river projects; however, many have some storage and tunnels to divert flows out of the river channel, access roads, and related transmission line development. NEC's State of the Environment Report identified that pressure on SRFL comes mainly from the demand for infrastructure for development (both hydroelectricity and roads) and mining. Data on permits issued for use of SRFL between 2008 to 2014 show that the highest demand for land was for infrastructure development in the form of rights-of-way for power transmission lines (9,426.16 ha), road construction (5,462.04 ha) and long-term land leases (RGoB, 2016a).

About 99.5% of electricity in Bhutan is estimated to be generated from hydropower – with the remaining portion generated from diesel power generating plants (Lean and Smyth, 2014). Roughly 75% of electricity generated in Bhutan is exported to India (ibid), and this is expected to increase given the hydropower sector development plans. A number of hydropower projects such as Chukha (336 MW), Kurichu (60 MW) and Tala (1020 MW) have been implemented with financial and technical assistance from India (see full list below). Bhutan requires about 300 MW of the 1,606 MW it currently generates. The huge surplus of hydropower generated in the peak season is exported to India, while in the winter lean season, Bhutan imports electricity from India.

The country has four major river systems: the Ammochu, Manas, Sunkosh, and Wangchu, hence, has substantial hydropower potential, which is estimated at about 30,000 MW. The RGoB is undertaking ambitious efforts to explore this potential and currently harnesses about 5% to 6% of its hydropower potential, according to the Asian Development Bank. There are a number of operational hydropower projects across the country, while others are under construction or planned/proposed (Annex 1).

In July 2006, India and Bhutan signed a framework agreement on hydropower development and trade, seeking to develop 10,000 MW of hydropower from 10 large projects. By 2014, the interest to reach the "10,000 MW by 2020" target was dampened, with recognition that the target itself is not achievable, and there is a need for increased evaluation of the social and environmental impacts (DGPC, 2014). However, 2014 also saw India and Bhutan reach an agreement to jointly promote hydropower development in four projects totalling 2,120 MW (RGoB and GoRI, 2014).

The public benefits and risks of hydropower development is further explored in the underlying driver section. This section focuses on the impacts hydropower projects have on forests. For every hydropower project executed, significant forests areas are lost. The figures vary depending on the locations and size of the infrastructure of the hydropower project, i.e., the dam itself and the ancillaries. In Table 5, we present recent hydropower projects, and the forests areas affected, which average about 272 ha per hydropower – though there are wide variations between the smallest project and the largest one. Based on those estimates, one could infer that on average, 0.4 to 0.8 hectares of forest are lost for every megawatt (MW) generation capacity, or an average basis, 0.5 ha of forest for every MW generation capacity. The figures in the table below also indicates that hydropower projects in Bhutan are obviously located in forested areas.

Table 5: Forest areas estimated to be lost due to a selection of hydropower projects

Name of hydropower project	Estimated power generation capacity (MW)	Total area affected (ha)	Forest area affected (ha)	% forest area	Forest area affected per MW
Dagachhu	126	83	60	72%	0.5
Mangdechhu	720	325	297	91%	0.4
Nikachu	118	101	100	99%	0.8
Baso chuu	64	N/A	N/A	N/A	N/A
Kurichhu	60	N/A	N/A	N/A	N/A
Chukha	336	N/A	N/A	N/A	N/A
Tala	1,020	N/A	N/A	N/A	N/A
PHPA I	1,200	561	491*	N/A	0.4
PHPA II	1,020	412	361*	N/A	0.4
Kholongchu	600	369	323*	N/A	0.5
Total / Average	5,264 / 526	1,851 / 309	1,632 / 272	/ 88%	0.5

Sources: All values are derived from respective project documents, i.e., EIA, ESIA, and project report

** The forest area affected could not be derived from documentation; therefore the average proportion of 88% is applied to estimate the forest area affected for these three projects*

Roads

According to the Asian Development Bank (ADB), a key development partner of the country, lack of accessibility and physical isolation is a major cause of poverty in Bhutan. The country's road network coverage is limited and unable to meet a growing transportation demands. Limited coverage of feeder roads also contributes to isolation of remote rural areas – further limiting economic prospects for the people.

Hence, the ADB has been supporting the Bhutan Road Network Project to improve the country's road infrastructure. In general, there is continuous and strong emphasis by both the Royal Government Bhutan (RGoB) and development partners to improve road infrastructure. Due to high forest cover, road construction is inescapably resulting into substantial deforestation in the country, particularly where roads are being built in forested landscapes. Because of the importance of road infrastructure to national development, every year the RGoB allots substantial areas of SRFL for road construction.

The extent of forests lost due to road construction depends on the right-of-way of the roads, which differs from one road type/class to another as specified in the Bhutan road design standards by the Ministry of Works and Human Settlement.

The SRFL allotted for road construction that are reported in national statistics for 2008 to 2014 are presented in Figure 24 below.

Source: From Forests Facts and Figures publications by Ministry of Agriculture and Forests (see section 4.)

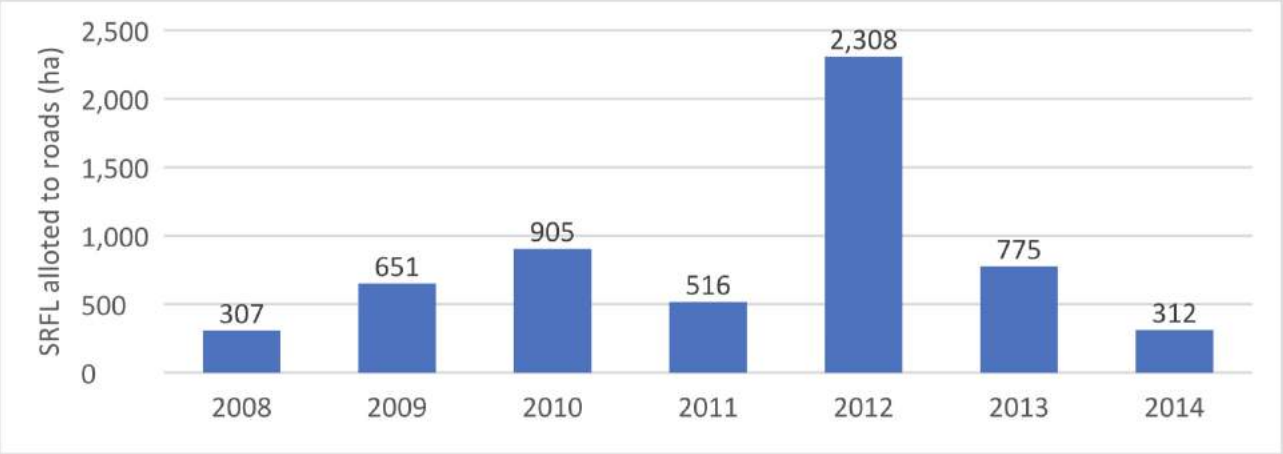


Figure 11: State reserve forest land allotted to roads in the year 2008 to 2014

Over the period 2008-2014, a total of about 5,770 ha of SRFL were allotted to road construction, which translates to an annual average of 820 ha. While there is considerable annual fluctuation, the current magnitudes of SRFL allotment for road construction is expected to continue since road infrastructure continue to be among the top development priorities of the RGoB and development partners. The density of road has been estimated to have doubled from about 1.5 km/km² in 2005 to 3 km/km² in 2011 (National Statistics Bureau, 2014).

It has been noted that infrastructure development such as construction of roads using heavy machinery and cutting of steep slopes is environmentally challenging in Bhutan's steep topography and fragile geological conditions. The quality of farm roads in particular is of concern given that most are earthen roads, poorly engineered, built at minimal cost, and with little to no maintenance. In addition, migrant road workers are often brought in to build roads, adding to the demographic pressures on surrounding forests and water (NSSC, 2014).

The country's Eleventh Five Year Plan (for the period 2013-2018) places ample emphasis on road infrastructure, which is also linked to other development priorities such as hydropower projects. About 31% of the rural population still resides one hour in walking distance from a road head, and thus the 11th Five-Year Plan seeks to increase access for more people. There are plans to upgrade and build national highways, and roads connecting to hydropower projects, districts (Dzongkhag), etc. Roads access is also intended to improve social services and economic prospects by practically linking almost every village in the country (Royal Government of Bhutan, 2013).

Power lines

Power lines are directly linked to hydropower developments projects. Forests are cleared to provide right-of-way and the width differs according to the voltages of the transmission line (Bhutan Power Corporation, 2016), ranging from 4 to 52 m (Table 10). Hence, a 4 - 52 m buffer has to be cleared along transmission lines for safety reasons. When multiplied by the extensive lengths of such lines, this results in substantial loss of forests.

Supply of energy is indisputably a key development priority of the RGoB. Hence, every year, the government allots large areas of SRFL for transmission lines – resulting into substantial forest loss. The quantities of SRFL allotted for transmission lines that are reported in national statistics for the year 2008 to 2014 are presented in Figure 12 below.

Table 6: Right-of-way for electricity transmission lines

System voltage (kV)	Right of way (m)
LV line	4
11	9
33	12
66	18
132	27
220	35
400	52

Source: Bhutan Power Corporation, 2016.

Source: From Forests Facts and Figures publications by Ministry of Agriculture and Forests (see section 4.)

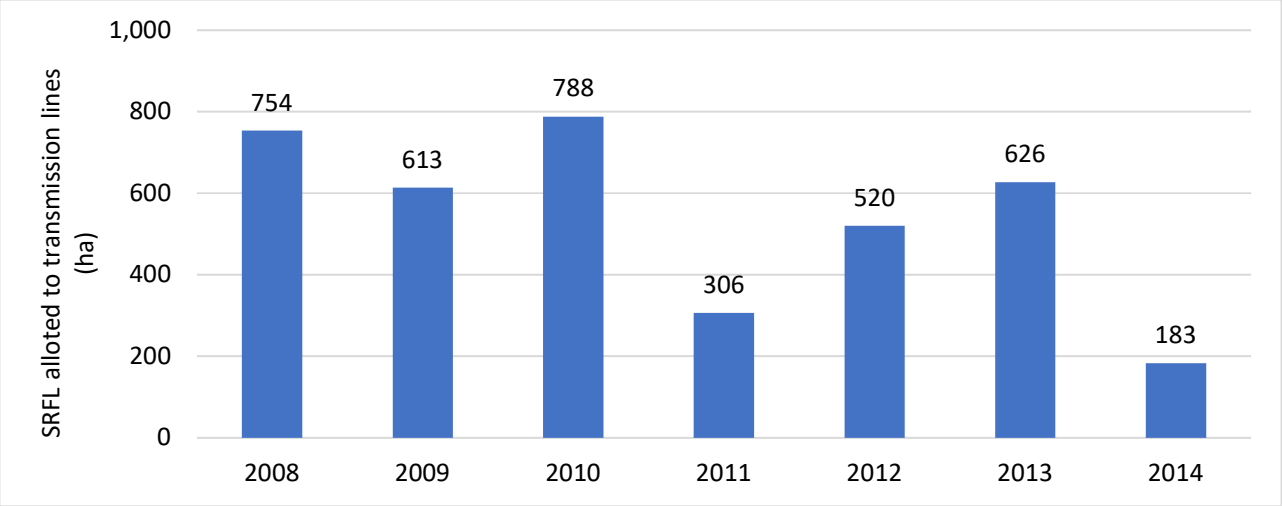


Figure 12: State reserve forests land allotted to transmission lines in 2008 to 2014

A total of 3,791ha of SRFL were lost due to rights of way for transmission lines and erection of pylons over the period 2008-2014, which converts to an annual average of 542 ha. The figures show annual fluctuations, with 2014 having the lowest number.

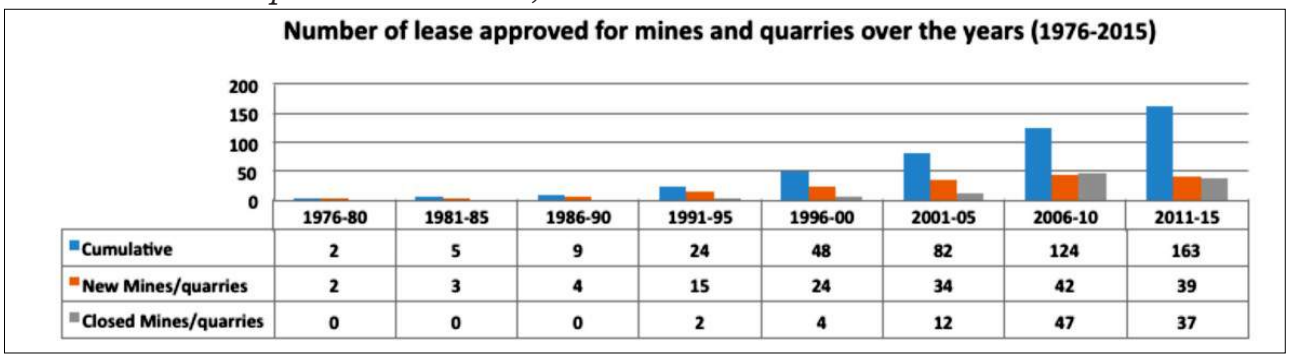
Mines and Quarries

The National Environmental Commission (NEC) State of the Environment Report identified mining as exerting significant pressure on SRFL. Permits issued for the use of SRFL for long term leases for mining amounting to roughly 3,800 ha out of the total of 5,207.67 ha leased between 2008 to 2014 (RGoB, 2016a). As of 2015, there were 48 active mines and quarries operating in Bhutan, of which 26 were stone quarries, and 22 were mineral mines. Minerals found in Bhutan are limestone, talc, gypsum, quartzite,

granite, marble, dolomite, coal, and iron ore. Current active mines and quarries are largely concentrated in western Bhutan (42%) with the largest number in Thimphu (7), Wangduephodrang (7) and Paro (6). The Southern region has 35% with the maximum in Samtse (11). The Eastern region has 19% with the highest number in Pemagatshel (6) (Anti-Corruption Commission, 2016).

Dolomite and gypsum mining is increasing, with dolomite production increasing from 0.39 to 1.50 MMT between 2002 and 2012, while gypsum increased from 0.11 to 0.31 MMT. Gravel, sand and rock mining also exist, supporting road construction and development.

Source: Anti-Corruption Commission, 2016



	1976-80	1981-85	1986-90	1991-95	1996-00	2001-05	2006-10	2011-15
Cumulative	2	5	9	24	48	82	124	163
New Mines/quarries	2	3	4	15	24	34	42	39
Closed Mines/quarries	0	0	0	2	4	12	47	37

Figure 13: Growth in total number of mines leased and closed (1976-2015)

Mining requires road development to access mine sites, and involve excavation. Significant adverse impacts of mining are land disturbance and fissure development from drilling, blasting, excavation, site clearing, destruction of vegetation, sedimentation, contamination of water and air with dust particles – affecting human health and impacting livelihoods through decline in agriculture production (NSSC, 2014).

3.2.5 Comparison statistical records with spatial results

The table below summarizes and compares the statistical records of deforestation attributed to the different drivers identified above against the spatial analysis. Figures are presented as an annual average of deforestation to account for the difference of the reference period used for the review and spatial analysis.

Table 7: Statistical records of deforestation 2000-2015 attributed to the different drivers

Driver	Statistical records of annual deforestation (ha/year)	Spatial analysis of annual deforestation (ha/year)
SRF land allotment for various purposes (excl. roads & transmission lines)	1,923	3,496
Hydropower projects	1,880	
Roads	820	
Mines and Quarry.	633	
Power lines	542	
Agriculture	No records	778
Total annual deforestation	5,798	4,274

The total annual deforestation of the statistical records of all drivers in Table 7 is 5,798 ha compared to 4,274 ha of total annual deforestation based on the spatial analysis. Taking into account that the driver 'allotment for various purposes' significantly overlaps with the annual deforestation areas in particular for agriculture, and hydropower, the total deforestation from statistical records without the SRFL allotment and the spatial results for agriculture amounts to 3,875 ha which is only marginally lower than the overall estimated annual deforestation estimated in the GIS study (4,274 ha).

3.2.6 Ranking of deforestation drivers

The ranking of drivers of deforestation is presented below, based on the extent of forest areas estimated to be affected annually by the drivers which was identified in the previous table. In addition, the annual GHG emissions are estimated based on the average carbon stock density calculated in section 3.4 (Scenario 2, year 2000).

Table 8: Ranking of deforestation drivers

Driver	Area affected annually (ha/ year)	Annual GHG emissions as a result of forest area loss (tCO2 e/ year)	Ranking in extent of deforestation
SRF land allotment for various purposes	1,923	604,852	1st
Hydropower projects	1,880	591,327	2nd
Roads	820	257,919	3rd
Agriculture	778	244,709	4th
Mines and quarries	633	199,101	5th
Power lines	542	170,478	6th

Stakeholder consultation workshops were organized for the three different regions in Bhutan, i.e. South Central, East and West. Representatives from different sectors were invited from each region to identify and rank their regional drivers of deforestation and degradation. In addition, Tarayana Foundation was commissioned to conduct local stakeholder meetings in various villages throughout Bhutan. Figure 14 summarizes the total scoring from all regions for the identified top 5 drivers of deforestation. A higher scoring indicates a higher rank of a particular driver. Apart from the present scoring and ranking, stakeholders were also asked to score the potential future impacts of the same drivers.

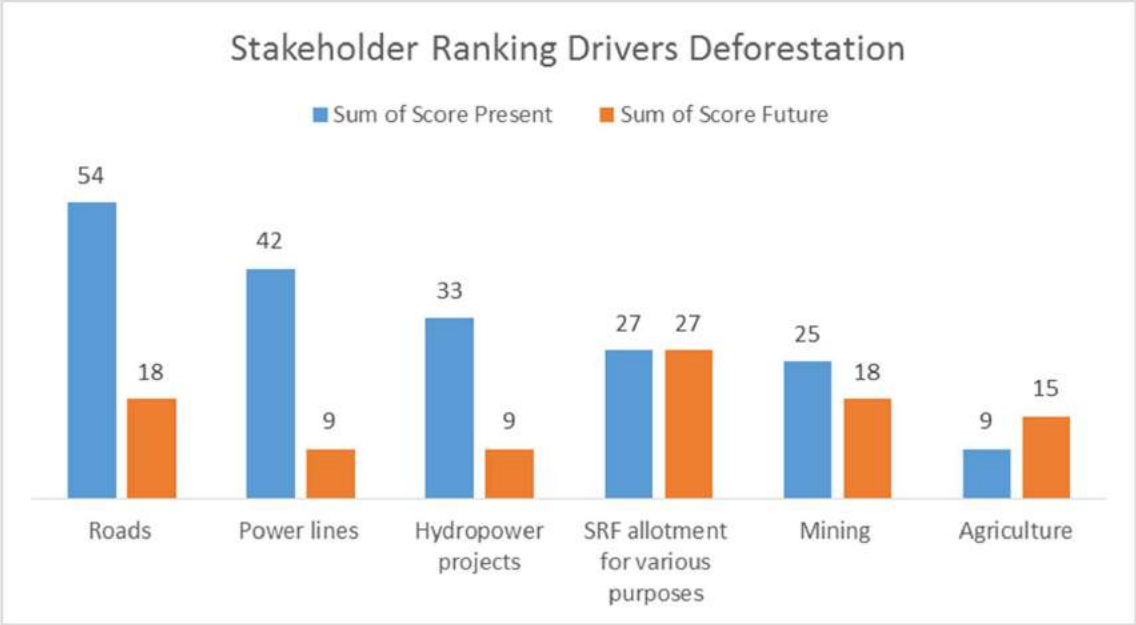


Figure 14 summary present and future impact scoring of drivers of deforestation as a result of exercises during regional consultation workshops

Stakeholders ranked the No 1 direct driver of deforestation as roads, followed by power lines, and hydropower projects. The rankings by stakeholders for both deforestation and degradation is based on the perceptions of people and the knowledge that they have of patterns in their region, and not necessarily on objective data. The allotment of SRFL, identified as No 1 driver in this study, is ranked only forth by the stakeholders. Assessing the ranking of the same drivers in the future, however, identified allotment of SRFL as well as mining and agriculture as the highest ranking drivers. This was justified by the future development of commercial agriculture leading to higher risk of deforestation.

3.3. Results - forest degradation

3.3.1 Summary national results of Degradation

In contrast to the results from deforestation in Bhutan which shows a forest cover increase, the findings of this degradation study suggest that forest degradation is occurring to some extent.

Table 9: Total national degradation (crown cover decrease) and improvement (crown cover increase) results 2000, 2010 and 2015

Change and period	Area affected in ha
Degradation 2000-2010	768,802
Degradation 2010-2015	573,484
Degradation 2000-2015	667,680
Improvement 2000-2010	542,928
Improvement 2010-2015	589,379
Improvement 2000-2015	456,794
Net change 2000-2015	-210,886
Net annual change 2000-2015	-14,059

Change and period

Considering the improvement of forest crown cover, the net degradation accounts for 210,886 ha of forest, or an annual average of 14,059 ha over the assessment period.

Table 10 below displays the crown cover percentage of each crown cover class (open, medium, dense) out of the total forest area in the three different years assessed.

Table 10: Forest crown cover classes in % of total forest areas in Bhutan and changes between 2000 and 2015

Forest Crown Cover (CC) Classes	Open Forest (10-30%)	Medium Forest (30-50%)	Dense Forests (>50%)	Total Forest Area (Ha)
CC Year 2000	9.5%	39.9%	50.6%	2,632,627
CC Year 2010	27.9%	17.3%	54.8%	2,650,306
CC Year 2015	23.9%	25.7%	50.5%	2,709,335

The share of dense forests remains remarkably high and is more than 50% of the total forest area in Bhutan. As a comparison, in the Indian State of Sikkim with similar altitudinal and ecological ranges, the forest cover of dense forests is around 15% (Forest Survey of India 2015). Significant changes have taken place in the other two crown cover classes. The area under medium dense forests (30-50% crown cover) has decreased from 40% in 2000 to only 26% in 2015 while the open, degraded forest class (10-30% crown cover) has increased from 10% to as much as 24% in 2015. This is a clear sign of degradation in some of the forests.

3.3.2 District level assessment of degradation

Figure 15 below summarizes the total forest area changes in the last 5 years based on the change categories and crown cover classes. It is presented as % shares of the total forest area in 2010 which changed or remained within these categories and classes.

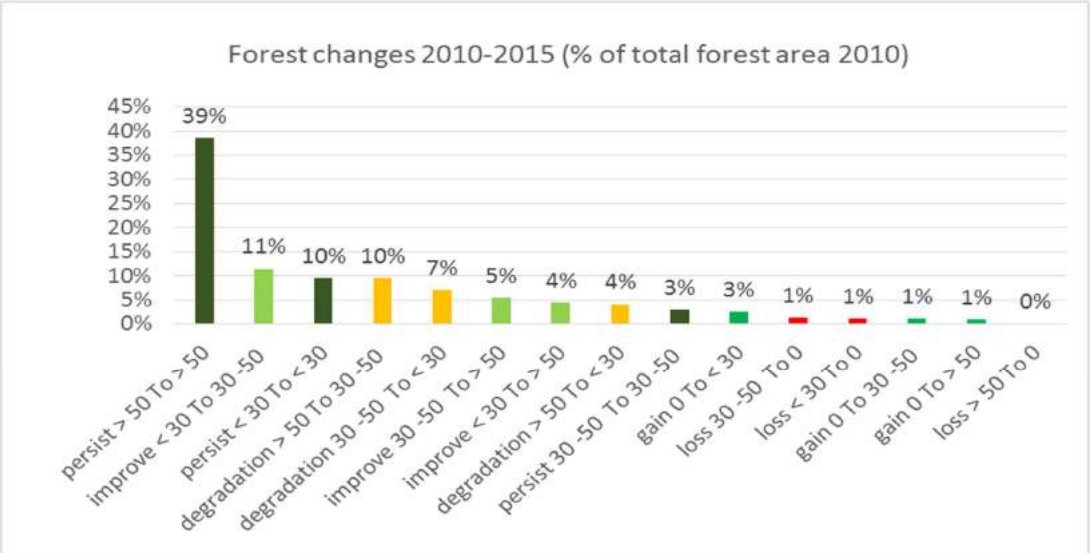
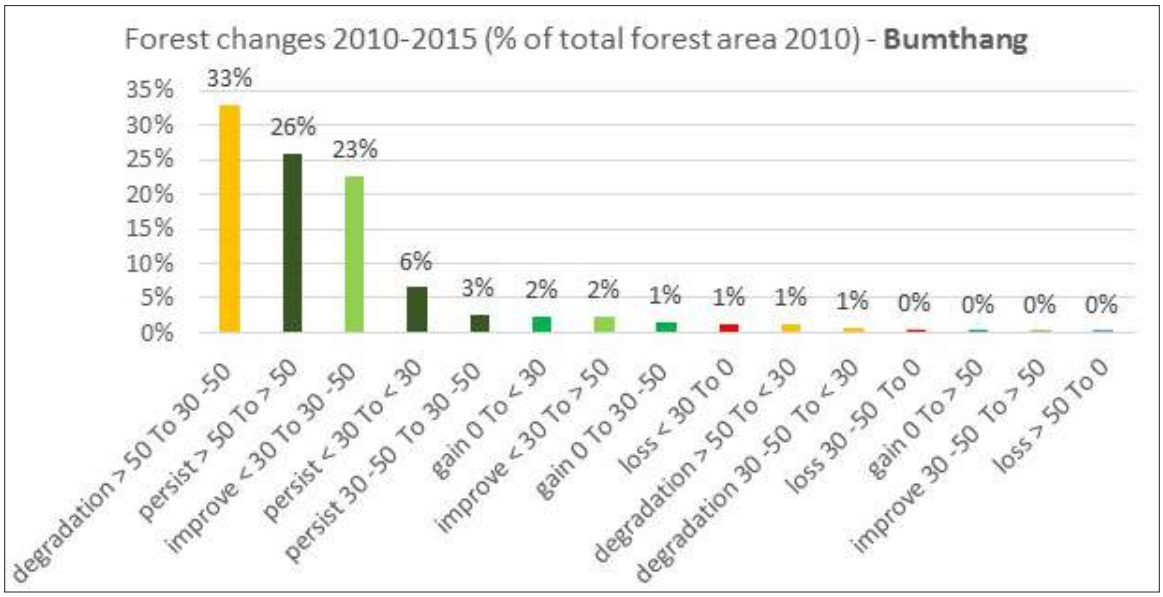
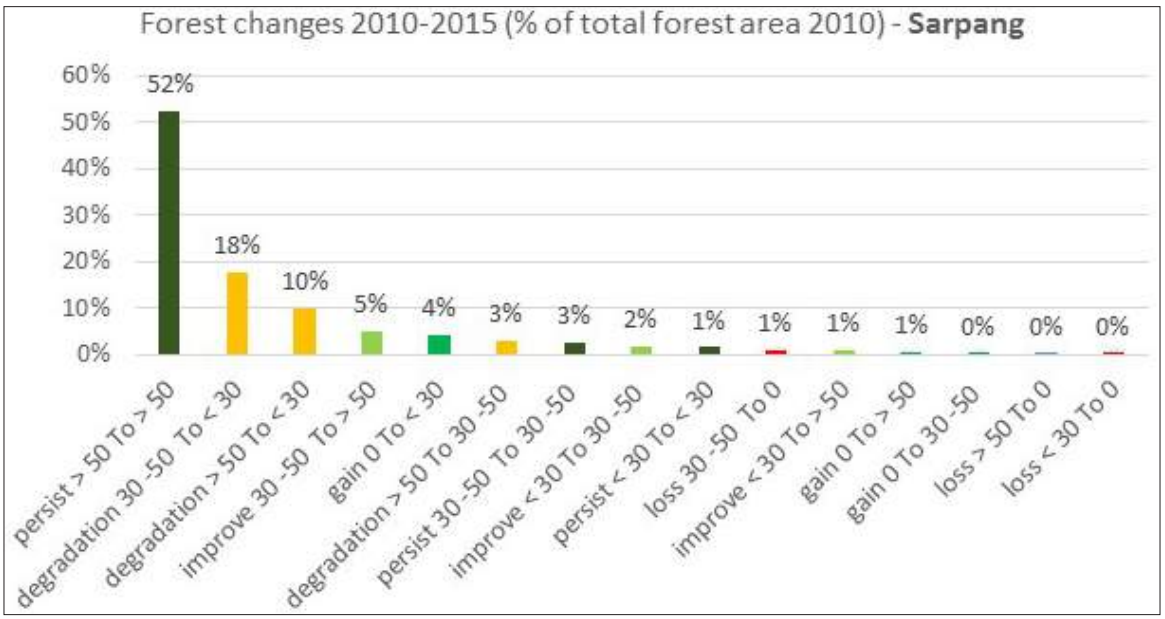


Figure 15: Percent of total forest area in Bhutan in 2010 persisted or changed to 2015, different change categories (numbers represent crown cover classes);example: 39% of the total forest area in 2010 in Bhutan persisted in the dense crown cover class (>50% crown cover), while 11% improved from open to medium-dense forests

As shown in the figure, most forest areas in Bhutan either remain (persist) within the initial forest crown cover class or improve to more dense forests. In contrast to this positive forest development, the degradation of forests towards more open crown cover classes should be equally considered significant; and the volume and carbon stock change analysis (see section 3.4) is giving more insights into the changes occurring within Bhutan's forests in terms of quality rather than just the quantitative (forest cover) assessment. If broken down to a district level, significant different patterns of forest changes can be observed for the same assessment period 2010-2015 between different districts. Exemplarily, four districts are presented below representing the main parts of Bhutan:





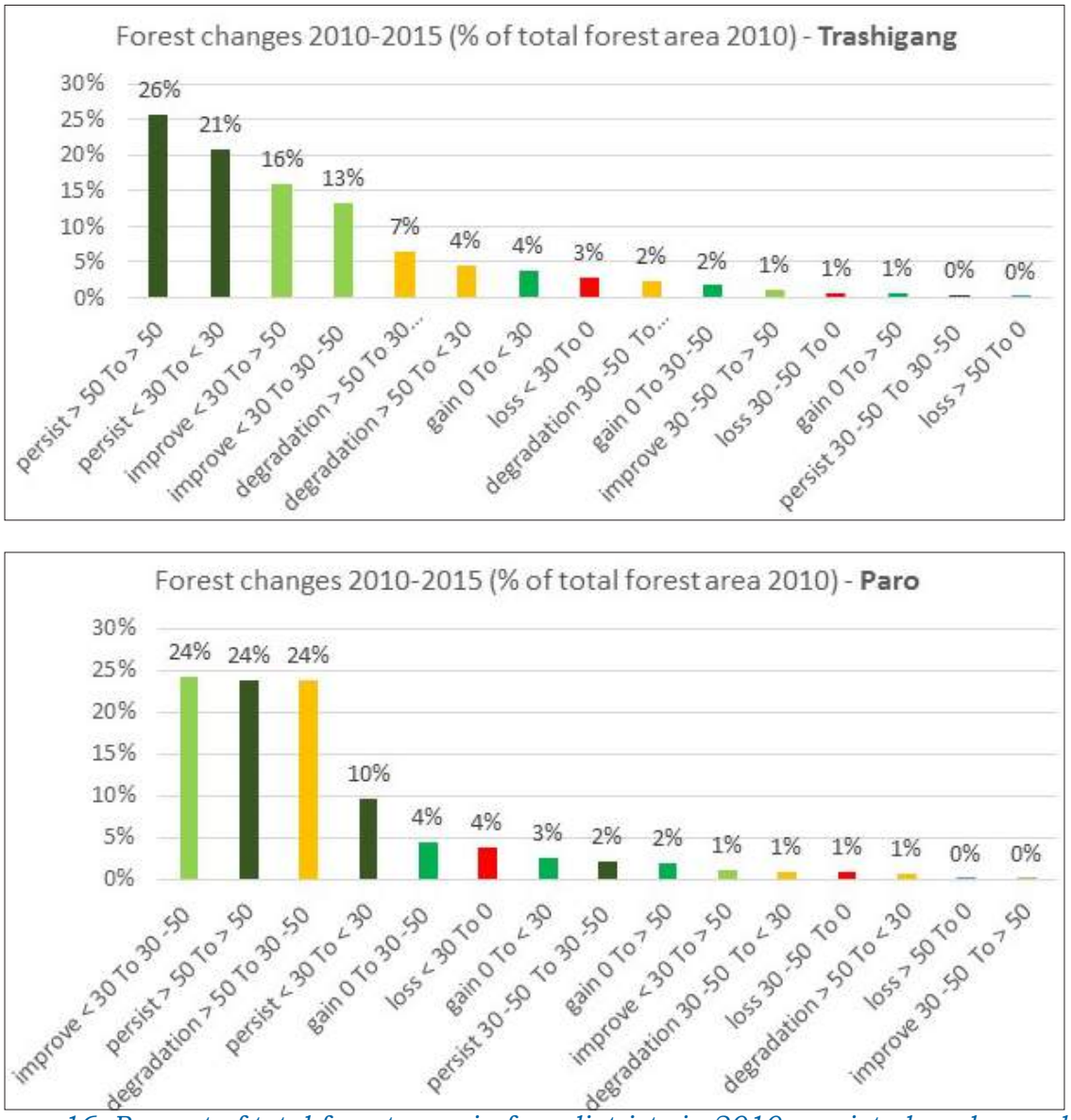


Figure 16: Percent of total forest area in four districts in 2010 persisted or changed to 2015, different change categories (numbers represent crown cover classes)

Table 11 summarizes the three main forest changes related to forest quality which occurred in each of the districts between 2010 and 2015 in percent of the total forest area of that particular district. A colour coding is used to illustrate a hotspot of forest degradation: 'Green' indicates no or positive changes, i.e. persisting forest areas with the same crown cover ('persist') or increasing crown cover ('improve'); 'yellow' indicates occurrence of degradation, however, crown cover decrease from dense to medium dense forests; 'red' highlights those districts with significant degradation from dense or medium dense forest to open forests. As this is a national-level assessment, district-level data is quite coarse and should only be used to identify initial hotspot areas, which then require further 'ground-truthing' and more detailed assessment of local drivers. For instance, the table below identifies Monggar as a hotspot, but further analysis identified strong degradation patterns that led for further deforestation, and poorly vegetated forest areas in fragile, steep southern facing slopes. The table is presented in alphabetical order.

Table 11: Major district-wise forest changes between 2010 and 2015 and assessment of hotspot districts

District	The three main forest changes occurred 2010-2015 (in % of total forest area of that district)	Hotspot identification
Bumthang	• degradation > 50 To 30 -50; 33% • persist > 50 To > 50; 26% • improve < 30 To 30 -50; 23%	
Chhukha	• persist > 50 To > 50; 45% • degradation > 50 To 30 -50 ; 10% • improve < 30 To 30 -50; 9%	
Dagana	• persist > 50 To > 50; 44% • degradation 30 -50 To < 30; 14% • improve < 30 To 30 -50; 9%	
Gasa	• improve < 30 To 30 -50; 28% • persist < 30 To < 30; 15% • degradation > 50 To 30 -50 ; 14%	
Haa	• persist > 50 To > 50; 38% • improve < 30 To 30 -50; 20% • degradation > 50 To 30 -50; 15%	
Lhuentse	• persist > 50 To > 50; 31% • persist < 30 To < 30; 20% • improve < 30 To > 50; 10%	
Monggar	• persist > 50 To > 50; 41% • persist < 30 To < 30;12% • degradation 30 -50 To < 30; 10%	
Paro	• improve < 30 To 30 -50; 24% • persist > 50 To > 50; 24% • degradation > 50 To 30 -50; 24%	
Pemagatshel	• persist > 50 To > 50; 48% • improve 30 -50 To > 50; 18% • degradation 30 -50 To < 30; 14%	
Punakha	• persist > 50 To > 50; 35% • improve < 30 To 30 -50; 24% • degradation > 50 To 30 -50; 16%	
Samdrupjongkhar	• persist > 50 To > 50; 45% • improve 30 -50 To > 50; 15% • degradation 30 -50 To < 30; 13%	
Samtse	• persist > 50 To > 50; 29% • degradation 30 -50 To < 30; 21% • improve 30 -50 To > 50; 17% • degradation > 50 To < 30; 10%	
Thimphu	• degradation > 50 To 30 -50; 27% • persist > 50 To > 50; 23% • improve < 30 To 30 -50; 23%	
Trashigang	• persist > 50 To > 50; 26% • persist < 30 To < 30; 21% • improve < 30 To > 50; 16%	

Trongsa	• persist > 50 To > 50; 37% • improve < 30 To 30 -50; 22% • persist < 30 To < 30; 14%	
Tsirang	• persist > 50 To > 50; 56% • degradation 30 -50 To < 30; 10% • improve 30 -50 To > 50; 7%	
Wangduephodrang	• persist > 50 To > 50; 37% • improve < 30 To 30 -50; 19% • degradation > 50 To 30 -50; 15%	
Yangtse	• persist > 50 To > 50; 24% • persist < 30 To < 30; 20% • improve < 30 To 30 -50; 16%	
Zhemgang	• persist > 50 To > 50; 57% • improve 30 -50 To > 50; 12% • degradation 30 -50 To < 30; 7%	

All the districts flagged red are located in the southern tropical or warm temperate zones dominated by broadleaf forests.

The following map summarizes the qualitative change of forests in Bhutan.

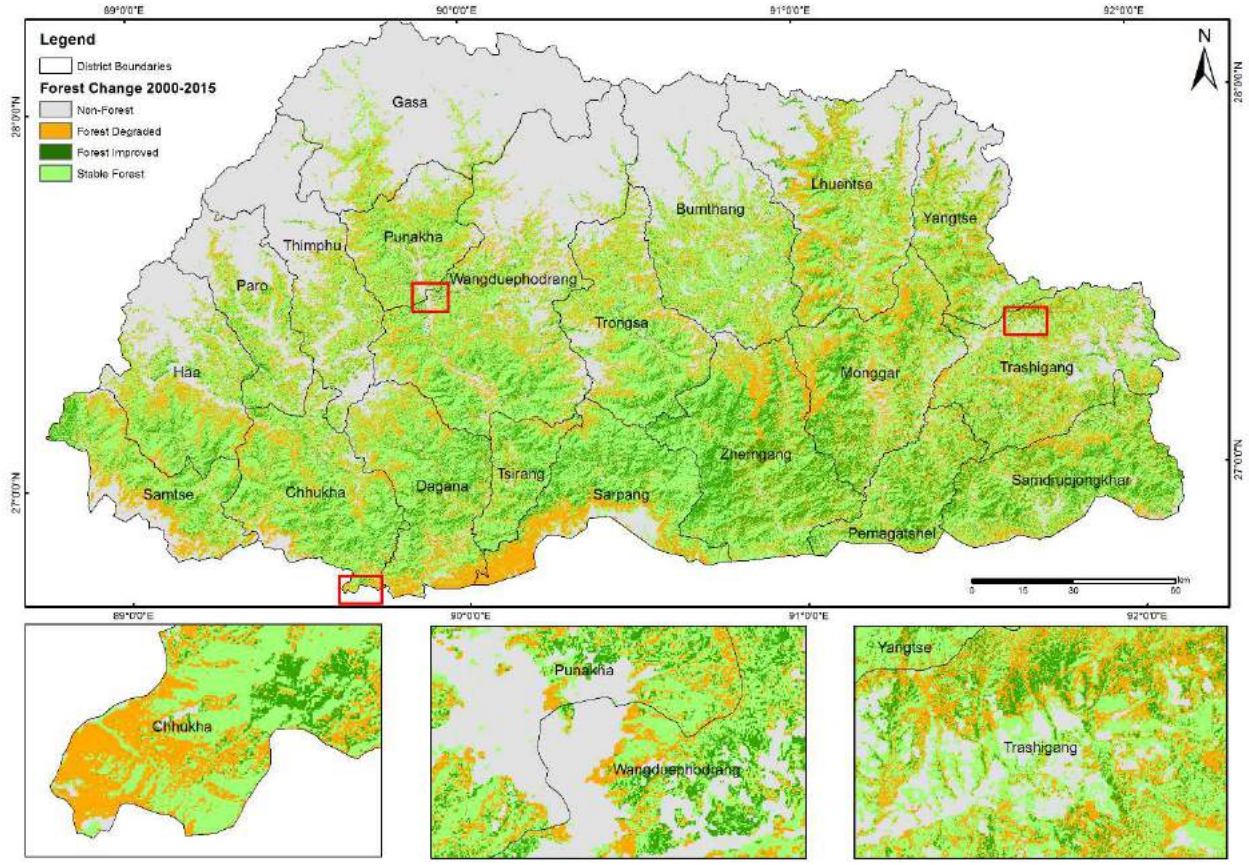


Figure 17: Forest degradation and improvement 2000-2015

3.3.3 Assessment of degradation patterns

Assessing the total degradation of 667,680 ha between 2000 and 2015 against the variables defined above in the methodology section, the following conclusions can be drawn:

- Forest types: Stratifying the forest area in Bhutan according to the three different forest types used in this study, 50% of the degradation in the assessment period 2000-2015 occurred within broadleaf forest, 48% within conifer forests and 2% within mixed forests. Table 13 shows that the majority of degradation within the broadleaf forest class occurred towards open forests while degradation in confer forests occurred from dense to medium dense forests.

Table 12: Area shares of forest degradation depending on forest type and crown cover change

Row Labels	Degradation 30 -50 To < 30	Degradation > 50 To 30 -50	Degradation > 50 To < 30
Broadleaf Forest	22%	7%	21%
Conifer Forest	19%	24%	5%
Mixed Forest	1%	1%	0%

- Elevation: 34% of the total degradation occurred in altitudes ranging from 2000-3000 m, 31% in areas above 3,000 m, 17% within zones between 1,000 and 2,000m, and 19% of degradation in forest areas below 1,000 m.
- Slope: 33% of the degradation occurred on land between 20 – 30°, 27% of degradation within 30-40°; 25% on forest land <20°, 23% on land with slopes >40°, and 16% above 40°.
- Distance to roads: 32% of forest degradation occurred beyond 5 km to the nearest road, 28% within 2-5 km to the road, 14% within 1-2 km, and 25% of degradation < 1 km from the nearest road
- Distance to settlements: 33% of the total degradation occurred nearest to settlements within a buffer of 0-1 km, 17% within 1-2 km distance to settlements, and 50% > 2 km
- Agro-ecological zones: Stratifying forest degradation according to the AEZs used in this study, 66% of the degradation occurred within the temperate zones of Bhutan, 17% in tropical/ sub-tropical zone and 19% in cool temperate (boreal) zones.
- Management regimes: First the table below shows the total area of degradation in ha within each of the management regimes assessed in Bhutan as well as the % share

Table 13: Areas under degradation during 2000 - 2015 including % of total degradation area

Management regime	degradation 30 -50 to < 30 (ha)	degradation > 50 to 30 - 50 (ha)	degradation > 50 to < 30 (ha)
FMU	10,207 (1.5%)	25,399 (3.8%)	6,063 (0.9%)
CF	2,413 (0.4%)	1,732 (0.3%)	2,865 (0.4%)
PA	112,262 (16.8%)	93,664 (14.0%)	59,004 (8.8%)
FAOEMR	153,669 (23.0%)	90,763 (13.6%)	109,639 (16.4%)

In absolute terms, most of the degradation occurred in forest areas outside of the other management regimes, in particular degradation from medium dense and dense forest to open forest conditions is significant. Also, 40% of the forest degradation occurred within forest areas under protection (PAs). This could be attributed to the rural timber entitlements to the community residing within the protected areas.

Next, the degradation is assessed as proportion within each of the areas under a certain management regime. Under all management regimes the largest share of the respective forest area is covered with persistent dense forests, always ranging around 40% of the areas (see below).

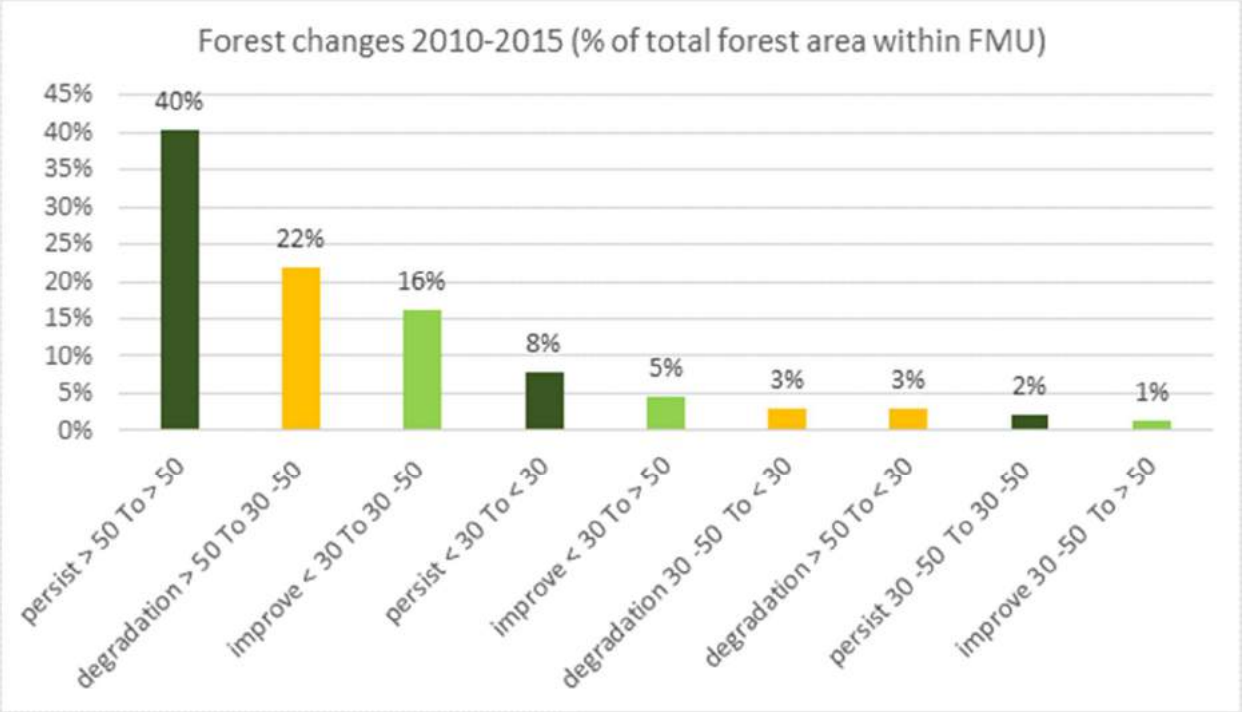


Figure 18: Forest change categories 2010 -2015 within FMU forest areas

22% of the FMU areas experience degradation from dense to medium dense forests. However, this opening of the forest cover most likely is a result of the logging activities using group felling and cable yarding systems and must not be considered as degradation per se since the harvesting is planned and executed along principles of sustainable forest management (i.e. annual allowable cut). These degraded areas in FMUs will recoup during the stages of working cycle and gain canopy closure.

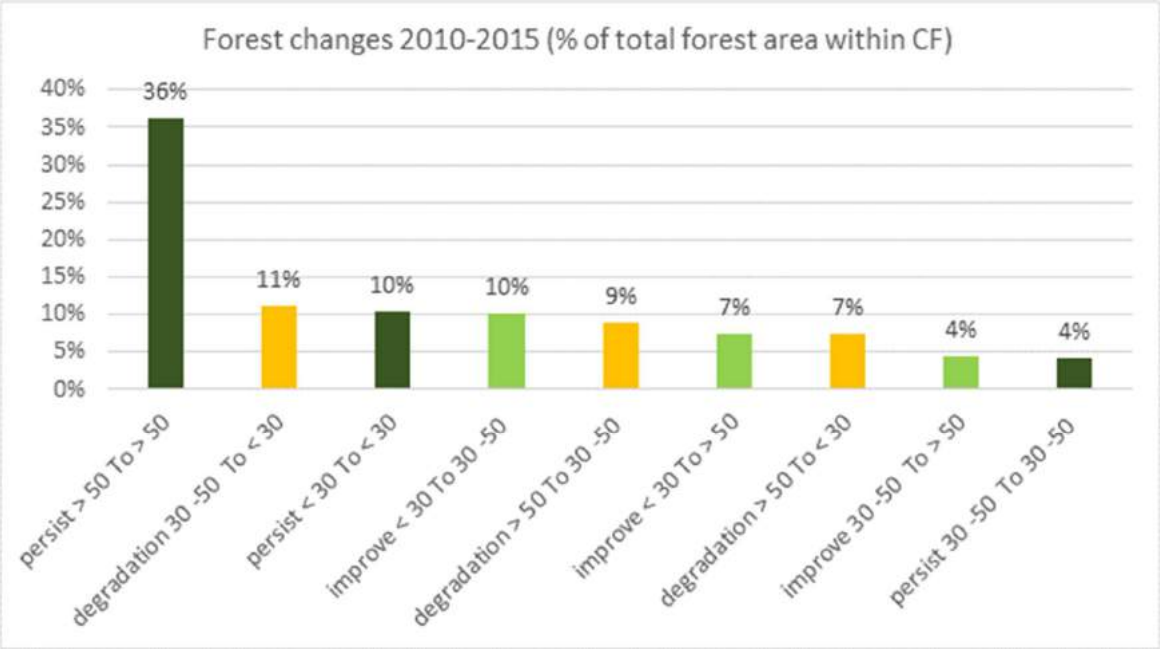


Figure 19: Forest change categories 2010 -2015 within CF forest areas

Apart from the large share of persisting dense forests, community management areas showed a balance between degradation and improvement ranging around 9 to 10%.

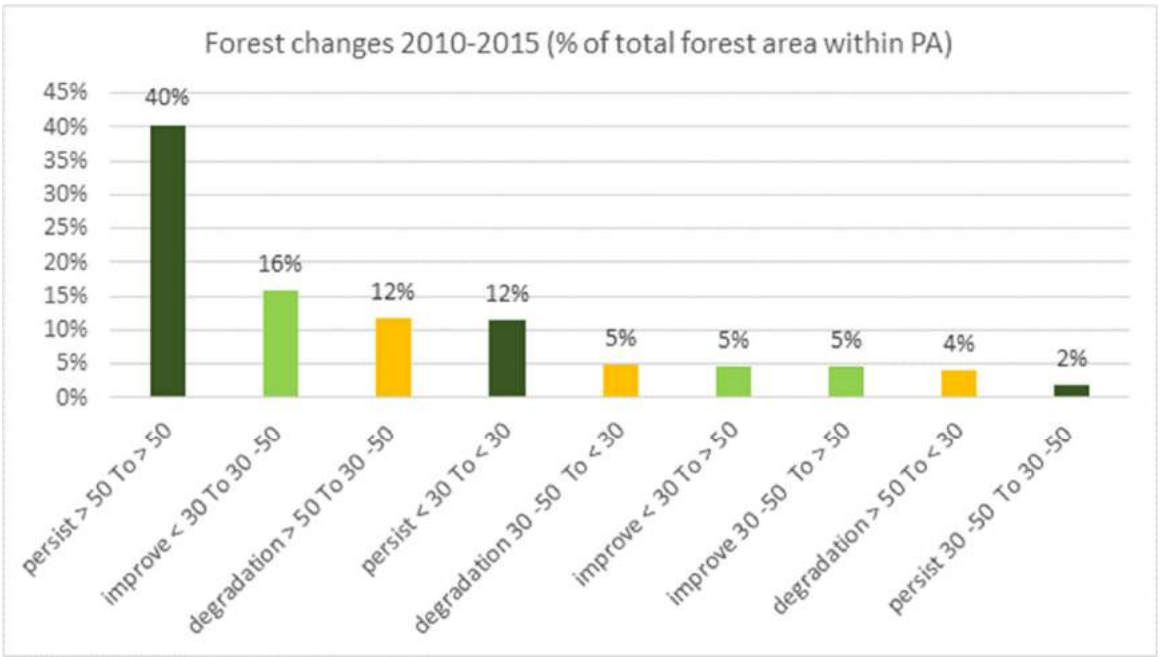


Figure 20: Forest change categories 2010 -2015 within PA forest areas

In protected forest areas, degradation of dense to medium dense forests occurred along with an improvement from open to medium dense forests.

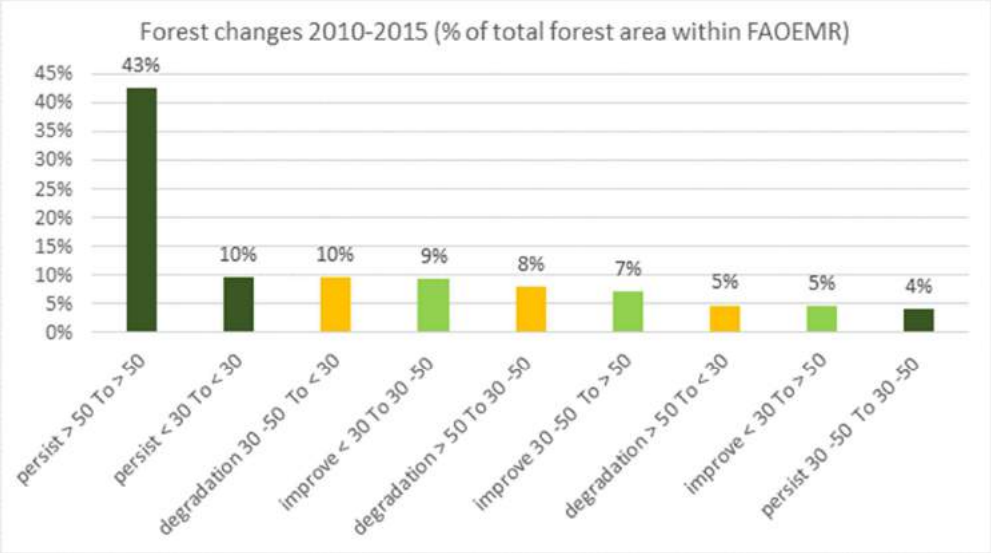


Figure 21: Forest change categories 2010 -2015 within FAOEMR forest areas

In forest areas outside of any of the existing management regimes, the persisting forests are dominating (43% dense and 10% open forests) with degradation occurring from medium dense to open forests along with improvement of the same category.

3.3.4 Drivers of forest degradation

Based on the spatial analysis of this study, forest degradation has more impact on Bhutan's forests compared to the deforestation. A number of human activities are degrading forests in Bhutan – lowering the carbon stock storage and productivity of the ecosystem in general. The drivers of forest degradation identified in this study are described in the subsequent section. It should be noted that these degradation drivers do not necessarily result in discernible changes in the forest cover.

Timber harvesting

The allocation of subsidized/concessional timbers is largely dealt directly by the DoFPS through its field offices. The government institutions responsible for managing extraction and supply of timber are the Department of Forest and Park Services (DoFPS), and the Natural Resources Development Corporation Limited (NRDCL). NRDCL implements Forest Management Plans in approved Forest Management Units (FMU) and Working Schemes (WS), operates outside of FMUs in coordination with DoFPS, and allocates and markets commercial timber (NRDCL, 2015). NRDCL's timber production in 2014 was 45,443 m^3, which was 90% of its target, and roughly 65% of the production NRDCL saw on 2013 and 2012 (ibid).

In the national statistics (Forests Facts and Figures), timber harvesting includes not only sawn timber, but a range of other wood products such as cham, dangchung, drashing, posts, firewood, poles, hakaries, logs, shinglep, tsim, wood chips, etc. National statistics, report timber extraction and supply according to three categories:

- Subsidized timber for rural areas
- Commercial timber
- Royalty Free timber

Timber is allotted at subsidized royalty rates to the rural population for house construction maintenance and repair as well as other purposes. Presently, an individual is allowed to avail subsidized timber (4000 cft in log form or standing tree basis in log form) once in 25 years for new construction. Subsidized timber for repair/renovation/extension (700 cft in log or standing tree basis in log form) of rural house is supplied once in 12 years. For making shingles standing trees are supplied once in 3 to 5 years depending on the climatic condition of the locality. Subsidized timber for new construction/ reconstruction of rural houses is allotted in either log, sawn or standing tree form.

Based on the national statistics (Forest Facts and Figures), most of the timber extracted in the period of 2009 to 2015 have been supplied as subsidized timber (72%), followed by commercial timber (27%), and Royalty free timber (1%). Hence, from these statistics, subsidized timber allotment constitutes the largest share of timber extracted from the forests in Bhutan (Figure 20).

Source: From Forests Facts and Figures publications by Ministry of Agriculture and Forests

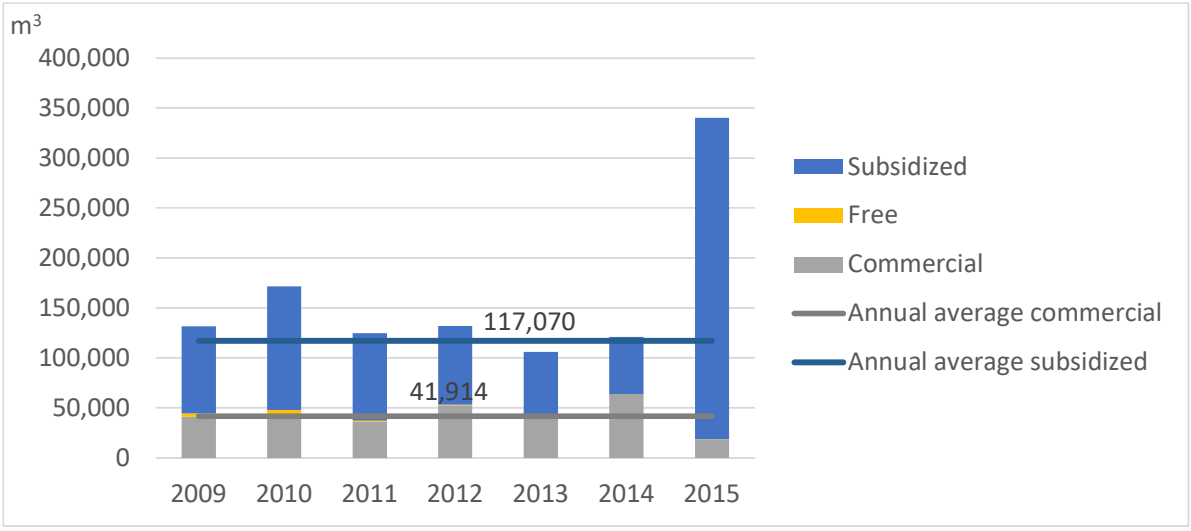


Figure 22: Timber extracted from forests and supplied in Bhutan from 2009 to 2015

Note: values in this graph exclude firewood, which is treated separately

According to national statistics, the amount of timber (excluding firewood) between 2008-2015, extracted from the country's forests and supplied in the country amount to 1,127,059 m^3 or an annual average of 161,008 m^3/ year over the same period. This is equivalent to about 19% of the estimated sustainable annual yield in the country (Gyeltshen, 2015). There is no systematic evaluation of the impact of different types of timber allotments on forest degradation. However, it is estimated that only a small percentage of forest area in the country is suitable for producing construction timber without compromising the principle of sustainable forest management (Tempa, 2011 quoting RGoB, 2011d). The restricting factors on overall forest productivity are economical, technological, social, and ecological in nature. About 24% of the forest areas are under strict protection – as they are National Parks, Wildlife Sanctuaries, Strict Nature Reserves, etc.; about 34% of the area are very steep and a large part falls above the timber line. Biological corridors occupy about 9% of the forest areas, and about 2% are community forests. Hence, timber extraction is likely to be concentrated in the few remaining feasible areas, which is about 14% (RGoB, 2011d) of the forest areas – Forest Management Units (FMU) areas and community forest areas inclusive.

The concentration of timber extraction in the few feasible areas would inevitably result in forest degradation.

In addition, the above estimates of timber extracted from the forests and supplied should be considered conservative since it does not include extraction that may not be documented, for example, unauthorised/ illegal extraction. Illegal timber extraction directly contributes to forest degradation due to several practical reasons. Firstly, being outright theft, it is done without employing sustainable forest management practices such as tree selection, correct felling, and forest rehabilitation after harvesting. Secondly, areas that may not necessarily be suitable or are due for harvesting can be targeted. Thirdly, those doing illegal logging are not necessarily concerned with maximising wood extraction from felled trees, hence, substantial wastage results, implying more trees are felled for a desired volume of products. When looking at the extent of forest offences reported in national statistics, in general, there has been an increasing trend in all forest offences across the country (Figure 23)

Source: National Statistics

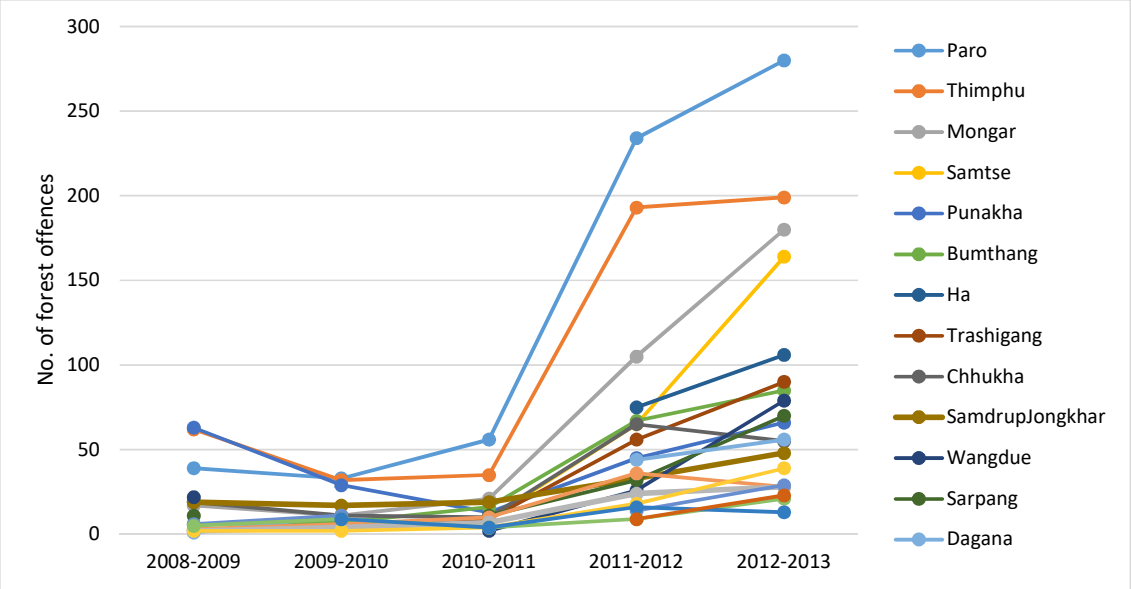


Figure 23: Trends in all forest offences across all districts in the country in 2008 and 2013

However, it cannot be concluded from these statistics to what extend offences are a directly related to illegal timber extraction. However, recognizing the importance of responding to illegal wildlife and timber poaching, the Government exacted a new policy in 2009 that allows employees of DoFPS, and informers, to retain a portion of the fines for any crimes they help detect. For wildlife poaching, informers can retain 100% as a reward, while for illegal logging informers can retain 25%. This might help explain why more cases have been reported since 2010 (ibid).

The NEC State of the Environment Report that the National Forest Inventory (NFI) that is currently underway will provide a detailed picture on the forest structure including age, growth rates, biomass, and carbon stock by different species, soil carbon and the overall health of the forests. It is hoped this driver analysis can provide further insights to support an accurate view of the country's forests. Forest degradation can be further deduced from available anecdotal evidence; for example, NEC references a DOFPS analysis from 2014 that evaluated the Forest Management Units (FMU) and

found that management prescriptions had not been consistently followed and four of the seven FMUs assessed had harvesting levels beyond the annual allowable cuts (AAC). Furthermore, there was generally very low success of natural regeneration or re-plantation in these FMUs (RGoB, 2016a). These topics, further explored in the underlying driver section of this report, indicates that timber extraction is negatively impacting forests.

Firewood

Firewood contributes the biggest share of energy for Bhutan - about 34% of total energy consumed in the country; followed by electricity (28.1%); coal (19.1%); diesel (13.4%), petrol (3.2%), liquefied petroleum gas (1.1%), kerosene (1.0%) and others (0.2%) (Gyeltshen, 2015).

Source: Dhital, 2009

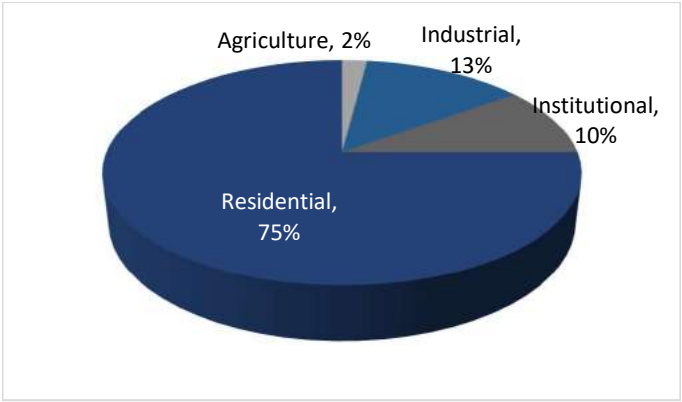


Figure 24: Major categories of firewood consumers in Bhutan

Residential consumers are obviously the number one category of consumers in terms of total consumption because of a comparatively higher per capita consumption of firewood at the household level. As shown in Figure 25, Bhutan has one of the highest per capita domestic fuel wood consumption in the world.

NRDCL supplies firewood from lops and tops after timber extraction. NRDCL's contribution to firewood needs is not demand based as it supplies whatever is left behind after timber extraction (NRDCL, 2015).

Source: Gyeltshen, 2015

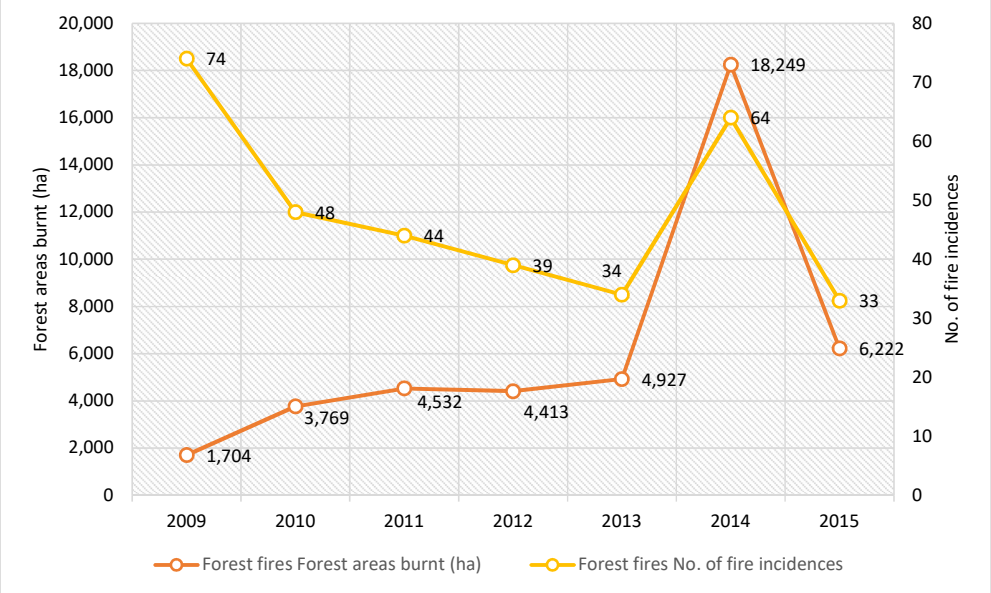


Figure 25: Per capita firewood consumption in Bhutan and other developing nations/ territory

In the short- and medium term, firewood will be the main source of energy, and is readily available in most parts of the country. Rural households consume more fuel wood than their urban counterparts. With only about 38.6% of the country's population estimated to be urban, large quantities of firewood are consumed annually by the large rural population. Firewood accounted for 90% of the fuel mix of the residential segment in 2005, and decreased to 87% by 2014 (MoEA, 2016). The efficiency of firewood devices is only 10%–15%. Firewood is mainly used for cooking, space heating, and lighting (RGoB, 2011a). Liquefied petroleum gas (LPG), along with electricity, and kerosene only accounts for 9% of fuels used, and this occurs mostly in urban areas. Further, LPG and kerosene are expensive, and only affordable for urban households. Though electricity has reached many rural areas, firewood is still preferred as it is a cheap and readily available source of energy. In addition, people in rural areas are allowed to collect dry firewood, free of royalty. Such collections are estimated to constitute 1% to 6% of the firewood supplied between 2009 to 2015.

Removal of trees as firewood from areas outside FMU's and other management regimes is impacting negatively on the forest resources of the country – leading to forest degradation. According to national statistics (Forest Facts and Figures) the amount of firewood, which has been extracted from the country's forests and supplied in the country amount to 594,552 m^3 between 2009 and 2015 (Figure 26), or an annual average of 84,936 m^3. This amount is equivalent to about 10% of the estimated sustainable annual yield in the country (Gyeltshen, 2015).

As a comparison, we estimated total firewood consumption using per capita consumption. Based on the Bhutan Energy Data Directory 2015 the total firewood consumption (including the residential, industry and transport sectors) in 2014 was 637,231.66 tonnes (MoEA, 2016). Divided by the total population of Bhutan in 2014, which was 745,153 (NSB, 2014), the per capita firewood consumption is 855 kg/year. This is still very high, however, showing a decreasing trend compared to previous figures (see Figure 25 above). Using the weighted average wood density of 0.469 tonnes/m^3 (FAO 2015), this calculates as 298,862 m^3; this estimate is about 3.5 times higher than the estimates of firewood extracted and supplied, which are reported in the national statistics. This difference should simply highlight the difficulty of reliably estimating actual firewood extraction. Considering this alternative estimate, firewood extraction would equal to about 35 % of the estimated sustainable annual yield in the country.

Hence, the RGoB has realised that firewood extraction is degrading the forests, and has begun to promote fuel-efficient cook stoves, use of biogas, electric bulb cookers, 100 units free electricity to rural areas, and tax subsidy on appliances such as boilers and rice cookers to reduce forest degradation.

Source: From Forests Facts and Figures publications by Ministry of Agriculture and Forests (see section 4.)

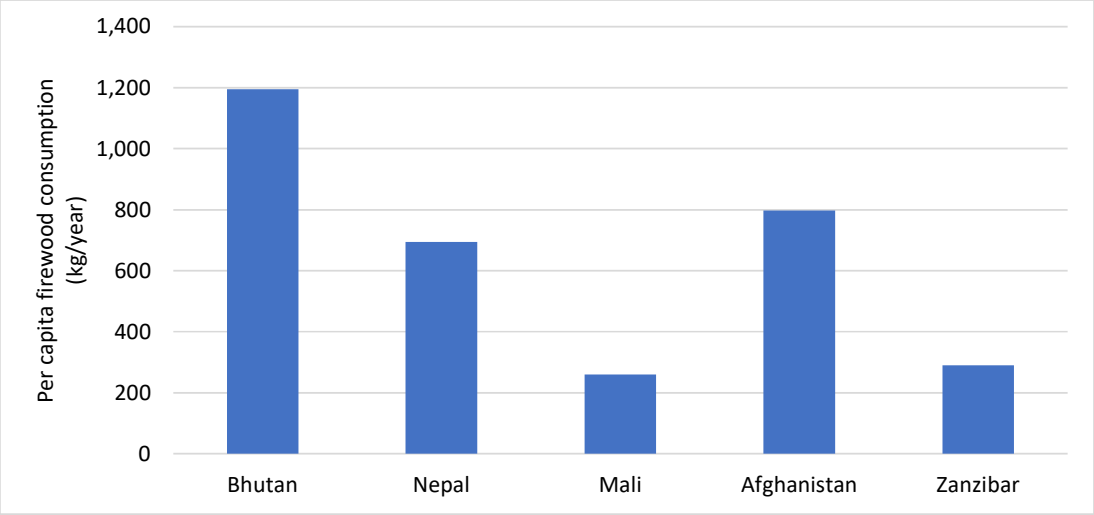


Figure 26: Firewood extracted from forests and supplied in Bhutan in 2008 to 2014

Forest fires

Each year, significant forest areas burn in Bhutan. Fires originate from many sources, which may be both intentional, i.e., arson-type fire set purposely to destroy the forest, or unintentional, i.e., due to negligence, for example, fires from cropland clearing, logging, mining, camping, picnicking and quarrying activities. Almost all of the forest fires in the country are found to be caused by human, either accidentally or intentionally (NSSC, 2014). The DoFPS is directly responsible for forest fire management and it is supported by the armed forces, volunteers, Dessups, communities with resource mobilisation and legislation. Apart from degrading the forests, fires also pose a risk in terms of destruction of property, injuries, and even death.

From the national statistics, it is clear that the DoFPS is grappling with fire problems in the country. Between 2009 to2014, 334 fire incidences have been recorded in the country, with the forest areas affected totalling 43,817 ha, or an annual average of 6,260 ha. There are annual differences, however, with 2014 posting the most forest areas burnt in a single year in recent times (Figure 23).

Source: Department of Forests and Park Services/Ministry of Agriculture and Forests, 2014; 2015.

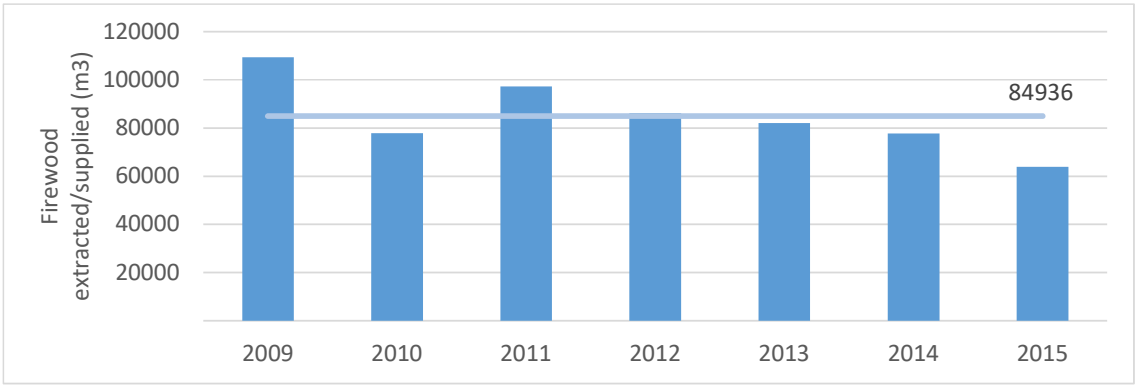


Figure 27: Forest fire incidences and areas burnt in Bhutan between 2009 to 2015

Most fires are reported to occur between November and April. This is the time when there is minimal precipitation and persistent winds. In addition, it is when farmers clear their farms and burn the agricultural residues, which contributes to fire breakouts.

Regionally, districts in the western and eastern regions have historically experienced more fires than the southern and central regions. These difference can be attributed to forest types, with some forest types such as pine and oak forests being associated with high fuel loads during the dry season. Other factors could be differences in availability of support such as forest fire volunteers, Desung, armed forces, etc., and accessibility to forests fire, facilitated by the existence of approach roads. NEC notes that the significant spike in forest area burned in 2014 is due to a major fire event in Wangduephodrang in early 2014, which resulted an almost four times the average annual area being burnt in that season.

Livestock

The grazing of livestock inside forests is an integral part of the farm production system in Bhutan. While forests are mostly state owned, farmers have legal grazing rights in some of the forests. Sampdup et al., 2010 found that even in areas near the capital Thimphu, cattle graze in the tsamdros (registered grazing land) located near settlements as well as in the forests during the day. Livestock grazing, especially when done in an unregulated manner in terms of intensity and livestock numbers, is generally considered to negatively affect forests in Bhutan (ibid). However, some people argue that there is not enough systematic and quantitative assessment to support forest degradation claim especially for conifer forests as removal of herbaceous biomass by grazing enhances conifer species regeneration. However, grazing was found to reduce the number and density of broadleaved species (Sampdup et al., 2010 quoting Roder et al. 2002) – underlining the forest degradation impact of livestock grazing.

Despite government initiatives to encourage the rearing of smaller and more productive herds of livestock, local communities continue to maintain large herds as an immediate source of cash income, and to utilize leaf litter for farmyard manure, which is an important source of nutrients for farming. There were an estimated half a million cattle in Bhutan in 2014, although the numbers are reported to be slightly declining over time (RGoB, 2016a). Another reason for maintaining large herds is the strong religious sentiment against culling herds, and the social status associated with larger herds (NSSC, 2014).

Livestock intensification is expected to help reduce the gap between supply and demand of livestock products. Bhutan's local cattle population is roughly 221,000 in 2014, while improved cattle numbers have increased 15% in the past few years to 83,000, while yaks have increased roughly 15% to almost 45,000 head (RGoB, 2015a). Cross breeding for dairy production is a major tool to intensify livestock production, and reduce the environmental load of livestock on common property resources. One study found that cross-breeds graze less in the forests and natural grasslands compared to local cattle, but cross-breeding was not found to reduce cattle numbers per farm (Sampdup et al., 2010).

Therefore, the impact of livestock grazing on forest degradation in Bhutan is arguably negative but localised, varying from place to place – depending on the forest types

and grazing intensities. Grazing is generally acknowledged to be contributing to forest degradation, although available data cannot allow an accurate assessment of its impact. The NEC's State of the Environmental Report also identifies over-grazing as a key driver/pressure on land resources (RGoB, 2016a). Therefore, the government is undertaking efforts to improve livestock management, e.g., supply of improved breed, enhancing pasture, and feed and fodder development programmes.

To estimate the impact of Livestock on forest degradation, the following assumptions are made for this study: With a cattle population of 500,000, the grazing density is about 1 cow for every 5 ha of forest. Compared with the estimated carrying capacity of 0.54 Livestock Units/ ha in Nepal for temperate rangelands associated with oak, mixed broad leaf, or blue pine forests (Pariyar 1995), the estimated grazing density in Bhutan on a national level is well below levels leading to significant degradation. However, on a regional level overgrazing might still occur in Bhutan.

3.3.5 Comparison statistical records with spatial results

The table below summarizes and compares the statistical records of forest degradation (not in including the improvement) attributed to the different drivers identified above against the spatial analysis. Figures are presented as an annual averages of degradation, either in annual areas affected or annual m^3 degraded. In order to compare degradation data given in m^3 and areas, all areas degraded have been converted into corresponding timber volumes in m^3 using an average of 7.4 m^3 per ha and year degraded. This is based on the different average degradation rates of crown cover changes (i.e. from dense to open, medium-dense to open and dense to medium dense forests) weighted according to the share of these crown cover changes of the spatially assessed annual degradation rate of 44,512 ha.

Table 14: Comparison of the statistical records with spatial results for forest degradation

Driver	Statistical records of annual degradation (ha/year)	Spatial analysis of annual degradation (ha/year)	Degradation in corresponding m^3 (m^3/year)
Timber harvesting	Given in m^3	not available	161,008
Firewood	Given in m^3	not available	84,936
Forest fires	6,260 ha	not available	46,397
Livestock	not available	not available	not available
Total annual degradation spatial analysis		44,512 ha	329,911

Using the weighted average degradation rate of 7.4 m^3/ha/year the degradation based on the spatial analysis of annually 44,512 ha of forests in Bhutan amounts to 329,911 m^3 per year. In comparison to this, the sum of annual degradation of the drivers in this study totals 292,342 m^3 per year. This results in a gap of annual 37,569 m^3, which might be a combination of unrecorded firewood, non-extracted timber for instance from transmission lines, as well as unquantified degradation from livestock and pest and disease. It has to be noted, that these results are interpreted on a national level, and that degradation has to be further assessed on a regional (district) level.

3.3.6 Ranking of degradation drivers

The ranking of drivers of degradation is on the extent of timber volumes estimated to be affected annually by the drivers. In addition, the annual GHG emissions are estimated based on the average carbon stock change calculated in section 3.4.

Table 15: Ranking of drivers of forest degradation

Driver	Annual degradation in corresponding m^3 (m^3 /year)	Annual GHG emissions as a result of forest degradation (tCO2 e/ year)	Ranking in extent of deforestation
Timber harvesting	161,008	159,019	1st
Firewood	84,936	83,886	2nd
Forest fires	46,397	49,599	3rd
Livestock	not available	not available	4th

With regards to the ranking of drivers of degradation during the stakeholder consultation workshops, Figure 28 summarizes the total scoring from all regions for the identified drivers of degradation. A higher scoring indicates a higher rank of a particular driver. Present as well as future ranks are presented.

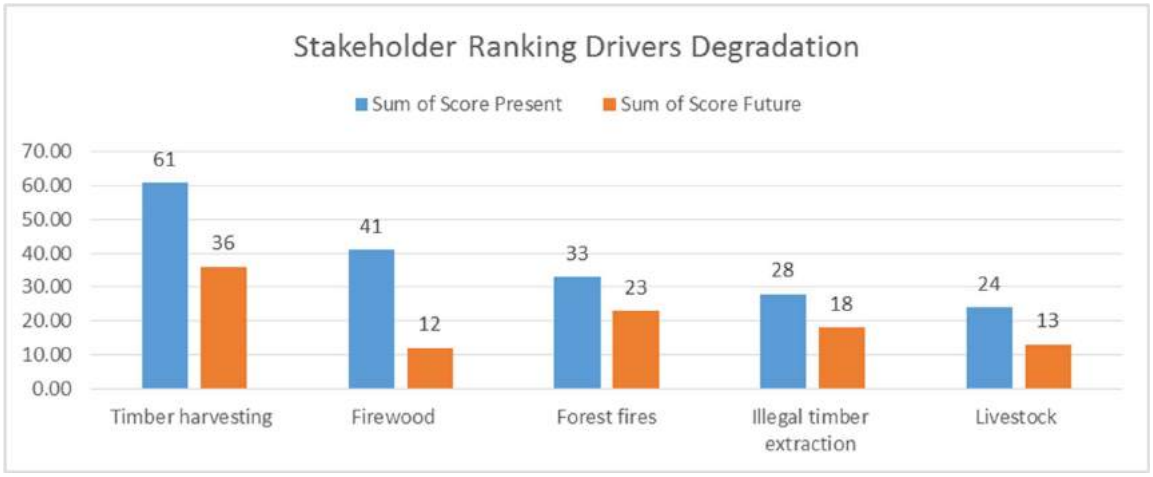


Figure 28 summary present and future impact scoring of drivers of degradation as a result of exercises during regional consultation workshops

With regards to forest degradation, the ranking by the stakeholders is similar to the findings of this study; timber harvesting and firewood extraction are ranked highest. In addition, illegal logging and livestock were ranked relatively high by the stakeholders.

3.4 Estimation of carbon stock changes between 2000, 2010 and 2015 to quantify forest degradation

Carbon stock changes have been calculated as the difference in carbon stock density (in tonnes CO2 per ha) of different forest types and crown cover density. The estimation follows IPCC GPG methodological guidance with the objective to present Tier 2 results. The following assumptions and data sources were used to establish average stocking volumes for each forest type and crown cover class.

The activity data (areas under different forest types) were taken from the GIS analysis of this study and aligned with the recent LULC 2016 and NFI reporting.

During the second mission early December 2016, the forest type specific stocking volume results of the National Forest Inventory (NFI) became available. Therefore the results of two scenarios with different average stocking volumes are presented in this study:

Scenario 1: Stocking volumes from a database complied from forest management information – FMUs, working schemes and CFs

Scenario 2: Stocking volumes derived from the latest NFI data aligned to the strata used in this study

For both scenarios, the stratum specific average stocking volume (in m^3/ha) can be found in the annex 5.

As a comparison, the carbon stock changes are compared with a simple Tier 1 IPCC default approach using the default factors from the Bhutan FAO FRA 2015 assessment (FAO 2015).

Scenario 1: Stocking volumes from a database complied from forest management information

- A forest database was established summarizing forest type specific numeric information from different Forest Management Units (FMUs) and Community Forest (CF) and working schemes (WS);
- Reliable minimum estimates of stocking volumes from 95 Community Forest Management Plans, 47 Forest Management Units Plans, and 9 Working Schemes were used to derive average weighted stocking volumes (m^3/ha) for the different forest types (broadleaf, conifer and mixed forests) and agro-ecological zones (Tropical humid, Temperate humid; Temperate humid all year, Boreal semi-dry, Boreal moist semi-arid, Boreal sub-humid).
- Each of these strata was further sub dived into open forests, medium dense and dense forests and the stocking volumes was adapted using reduction factors based on scientific publication (Tenzin & Hasenauer 2016) as well as references from similar forest types in neighbouring Indian states based on FSI data in India. Overall this resulted to around 50 different strata in Bhutan for which an average stocking volume was derived.

Scenario 2: Stocking volumes derived from the latest NFI data aligned to the strata used in this study

Based on the AEZs used in this study and the vegetation zoning of Bhutan (Chhetri 2011), the different forest types of the LULC and the NFI were allocated to the AEZ and forest types of this study in the following way:

- By merging the LULC 2016 forest types with the 2015 map of this study, the % shares of each LULC forest type within each AEZ and dominant forest class of this study were derived.

- Based on this, the average stocking volume results of the NFI for the different forest types were used to estimate weighted average stocking volumes in m^3/ha for strata in this study
- For each AEZ and dominant forest class in this study, the average crown cover 2015 was calculated. It is assumed that the average stocking volume estimated for a particular stratum represents this average forest crown cover for that stratum. The average crown cover for most strata ranges between 30-50%.
- For the strata representing other crown cover classes than the average (in most cases dense and open forests) the stocking volumes was adapted in line with scenario 1 using reduction factors based on scientific publication (Tenzin & Hasenauer 2016) as well as references from similar forest types in neighboring Indian states based on the same FSI data in India as above.

The stratum specific stocking volumes of the two scenarios were used to derive the carbon stock changes from 2000 to 2015 - the changes are a result of the changing areas within the 50 strata as a result of crown cover increase or decrease. To convert volume into carbon the following Tier 2 default equations and factors were applied (State Forest Administration, China 2014[1]):

- **Conversion stocking volume (V= m^3/ha) to aboveground biomass (BAGB= t d.m./ha):**
  - Broadleaf forests: BAGB = 3.322268 x V0.687013
  - Conifer forests: BAGB = 3.2847715 x V 0.6885095
  - Mixed conifer broadleaf forests: BAGB = 3.30351975 x V0.68776125
- **Root –to-shoot ratios:**
  - Broadleaf forests: 0.29
  - Conifer forests: 0.27
  - Mixed conifer broadleaf forests: 0.25
- **Carbon fraction:**
  - Broadleaf forests: 0.49
  - Conifer forests: 0.51
  - Mixed conifer broadleaf forests: 0.50
- **Litter %:**
  - Broadleaf forests: 3-5% (depending on the crown cover)
  - Conifer forests: 4-9% (depending on the crown cover)
  - Mixed conifer broadleaf forests: 3-4% (depending on the crown cover)
- **Deadwood fraction: Default of 2%**

1 All values applied are from the State Forestry Administration (SFA 2013) in China which were compiled in the frame of the emerging domestic carbon market and the development of a forest accounting protocol for improved forest management activities throughout China. The default equations and values were selected for climatic an ecological zones which match the conditions in Bhutan. The Chinese methodology can be accessed here and the default equations and values can be found in the Annex of this Methodology.

Results Scenario 1:

Table 16: Scenario 1 Analysis of carbon stock changes between 2000 and 2015 - Tier 2 approach

	Area 2000 (ha)	Area 2015 (ha)
	2.6 Mio	2.7 Mio

Tree Biomass C_{TREE}	2000	2015
Density C_{TREE_ha} ($tCO_2\ ha^{-1}$)	306.6	296.1
Total C_{TREE} ($tCO_2\text{-}e\ a^{-1}$)	807,137,903	802,267,015

Dead wood $C_{dead\ wood}$	2000	2015
Density C_{DW_ha} ($tCO_2\ ha^{-1}$)	5.8	5.6
Total C_{DW} ($tCO_2\text{-}e\ a^{-1}$)	15,174,192	15,082,619

Litter C_{litter}	2000	2015
Density C_{LI_ha} ($tCO_2\ ha^{-1}$)	7.2	7.2
Total C_{LI} ($tCO_2\text{-}e\ a^{-1}$)	19,026,768	19,557,217

Scenario 1

Total Bhutan	(tCO_2-e)
2000	841,338,864
2015	836,906,852
Change	-4,432,012
Annual Change	-295,467

As depicted in Table 16, in scenario 1, the total carbon budget within the forest areas of Bhutan has decreased from 841 million tCO2 to 836 million tCO2 which results in a decrease of 4,432,012 tCO2 for the 15-year period. The average annual decrease amounts to 295,467 tCO2/year which is remarkably similar to the total annual degradation of the degradation drivers (295,544 tCO2, see Table 15). In terms of the carbon density of Tree biomass (above and belowground biomass) the area weighted carbon stock densities decreased from over 306 tCO2/ ha in 2000 to 296 tCO2/ ha in 2015. This represents a reduction of 0.7 tCO2 per ha per year.

As a comparison, the Tier 1 IPCC approach results in a total of 1,102 M tCO2 for the year 2000, which reduces to 1,082 M tCO2 in 2015. This corresponds to a reduction of 0.05 tCO2 per ha per year.

Results Scenario 2:

Table 17: Scenario 2 Analysis of carbon stock changes between 2000 and 2015 - Tier 2 approach

	Area 2000 (ha)	Area 2015 (ha)
	2.6 Mio	2.7 Mio

Tree Biomass C_{TREE}	2000	2015
Density C_{TREE_ha} (tCO_2 ha^{-1})	386.0	369.8
Total C_{TREE} (tCO_2-e·a^{-1})	1,016,241,551	1,001,879,458

Dead wood $C_{dead\ wood}$	2000	2015
Density C_{DW_ha} (tCO_2 ha^{-1})	7.3	7.0
Total C_{DW} (tCO_2-e·a^{-1})	19,105,341	18,835,333

Litter C_{litter}	2000	2015
Density C_{LI_ha} (tCO_2 ha^{-1})	6.7	6.8
Total C_{LI} (tCO_2-e·a^{-1})	17,619,428	18,361,887

Scenario 2

Total Bhutan	(tCO_2-e)
2000	1,052,966,320
2015	1,039,076,679
Change	-13,889,641
Annual Change	-925,976

Scenario 2 uses significantly higher stocking volumes from the NFI for each of the forest strata which results in overall higher total carbon budgets within the forest areas of Bhutan. Nevertheless, the carbon budget has decreased from 1,052 million tCO2 to 1,039 million tCO2 which results in a decrease of 13,889,641 tCO2 for the 15-year period. The average annual decrease in this scenario amounts to 925,976 tCO2/ year. Again comparing total annual degradation in tCO2 per year of the degradation drivers (295,544 tCO2, see Table 15), a huge gap is identified according to this scenario as a result of the significant higher carbon stock densities and consequently higher stock changes. The area weighted carbon stock densities decreased from over 386 tCO2/ ha in 2000 to 370 tCO2/ ha in 2015. This represents a reduction of 1.1 tCO2 per ha per year.

In order to justify the carbon estimations of this study, the estimations of different carbon pools calculated from NFI data (scenario 2) are compared with the reported carbon budgets of the FRA 2015 (table 18). Overall the carbon estimates in this study are slightly lower than the reported estimates, the stratification and consistent analysis of crown cover classes being the main reason for it. This study indicates a reduction of the total carbon budget as a result of degradation while the FAO status report indicates an increase.

Table 18: Comparison of total carbon stocks estimated for this study using NFI data with FRA 2015 data (all figures in million metric tonnes of CO2 e)

Carbon Pool (M t CO_2 e)	FRA 2000 (FAO 2015)	FRA 2015 (FAO 2015)	This Study 2000	This Study 2015
Trees (above and belowground biomass)	1,019	1,074	1,016	1,002
Dead wood	na	na	19	19
Litter	161	165	18	18
Total	**1,181**	**1,239**	**1,053**	**1,039**

This analysis confirms the overall findings of this study that the total forest area has increased, while the quality of forest has decreased, which results in lower carbon densities as well as in decrease of the total forest carbon budget.

4. Actors, motivations and underlying drivers

4.1 Methodology

Underlying drivers are the complex interactions of fundamental, social, economic, political, cultural and technological processes that influence actors to exert pressure on forests. These are referred to as indirect causes, and they are often distant from their area of impact. The objective for identifying underlying drivers of deforestation and forest degradation in Bhutan was to assess the decisions and motivations that conceptually and practically influence the direct drivers identified in Chapter 3. This process relied on expert interviews with stakeholders and key government departments, and in-depth literature reviews. This chapter concludes with a correlation between the direct drivers and the underlying drivers, in order to present the causal relationships between them.

4.2 Actor and motivation analysis

A range of actors play a role in or have a stake in deforestation and forest degradation. Below is a general framing of various actors, their motivations, and opportunities for positive engagement towards REDD+ activities. In defining policies and measures to address driver pressure, consideration will need to be given to how PAMs shift the motivations of actors and influence land use behaviour.

Table 19: Actors, motivations, opportunities

Actors	Motivations	Opportunities
Government agencies and public sector		
Department of Forests and Park Services (DoFPS)	Sustainable management of forests and conservation of wild biodiversity resources	Build on strong track record of Bhutan's conservation leadership Improve efficiency in wood utilization and technology
National Environment Commission	Highest body overseeing environmental priorities and management; EIA/SIA assessments; oversees Dzongkhag environment officers	Linkages to policy (and cross-sectoral strategies) and international climate finance
Department of Geology and Mines (DGM)	Sustainable utilisation of mineral resources through policy guidance and adoption of best practices.	Potential for effective monitoring and ensuring environmental safeguards
Ministry of Works and Human Settlement – Departments of Human Settlements (DoHS) and Roads (DoR)	Roads: Environment friendly road construction Human Settlement: sustainable land use plan	Roads: Interested in climate-proofing road infrastructure investments Human Settlement: Sustainable in National Land Use Plan, sees future urbanization as providing the mandate
Natural Resources Development Corporation Limited (NRDCL)	Timber extraction and marketing, lops and tops for firewood, extraction and supply of sand and boulders	Build capacity for sustainable forest management and utilization through improved wood harvesting and utilization technology as its mandate is to harvest, transport and market timber
Department of Agriculture (DoA)	Sustainable utilization of limited arable agriculture land and contribute to food self sufficiency	Opportunity to collaborate in land use planning for forest land (lease) capability zoning for commercial agriculture within purview of Land Act of Bhutan, 2007 (LA,2007) and Forest and Nature Conservation Act (FNCA, 1995), National Environment Protection Act (NEPA, 2000)and other relevant acts
Department of Livestock (DoL)	Improved rangeland management, better livestock genetics	Opportunity to carry out assessment of carrying capacity of rangelands, integrated management through cross-sectoral involvement of livestock, agriculture and forestry.
Ministry of Economic Affairs (MoEA)	Defining goals for public & private sector development, including hydropower, geology and mines, and renewable energy, cottage and small industry	Development of National Land Policy and land use plan, development of timber pricing,efficient, + sustainable and viable timber industry and eco-tourism development
Druk Green Power Corporation (DGPC)	Hydropower development	Collaborate with DoFPS in terms of sharing spatial data for river/forest area while project planning

Gross National Happiness Commission	Has a strong policy mandate, key for cross-sectoral coordination	12th Five-Year Plan – how can climate and forests best align with other sector priorities?
National Land Commission	Land survey, cadastre, registry	Land lease agreements, helping develop Land Use Policy (and Law), land use planning and zoning
Dzongkhag & Geog Administrations		Collaborate with forest offices in implementing various REDD+ PAMs
Private sector		
Rural community	Livelihoods, NWFP collection	Potential for strengthening stewardship and participation of rural community in natural resource management while also providing them with alternative livelihood needs
Small and medium enterprises	Woodbased industries is an important actor in wood processing value chain and also for private sector development	Potential for networking and support for local production systems, improved efficiency of agriculture production and value adding to forest products
Wood based industries	Businesses/Trading – technological capacity is not high, can't compete with Indian producers on price and volume	Potential for development of domestic timber sector business, value addition of timber and improvement of technological capacity
Herders (tsamdro)	Fodder collection, grazing land access	Potential for stewardship strong, but decreasing in number.
Agricultural and NWFP producers – non-shifting cultivators, or small scale or not relying on leases	Agriculture farming system in Bhutan is subsistence and integrated & farmyard manure and forest surrounding agri farms are important source of nutrition for crop productivity and to sustain livestock production	Stewardship potential could be high due to reliance on ecosystem services
Agriculture producers - commercial	Land leases increasing and expanding land area	
Mining quarry operators	Extraction of mineral resources, business promotion contributing to private sector development	Collaboration with regional government/local authorities key, and effective EIA assessment and monitoring. Ensure that rehabilitation of mined areas
Service Providers (Forestry) – subcontractors	EIA Services/Private Forest Plantation Establishment	EIA assessment/private-owned forest plantation establishment (may have potential for export promotion)
Bi-lateral or Multi-lateral Development Organizations	For those investing directly in driver activities, such as hydropower development,	Investment standards (World Bank performance standards, ADB standards), opportunities for greater private
	motivation is economic development. Some consider social/environmental impacts, others are less concerned.	investment (e.g. timber sector value-addition)
Civil Society		
Civil Society organisations – Tarayana Foundation, WWF, others	Economic development, conservation, social and cultural aspects of forest and land use	Provide better information/community awareness, capacity, encourage community participation and collaboration in managing forests and natural resources

The underlying driver analysis below will reference these actors and their motivations in the context of exploring the governance, social and economic forces that influence behaviour.

4.3. Governance challenges and law enforcement

Expert and stakeholder interviews, along with a literature review, suggest a range of governance aspects that are unpacked here along the following topics:

- Decisions without integrated planning and guidelines, particularly related to cross-sector alignment or conflict (sub-issue is lack of spatial planning guidance)
- Implications of expanding hydropower
- Capacity constraints, including law enforcement and controlling illegal activity
- Rural timber allotment and pricing/subsidies
- Climate change is not yet fully mainstreamed into development planning

4.3.1 Decisions without integrated planning and guidelines, particularly related to cross-sector alignment or conflict (sub-issue is lack of spatial planning guidance)

The decision-making on urban development and infrastructure expansion is occurring in a piecemeal approach without the long-term national spatial planning policy. As per SRFL allotments for various uses (hydropower, transmission lines, roads, etc.) identified in the direct driver section of this report, there are hundreds of decisions that are made on development at project levels, with input from line ministries and approval by local government, but lacking guidance by policy, decision-criteria, and spatially-explicit sector master plans to guide decisions, particularly when there are potential trade-offs. Numerous interviewees noted the scientific and technological limitations in these decision-making processes.

Sectoral conflict appears to come from the Land Act defining the mode of decision making on land use, allowing for subdivision and leasing, without all guidance decision-makers feel is necessary. NLCS mandate is for land administration, management, surveying and mapping. While the NLCS recognizes the challenge on the land from increased lease applications, it cannot provide policy directions as broader guidance has to come from line agencies and GNHCS. But line agencies and GNHCS interviewed indicate a disconnection between the sectors in shared planning, implementation and decision making processes. This appears to be the case for decisions on agricultural leases, despite the existence of 'Interim Guidelines on Lease of SRFL for Commercial Agriculture (2011)'. After the Land Act was amended, that allowed leasing of SRFL for commercial agriculture, the number of leasing applications for new leases such as cardamom plantations, has increased over the years. The local governments do not have the means to limit these applications, so NLCS instituted a temporary ban in order to provide space to identify solutions. The new Forest and Nature Conservation Rules and Regulations (2017) provide guidance on forestry clearances for allotments or leases of SRFL.

Government agencies are pursuing development in sectoral approaches, placing competing pressure on the land, but without the most effective means to identify how the plans and programs of one sector will affect that of others. Unfortunately, no clear mechanism exists to harmonise actions to avoid or mitigate

conflicts. Examples of competition between agricultural land and urban uses were often cited by interviewees. Decisions made at local levels require sectoral coordination at local levels, but that appears to be weak, despite the work of Committees. The NLCS recognizes the need for long-term vision to guide the direction of land management, but may not have adequate spatial or sectoral guidance.

Guidance and planning among agencies is limited. The Department of Urban Planning and Development shared examples of information on wildlife corridors coming too late into local committee decision-making. Druk Green Power Corporation (DGPC) identified that they do not have a map of important watersheds or prioritized watershed values to help guide their review of plans for hydropower development. DGPC indicated that if they had information on critical watershed areas, they would be willing to bring that information into their mapping and information systems. The interviews with various ministries identified that while a lack of information sharing among ministries exists, there is a willingness for more integrated planning and decision-making, if such information were available.

Environmental Impact Assessments (EIAs) cannot be expected to replace sector policies, plans and guidelines. While there is strong interest within government to complete EIAs for development projects, indications are that EIA processes in some cases occur after the project concept is agreed to, not all EIAs are made publicly available, and the cumulative impacts of multiple projects within large watersheds has not systematically occurred. When Bhutan and India signed the 2006 Umbrella Agreement for hydropower development (10 mega-projects), feasibility studies and detailed project reports were commissioned, and agreements between the governments forged on that basis. The environmental and social impact assessment occurred after the signing of the agreement. The Project Authorities for Punatsangchhu I, Punatsangchhu II and Mangdechhu hydro projects conducted EIAs which are available from NECS, if requested. Though a National Integrated Water Resource Management Plan was prepared in 2016 to help ensure water resources are protected, conserved and managed equitably, and a Bhutan Water Security Index (BWSI) was developed in 2015, integrated basin impact assessments have not been found, and decisions appear to be on a site-by-site basis. One example is the EIAs prepared for the Kuri-I Hydropower Project (1150 MW), which includes assessment of project-related impacts, but the only impact assessed beyond the footprint of the project site was the potential for a dam burst (DGPC, 2015).

4.3.2 Implications of expanding hydropower

Expansion of hydropower facilities will have increasing impacts on forests due to facility siting and related infrastructure. Government is trying to address forest loss due to hydropower projects by requiring compensatory afforestation to be undertaken. The legal framework stipulating compensation for environmental damage is the Environmental Assessment Act, 2000. The practice is to require two trees be planted for each tree cut. Furthermore, two mechanisms exist to offset the impacts of hydropower development: a) a plough-back mechanism of 1% of the royalty is to be paid to the MoAF on annual basis for sustainable management of watersheds (RGoB, 2017; RGoB, 2008b), although this is yet to be operationalised, and b) compensatory plantation development is to be provided at the time of project development, which in practice has been a 'thumb rule' of double the area taken up by the project for development activities (RGoB, 2017). The

afforestation and other activities under the ambit of Environmental Management Plan of Hydropower projects are only for project periods, whereas these activities require continuous funding for long-term maintenance. The afforestation activities will now to be managed by the Green Bhutan Corporation Ltd., formed in 2017, in collaboration with DoFPS and local government.

There are plans for 18,380 MW of hydropower to be developed, and the financial pressures that drive the scale of this development is a key underlying driver. Further, Hydropower currently accounts for more than 40% of Bhutan's national revenue and 25% of gross domestic product (GDP). Revenue from hydropower exports to India will help offset the reductions in donor support (RGoB, 2013). However, hydropower's contribution to Bhutan's national budget has reduced while external debt has increased and hydropower now accounts for 60% of that debt and negotiated prices India buys power at are below commercial values (Ogino and Hamanaka, 2011). The steady increase in domestic demand (estimated to increase 17% per year (Ogino and Hamanaka, 2011) for energy will continue to eat into projected export revenues (DGPC, 2014), partially due to the rural subsidies of electricity in Bhutan. The prioritization of hydropower development as the primary source of foreign exchange and economic development is clear. The financial commitment associated with hydropower expansion is a potent underlying driver that will put pressure on the country's forests.

4.3.3 Capacity constraints and/or weak management, including law enforcement and controlling illegal activity

Capacity constraints appear to occur on a range of levels. Interviews with DoFPS indicate that capacity in numbers of staff is adequate, but the enrichment of knowledge and capacity to implement policies on the ground are needed. This is particularly the case with knowledge about climate change impacts and adaptation and wood utilization and technology. Interviewees also specifically noted the knowledge and governance capacity needs at local governance scales, comprised of 20 Dzongkhags containing 205 Geogs. The field offices of DoFPS develops and implements all forestry plans and programs. Almost all approving and monitoring responsibilities have been decentralized to the DFO/CFOs and Range Officers, and only matters that are beyond the control of local authorities are forwarded to the Department and Ministry (Department of Forests and Park Services, 2011). The Field Offices will be the local level administration for REDD+ activities. This is the level at which many sectoral trade-offs will be addressed in the future, particularly as local governments figure out how to deliver on the National Economic Development Policy which relies on the 'five jewels'—hydropower, agriculture, cottage and small industries, tourism and mining (RGOB, 2016b).

Despite the existence of policies, effective management plans are lacking. A critique in the National Biodiversity Strategies and Action Plan notes that while forestry legislations require all areas under state forest to be strategically guided by sustainable management plans, as of 2014, only 6.4% of the SRFL under Forest Management Units and Working Schemes and 2.2% under Community Forests have well formulated resource management plans (RGoB, 2014).

Law enforcement and stemming illegal activity is an increasing challenge. The majority of the forest offences in Bhutan seem to be small-scale and opportunistic.

However, there also appear to be some illegal logging in isolated instances in places such as Paro and Sarpang, and cross-border smuggling into India (RGoB, 2015b).

The Ministry of Agriculture and Forests identified in the 11th Five Year Plan Mid-Term Review (2015b) that the number of forestry offences is the primary 'at risk' indicator given the number of wildlife and illegal timber crimes detected. The Ministry finds that unpredictable and efficient patrolling by forestry staff and strong community based informers leads to high detection rates, but the number of incidences means the underlying reasons for it are not being adequately addressed.

The demand for valuable timbers is identified by the Anti-Corruption Commission of Bhutan as one of the main reasons for illegal felling of trees. This is further facilitated by abundance of chain saws, which enable illegal or unauthorized felling. The Anti-Corruption Commission of Bhutan recommended that the DoFPS consult with the Ministry of Economic Affairs to identify how to control people from owning numerous power chain saws in villages, and suggested that Introduction of a licensing system for chainsaws may be an option (ACC, 2009). The Forest and Nature Conservation Rules and Regulations 2017 now contain provisions in Section 20.3 mandating that power chainsaw owners register with the Department for operating power chainsaws, and all registered saw mill/portable saw millers/power chainsaw owners shall saw rural timber only after obtaining sawing permission from the nearest Range Office (RGoB, 2017). It will be important to monitor the effectiveness of this recent policy change.

4.3.4 Rural subsidized timber allotment

The Rural Subsidised Timber Policy was designed to provide building supplies to rural communities for rural housing and related needs, and has directly helped address poverty. Based on expert interviews, there is growing discomfort with this system of entitlement, which may have been more appropriate when wood houses needed to be rebuilt every 25 years, and repairs every 12 years, but with the application of more modern building techniques this may no longer hold true. The concept of entitlement itself may need to be updated, as it is based on demand from the beneficiaries, not what the forest can sustainably provide, and local people are not involved in the management of the forest, and therefore are not aware of the relationship between their entitlement and sustainable use of the forest around them (Tempa, 2011). There is also concern that the entitlement competes with community forestry, which is a local forest governance approach that relies on local community management.

The Ministry of Agriculture and Forests (RGoB, 2011d) already identified major challenges regarding the rural timber allotment policy including:

- The overall resource base of forests in Bhutan for commercial timber production is very limited given the large area of protected areas, and very remote and very steep mountain terrain. Basically, only around 14% of the total forest area is considered capable of supplying quality construction timber.
- The demand for construction timber in rural areas is very high and is increasing. With the rapid economic development taking place in various parts of the country, the need for housing has gone up substantially. Houses are constructed particularly in suburban areas for rental and commercial purposes. **Some pre-existing households in suburban areas are still allotted subsidized timber.**
- The present allotment system has many loopholes that provide opportunities for

diverting the rural subsidized timber to urban markets, basically relabeling it as commercial timber. **This is incentivized by the price difference between rural and commercial timber which has widened.**

Though the amount of timber supplied to serve the subsidy has changed from year to year, with a high in 2015, the amount is generally 72% of overall timber harvested. In 2015, DoFPS Forest Facts & Figures indicate that out of a total of 340,254 m^3, only 18,380 m^3 accounted for commercial use, whereas rural use amounted to 321,780 m^3, or 95% of the total supply.

The spatial analysis of degradation on a district level reveals insights with regards to this sanctioned degradation. If we analyze which district experienced the highest relative degradation (% areas of degradation subject to the specific forest areas of that district) shows that degradation ranges between 16% and 33% for all districts, or on average, 26% of a particular district forest area. This means that throughout Bhutan, similar degradation occurs which is rather independent from different user groups, biophysical conditions, etc.

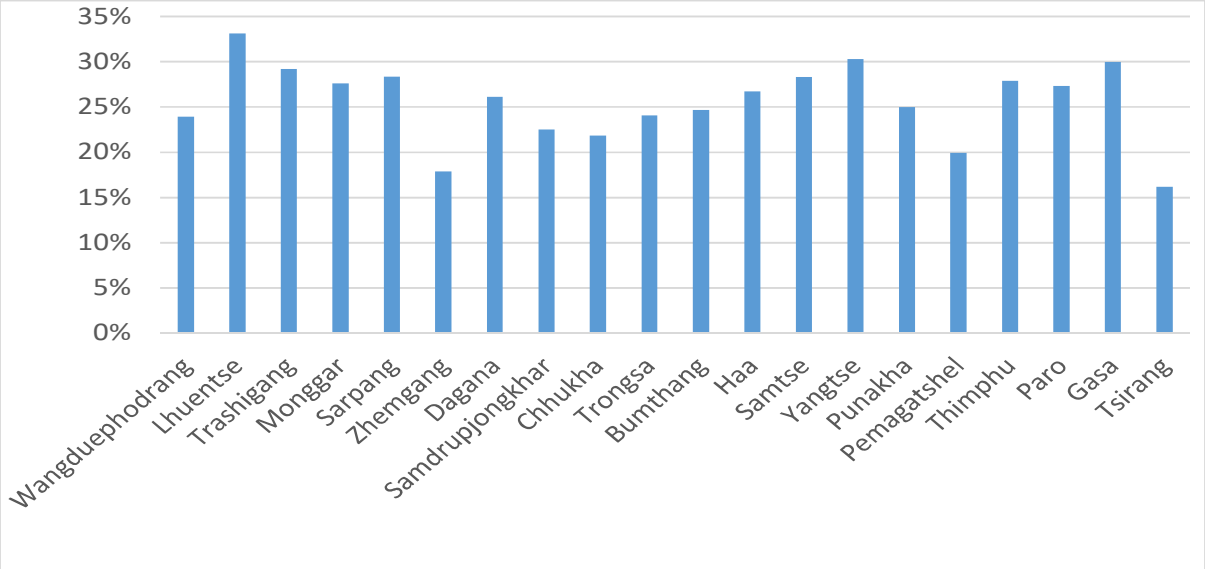


Figure 29: Share of degradation in relation to the specific direct-wise forest areas

The Anti-Corruption Commission (ACC) identified that periodic entitlements may be suitable, the monitoring of entitlements was problematic, and there was no implementation of the Forest and Nature Conservation Rules (2006), sub-section 8 of section 97, where it states that the civil authorities and forestry officials should check the utilization of the timbers. The lack of monitoring lead to the inability of officers to monitor the allotment eligibility time-gap criterion (ACC, 2009). Besides effective monitoring, the ACC also identified that having Gewog officers involved in monitoring was a conflict of interest, and therefore recommended that only forest officers should have that responsibility. Para number 323 in the FNCRR (2017) states, that, "Upon utilization, the applicant shall obtain a certificate from the Gup and submit to the CFO stating the utilization status of the subsidized timber. The forestry officials shall check the utilization of the timber from time to time," indicating that the CFO now is the sole monitor (not the elected local government official), and therefore the concern that ACC initially raised over civil authorities having a role in monitoring has been addressed.

The ACC noted that the loaning of timber should be disallowed, as it was found to be one of the major difficulties faced during the course of monitoring by forestry staff (ACC, 2009). Paragraph 321 (3) of the FNCRR (2017) has incorporated this change. The Rules provide for the establishment of forestry check-posts at strategic locations.

One of the important changes to the FNCRR of 2017 is that rather than having a standing tree basis for the allotment from NRDCL, there is now a volume based allotment in standing or log form (irrespective of the requirement of Drashings, Cham, tsims, shingle, dangchung). The Rule allows for differentiation between whether a household plans for a one- or two-story house (2,000 or 4,000 cft respectively). There will be a need for adequate capacity at field level to calculate this when allotments are made, to ensure this rule is followed.

Given the recent positive changes to the FNCRR of 2017, there may be little political appetite to further reform Rural Subsidized Timber. Reforming this policy is politically sensitive and socially challenging, because it is an important institution for rural livelihoods. But not doing anything can have even far reaching impacts on the forest resources which are the generational assets. There are several strategies that need to be considered. One of these involves the option to phase out rural subsidized timber to be replaced by community forestry. Other policy ideas involve strengthening oversight and monitoring, or more ambitious reforms on the rules governing rural timber supply.

It may be extremely difficult to 'fool proof' the allocation and monitoring procedures to ensure that timbers are approved and utilized only for the intended purposes. Allowing for some time to implement the new Forest and Nature Conservation Rules will be necessary, in order to assess how effective these changes are. But even if these changes are effective, the remaining question regarding effective forest management for long term sustainability in the context of serving an entitlement system remains.

4.3.5 Climate change is not yet fully mainstreamed into development planning

There is clear recognition that climate change is having an impact on Bhutan's forests, water systems, glacial flows, and agricultural production (RGoB, 2015c; NSSD, 2013). Available data suggests that localized impacts of climate change are occurring, as identified by the Sectoral Adaptation Plan of Action (SAPA) of 2016. A Global Environment Facility project, implemented by the government in collaboration with the UNDP, is helping to address decreasing water volumes. Bhutan also completed a National Adaptation Plan of Action (NAPA) in 2006 and is working on a National Adaptation Plan (NAP) to help prioritize medium- to long-term climate risks and appropriate response measures. However, the policy and arrangements to address climate aspects are not refined yet, though in the RNR Sector Adaptation Plan of Action 2016 provides an updated view on potential impacts and adaptation strategies (RGoB, 2016d). The INDC submitted to the UNFCCC notes that since the intended actions in the INDC apply to the post 2020 period, the priority mitigation and adaptation actions within the INDC will be considered and integrated in the preparation of the 12th Five Year Development Plan (2018□2023) and also subsequent five-year plan periods (RGoB, 2015c). Related to governance in the context of mitigation and adapting to a changing climate, many studies suggest a strong need to bring both biodiversity conservation and the management of forests as carbon sinks into the Forest Act (RGoB, 2014b; Wangdi et al, 2013) including the need to deliver on the enrichment of knowledge and

capacity development on climate impacts, mitigation and adaptation all the way to the village levels.

4.4 Economic, social, poverty and tenure aspects

4.4.1 Poverty

The cycle of poverty in some regions and rural areas (and perhaps increasingly in urban areas, too) in Bhutan is a noted underlying driver that is interconnected with land degradation and food security. That said, Bhutan's poverty reduction in the last decade has been rapid, broad-based, and inclusive. Between 2007 and 2012, the poverty rate halved and Bhutan has almost ended extreme poverty. Incidences of poverty are not distinguishable between landless and small or marginal land holders, and there is speculation this could be due to landless households engaged in agriculture are able to lease-in land and the share of produce to tenants has risen, while lessors have found non-farm occupations or have emigrated from rural areas (National Statistics Bureau, 2014). Interviews indicated that pressures to degrade forests is strong, both for economic and practical reasons.

Poverty also relates to dependence on wood fuel. Separate plantations dedicated to fuel wood production do not exist, and some regions experience a surplus of fuel wood, while others have a deficit. Despite many people using stoves for heating and cooking, the energy efficient stoves are not preferred by users, as they also use the stoves for household heating. The Department of Livestock has explored the promotion of biogas, but there are challenges such as metal rusting. Another attempt made by the Ministry of Economic Affairs, which has piloted 900 eco-stoves. The programme is now rolling out in four districts, but the budget is not large enough to expand to other areas.

4.4.2 Demographic factors

By 2030, 50% of Bhutanese will be urban, according to UN population statistics. The Department of Agriculture has observed migration from the East and Central areas to Western areas, with farm abandonment occurring in areas experiencing outmigration, especially in economically depressed areas where people are not able to produce enough food on their farms. Many of the abandoned farmlands are former slash-and-burn cultivation lands, some of which are reverting back to shrubland (and then forest) and see increasing wildlife conflict.

Interviewees and the 11th Five Year Plan also indicate that nomadic herding is on the decline, due to the lack of economic gains from this and availability of other alternatives. The herding culture is becoming less attractive to the younger generations, and it is feared this traditional practice could become extinct, also compromising the integrity of the biodiversity resources in the high land areas (RGOB, 2013). Reduced grazing has resulted in the juniper forest expanding into old grazing lands, thereby increasing woody biomass.

Due to the Land Act of 2007 and resultant land reforms, **issues related to forest land tenure (besides tsamdro and tseri use) such as customary land rights and land tenure in general were not identified in the expert interviews as a key underlying driver.** This indicates that customary rights holders in Bhutan can access forests for

their needs to the extent that forests continue to support livelihoods and local uses. Common property resources (CPR) are the key for subsistence of smallholders, and appears to be quite well organized. Addressing changes to tenure arrangements to support REDD+ objectives and goals is therefore not a priority.

5. Opportunities for "+" activities

Based on observations of activities that degrade the forest (rural timber allotment, firewood collection, etc.), this section identifies some inefficiencies in current forest management that leads to increased forest degradation and loss of carbon, and opportunities for improved management to increase forest quality and carbon storage.

A redefinition of the forest management system is one means to achieve this. Bhutan has over 51.44% of its land area under protected areas network system, besides other forest defined as Forest Management Units, Working Schemes, Local Forest Management areas, Community Forests, and there are also Watershed Management Plans and Wetland Management Plans. But within all of these areas, more attention could be paid to defining protection for high carbon stock/high conservation value forest, areas suitable for sustainable management, areas suitable for forest loss, and areas suitable for increasing forest cover and carbon enhancement. For example, steep, ecologically sensitive areas could be dedicated to protection to conserve carbon stocks, while afforestation, reforestation and enrichment planting could be promoted in degraded and barren areas. The intensification of sustainable management for timber and NWFPs would be suitable in forests with higher production potential.

Forest areas outside existing management regimes, and that comprise the major source of timber supply, are not as well-managed as FMUs. These are opportunity areas for better management, and therefore increased carbon stocks. That said, even within FMUs, there is room for improvement. Evaluation reports of FMUs under operation revealed varying degrees of compliance failures during implementation. Regeneration of harvested forest areas in FMUs have only average survival status, and the scientific principles applied in silvicultural operations of forests have been criticized as a 'one size fits all approach.'

There may be potential for Community Forests to participate in increasing carbon stocks, particularly in degraded areas, or where there could be good economic value for communities to invest in increasing forest carbon stock, such as economically valuable timber production in the warm, humid broadleaf forests. Community forests have faced challenges when established on degraded lands, and then have not been able to sustain themselves. Community Forests are a means to provide multiple benefits for local livelihoods, conservation and biodiversity, and helps forge a management and stewardship link between people and the forests around them. There are 676 CFs covering 75,299 ha of forest land and involving 28,239 rural households as of 2016. The total number of executive members indicates there are 2455 males and 539 females (Source: FIMS, DoFPS). As of 2013, about one third of all rural households in Bhutan are members of a CFMG. In some Dzongkhags, more than half of all rural households are members of a CFMG. However, the progress of the CF program has been largely judged by number of CFs created rather than the quality of plans and impacts of CF management. This is an area for improvement, and could bring direct land stewardship and economic benefits.

Interestingly, one of the best ways for Bhutan to increase its forest carbon stocks is to maintain its wood imports. A 2015 assessment found that the trade in wood products with India resulted in the net displacement of 27% of the total volume of wood products consumed in Bhutan between 1996–2011. While prior to 2009, Bhutan's domestic demand was largely met by domestic supply, after 2009, urban demand greatly outstripped supply, and imports increased. By 2011, the majority of wood products consumed (excluding firewood) in Bhutan was from India, and the majority of that was wood charcoal. Bhutan has imported increasing quantities of wood charcoal from India to process calcium carbide and ferrosilicon, which is then exported to India. Most Indian wood likely has originated from tree plantations in India. Jadin et al (2015) postulate that since Bhutan has few tree plantations and very valuable natural forests, the net international-level ecological impacts of this land use displacement should be viewed as positive.

Jadin et al (2015) construct a picture of imports/exports and production/consumption, which helps decipher the significant gap between wood demand in Bhutan, and the amount of that which is supplied by NRDCL and DoFPS (refer to figure 25(b).) Total production is divided between the two agencies responsible for production, while total consumption is divided among rural and urban areas. Figure 25 (a) depicts annual imports and exports between 1996 and 2011, with positive bars corresponding to imports, and negative bars corresponding to exports. By far the largest imports are wood charcoal, while "other products" includes anything that is not wood charcoal, logs, or sawn and chipped wood. Thus, "other products" includes veneer sheets, plywood, wood packing, wood pulp, uncoated Kraft paper and paperboard, clay-coated paper and paperboard, and wooden furniture. The categories targeted by the ban on export of timber in primary form, "logs" and "sawn and chipped wood," are grouped together.

Source: Jadin et al, 2015.

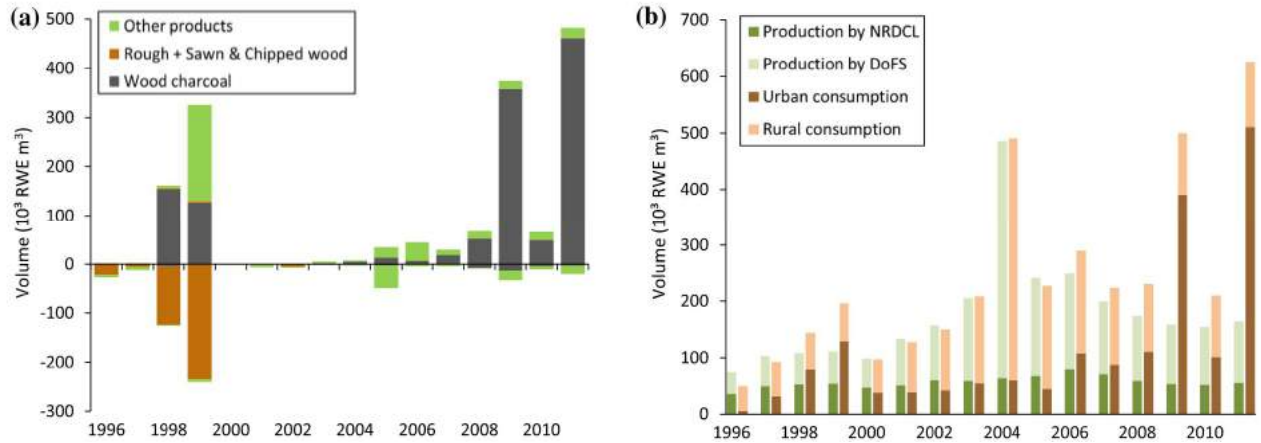


Figure 30: (a) Annual imported and exported quantities of the ten main forest products traded by Bhutan between 1996 and 2011 (in round wood equivalent volume), and (b) Reconstruction of the total annual production and consumption of roundwood in Bhutan

Given the large increasing demand for wood charcoal for its emerging chemical industries, it would be useful for Bhutan to predict what this demand will be in the future.

6. Future deforestation and forest degradation

6.1. Methodology

The largest concern is the increased degradation of Bhutan's forests, which is increasing at a rate faster than earlier patterns. The conversion of arable land and forests into other land uses is also increasing at a rate faster than it historically did. This section assessed future projections based on spatial analyses and quantified estimations, linear projections based on currently observed patterns, and a degradation risk map, to provide a basis for estimating future impacts. Most projections in this section assume business as usual (historical patterns) projections into the future, except for those where there is specific information to guide future projections, such as hydropower development plans. Projections into the future, based on BAU, inherently does not bring in the range of nuances which will impact future drivers, such as population growth, policy change, changes in consumption patterns changes in trade patterns, and other factors which could be modelled. An option is use of a computable general equilibrium (CGE) model to better project how changes in policy, technology or other external factors would impact forests, and this driver assessment has not relied on such detailed macro-economic modelling, but rather relies on linear modelling. This means that projections in this section may underestimate some future drivers, and yet for others where future assessments are based on known variables such as development plans, projections are indicative of current commitments and intentions.

Projecting underlying drivers into the future, and their influence on direct drivers, is noted where possible below. However, projections on future connections between underlying and direct drivers contain a high level of uncertainly, given changes that can occur in government decisions, commodity and regional economic demand factors, social aspects, etc.

6.2 Projecting the impact of deforestation drivers

6.2.1 Allotment of SRFL for various purposes

Bhutan predominantly practices planned deforestation programs. Under various planned programs, the Government allots SRFL for various purposes, and clearing of SRFL for agriculture, hydropower, roads, mining, and transmission lines. These purposes are the major factors as drivers to deforestation.

Annex 5 shows historic trends of SRFL allotment for various uses. Agriculture, hydropower, roads, mining and transmission lines are the top uses affecting the forest cover. However, in the absence of comprehensive statistics, trend analysis has not been ascertained. Assuming the historical (2008-2014 period) average of forest area lost (1,923 ha) due to all allotments (excluding allotments for roads and transmission lines), the average deforestation predicted to occur between now and 2030 due to RGoB allotments of SRFL for various purposes is 28,845 ha.

6.2.2 Hydropower

Hydropower is estimated to remain a dominant driver of deforestation, given development plans underway. Among the deforestation drivers, hydropower has

historically had the highest average SRFL allotment. Based on reviews of proposed hydropower projects which are listed in Annex 1 and on the assumption made in Section 3.2.4 that future hydropower development would follow the same pattern as previous hydro impacts on forests in Bhutan, we spatially estimated the per hectare impacts of previous hydropower development, which results in an average of 1 to 4 hectares of forest being lost for every megawatt (MW) generation capacity developed. Thus, if we extrapolate into the future assuming an average of 2 ha of deforestation for every MW generation capacity developed, we predict that the development of 18,380 MW may generally impact about 39,760 hectares of forest (refer to table below).

Table 20: Simple extrapolation projection of hydropower development impacts on forests

Hydropower project	MW	Potential hectare impact
Punatsangchhu-I	1,200	2,400
Punatsangchhu-II	1,020	2,040
Mangdechhu	720	1,440
Kholongchu	600	1,200
Wangchhu	570	1,140
Nikachhu	210	420
Bunakha	180	360
Amochhu	540	1,080
Chamkharchhu-I, II, III	770+1890	5,320
Sankosh	2,560	5,120
Kuri Gongri Hydropower Projects (I&II)	2,600 (and 3,000 hectares of land planned to be submerged)	8,200
Kuri I (Rotpashong)	1125	2,250
Nyera Amari Hydropower Projects (I&II)	442	884
Gamrichhu Hydropower Project (I&II)	140	280
Dangchhu Hydropower Project	135+150+78	726
Khomachhu Hydropower Project	336	672
Gamrichhu Hydropower Project	64+79+80+91	628
Pachhu Hydropower Project		0
Manas RS I	1800	3,600
Manas RS II	1000	2,000
Total:	**18,380 MW**	**39,760 hectares**

Note that these rough projections do not include spatial assessment of the actual proposed development sites. Bunakha, Sunkosh, and Amochhu are all expected to have significant land clearing impacts as they are mega reservoir-based hydropower projects. The estimation that Kuri Gongri would require an additional 3,000 ha for a reservoir has been included in the rough estimate. Whether all planned hydropower projects will be successfully implemented is not possible to predict as they are highly dependent with funding and political circumstances. Nonetheless, hydropower projects will arguably remain among the top drivers of deforestation in Bhutan, as they have been historically.

6.2.3 Roads

Given the priorities in Bhutan's 11th Five-Year Plan (to 2018) on road improvements, in order to provide road access to rural areas for market and development access, road development will continue (RGoB, 2013). The emphasis on road infrastructure is also linked to other development priorities such as hydropower projects. There are plans to upgrade and build national highways, and roads connecting to hydropower projects, districts (Dzongkhag), etc. The Department of Roads is interested to improve construction standards of roads to make them more climate proof and to ensure the long-term value of investments in roads, and this is an area for greater collaboration and capacity development. Road access is also intended to improve social services and economic prospects by practically linking almost every village in the country (RGoB, 2013). The dzongkhags with the highest network of roads are Trashigang, Mongar and Chukha with sizeable connectivity of national highways, dzongkhag roads and farm roads. The least connected dzongkhags are Yangtse, Tsirang, Haa and Gasa (RGoB, 2016), indicating these would be the areas with greater emphasis on road construction in the future. Assuming the average forest area lost due to road construction in the period 2008-2014, the average deforestation attributable to roads would be predicted at about 4,100 ha between now and 2020, and up to 12,300 ha by 2030. It is important to note that increased road development in remote and forested areas often results in easier access to illegally extract resources (Tenzin & Hasenauer 2016). This was visible in a FMU reviewed for this study (Paro-Zonglela FMU, visited 24.06.2016) where trees were illegally cut at the roadside, and interviewees noted this also happens in other regions.

6.2.4 Agriculture

Despite rural abandonment of farms which helps offset the amount of forest being converted to agriculture, indications are that agriculture as a driver of deforestation will have increasing prominence in the future. Agriculture is the most important sector in the economy, contributing 16.8% of GDP, employs 59.4% of the population, and accounts for 4.3% of exports. The government places agriculture at the centre of the development agenda, in part due to the rising trade deficit and the need to substitute imports. The sector's growth is insufficient to address poverty issues, food security and lead to sustained GDP growth (RGoB, 2013).

The need to address food security and increased self-sufficiency in agricultural production is identified in the 11th Five Year Plan. Domestic production of cereals meets only 66% of the total requirement. The country is only 47% self-sufficient in rice, 47% in wheat, 40% is pulses and less than 10% in oils. However, the country has the potential to increase both production and productivity. Further, about 80% of national domestic beef consumption requirements are still imported. Similarly, about 97% of total fish consumption and 83% of total pork consumption are all met from imports. Thus, the 11th FYP prioritizes investments in boosting the enabling environment for increased livestock production (RGoB, 2013). It is unclear what guidance exists on appropriate land use to reach these goals, though the 11th FYP does indicate various methods of increasing yields on the existing agricultural lands, such as through improved genetics for livestock and irrigation for agriculture.

However, the available options for improved agriculture production are challenged

by Bhutan's geography. In a discussion with the Department of Agriculture, the following mismatch was identified: Less than 8% of the total area is cultivatable, and based on 2010 land cover mapping, it was found that more than 65% of the population is cultivating on 2.93% of the land. Farmers cultivate on up to 38% slopes, and their landholdings are limited, as most farmers have less than one acre. Land degradation and surface erosion was identified by a range of interviewees as a 'silent disaster' that affects livelihoods, and is also a difficult to change (National Statistics Bureau, 2014). The National Action Programme to Combat Land Degradation helps provide solutions, and the National Rehabilitation Project seeks to take sharecroppers with no landholding in their name and identify areas where they can settle and steward land (will occur in SRFL).

Indications are that as urban development places pressures to expand on flat paddy areas, it will displace agricultural production to other areas (such as forests and steep slopes) or alternatively cause an increase in food imports (which may spare forest but increase food prices). Increasing pressure for commercial cultivation is also a noted trend, as evidenced in the large number of land leases applied for in order to cultivate cardamom, and increased commercial production could impact forests, if land is not available elsewhere.

Assuming the average forest area lost due to conversion to agriculture assessed with the spatial analysis 2000-2015 (as well as taking into account the area converted back to forests), the average deforestation would be predicted at about 3,890ha between now and 2020, and up to 11,670 ha by 2030.

6.2.5 Mining

Mining has historically been among the top four SRFL allotments. Mining is one of the fastest growing industries in the country, with a growth rate of about 17% in 2014 (Anti-Corruption Commission, 2016). Hence, it can be reasonably expected that mining will continue to exert an increasing pressure on forests resources. Dolomite and gypsum mining in particular are increasing – with production more than doubling between 2002-2012 (Anti-Corruption Commission, 2016). Hence, in the short- to medium term, deforestation pressure due to mining is expected to increase. National Land Commission data for land leased on long term shows that highest demand for leased land was for mining at 1550.18 Ha (RGoB, 2016a), and interviews suggest this interest will grow. Mining is one of the fastest growing industries of the country, with revenue generated from the mining and quarrying sector increasing 20.86% in 2014 compared to 2013, to Nu. 3376.43 million. The growth rate recorded for the sector was 17.01% in 2014. The share of mining and quarrying to GDP is about 3%.

On the policy side, government is working on a Mineral Development Policy, but the process has identified many differences among stakeholders. The policy may be approved by the end of 2016. There is also a call for review of the Mines and Minerals Act. **One clear recommendation to DoFPS is to provide guidance and direction to the review of this Act.**

Development and enforcement of proper environmental regulatory frameworks would be required in order to balance revenue generation from mining and environmental conservation. Assuming the average forest area lost due to mines and quarries in the

period 2008-2014, the average deforestation would be predicted at about 3,165 ha between now and 2020, and up to 9,495 ha by 2030.

6.2.6 Power lines

As for power transmission lines, historical statistics indicate that SRFL allotted to this driver has declined in the 2008-2014 period, though this does not correspond to the impact expected to result from increasing number of hydropower projects being developed in the country. Assuming the average forest area lost due to construction of transmission lines in the period 2008-2014, the average deforestation would be predicted at about 2,710 ha between now and 2020, and up to 8,130 ha by 2030.

Though there is dampened interest in the "10,000 MW by 2020" hydropower target that Bhutan signed in a hydropower development and trade cooperative agreement with India, development continues. Considering that the country plans to undertake some 15 hydropower projects in the country by 2020, and another 58 by 2030, it is reasonable to predict that more forests will continue to be lost due to Power lines. Linear assumptions of future forest loss based on the average forest area lost over the 2008-2014 period is not logical, given the development plans for hydropower. Rather it would be more suitable to refer to Annex 2 on the prospective power grid by 2030, and to estimate clearance based on line capacity planned in various regions and the access routes.

6.3 Projecting the impact of degradation drivers

Except livestock, the future impact of all other forest degradation drivers are predicted to exert constant or even increasing pressure on forests.

6.3.1 Timber harvesting

For timber, the historic statistcs indicate a fairly stable extraction and supply from Bhutan's forests, with the exception of a significant leap in 2015. However, considering future demand by a growing population and urbanisation, timber extraction from Bhutan's forests can be expected to increase or at most remain stable.

Source: From Forests Facts and Figures publications by Ministry of Agriculture and Forests (see section 4.). Note that timber includes all wood products reported in the stats, e.g., cham, dangchung, drashing, posts, firewood, poles, hakaries, logs, shinglep, tsim, wood chips, etc; but excludes firewood.

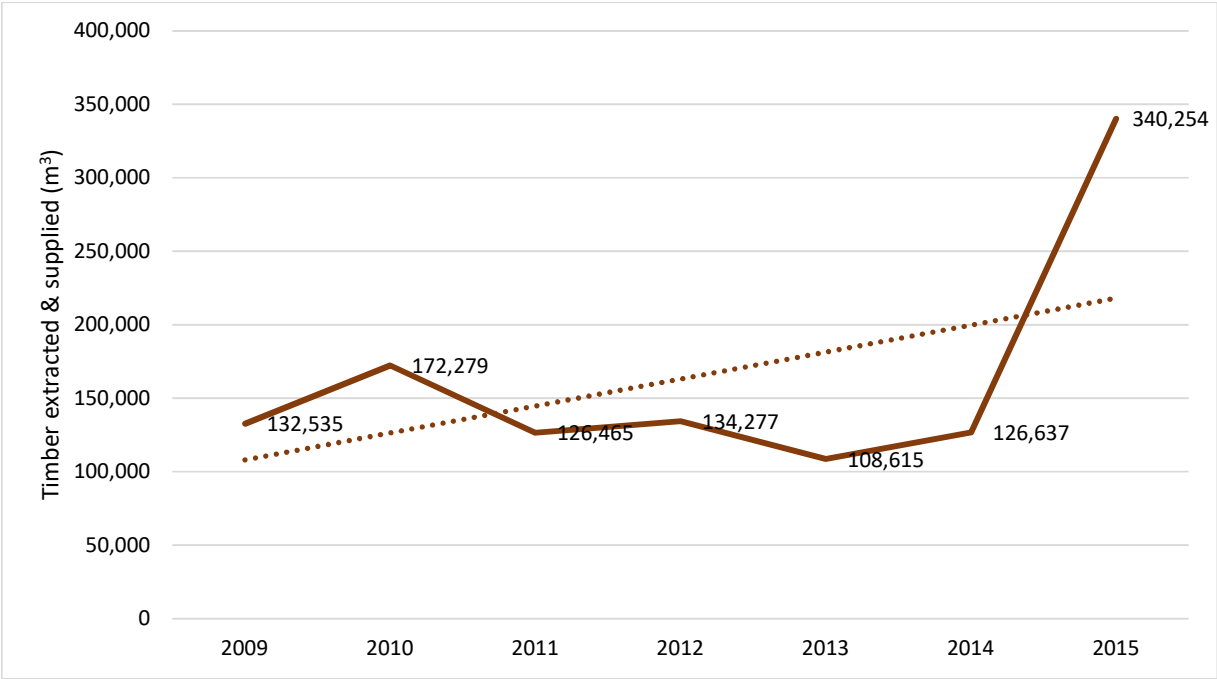


Figure 31: Timber extracted from forests and supplied in Bhutan in 2008 to 2014

There is further evidence indicating that timber trading is lucrative, with illegal sale of subsidized rural timber having been detected (Anti-Corruption Commission, 2016), and FNCRR (2017) changes seek to address this. Also timber offences are on the rise. Hence, the pressure to extract more timber from Bhutan's forest is evident, and predictably increasing – and so will be the future impact on forest degradation.

6.3.2 Firewood

Presently, and in the short- and medium term, firewood is and will be the main source of energy in the country. It is cheap and readily available in most parts of the country. Based on the latest data, the per capita consumption of fuel wood has decreased in the past years (MoEA, 2016), however, it is still one of the highest in the world, and this is due to its value both as a source of fuel and also the key source of household heating. Rural households consume more fuel wood than their urban counterparts. With only about 38.6% of the country's population being urban, a large quantities of firewood are consumed annually by the remaining large rural population. Bhutan's Second National Communication to the UNFCCC noted that the residential sector mainly consumes firewood, kerosene, liquefied petroleum gas (LPG), and electricity.

The rate of urbanisation in Bhutan is estimated at about 3.69% (CIA World Factbook 2013-14); while population growth rate is estimated at 1.3%, and is declining since 2002 (World Bank, 2016). Hence, it can be reasonably predicted that the impact of population growth rate on firewood consumption will reduce and will also be muted by

urbanisation growth rate. Some evidence already show a declining trend in the amount of firewood extracted from forests and supplied in Bhutan in 2008 to 2014 (Figure 30). However, this statistics would be treated with caution and it excludes consumption that is not documented in this official supply channel. As noted in section 3.3.1, the per capita consumption (which includes all firewood users such as residential, industrial and transportation) appears to be 3.5 times higher than the estimates of firewood extracted and supplied as reported in the national statistics, and is equal to about 35 % of the estimated sustainable annual yield in the country.

Source: From Forests Facts and Figures publications by Ministry of Agriculture and Forests (see section 4.)

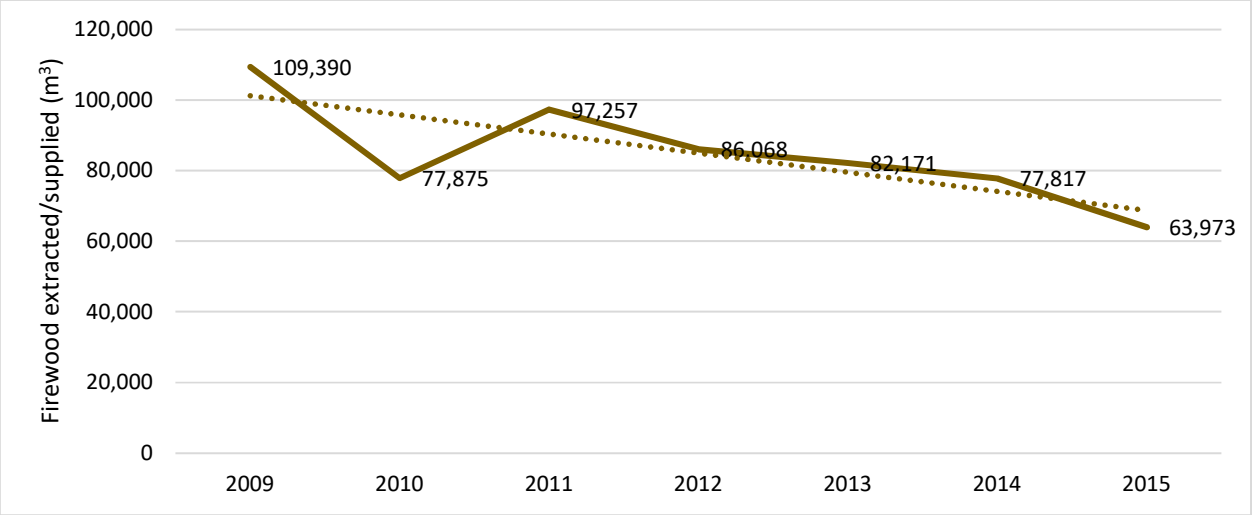


Figure 32: Firewood extracted from forests and supplied in Bhutan in 2008 to 2014

In addition, there are efforts to increase the use of energy-efficient cook stoves in many parts of the country. Hence, firewood extraction can be predicted to continue to exert a marginally reduced but still significant degradation pressure on the forests. This is coupled with the fact that firewood is also supplied by the government free of charge to people living in rural areas.

6.3.3 Fires

Historically, fire occurrences have been declining in Bhutan while the area burned has been increasing (see section 3.3.4). Nevertheless, there are a number of reasons to predict an increasing trend of forest fires in the future. Bhutan's future climate outlook indicates a warmer climate. There is a consistent finding across climate projection models of a warming pattern, with greater temperature changes predicted during the winter months (Asian Development Bank, 2016). As noted by Westerling et al. 2006, increase in number of wild fires in many of the world's fire prone ecosystems in the last two decades can be partly attributed to a changing climate – with warmer temperatures and reduced precipitation being key factors. Hence, a future warmer climate for Bhutan will most likely translate into increased forest fires. This is coupled with the country's rugged terrain – making fire control very difficult. In addition, the capacity to manage fires is currently weak, and not expected to drastically improve soon. Assuming a continuation of the annual average area of forest areas burned, one could predict that between now and 2030, about 93,800 ha of forest would be subject

to fire across the country.

6.3.4 Livestock

The NEC's State of the Environmental Report identifies over-grazing as a key driver/ pressure on land resources (RGoB, 2016a). Thus, the government is undertaking efforts to improve livestock management, e.g., cross-breeding, enhancing pasture, and feed and fodder development programmes. Available statistics already indicate a decline in cattle population. Coupled with predicted increase in the use of improved breeds, which have been reported to graze less in the forests, the overall impact of livestock grazing on forest degradation is predicted to decrease.

Source: RGoB, 2016a.

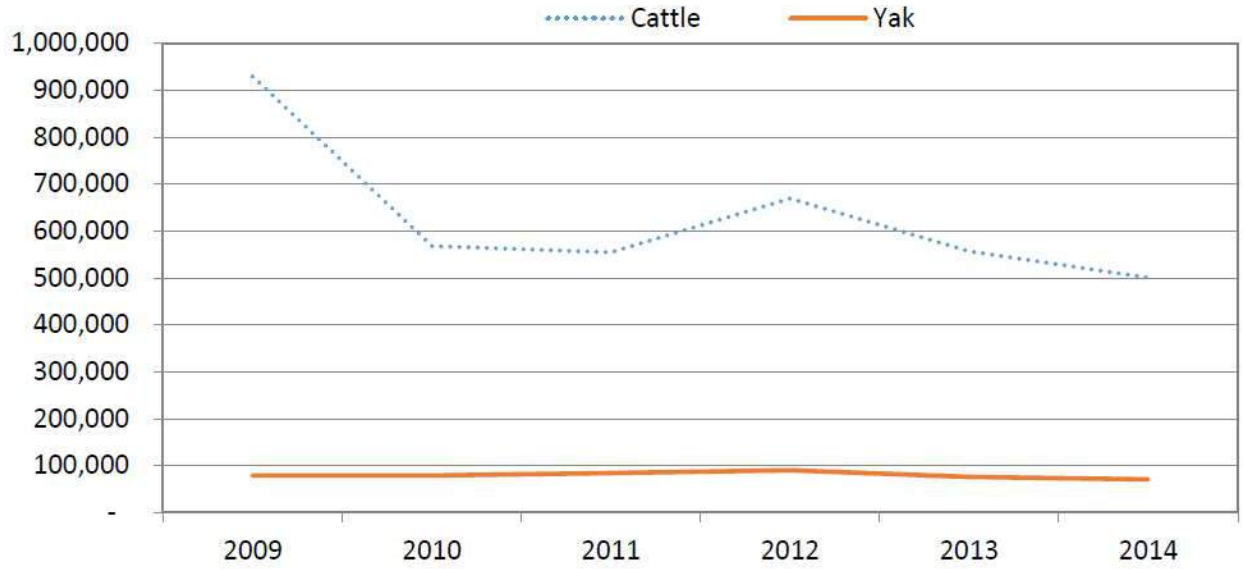


Figure 33: Trends in population of cattle and yak in Bhutan in 2009 to 2014

The population of free grazing cattle and yaks are seen to be diminishing gradually over the past decade. This trend suggests a decline in the pressure on land from grazing. The recent changes in tsamdro and grazing are positive for REDD+ and provide a basis for improving the linkages between livestock and forest management. The Department of Livestock is focused on carrying capacity assessments, rangeland improvements, improving species and improved pasture. Of concern to the Livestock Department is the warming of the higher elevation areas, resulting in cattle grazing moving up into these higher areas due to climate change impacts. The centralization and redistribution of tsamdro leasing should help improve rangelands by allowing greater ownership and stewardship, and this is occurring both in the highlands and lowlands. As livestock leasing falls under agriculture leasing, it cannot switch to other uses.

6.4 Future forest degradation risk analysis

Since forest degradation being the main forest change affecting the quality of forests in Bhutan (the forest area has increased), a spatial assessment of future risk of degradation has been done in this study.

Methodology

There are statistical models/tools available to project the future land use land cover change such as Terrset Land change modeller, Random forest in R. These models can predict the land cover change based on the historic trend and rate of deforestation/ degradation taking bio physical parameters such as distance to infrastructure (road, settlement, markets), elevation and slope, pattern/trend in land change into account. However, such models have a major limitation that it can't take policies or other non-spatial variables into account which directly affect the rate of the deforestation/ degradation. Considering above limitations in statistical model we decided to use the multi-criteria decision analysis (MCDA) to prepare the future forest degradation risk map. In the process of MCDA basic analysis is similar to statistical models i.e. looking for correlation in physical parameters and the degradation. The advantage of MCDA over static statistical models is that certain influences of different variables for the future will be ranked and assigned weights which can be done in various ways including through expert opinion, participatory processes and surveys.

Methodological approach

- First step is to identify weightings of risks of different parameters to prepare a realistic model of areas under risk of degradation
- In this process we are not using only binary input data such as 'under risk' or 'no risk' as proposed in the Boolean overlay, but ratio data:
- Elevation: "high/ medium / low"
- Slope: "steep / moderately steep/ not steep"
- Distance to road and settlement: " 0-1 km / 1-2 km / >2 km"
- Fragmentation of forests: "patch; edge, perforated, core < 250 ac, core 250 – 500 ac, core > 500 ac
- Selection of these ratios were based on the analysis of all physical variables overlaid with degradation maps. A correlation analysis was done with all of these parameters against forest degradation showing either positive or negative correlation.
- Standardization: the different measurement scales of the ratios of parameters were standardized with numerical index scales i.e. 1-3 are assigned to the input data. Consequently, the values of the resulting physical features (factor) layers will no longer have units but a risk index.
- Distribution of weights: each physical parameter layer receives a weight. The weight reflects the relative importance of the each layer respective to the other. The largest weight is assigned to the most important layer. The correct choice of weights is based on the statistical analysis of all physical variables together with degradation maps (correlation analysis). To assign weights we have used weighing by ranking method
- Application of the algorithm: the algorithm of the weighted linear summation multiplies

Table 21: weighing by ranking of parameters to assess forest degradation

Layer	rank	weight	normalized weight
Elevation	1	4	0.40
Road	2	3	0.30
Settlement	3	2	0.20
Slope	4	1	0.10

all grid cells of a layer by their weight. Then, the layers are added together. In the resulting risk map layer the risk cells have high values while the no risk cells have low values.

Limitations of this approach: The selection of weights certainly considerably influence the results of risk analysis. Usually, experts facilitate the weighting process and thereby rely on various sources of information. In the case of this study we used statistical analysis of all available physical features. However, different experts implement the weightings according to their own interpretation. Therefore, interpretation should be considered with caution and more seen as a starting point for further national as well as regional consultations. Nevertheless, this method represents a transparent method which provides a good basis for further discussion and investigation. For instance, the weighting and ranking method could be repeated in an open stakeholder process at regional (district) level.

The maps below display the different risk maps for each of the factors before weighted linear summation of all variables used in the process.

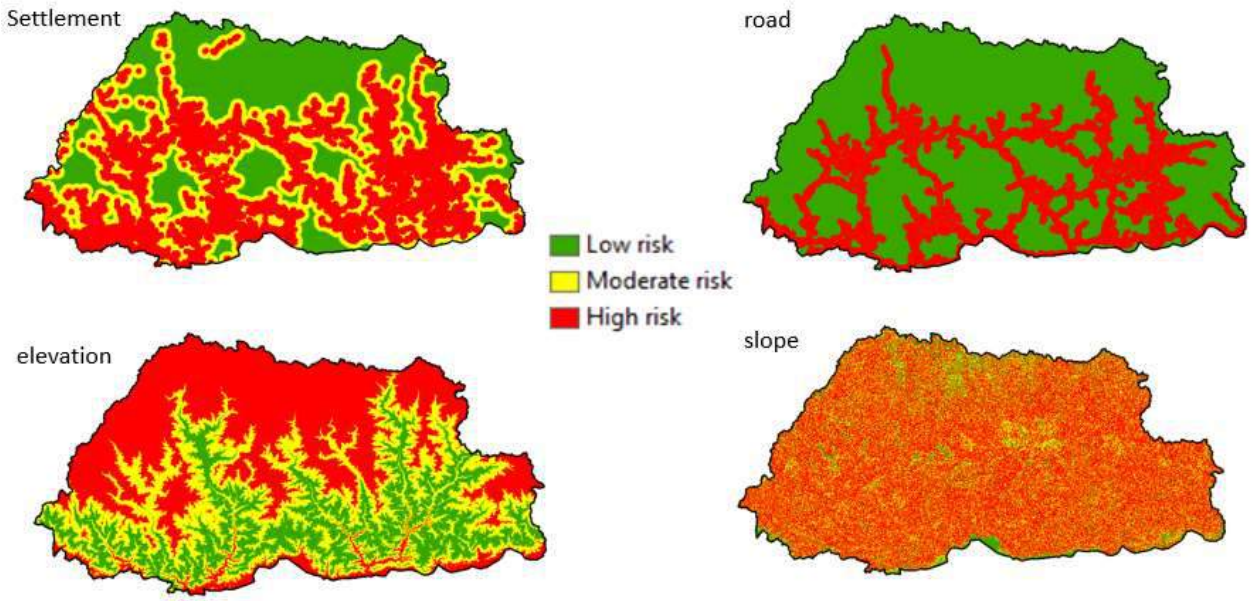


Figure 34: Factor Maps classified based on risks

Finally, a risk map is presented below showing the risk of future forest degradation as a result of the ranking based on historic degradation analysis of physical parameters. The risk map does not show any new risks or projected changes of policies, etc. it is a status assessment of existing forest areas more likely to be affected in terms of degradation.

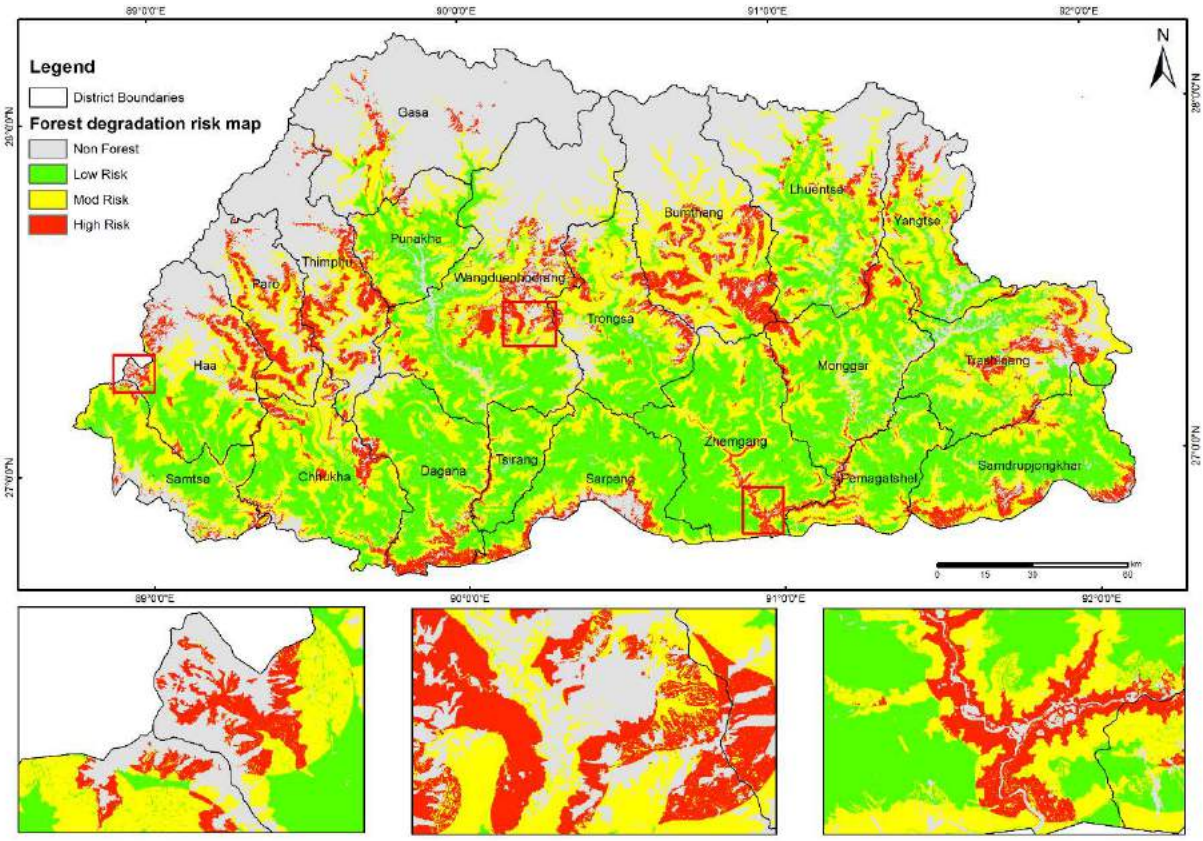


Figure 35: Bhutan overall forest degradation risk map

The main hot spots of high risk degradation are along the southern border including the valley bottoms. More distinctively, the zones in the higher altitudes around Paro, Thimphu, Trongsa, Bumthang and Trashigang are characterized with forest areas of higher risk of future degradation. Above risk map is based on only four variables with categorised in 3 risk ranks therefore looks more broad. Re-ranking and introducing the other variables with this methodological approach will improve the accuracy of the map and highlight specific areas under high risk. Also the above risk map doesn't show the degradation in different forest canopy covers. In the centre zoomed box in map shows isolated patches of forest which are under more risk of either deforestation or degradation due to manmade or natural causes.

Certainly, to understand patterns and risks of future degradation especially on a regional level, more factors need to be taken into account. The method presented here would easily allow to be adapted to more degradation and/or deforestation factors once discovered through local field assessment and surveys.

The three maps below further define the risk of forest degradation for the different forest crown cover types - dense forests, medium dense forest and open forests.

Risk maps for different forest canopy covers:

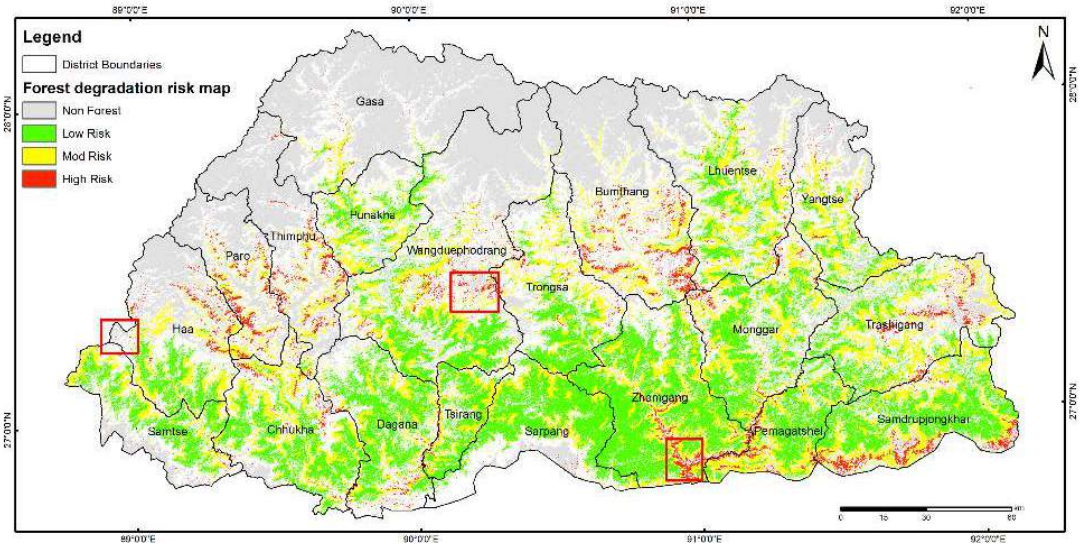


Figure 36: Bhutan forest degradation risk map for canopy cover > 50 %

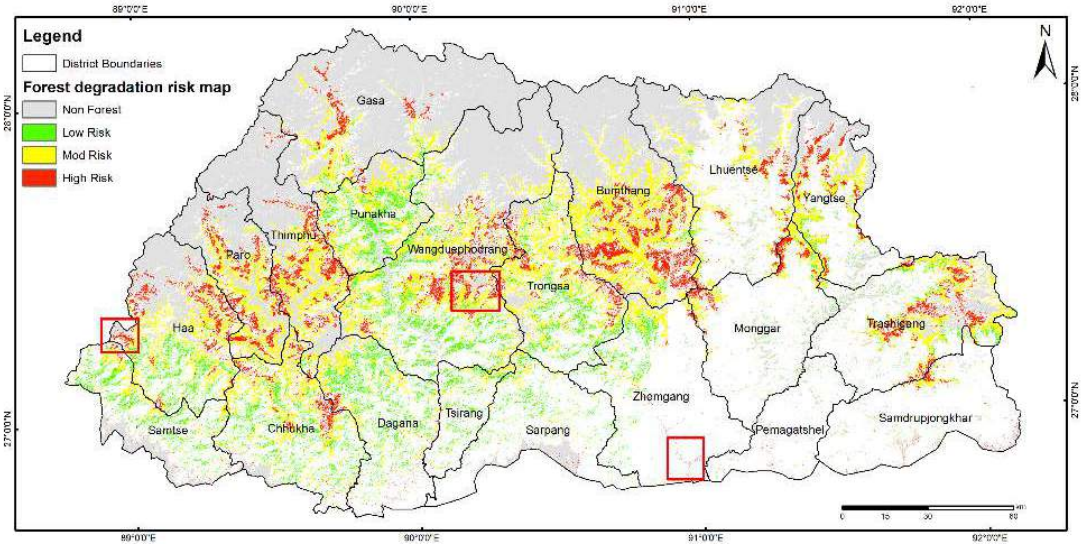


Figure 37: Bhutan forest degradation risk map for canopy cover 30 - 50 %

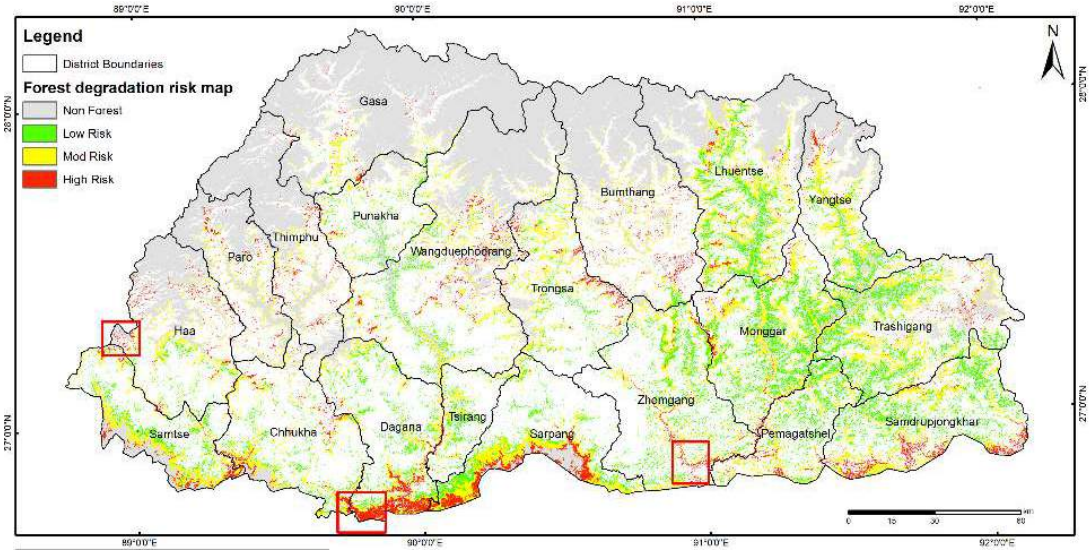


Figure 38: Bhutan forest degradation risk map for canopy cover 10 – 30 %

7. Regulatory and policy framework

7.1 Overarching policy and legislation

The basis for Bhutan's strong commitment to its forests stems from the **Constitution of the Kingdom of Bhutan**, which directs every Bhutanese person, as a trustee of the Kingdom's natural resources, to contribute to the protection of the natural environment, conservation of the rich biodiversity of Bhutan. Government is directed to protect, conserve and improve the pristine environment and safeguard the biodiversity of the country; prevent pollution and ecological degradation; secure ecologically balanced sustainable development while promoting justifiable economic and social development; and ensure a safe and healthy environment. The Government is further directed to ensure that, in order to conserve the country's natural resources and to prevent degradation of the ecosystem, a minimum of sixty percent of Bhutan's total land shall be maintained under forest cover for all time (RGoB, 2008a).

Gross National Happiness – Bhutan's unique development philosophy aims to measure the aspects of life beyond material well-being. GNH is therefore regarded as a richer objective than GDP or economic growth. In GNH, material well-being is recognized as important but it is also important to enjoy sufficient well-being in terms of community, culture, governance, knowledge and wisdom, health, spirituality and psychological wellbeing, a balanced use of time, and harmony with the environment. The 2015 GNH Index, which is estimated based on a national survey found that there were favourable increases in sufficiency levels in two indicators: environmental issues and avoiding harm from wildlife, and a decrease in the sufficiency level of one indicator: responsibility to the environment, with no changes in urbanization (Centre for Bhutan Studies and GNH Research, 2015). A discussion with government officials indicated a need for a better set of indicators to measure the health of the ecosystem, including a robust information management system.

The **National Environmental Strategy, "the Middle Path,"** recognised the need to develop the economy while still maintaining the country's rich cultural heritage, traditional values, and natural resource base. The NECS outlined three main avenues of sustainable economic development: expanding hydropower, increasing agricultural self-sufficiency and expanding the industrial base. The NES noted that expanding the hydropower sector depends on maintaining the integrity of the country's watersheds, and thus threats to the country's forests - illegal cutting, unsustainable rangeland practices, agricultural expansion and road development - would have to be minimised (RGoB, 1998).

Bhutan 2020: The Vision 2020 document contains the National aspirations and vision for a 20-year time frame. It re-affirms the notion of GNH as the central development concept for the country. The Vision predicts increasing threats to biodiversity and has placed environmental conservation at the core of the developmental strategy. Thus, the vision states that the environment is, "…not treated as a 'sector' but rather as a set of concerns that must be mainstreamed in our overall approach to development planning and which must be buttressed by the force of law (RGoB, 1999)."

National Environmental Protection Act of Bhutan 2007, is the umbrella legislation that defines the roles and responsibilities of key agencies in environmental management

and sets out requirements for the protection of the physical and ecological environment. It also promotes the use of clean energy and alternative technologies to reduce use of fuel wood/timber from primary forests and calls for conservation and protection of wetlands, alpine regions, watersheds, and other vulnerable ecosystems in addition to the existing protected areas. The Act is based on a range of principles including inter-generational equity, the Middle path strategy, precautionary principle, the principles of 3Rs (reduce, reuse, recycle), polluter pays principle, rights to information and justice, and payments for environmental services. Chapter 5 does identify the importance of ecosystem integrity, and also reinforces the Constitutional commitment to maintain a minimum of 60% of Bhutan's total land under forest cover for all time, and that any changes in the present national forest cover and protected areas shall be made only by the Parliament (RGoB, 2007b). The Act does not mention climate change explicitly, but the overarching framework implicitly encompasses considerations for addressing forest degradation.

The Environmental Assessment Act of Bhutan 2000 stipulates that an environmental clearance is a prerequisite for development consent, and shall set out the environmental terms for project requirements. Information shall be made available to the public as per Chapter 4. (RGoB 2000). The Act is supported by 'Regulations for the environmental clearance of projects,' developed by NEC and enacted in 2001. The Act and Regulations focus on project-level proposals, and do not provide guidance on how to address multiple projects proposed in water catchments, for example.

7.2. Land

The preeminent law guiding land use is the Land Act of 2007. It allows for both leasing and allotment of GRF (now SRFL), and states the procedural steps to process such filings for changes and how to record the changes, but does not provide criteria for evaluating the proposals.

- The Act created the National Land Commission, and directs the Commission to, among other activities, certify land categories, approve cash compensation for land acquired, allot SRFL to Government institutions and Gerab Dratshang, recommend appropriate tax measures, approve exchange of rural registered land with SRFL. The Act empowers the Commission Secretariat to work with local (Gewog, Dzongkhag and Thromde levels) government to carry out provisions of the Act. Though the Act empowers the Commission to carry out cadastral activities (to be documented in the Thram), provides guidance on who can own land, rights and obligations on land owners, procedural aspects related to land, it does not provide zoning or policy guidance on land use.
- For leases of SRFL, the Ministry of Agriculture is to prescribe the rules of the leasing arrangement. The Act also states that trees, either grown naturally or planted, in registered land shall belong to the landowner, which was a change from previous legislation.
- Land rules and regulations which came into effect in 2009 further defined procedures for land exchanges and leasing in SRFL. The leasing allowances in SRFL include land for tsamdro/pasture development, sokshing and commercial agriculture farms and any economic activity such as mining, industrial activity and development activity. Leases are not to exceed 30 years, except for Highlanders practicing tsamdro/pasture development, in which case the lease period is a

minimum of 30 years. If minerals of strategic value are identified on lease land, the lease could be terminated with compensation. Approval by the relevant ministry is required, and a management plan to guide use of the land is mandated in regard to the leasing of SRFL (RGoB, 2009b; RGoB, 2007a).

With the objective of deepening the decentralization process, **The Local Government Act of 2007 was reviewed and amended in 2009**. The key provisions related to land and forest management include the following:

- The act empowers the Dzongkhag Tshogdu to provide regulatory oversight on functions relating to water, air and noise pollution and other environmental degradation.
- The Act stipulates that the Gewog Tshogde is to monitor establishment and operation of mines and quarries in consultation with the concerned community, regulate the protection and harvesting of edible forest products in the community forest, prevent illegal construction and all other types of encroachment in community land as well as on government land and government reserved forest land. The Gewog Tshogde is to be the custodian of community land, community forests, including sokshing, nyekhor tsamdro, and medicinal herbs and prevent illegal house construction and all other types of encroachments in community land as well as on government land and forests; conserve and protect water sources, lakes, springs, streams, and rivers (RGoB, 2009a).

The revised **Economic Development Policy** (dated June 2016) provides the basis for promoting "Brand Bhutan" based on its rich natural resources and culture, along with strategies for promotion of the Five Jewels, which are the sectors constituting the core growth areas. These sectors include hydropower, cottage and small industries, mining, tourism, and agriculture. It provides guidance for the general policy reforms sought to promote the right enabling environment for business. The policy also outlines the importance of land use through proper land use planning as highlighted below:

- The relevant Government agencies responsible for promoting respective sectors of the economy shall proactively identify land in collaboration with the NLCS and develop/facilitate development of infrastructure for growth of businesses.
- Local Governments in collaboration with the NLCS shall identify industrial areas within their respective jurisdictions by 2016 to facilitate establishment of industrial land service activities.
- The allotment of SRFL shall be prioritised on strategic business activities such as large stand alone projects with cluster effects and public utility services.
- The NLCS shall prepare a national land use plan (Zoning) which will outline use of land for optimal use by 2017. For this purpose, all relevant sectors shall provide sectoral parameters to NLCS by 2016 (RGoB, 2016b).

The above sections are discussed in more detail in the policy and measures section at the end of this report, as it provides an important and timely foothold to address sustainable land use issues, REDD+ goals included. The Economic Development Policy of 2016 indicates that a range of Acts should be reviewed and revised, including the Land Act, 2007; the National Environment Protection Act, 2007; and the Local Government Act, 2009 (RGoB, 2016b).

7.3 Forests

Beyond the Constitutional commitment and others as mentioned above, the following are specific policies and regulations regarding forest management:

The 2011 National Forest Policy defines the overarching goal of sustainable management of forest resources and biodiversity to produce a wide range of social, economic and environmental goods and services for the equitable benefit of all citizens and the natural environment while still maintaining a minimum of 60% forest cover thereby contributing to GNH. The Policy references the previous 2009 version seeking an integrated landscape level approach to sustainable forest management; that all SRFL must be brought under management schemes for forest products or ecosystem services; there must be emphasis on poverty reduction, promotion of forest-based industries (value addition and waste minimization) through sound resource assessment; conserving the representation of the country's biodiversity; promote science based and participatory approaches to forest governance and management that respects the cultural values of the forests; integrates climate change, disaster management and new challenges and opportunities in forest governance and management; and enables payment of environment services (RGoB, 2010).

The Policy states that about 14% of percent of the forest area is economically accessible and available for commercial timber production, and of that, about 5.8% is under current FMU management plans, with another 8.2% planned for in the future. The remaining area is considered not suitable for harvesting timber using current technology and under the prevailing economic circumstances, and most of this area is used on an ad hoc basis for rural timber supplies. This category also includes the area above 4,000 metres. It was estimated in the Policy that about 4% of the forest land will be designated as Community Forests by the end of 2013 (RGoB, 2011d).

The Policy mentions Bhutan's international commitments, such as the UNFCCC, but does not provide coherent guidance to decision-makers and managers on how to bring climate change considerations into forest management. However, there is brief mention in Section 2.5 subsection 2.5.1 on 'production forests,' to 'minimize or reduce impact of climate change on sustainable forest management and development through appropriate adaptation and mitigation measures; and contribute to and avail benefits from carbon sequestration through measures such as afforestation, reforestation, reduced deforestation and forest degradation.'

Forest and Nature Conservation Act 1995 – provides the primary authority for forestry activities in the country. It lays out a framework for the conservation and sustainable management of forest resources and has separate chapters on soil conservation, community forestry, protected areas and protection of wildlife. The Act is a major vehicle to achieve the Constitutional requirement of maintaining 60% forest cover. The Act also recognises the traditional and cultural rights of local people to access and use forest resources. The Act is operationalised through instruments such as the Forest and Nature Conservation Rules and Regulations and various technical guidelines and manuals.

The Act allows the use of forest resources through permits and licenses. The issuance of permits or licenses is subject to the development of a management plan. The Act

defines jurisdiction for the use of what is allowed in Government Reserve Forests (now SRFL) including domestic use of forest produce (e.g. fodder, etc.), and also provides the Ministry with the ability to define rules regarding transport, import and export of forest products. The Act allows for private forestry in privately registered lands.

Forest and Nature Conservation Rules and Regulations of 2017 are a revision of the 2006 version and are designed to operationalise the Forest and Nature Conservation Act. They cover general aspects of managing State Reserved Forest Land (SRFL) as well as detailed management prescriptions for different categories of SRFL including FMUs, CFs, PAs and watersheds. They also include procedures for allocation and utilisation of forest resources, research and forest based industries.

The Rules and Regulations address issues of specific relevance to deforestation and forest degradation. These include:

- Criteria for forest clearances as allotments or leases are identified, as well as procedures. They define procedures for SRFL management planning and implementation. While the rules do not provide guidance as to what values, formats and minimum reporting requirements must be in management plans, it does state that takings of forest produce shall be planned on a sustained yield basis as prescribed in the code. The rules contain changes to the Rural Subsidized Timber Allocation entitlements and procedures.
- Approaches to assess watersheds across the country, to identify those that are degraded or critical, and to develop management plans to mitigate or remove the degrading influences.
- A plough-back mechanism of 1% of royalties from hydropower development, to be paid to MoAF on an annual basis for sustainable management of watersheds. The Rules also mandate the provision of funds for compensatory plantations, to offset the impacts of mega-projects and development projects. The requirement is to provide funding for double the area taken up by the project, and the funds must be made available prior to project commissioning.

7.4 Community and Social forestry provisions

The Forest and Nature Conservation Act 1995 provided the legal basis for community forests, and the Forest and Nature Conservation Rules and Regulations 2017 define the roles and responsibilities for Community Forest Management Groups (CFMG) and the role of the DoFPS to help prepare management plans and carry out monitoring and evaluation. The National Community Forestry Strategy provides strategic guidance for future implementation.

The Land Act of Bhutan 2007 also affects community forestry. The Local Government Act 2009 appoints the Gewog Tshogde as custodian of community land and forests. This act and the Local Government Rules and Regulations 2012 clarify the roles and responsibilities of local governments for local development and the interface with community forests (Dorji and Schmidt, 2014).

7.5 Climate Change

Bhutan submitted its I**ntended Nationally Determined Contribution to the UNFCCC**

in September 2015. The INDC identifies that highest GHG emissions come from the agriculture sector, however they have remained relatively constant. Emissions from sectors such as industrial processes and transport are showing a rapidly increasing trend, with 191.6% and 154.3% respective increases between 2000 – 2013. The INDC notes forests currently cover 70.46% of the land area of Bhutan and sequestration by forests is estimated at 6.3 million tons of CO2 and emissions in 2013 are estimated at 2.2 million tons of CO2 equivalent.

- The INDC identifies mitigation plans and priority actions, based on a range of pre-existing policies and commitments, for sustainable forest management and conservation of biodiversity to ensure sustained environmental services through:
    - Sustainable management of forest management units (FMUs), protected areas, community forests, forest areas outside FMUs, and private forests
    - Enhancing forest information and monitoring infrastructure through national forest inventories and carbon stock assessments
    - Forest fire management and rehabilitation of degraded and barren forest lands
- The INDC also focuses activities around renewable energy generation and climate smart agriculture, which can have compatibility with the sustainable forest management component, if designed to do so.
- Adaptation plans and priority actions also include sustainable forestry components. Bhutan's INDC reinforces the Second National Communication to the UNFCCC, which defined the high vulnerability of Bhutan to the adverse impacts of climate change due to the fragile mountainous ecosystem and the country's economy. The most vulnerable sectors are water resources, agriculture, forests & biodiversity and hydropower sectors.

While climate change is referenced in Section 2.5.1 of the National Forest Policy, both mitigation and adaptation priorities do not seem to feature in any other policy or legislation. Bhutan is creating a National Adaptation Plan and seeks to integrate priorities in the INDC in the preparation of the 12th Five Year Development Plan (2018-2023) and also subsequent five-year plan periods (RGoB, 2015c).

7.6 Biodiversity

The Biodiversity Act of Bhutan, 2003 provides for conservation and sustainable use of biochemical and genetic resources, equitable sharing of benefits from the use of genetic resources as well as transfer of technology and capacity building at national and local levels for conservation and use of biological diversity. More than half of Bhutan is under protected area management, and Bhutan is internationally recognized for its protected area management and biodiversity conservation (RGoB, 2003).

The National Biodiversity Strategies and Action Plan of Bhutan 2014 is a comprehensive document to guide decisions related to biodiversity protection. A significant portion of the priorities within the Plan are related to increasing awareness of biodiversity and developing the knowledge, capacity and monitoring systems to effectively manage for maintenance of biodiversity values. Two national targets are of most relevance for REDD: a) National Target 5: By 2018, high-biodiversity value habitats are mapped, the rate of loss is accounted, trends monitored and overall

loss and fragmentation reduced, and b) National Target 7: Areas under agriculture and forestry, including rangeland are managed through the adoption of sustainable management practices, ensuring conservation of biological diversity (RGoB, 2014b).

7.7 Water

The Water Act of Bhutan, 2011 mentions the threat of climate change impacts on water resources in the preamble, that minimum flows in rivers should be considered, and includes the polluter pays principle. It identifies the National Environment Commission as a lead agency to coordinate national integrated water resources management. A range of competent authorities are identified as responsible for implementation (and reporting back to NEC), including the Ministry of Agriculture and Forests—for land-use, irrigation, watershed management, water resources in forests, wetlands and protection of catchment areas; and the Ministry of Economic Affairs—for water resources data relevant for the National Integrated Water Resources Management Plan, and planning and designing of water resource infrastructure including dams and GLOF issues. The Act directs NEC Secretariat to complete a National Integrated Water Resources Management Plan and River Basin Management Plans (RGoB, 2011b).

The Bhutan Water Policy of 2007 seeks an integrated approach for effective management of water resources, references climate change, and the need to find an equitable balance between the needs of water management and the demands of water users. In the case of hydropower development and transmission of energy, the policy notes the linkages with upstream, downstream and en-route water and land-users and therefore identifies a need for cooperation and coordination in working out trade-offs (RGoB, 2007c).

Watershed Management: The Watershed Management Division (WMD) in the Department of Forests and Park Services, is the designated national focal agency for operationalizing a watershed management program as part of a larger initiative to develop integrated frameworks for major river basins in the country. The enabling legislation for watershed management includes Article 5 of the Constitution, Bhutan 2020, the National Forest Policy, Forest and Nature Conservation Act of 1995, the Land Act of 2007, Bhutan Water Vision 2025, Bhutan's Water Policy of 2008 and Bhutan's Water Act of 2010. However, this legislative framework suffers from overlapping responsibilities, unclear jurisdiction for implementation, lack clear-cut resource allocation for watershed management and lack of emphasis on ground-level coordination.

A "Roadmap" for Watershed Management to guide the implementation of strategies aimed at improving the management of the country's watersheds, was developed in 2009 and adopted in 2011. It included a strategy to focus watershed management planning initially on degraded and critical watersheds requiring urgent management interventions. This approach is codified in the FNCRR of 2017. A novel aspect of watershed management planning in Bhutan is that activities proposed to mitigate or remove degrading influences are integrated into existing area-based management plans such as Geog and Dzongkhag annual and five year plans, FMU annual and five year plans, Conservation Area Management plans, etc. In addition, planning is carried out "in the context of climate change." The challenge for the future is to facilitate the implementation of "climate smart" watershed management plans in degraded watersheds.

The Waste Prevention and Management Act of 2009 covers waste management and applies the precautionary principle and polluter pays approach to addressing individual responsibility for pollution. However, it does not include carbon dioxide or reference to climate change. The Waste Prevention and Management Regulations 2012 identify roles and areas of implementation related to waste management. They include a section regarding management of waste in SRFL, but do not include any climate change components.

7.8 Other concepts of note

Payments for Ecosystem Services (PES) is enabled by the National Forest Policy. Bhutan also has some experience with benefit sharing under PES schemes. A PES Feasibility Study was undertaken by FAO in 2009 and identified certain positive conditions for PES implementation. As per the recommendations of the feasibility study, PES was piloted for three environmental services in three locations in the country. A National Framework for PES and Field Guides have been developed, and Bhutan is looking to refine an assessment of ecosystem service valuation.

A number of other activities are underway, which are already building the enabling environment for REDD+, as per Bhutan's R-PP:

- National Forest Inventory (NFI) completed and data analysis is on-going
- National Forest Monitoring System (NFMS) – land use and land cover map 2015, a participatory monitoring framework for CFs being developed
- Valuation of ecosystem services starting soon
- Potential REDD+ pilot actions in 5 CFs
- Forest Reference Emission Levels (FREL) – contract awarded
- REDD+ PES pilot site selected
- Piloting Heritage Forests in 20 sites, one each of the 20 districts under implementation

8. Recommendations for criteria to prioritize strategic options and pathways to address direct and underlying drivers

This section provides an initial basis for considering policy and measure (PAM) measures in the REDD+ context. It should be deliberated on and revised by stakeholders and technical working groups as part of refining the REDD+ National Strategy.

The Cancún Agreement (COP 16) on REDD+, "Decides that the (REDD+ activities) undertaken by Parties should be implemented in phases beginning with the development of national strategies or action plans, policies and measures, and capacity-building, followed by the implementation of national policies and measures and national strategies or action plans that could involve further capacity-building, technology development and transfer and results-based demonstration activities, and evolving into results-based actions that should be fully measured, reported and verified (Decision 1/CP.16, paragraph 73)."

The intent of the Cancún Agreement, and the Warsaw framework, is for national policies

and measures to respond to the pressures on forests as a means of achieving REDD+ objectives. This driver assessment takes note of the historical and future drivers of deforestation and forest degradation in Bhutan, in order to provide a stronger sense of what policies and measures could be put in place today to anticipate pressures on the forest into the future. PAMs are a key part of a National REDD+ Strategy, and are the means by which countries address driver pressures from within and beyond forestry sector.

In general, the prioritizing PAMs should consider a range of general factors, including:

- Significance of each driver (impacts on forests, level of emissions or potential for removals)
- Relation of each driver with the various REDD+ activities
- Development priorities or political feasibility
- Capacity to tackle the driver activity
- Implementation costs
- Potential REDD+ safeguards triggered

Bhutan is developing, becoming more urban, may graduate into middle-income economic status soon, and the country's relationship to its forests is dynamic. This report identifies that forest cover as a measure of forest health is perhaps not the only measure for forest health. Degradation may have larger impacts on the forest, its functions, and its biodiversity than forest cover. Refreshing Bhutan's vision and commitment to its forests inherently entails a contemporary view of forests and projections into the future, to define interventions and actions that maintain the integrity of the forest, while allowing for future development that is compatible.

A national strategy for REDD+ can **refresh Bhutan's commitment to sustainable forest management, positioning forests in relation to the sectors that exert pressure on forests, supporting the balance that GNH strives for, and fulfilling Bhutan's INDC commitment**. Bhutan already has a long-standing commitment to steward its forests, and this is enshrined in the Constitution. Further, Bhutan aspires for progress to be holistic, inclusive, equitable and sustainable, where political and spiritual matters are in balance. Bhutan's positive state of the natural environment has directed Bhutan to pursue a green economy. A key aspect of realizing this goal while developing the economy is stronger planning at the Gewog level, in order to feed into developing the 12th Five-Year Plan, and also promote small business development (Tobgay, 2015). These are aspirations that are strongly connected to land (particularly business development related to agriculture, mining, or other activities), and therefore it will be useful to consider how the pillars and domains of GNH can help guide the direction for REDD+ to underpin and implement these values and goals. The **GNH Index can provide a useful means to evaluate the non-carbon benefits of PAM options**. The GNH pillars and domains provide a nationally-defined set of non-carbon benefit goals and measures, which are captured in the GNH Index, and could be further refined and adapted to REDD+ in Bhutan.

Bhutan should likely also filter PAM options against the objectives being developed for the 12th Five-Year Plan. The 12th Five-Year Plan may be a very suitable vehicle in

which to position cross-sectoral strategies.

A key methodological step in evaluating PAM options is to consider what counter-measures to address drivers are already in place, those that are in place but could be improved, and those that might have been identified already but not yet implemented.

Based on the direct and underlying drivers identified in this report, key observation to guide assessment of PAM selection criteria include:

1. Degradation should be prioritized over deforestation, as forest cover is increasing, slightly while the forest as a whole is degrading. Carbon stock assessment of the forest can be a proxy measurement of forest health, but clearly there are other values to be accounted for, including the rich species distribution of forest types, biodiversity values, watershed values, climate adaptation functions, cultural values and others.
2. The relative impact of the Subsidized Rural Timber Allotment Policy on the amount of timber harvested each year, and the inconsistency with principles of sustainable forest management, deserves a re-think that goes beyond amending the Forest and Nature Conservation Rules.
3. It is appropriate to acknowledge that future deforestation will happen, so it is advisable to prioritize the suitability of the loss of some forest areas under different scenarios which safeguard high conservation value and high carbon stock forests
4. Eco-regional distribution of forests is important, so evaluation of intervention options should make sure not to weigh interventions for one forest-type at the expense of others.
5. Hydropower development and associate infrastructure development will have a large impact on the forest.
6. Interventions that address the trade-offs between sectors are important, and would address a current weakness in governance – National Land Use Policy and spatial land use planning/zoning as an option. Simply addressing needs from the forest sector perspective will not reconcile the conflicting priorities between sectors.
7. The cultural significance of forests in Bhutan must not be overlooked, and the NWFPs and traditional uses of the forest are an important part of culture and livelihoods.
8. The adaptation benefits and values of forests are crucial, and yet integration of climate considerations into current forest management and planning is not clear. This presents a large opportunity.

Sectors need to prepare strategies to mainstream climate into their plans and to guide activities, as per the SAPA (RGoB, 2016d). While climate adaptation and mitigation are clearly defined in Bhutan's INDC, the existing sectoral and development policies have not yet been amended to reflect this priority. The Forest and Nature Conservation Act, 1995, and associated Forest and Nature Conservation Rules and Regulations of 2017 omit climate change priorities. While the National Forest Policy of 2011 includes mention of climate mitigation and adaptation, it does not provide guidance on how to pursue this in relation to other priorities, such as 'maximise production of forest resources per unit area.'

Prioritizing which legislative vehicle is suitable to promote REDD+ objectives is important, and deserves further scoping in the National REDD+ Strategy development phase. While the Forest and Nature Conservation Rules of Bhutan of 2006 were amended in 2017 and clearly new changes have been made to address earlier short-comings and conflicts, Rules by their nature cannot carry the policy direction that is contained in the Forest and Nature Conservation Act of 1995 (which the rules implement). Therefore, defining PAM options must consider what policy direction is best placed in rulemaking, versus the Act.

A means to address the subsidized rural timber allotment could come through direction given to MoAF in the agriculture section of **the new Economic Development Policy of 2016 states:**

7.6.16 The MoAF shall review the current timber allocation policy with particular focus to rationalise timber subsidy to ensure optimal utilization of the timber resources.

7.6.17 The MoAF and MoEA shall adopt a strategic framework to add value and enhance the competitiveness of the wood based industry by 2018.

7.6.18 Integrated wood industry development will be accorded priority and outdated sawmilling operations phased out by 2018. Sale and trading of timber in processed form shall be promoted to ensure optimal utilization.

Addressing land use planning and inter-sectoral coordination on land use may be best addressed through the foothold provided by the new Economic Development Policy (EDP). The EDP provides the current basis for promoting "Brand Bhutan" based on its rich natural resources and culture, along with strategies for promotion of the Five Jewels, which are the sectors constituting the core growth areas. These sectors include hydropower, cottage and small industries, mining, tourism, and agriculture. Section 7 provides guidance for the general policy reforms sought to promote the right enabling environment for business. The first one is with regards to the access to Land:

- First, the EDP directs the relevant Government agencies responsible for promoting respective sectors of the economy to proactively identify land in collaboration with the NLC and develop/facilitate development of infrastructure for growth of businesses (RGoB, 2016b). However, NLC does not have land management policies and guidance, and nor is there a national land use plan, such as zoning or integrated spatial planning to guide such decision-making. Further, as outlined in the underlying driver sector, planning that looks at future pressures and needs (e.g. increasing urbanization, climate change impacts) as a basis for navigating sectoral-trade-offs has not yet been assessed.
- Second, the EDP directs Local Governments in collaboration with the NLC to identify industrial areas within their respective jurisdictions by 2016 to facilitate establishment of industrial and service activities (RGoB, 2016b). While this is in keeping with the intentions for devolution of governance to local scales, it omits the broader planning capacity that line agencies should bring to this evaluation. This activity also assumes that cross-sectoral trade-offs would be addressed at the local scale, but the lack of capacity at local scales to serve this need are weaker than at the national level. Therefore, national-level guidance to help inform local decisions on siting would be necessary.

- Third, the EDP identifies that the allotment of SRFL shall be prioritised on strategic business activities such as large stand alone projects with cluster effects and public utility services (RGoB, 2016b). While such prioritization is logical, DoFPS does not yet have a master plan for appropriate siting of large-scale (or small-scale) development where it would be agreed that on a set of criteria, deforestation and/or forest degradation would be allowed. This report proposes that this exercise be completed to help guide 'sanctioned deforestation,' in order to minimize degradation of the forest, while recognizing that forest cover may decrease as future development occurs.
- Lastly, the EDP directs NLC to prepare a national land use plan (Zoning) which will outline use of land for optimal use by 2017. For this purpose, all relevant sectors shall provide sectoral parameters to NLC by 2016 (RGoB, 2016b). NLC is already preparing to respond to this, though the process has not yet started. However, such a process will benefit from a higher-level policy and plan to guide zoning. Therefore, while NLC can continue collecting data from ministries on their proposed land uses and priorities, this proposal seeks development of a land use policy and plan to guide zoning decisions, particularly with a longer-term vision in mind.

While NLC recognizes the challenges on the land from increased lease applications, its mandate is for land administration, management, surveying and mapping, not policy direction. At the same time, the Gross National Happiness Commission (GNHC) recognizes its role in setting policy direction, and convening various ministries together to identify solutions. Thus, both agencies have recently identified that GNHC could facilitate and convene at the inter-ministerial level, while NLC could fulfill the role of technical coordinator, in order to carry out a Land Use Policy, Plan and zoning. It is recommended that dialogue between these agencies continue, in order to carry this approach forward, as it will help achieve REDD+ goals. The Department of Urban Planning is already engaging some potentially compatible activities in the southern Broadleaf region, with support from JICA, and this could be integrated in a national-level planning process. There will also be a need to identify how a Land Use Plan can best enable compatible decisions at Dzongkhag and Geog scales (thus has a capacity-building component to support local governance).

Payments for ecosystem services could provide both domestic and international opportunities to compensate good stewards of forest resources. For instance, incentives paid for by users downstream to keep riparian buffers in critical watersheds well managed, as one of many options, can be explored. Bhutan's temperate forests are its most valuable ecosystem service (Kubiszewski et al, 2013), though the challenge will be how to identify a willing buyer that directly benefits from the provision of these services (such as India). Identifying innovations in PES options and in subsidy and fiscal policy in the PAM identification process can help focus in on how to adjust such schemes in order to shift behaviour, and should be explored further in the National REDD+ Strategy process.

9. Recommendations for policy and measure responses to address drivers

The following table summarizes each driver of deforestation and forest degradation, it's current and future projected impacts, what underlying drivers were identified that affect the direct drivers, and what recommended interventions could address the driver pressure. These recommendations would be further reviewed and considered in the National REDD+ Strategy development process.

	Underlying drivers that affect direct driver	Possible initial PAM options
Degradation drivers by rank		

Timber harvesting
About 161,008 m^3 harvested annually
72% of timber harvest serves subsidized rural timber allotments
Future projection: Based on historical trends, 805,042 m^3 between now and 2020, and up to 2,415,125 m^3 by 2030.
	• Subsidized rural timber based on entitlement may not be not sustainable:
	  • There has been no assessment of what the viable needs are for rural households (demand side)
	  • Entitlement has not allowed for an assessment of sustainable supply requirements, and concept of 'entitlement' may be outdated and does not serve the intended purpose
	  • Pre-existing households now in suburban areas still qualify as 'rural'
	  • Allotment policy skews the timber pricing structure
	• Illegal timber trading based on subsidized timber has been lucrative. The FNCRR 2017 states that surplus timber from rural house constructions can be sold upon payment of 25% of the existing NRPC rate, in order to legalise the usage of surplus timber and to deter the black market.
	• Community forestry - success largely judged by #'s of CFs, not necessarily by improved management.
	• the majority of wood products (excluding firewood) consumed in Bhutan was from India, the majority of which was wood charcoal. This suggests Bhutan should
		1. FNCRR 2017 has revised provisions for rural timber allotment, so it is unlikely there will be substantial changes in the near-term. Key operational task given to DoFPS in the Economic Devo Policy of 2016 is section 7.6.16 which states the need to 'rationalize timber subsidy to ensure optimal utilization of the timber resources.' Need to analyse the actual requirement rural timber, what the forest can supply and the gaps, and develop necessary analytics to inform the redesign. Identify how to correct pricing distortions (NRDCL and rural timber).
		2. Related to illegal pressures, oversight of allotment, transit offenses, need to build capacity and strengthen the ability of field level forest department staff (staff, equipment, knowledge, monitoring)
		3. Develop an Indicator of Forest Health, for use by GNHC.
		4. Community forestry: Capacity-building, better planning, and SME development potential. Ensure CF's are not also sourcing timber needs from allotment (it rationalizes use and builds sustainability within their own systems, and makes it easier to monitor as wood can only come from one source). When establishing CFs, ensure area and volume is appropriate to their needs.
		5. Manage forests to maintain high-carbon stocks in prioritized FAOEMR, FMU and CF areas, while defining

	maintain its level of imports of wood products from other countries to keep its natural forests (which are of high ecological value), though evaluation of impacts of sourcing wood products from other countries is recommended. • FAOEMR are not as well managed as FMUs • NRDCL is the most important stakeholder in the forest sector, however they are operating under constraints (strong regulation, pricing, capacity building needs) • FMU management to always done by plan (subsidy policy pulls timber) • There are underutilized species such as hardwoods, and efficiency of timber utilization and processing could be improved	other forest types as suitable to more intensified production: • FAOEMR comprise the major source of timber supply, are not as well-managed as FMUs. Stratification of management objectives based on goal of increasing carbon stocks and high-conservation-value forests (so that if forest area decreases, carbon stocks still increase). Refinement of the Rapid Resource Assessment – to provide more granularity on management objectives for different forest qualities • Manage based on forest carbon density and other attributes • Afforestation and reforestation on barren and degraded areas; can be for economically valuable species (commercial and export) or other purposes • Enrichment planting within open forests, also enrichment planting as compensatory activity rather than complete new reforestation • Develop web-based multiple use management information system (open-source MIS) supporting monitoring as well as planning and management of forest resources (possible for other land uses to be included). 6. Capacity-building for DoFPS to support FNCRR 2017 implementation, including at local levels, to calculate the 4000 cft limit or equivalent for rural timber allotment per household. Conduct further research to calculate how much cft is really needed for house construction- one and two storied. Monitoring, information, hardware components are also necessary.

		7. Find ways to promote demand for lesser known broadleaf timber species. Develop regional forestry and timber supply chain clusters with the full range of actors, from planning, production, processing, marketing, markets. The goal is improved supply chain development for prioritized new product lines (including promotion of value-addition). 9. To address illegal timber trade, stronger timber tracking and chain of custody verification. The new rules on chainsaw registration and licensing could be effective, but very hard to monitor. Increased road checks recently put in place.
Firewood About 84,936 m^3 harvested annually (av. 2008-2014), equal to about 35% of the timber harvest amount (is additional to) Future projection: based on historical trends about 424,680 m^3 between now and 2020, and up to 1,274,041 m^3 by 2030.	• Key for household heating, not only cooking • Is > 90% of the residential sector's energy demand, yet efficiency of woodfuel burning devices is only 10%–15%. • Is the cheapest source of fuel and allotted free of royalty in rural areas • In future, as long as electricity access increases (and electricity prices are subsidized), households will switch fuels away from wood	• Plantations for woodfuel on cleared or degraded areas • How to increase efficiency in woodfuel devices, while supplying an alternative source for household heating? Or focus on fuel-switching for cook stoves? Upscaling of Min of Economic Affairs cookstove project • Need to address the institutional and urban demand for firewood • Changing entitlement system so that rural households don't depend on 2 trees, but use more lops and tops or salvage or scrap timber • Upscaling of briquette-making
Forest fires Annual average: 6,260 ha Future projection: 93,800 ha between now and 2030; ; or 231,985 m^3 between now and 2020, and up to 695,955 m^3 by 2030.	• Climate change impacts expected to increase fires • Almost all fires are human induced – either intentionally or unintentionally, and agriculture appears to be an	• Government already sees this as a risk factor, and a forest fire strategy is in place, but inadequate capacity to effectively carry this out (field division levels). Training and awareness raising. • Increase volunteer firefighting at Dzongkhag level

	important source (lemongrass distillation in East) • Pine forests more susceptible between November and April	
Livestock Average forest area affected annually: not available, on a national level insignificant Future projection: Decreasing trends.	• 500,000 head nationally, though numbers are declining • Redistribution of Tsamdo leasing so far having positive impacts for pasture management and socio-economic benefits • Grazing density is about 1 cow for every 5 ha of forest. • Practice of nomadic herding is on the decline	• Awareness that free-ranging of cattle has greater impacts on forests (carrying capacity assessments), but interconnectedness of livestock and grasslands/forests is strong. More research and awareness is needed to understand livestock browsing of regeneration after grazing (social and institutional aspects). • Encourage stall-feeding (intensification and reduced grazing)
Deforestation drivers by rank		
Allotment of SRFL for various purposes Average forest area affected annually: 1,923 ha Total area estimated to be affected by 2030: 28,845 ha	• Decisions made without sufficient policy and guidance, criteria to support decisions on use and locations, or spatially explicit long-term/master plans • Land Act and is the key policy guide, and FNCRR (2017), 'Interim Guidelines on Lease of GRF Land for Commercial Agriculture of 2011,' NLC Rules and Regulations 2009, also apply. • Policy/planning guidance which does exist does not include robust assessment of future challenges and needs, such as increased urbanization or climate change • No clear mechanism yet to address sectoral trade-offs (and devolving to local	• Pursue concept of a National Land Use Policy – find where is best to house this. In order to increase or maintain carbon stocks, land use planning will help to identify land suitable for development while reducing deforestation/degradation pressures. Must have high-level political engagement, as well as technical component • Phased process, with policy and zoning developing in tandem, but both need to be reinforcing of the other. • Zoning should include suitability and carrying capacity considerations. • Find how Land Use Plan can best enable compatible decisions at Dzongkhag and Gewog scales

	levels to sort trade-offs may not be best way to handle) • Lack of zoning (DoFPS is only agency to have done this, in forest areas falling within management regimes) • Lack of info sharing between ministries	• Based on Land Use Policy, Plan and zoning, can have more detailed technical guidelines to inform allotment decisions.
Hydropower projects Average forest area affected annually: 1,880 ha Total area estimated to be affected by 2030: Based on hydropower development plans 39,760 ha Based on linear trend: 28,200 ha	• The prioritization of hydropower development as the primary source of foreign exchange and economic development is clear. The financial commitment associated with hydropower expansion is a potent underlying driver that will put pressure on the country's forests. • EIAs have occurred after the Umbrella Agreement with India (not before) and cumulative impacts of multiple projects within large watersheds has not systematically occurred • After the development clearance is given, and the DPR approved, and when it comes to the operational level, then detailed assessments are done (so aspect is mitigating impact of specific activities, rather than evaluating whole project). • DoFPS needs to holisticly assess the broader environmental impacts from hydropower development	• Jointly review hydropower expansion plans from a watershed and forest management perspective (basin-wide), strengthen capacity to carry out such reviews and share information with relevant agencies. • Explore trans-boundary PES mechanisms aimed at compensating upstream land managers in Bhutan for sustainably managing the landscape to produce high-quality water • Create a more refined assessment of ecosystem valuation (water/forests) • Account for timber harvested from hydropower and infrastructure development • Project proponent should report on the broader environmental impacts from hydropower development as a holistic package and not piecemeal (basin-wide- including power transmission lines and roads).
Roads	• Linked to government commitment to reach every village by road – critical for	• Consider de-emphasizing roads as a PAM intervention, as road build-out is a large priority for rural access, and much investment has already

Average forest area affected annually: 820 ha (does not include farm roads) Total area estimated to be affected by 2030: 12,300 ha	economic development and market access • Road infrastructure also linked to hydro and transmission line development • Road standards can be poor, and erosion high (low cost procurement) • Road access in forested areas increases ease of illicit activity (e.g. use of chainsaws to quickly clear timber and firewood)	occurred. Emphasis should be on appropriate siting for roads not yet built, seeing how to increase quality of road construction, and include 'climate-proofing' in road construction and investments so they will be durable, minimize erosion. • Account for timber harvested from road construction
Agriculture Average forest area affected annually: 778 ha Total area estimated to be affected by 2030: 11,670ha	• Challenges with 65% of population cultivating on 2.93% of the land, on up to 38% slopes, and limited landholding sizes (less than one acre). Not clear where agriculture expansion could occur. • A major focus of 11th Five Year Plan, rising trade deficit and the need to substitute imports. • Commercial products (cardamom) increasing • Increased pressure on paddy land from urban development could have displacement effects into forests or wetlands • Rural to urban migration leads to farm abandonment	• Improved planning and decision-making on leases for commercial production via a Land Use Plan. Regional/geographic focus is in the southern sub-tropical regions • Long-term planning to inform future agric siting suitability and sectoral trade-offs • Upscaling climate smart agriculture practices for Bhutan which contributes to less emissions and more enhancement of carbon stocks, in particular soil carbon. This will also increase the resilience of the agricultural production against climatic changes. Practices include agronomic practices, precision fertilizer application, organic fertilizers through composting, mulching, cover crops, agroforestry systems with soil fertility enhancing trees and long-term shade tree systems, etc. Studies from North East India concludes that agroforestry and other sustainable land management practices lead to sequestration rates ranging from 2.5 to 6 tCO_2 per ha per year. CONDENSE
Mining and Quarries	• Revenue increased 20.86% on 2014 and sector growth rate was 17.01% in 2014	• While DoFPS already provides forest clearances to Mines and Minerals Act (Ministry of Geology and

Average forest area affected annually: 633 ha Total area estimated to be affected by 2030: 9,495 ha	• Major new priority for government, leasing of SRFL for this purpose expected to grow, but niche is in low-value minerals and possibilities for value-addition are low • Decisions on mining allowance are not made on a sustainable expansion basis, rather it's more opportunistic, based on deposits found. • Mines and Minerals Act provisions are not closely followed for reclamation and restoration) • EIAs cannot be expected to replace sector policies, plans and guidelines	Mines), there is a need to strengthen capacity to ensure DoFPS staff convey the importance of high conservation value areas. • Appropriate siting and zonation through land use plan/zoning is needed (now decisions are largely based on whether a deposit is found). • State Mining Corporation provides opportunity to improve standards • Additionally, Dept of Geology and Mines should ensure mining areas are rehabilitated (monitored by DoFPS and NEC). Coordination between DGM and local government & DoFPS • Account for timber harvested from mine sites
Power transmission lines Average forest area affected annually: 542 ha Total area estimated to be affected by 2030: 8,130 ha	• Linked to hydro development. They are inevitable, once the hydro development plan is agreed to.	• Assess future build-out scenario, develop guidelines, minimize forest losses • Include power transmission lines in hydropower project EIA processes, so that the whole package can be assessed (and calculate volume- should go into FIMs) • Bring this into the national land use planning process to weigh against different sector needs • Account for timber harvested from power transmission line development (NFMS, MIS App)

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Annexes

Annex 1: Hydropower projects in Bhutan

Sources: Druk Green website for completed projects, accessed 30 June 2016, International Rivers website, communication with Druk Green staff and consultants; Central Electricity Authority (2012).

Project	*River*	*Status*	*Project details*
1. Chukha Hydropower Project	Wangchhu River, Chukha district	Completed 1988	336 MW, uses discharges of Thimphu, Paro and Haa valleys. Built in mid-1970's. Funded by India: 60% grant, 40% loan at 5% interest payable over 15 yrs. Up to 90% of power generated exported to India.
2. Tala Hydropower Plant	Wangchhu River, Chukha district, downstream from Chukha HP	Commissioned 2006-2007	1,020 MW, 92-metre high concrete dam, and 23 km long headrace tunnel. Funded by India: 60% grant, 40% loan at 9% interest rate. Must meet domestic energy needs previously met by CHP. Surplus power exported to India at fixed rate as per Power Purchase Agreement of Nu.1.80/kWh.
3. Kurichhu Hydropower Plant	Kurichhu River, Mongar Ditrict	Completed 2001, Commissioned 2006	60 MW, run-of-river, but dam of height 55 m. Has a fish ladder. Funded by India: 60% grant, 40% loan at 10.75% interest payable over 12 yrs. 60% of energy exported to India. Since 2007, Ferro-Silicon factory in Samdrupjongkhar increased domestic consumption.
4. Basochhu Hydropower Plant	Basochhu/Rurichu Rivers	Commissioned in 2002 and 2005	64 MW, mean annual energy generation of 291 MU. Financed by Government of Austria, just over half as loan, the rest grant. All energy generated is sold within Bhutan.
5. Dagachhu Hydropower	Dagachhu River	Commissioned in 2015	126 MW. First Public-Private Partnership venture: Druk Green holds 59%, Tata Power Company holds 26%, National Pension and Provident Fund of Bhutan holds 15%. Bhutanese management team. Funded by ADB and others by a 60:40 debt equity ratio. All power exported to India to Tata Power Trading. Cross-border Clean Development Mechanism project.
6. Punatsangchhu-I	Punatsangchhu River	Under construction, likely commissioned in 2018	1,200 MW, 130 metre high concrete dam, two diversion tunnels and a headrace tunnel 10 km in length. Funded by India with 40% grant/60% loan, payable at 10% interest. Project cost escalated from US$554 million in 2006, to US$1.74 billion. In 2013, the right bank gave way, due to geological instability.

7. Punatsangchhu-II	Punatsangchhu River	Under construction- began 2010, running behind schedule	1020 MW, 86 metre high concrete dam with a headrace tunnel of 8.6 km. Funded by India with 30% grant/70% loan, payable at 10% interest.
8. Mangdechhu	Mangdechhu River, Trongsa district	Under construction, behind schedule	720 MW, 56 metre high concrete dam and 13.5 km headrace tunnel. Funded by India with 30% grant/70% loan. In August, 2015, a major landslide buried five workers at the site.
9. Kholongchu	Kholongchhu River	Under construction	600 MW, 95 metre dam with a headrace tunnel of 15.77 km. Part of "10,000 MW by 2020" bilateral co-operation between the RGOB and GOI. Debt equity ratio of 70:30 with a 50:50 equal shareholding for Druk and SJVN. 40 km of project roads under construction.
10. Wangchhu	Wangchhu River in Chukha District	Under construction	570 MW, 134 metre high concrete dam, with a 12.38 km long headrace tunnel. Part of "10,000 MW by 2020" bilateral co-operation between the RGOB and GOI. Debt equity ratio of 70:30 with a 50:50 equal shareholding for Druk and SJVN
11. Nikachhu	3 km downstream of the confluence of the Nikachhu and Chhunabachhu in Trongsa district	Under construction	118 MW, 33-metre high concrete dam. ADB funded: 60% (US$120 million) as loan, $25 million a grant. India's Power Trading Corporation to purchase all power, Government of West Bengal has signed a MOU with PTC to purchase all electricity generated by this project.
12. Bunakha	Upstream from Chukha, Raidak River.	Proposed	180 MW, under "10,000 MW by 2020" bilateral co-operation between the RGOB and GOI. Debt equity ratio of 70:30 with a 50:50 equal shareholding for Druk and THDC. GoI sub-agreement with state government of Uttar Pradesh.
13. Amochhu		Proposed, DPR in process	540 WM, reservoir dam project. Financing and willingness to move forward questioned as security risks exist, given proximity between China and India, and social impact of of 50 to 60 households needing to be relocated.
14. Chamkharchhu-I		Proposed, DPR & ESIA study complete	770 MW, under "10,000 MW by 2020" bilateral co-operation between the RGOB and GOI. Debt equity ratio of 70:30 with a 50:50 equal shareholding for Druk and NHPC.
15. Sunkosh	Sunkosh Chhu	Proposed, DPR & ESIA study completed	Downsized from 4,060 MW to 2,560 MW

16. Kuri Gongri Hydropower Projects (I&II)	Near confluence of Manas, Kuri and Gongri rivers	Proposed – pre-feasibility stage, recommended to DPR	2,640 MW, 3,000 hectares of land planned to be submerged, 250m tall dam with gross storage capacity of 2,621M m^3 of water, 26km length reservoir along the Kurichu and a 24km one along the Gongrichu Rivers.
17. Kuri I (Ratposhong)			1125 MW
18. Nyera Amari Hydropower Projects (I&II)		Proposed – pre-feasibility stage, recommended to DPR	442 MW
19. Gamrichhu Hydropower Project (I&II)		Reconnaissance study completed	Gamrichu-1 (from Sakteng to Thragthri): 50 MW Gamrichu-II (from Thragthri to Tholong): 90 MW
20. Dangchhu Hydropower Project		DPR & ESIA study	
21. Khomachhu Hydropower Project		Pre-feasibility study completed	
22. Gamrichhu Hydropower Project		Reconnaissance study completed	
23. Pachhu Hydropower Project		Reconnaissance study completed	
24. Mochhu Hydropower Project		Reconnaissance study completed	
25. Lower Dagachhu Hydropower Project		Reconnaissance study completed	
26. Shongarchhu Hydropower Project		Reconnaissance study completed	
27. Maochuu Hydropower Project		Reconnaissance study completed	

Annex 2: Interviews and persons consulted

Structured interviews and informal information gathering interviews were carried out with experts, government staff and stakeholders, ranging from government ministries to sub-national government representatives, civil society organizations and community members. Below is a list of the various bi-lateral meetings, consultations, write-shops and regional workshops, that informed development of this report.

Bilateral discussion with relevant stakeholders from June 21-30, 2016

No	Name	Designation	Organization
1	Mr. Phento Tshering	Director	Department of Forests and Park Services
2	Mr. Yeshi Dorji	Chief Survey Engineer, officiating director, Dept. of Survey and Mapping	National Land Commission
3	Mr. Tashi	Sr. Survey Engineer/Head	Cadestral Information Division, NLC
4	Mr. Geysar	Sr. Survey Engineer/Head	Geoinformatics division, Map Production, NLC
5	Mr. Jigme Tenzin (77115760)	Sr. Survey Engineer, head	Land Management Division, NLC
6	Mr. Karma Galey	Director	Department of Roads, ministry of Works and Human Settlement (MoWHS)
7	Mr. Meghraj adhikari	Urban Specialist	Department of Human Settlement, MoWHS
8	Mr. Jamyang	Specialist	National Soil Service Centre (NSSC), Department of Agriculture, MoAF
9	Mr. Phuntsho Gyeltshen	Sr. Soil Survey and Land Evaluation Officer	Soil Survey unit, NSSC, Department of Agriculture, MoAF
10	Mr. Haka Dukpa	Land management officer	Land Management Unit, NSSC, DoA, MoAF
11	Dr. Tashi Samdrup	Director General	Department of Livestock, MoAF
12	Mr. Tawchu Rabgay	Livestock officer, Research and Extension Division	Department of Livestock, MoAF
13	Mr. Chador Tenzin	Head	Druk Green Consultancy, Projects Department, Druk Green Power Corporation
14	Mr. Tandin Tshering (17702320)	Assistant Manager	Environment & CDM Unit, DGC, Projects Department, DGPC
15	Mr. Tshering Phuntsho	Assistant Manager	Environment & CDM Unit, DGC, Projects Department, DGPC
16	Mr. Krishna Bdr. Rai (17277515) (krishnarai@bpc.bt	Deputy Environment Officer	Bhutan Power Corporation
17	Ms. Sonam Yangchen	Asst. Environment Officer	?
18	Mr. Sonam Tashi	Chief Planning Officer	Policy and Planning Division, Ministry of Economic Affairs
22	Mr. Jamyang Phuntsho	Program Officer	Tarayana Foundation
23	Ms. Thinley Bidha	Field Officer, Samtse	Tarayana Foundation
24	Mr. Jigme	Field Officer, Zhemgang	Tarayana Foundation
25	Mr. Thinley Namgyel	Chief Environment Officer	National Environment Commission

2nd Review write-shop - January 13 & 16, 2017

No	Name	Designation	Organization
1	Tashi Palden	Sr. Survey Engineer	NLC
2	K.B Samal	National Consultant	
3	Matthias Seebauer	Consultant/RS & GIS epxert	UNIQUE
4	Prashant Kadgi	GIS/RS expert	UNIQUE
5	Gabrielle Kissinger	Consultant	Lexeme Consulting
6	Ugyen Lhendup	Chief Program Officer	BTFEC
7	Pema Wangda	Chief Forestry Officer	WMD
8	Ashit Chhetri	Manager	NRDCL
9	Arun Rai	Dy. Chief Forest Officer	FRMD
10	Jigme Tenzin	Sr. Forest Officer	WMD
11	Kelly T. Dorji Tamang	Sr. Forestry Officer	Thimphu Division
12	Sonam Peljor	Asst. Planning Officer	PPD/MoAF
13	Sonam Peldon	Dy Chief Forestry Officer	SFED
14	Lobzang Dorji	Chief Forestry Officer	FRMD
15	Don Gilmour	AVID	WMD
16	Samten Wangchuk	Dy. Chief Forestry Officer	WMD
17	Rixzin Wangchuk	Forestry Officer	SFED
18	Kezang Yangden	Dy Chief Forestry Officer	FRMD
19	Sigyel Delma	Dy Chief Forestry Officer/National REDD+ Coordinator	WMD
20	Nidup Tshering	Asst. Livestock Officer	WMD

Review write-shop from December 29-30, 2016

No	Name	Designation	Organization
1	Chimi Yangden	Asst. Environment Officer	BPC
2	Nima Gyelpo	Sr Survey Engineer	NLC
3	Rixin Wangchuk	Forestry Officer	SFED
4	YontenPhuntsho	Sr. Forestry Officer	FRMD
5	LobzangDorji	Chief Forestry Officer	FRMD
6	Gyembo Tenzin	Executive Engineer	DoA
7	Ugyen Lhendup	Chief Program Officer	BTF
8	Norbu Wangchuk	Chief Program Officer	GNHC
9	Nima Dolma Tamang	Asst. Environment Officer	NRDCL
10	Tashi Tobgyel	Chief Forestry Officer	Gedu Division
11	Kezang Yangden	Dy Chief Forestry Officer	FRMD
12	Kelly T Dorji	Forestry Officer	T/phu Division
13	Phuntsho	Forestry Officer	FRMD
14	Lungten Norbu	Specialist	WMD
15	Sonam Yuden	Asst. Environment Officer	BPC
16	Sigyel Delma	Dy Chief Forestry Officer	WMD
17	K B Samal	Consultant	WMD
18	Samten Wangchuk	Dy Chief Forestry Officer	WMD
19	Lungten Norbu	Specialist	WMD
20	Nidup Tshering	Asst. Livestock Officer	WMD
21	Pema Dema	Asst. Administration	WMD
22	Kinley Dem	Forest Ranger	WMD

Stakeholder Consultation workshop - Zhemgang on 27th June, 2016

No	Name	Designation	Organization
1	Dorji Wangchuk	Gup	Trong
2	Dorji Wangchuk	Gup	Nankhor
3	Kinzang Gyeltshen	Chief Forestry Officer	Bumthang
4	Pankey Drukpa	Chief Forestry Officer	JSWNP
5	Kezang Dorji	Forest Ranger II	ZFD
6	Sonam Phuntsho	Sr. Forest Ranger II	ZFD
7	Chundu Dorji	Forest Ranger II	FMU/Buli
8	Chencho Wangdi	Forest Ranger II	FMU/Chendebji
9	Rela Bdr.	Forest Ranger II	ZFD
10	Tshering Wangdi	Asst. Forestry Officer	Panbang
11	Sherab Jamtsho	Sr. Forest Ranger	Khomshar
12	Tashi Dendup	Research Officer	Trongsa
13	Tulsi Chhetri	Unit incharge	Tingtibi/Zhemgang
14	Karma Chewang	Sr Dzongkhag Agriculture Officer	Trongsa
15	Yonten Gyelthen	Chief Environment Officer	MHPA
16	Sigyel Delma	Dy Chief Forestry Officer	WMD
17	Kinley		Jakar
18	Tshering Tobgay	Dzongkhag Agriculture Officer	Zhemgang
19	Dhona		Zhemgang
20	Dorji Rinchen	Consultant	
21	K.B Samal	Consultant	
22	Kezang Wangmo	Forestry Officer	ZFD
23	Tashi Dendup	Environment Officer	Zhemgang
24	Ugyen Tenzin	Chief Forestry Officer	Zhemgang
25	Gembo Dorji		ZFD
26	Pema Gyeltshen	Asst. Administration	ZFD
27	Gabnelle Kissinger	Consultant	Lexeme Consulting
28	Sherab Norbu		TFD/Bumthang
29	Karma		NRDCL/Bumthang

Meeting with DoFPS staff on December 6, 2016

No	Name	Designation	Organization
1	Matthias Seebaur	Consultant	UNIQUE
2	Sangay	Specialist	NCD
3	Pema Wangda	Chief Forestry Officer	WMD
4	Kinley Tshering	Chief Forestry Officer	FPED
5	Yonten Norbu	Forestry Officer	SFED
6	Wangdi Dukpa	Offtg. Chief Forestry Officer	NRED
7	Sonam Choden	Sr. Forestry Officer	WMD
8	Jamyang Phuntshok	Dy Chief Meteorology Officer	WMD
9	Kuenzang OM	Agriculture Officer	WMD
10	Rxzin Wangchuk	Forestry Officer	SFED
11	Lungten Norbu	Specialist	WMD
12	Damber S. Rai	Chief Forestry Officer	FPED
13	Nelson Garpare	Consultant	Consultant on MTR
14	Samten Wangchuk	Dy Chief Forestry Officer	WMD
15	Sigyel Delma	Dy Chief Forestry Officer	WMD
16	Ugyen Penjor	Forestry Officer	FRMD
17	Dorji Wangdi	Sr Forestry Officer	FRMD
18	Tshewang Lhamo	Forestry Officer	NRED
19	Tshering Pem		NRED
20	Norbu Wangdi		UWICER
21	K.B Samal	Consultant	National Consultant

22	Gabnelle Kissinger	Consultant	Lexeme Consulting
23	Kinley Wangchuk	Driver	WMD
24	Kinley Dem	Forest Ranger	WMD
25	Ugyen Dema	Agriculture Officer	WMD
26	Kencho Lhendup	Driver	WMD
27	Shacha Lhamo	Forest Ranger	FPED
28	Pema Wangmo		FPED
29	Kelzang Eden		DoFPS
30	Tshering Dorji		DoFPS
31	Namgay Tshering		FPED
32	Yonten Phuntsho	Sr Forestry Officer	FRMD

Bilateral discussion with relevant stakeholders from December 5-9, 2016

No	Name	Designation	Organization
1	Mr. Sonam Wangchuk	Secretary	National Land Commission
2	Mr. Tashi	Sr. Survey Engineer/Head	Cadestral Information Division, NLC
3	Mr. Jigme Tenzin (77115760)	Sr. Survey Engineer, head	Land Management Division, NLC
4	Mr. Norbu Wangchuk	Chief Planning Officer	Gross National Happiness Commission (GNHC)
5	Mr. Mewang Gyeltshen	Director	Dept. of Renewable Energy, Ministry of Economic Affairs
6	Ms. Sonam Lhaden Khandu	Dy. Chief Environment Officer	Climate Change Division, National Environment Commission
7	Mr. Karma Dukpa	Chief Executive Officer	Natural Resources Development Corporation Ltd. (NRDCL)
8	Mr. Ashit Chhetri	Program Officer	Production Unit, NRDCL
9	Mr. Kinley Tshering		NRDCL
10	Ms. Tamang		NRDCL
11	Mr. Kinley Tshering	Chief Forestry Officer	Forest Protection and Enforcement Division., DoFPS
12	Mr. D.S Rai	Chief Executive Officer	Green Bhutan Corporation
13	Mr. Younten Norbu	Dy. Chief Forestry Officer	Social Forestry and Extension Division, DoFPS
14	Ms. Sonam Choden	Sr. Forestry Officer	Watershed Management Division, DoFPS
15	Ms. Sonam Pem	Director	Tarayana Foundation

Consultation workshop for Eastern Region from November 27-28, 2016

No	Name	Designation	Organization
1	Sangay Tenzin	Asst. District Livestock officer	Department of Livestock , MoAF
2	Sherub	Community Forest Management Chair person	Local Organization/Tajarong CF
3	Dorji	Geog Administration Administration	Local Govt. Administration
4	Jigme Dorji	Livestock Extension Officer	Department of Livestock, MoAF
5	Tashi Tenzin	Community Forest Management Chair person	Local Organization/Ngar Pangkapzur CF
6	Sangay Dorji	Community Forest Management Chair person	Local Organization/Yakpugang CF
7	Gyempo Gyeltshen	Engineer	Bhutan Power Corporation
8	Dendup Tshering	Divisional Forest Officer	Department of Forest & Park Services, MoAF
9	DC Bhandari	District Agriculture Officer	Department of Agriculture, MoAF
10	Karma Tempa	Park Manager	Department of Forest & Park Services, MoAF
11	P.B Mongr	Forest Officer	Department of Forest & Park Services, MoAF
12	Kelzang Wangmo	Sr. Forest Officer	Department of Forest & Park Services, MoAF
13	Kado	Geog Adm. Officer	Local Govt. Administration
14	Dorjee	District Agriculture Officer	Department of Agriculture, MoAF
15	Sonam	ReginalCordinator	
16	Karma Chophel	Geog Adm. Officer	Local Govt. Administration
17	Tshering Phuntsho	Geog Adm. Officer	Local Govt. Administration
18	Khampa	District Agriculture Officer	Department of Agriculture, MoAF
19	Sonam Choden	District Environment Officer	District Administration
20	Jamgyang Choden	Forest Officer	Department of Forest & Park Services, MoAF
21	Indra Prasad Dahal	Surveyor	Local Govt. Administration
22	Pema Tsheten	Surveyor	Local Govt. Administration
23	Sonam Zangpo	Sr. Forest Officer	Department of Forest & Park Services, MoAF
24	Kezang Penjor	Executive Engineer	Department of Roads, MoWHS
25	Dorji Khandu	District Environment Officer	District Administration
26	Karma Jamtsho	Sr. Ranger	Department of Forest & Park Services, MoAF
27	Chophel	Sr. Ranger	Department of Forest & Park Services, MoAF
28	Sonam Dorjee	Divisional Forests Officer	Department of Forest & Park Services, MoAF
29	Pema Wangchuk	Project Manager	Bhutan Power Corporation
30	Tashi	Sr. Ranger	Department of Forest & Park Services, MoAF
31	Thinley Wangdi	Park Manager	Department of Forest & Park Services, MoAF
32	Sachin Limbu	District Environment Officer	District Administration
33	Tshering Dekar	District Environment Officer	District Administration

Stakeholder Consultation for South-central region from December 1-2, 2016

No	Name	Designation	Organization
1	Ghana shyamLamchaney	SDDNYT(Coordinator)	Local Organization
2	Rinchen Dorji	Geographic Information System	UWICER, DoFPS
3	Karma Dorji	Chief Engineer	Department of Roads, MoWHS
4	Karma Dorji	Executive Engineer	Department of Roads, MoWHS
5	Kinley Wangchuk	Chairman, Community Forest	Local Organization/ Rinchen Norbueling CF
6	Ugyen Lhaden	GeogAdm Officer	Local Governmnet
7	Passang Wangdi	Asst. District Livestock Officer	Department of Livestock,MoAF
8	Sangay	GeogAdm Officer	Local Governmnet
9	Tashi Dhendup	Sr.Forest Officer	Department of Forest & Park Services
10	Sangay Wangchuk	Forest Officer	Department of Forest & Park Services
11	Domang	Sr.District Agriculture Officer	District Administration
12	Ugyenla	Land Record Officer	District Administration
13	Kinley Zam	Engineer	Bhutan Power Corporation
14	Pema Wangchuk	District Livestock Officer	Department of Livestock, MoAF
15	TandinDorji	District Environment Officer	District Administration
16	Tshering Dhendup	Park Manager	Department of Forest & Park Services
17	Kinga Dorji	Livestock production Officer	Department of Livestock, MoAF
18	DechenDorji	Engineer	Bhutan Power Corporation
19	Karma Wangchuk	Program Officer	Non Government Organization
20	Ugyen Namgyel	Park Manager	Department of Forest & Park Services
21	Kencho Dukpa	Divisional Forest Officer	Department of Forest & Park Services
22	Dimple Thapa	Divisional	Department of Forest & Park Services
23	Karma Tenzin	GeogAdm Officer	Local Government
24	Tashi Dhendup	Land Record Officer	District Administration
25	Khandu Wangchuk	Local Elected Leader	Local Government
26	Dorji Khandu	Community Forest Chairperson	Local Organization/Tsherang CF
27	Phuntsho	Chair Person, Community Forest	Local Organization/ Chhumey CF
28	Dorji Phebdang	Natural Resources Deve. Corporation Ltd.	Simi Government Organization
29	SangayDorji	Sr. Forest Officer	Department of Forest & Park Services
30	Sithup Lhendup	Sr. Forest Officer	Department of Forest & Park Services
31	Jigme Dorji		Department of Geology& Mines
32	Sarada Summar	Forest Officer	Department of Forest & Park Services
33	Tshewang Jaimo	Forester	Department of Forest & Park Services
34	Chudu Tshering	Mangmi (local elected representative)	Local Government
35	Dorji Rabteen	Park Manager	Department of Forest & Park Services

36	Jambay Ugyen	District Agriculture Officer	Department of Agriculture, MoAF
37	SangayDorj	Private Entrepreneur	Local Organization
38	PhubDhendup	Divisional Forests Officer	Department of Forest & Park Services

Stakeholder Consultation for Western Region from December 27-28, 2016

No	Name	Designation	Organization
1	Dolay Tshering	Sr. Forest Ranger	JKNSR
2	Sonam Gyelpo	Asst. Envt. Officer	T/phuDzo
3	Hari Prasad Adhikari	Chief Dzongkhag Agriculture Officer	Samtse
4	Yonten Phuntsho	Sr. Forestry Officer	FRMD
5	Thinley Bidha	Field Officer	Samtse
6	Sonam Yuden	Asst. Envt. Officer	BPC
7	Nima Norbu	Dzongkhag Livestock Officer	Gasa
8	Thinley Phuntsho	Asst. Dzongkhag Livestock Officer	Chukha
9	Sonam	Chief Dzongkhag Agriculture Officer	Chukha
10	Soanm Jamtsho	Geog Administrative Officer	Loggchina/Chukha
11	Kezang Lhendup	Geog Administrative Officer	Sephu/Wangdue
12	Tashi Dendup	Forestry Officer	Wangdue
13	Nima Dolma Tamang	Asst. Environment Officer	Thimphu
14	Rixzin Wangchuk	Forestry Officer	SFED
15	D.B Rasaily	Sr. Unit Manager	
16	Nima Gyelpo	Sr. Survey Engineer	NLC/Tphu
17	Ngawang Dorji	Environment Officer	Samtse
18	Dhodo	Sr. Dzongkhag Agriculture Officer	Thimphu
19	Dorji Wandi	Dzongkhag Environment Officer	Wangdue
20	Sonam Zangpo	Sr. Dzongkhag Agriculture Officer	Wangdue
21	Karma Tenzin	Chief Forestry Officer	Wangdue
22	Hari Maya	Asst. Engineer	Darla
23	Chunu Ghalley	Jr. Engineer	Darla
24	Lobzang Dorji	Chief Forestry Officer	FRMD
25	Sigyel Delma	Dy Chief Forestry Officer	WMD
26	K B Samal	Consultant	WMD
27	Samten Wangchuk	Dy Chief Forestry Officer	WMD
28	Lungten Norbu	Specialist	WMD
29	Nidup Tshering	Asst. livestock Officer	WMD
30	Kinley Dem	Forest Ranger	WMD

Annex 3: Methodological outline and protocol - GIS and spatial tasks
Summary description spatial tasks for Bhutan:

Collect all relevant data, but from DoFPS, satellite data available in the public domain (such as Global Forest Watch and others). Spatially disaggregate data by sub-region and forest type. Methods: Assess what spatial information al-ready exists in DoFPS, including different datasets during the LUPP (1995) and LCMP (2011) mapping processes, and FREL development. Ensure data and analysis can be integrated into Bhutan's NFMS. Spatially explicit analyses, spa-tially disaggregated by sub-region and forest type, and including quantification of emissions/removals. Spatially identify deforestation and forest degradation hot-spots and geographic areas where the pressure stems from. Correlate land use change to specific drivers of deforestation and forest degradation and their socio-economic context (refer to next task)

Spatial data analysis

Mapping Area
The mapping area for the Land use classification is the total area of Bhutan

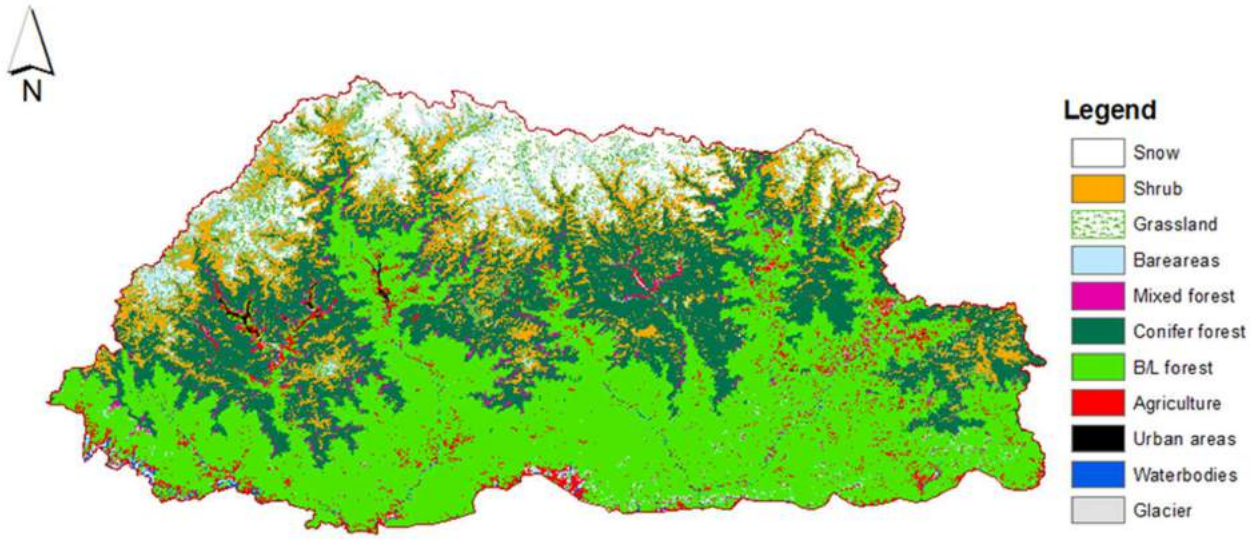


Figure 39: Area of interest (mapping and analysis task)

The following spatial data were received from Bhutan on which basis the land cover and land use change analysis was done:

- Country boundaries (Vector data)
- Forest management units (Vector data)
- Community forest (Vector data)
- ICMOD Land use and landcover data (2000, 2010 als Raster Data)
- LCMP 2010 Land use and Land cover data (Raster und Vector data; combination from Landsat imagery (2004-2009).

Satellite imagery:
For the LUC in Bhutan we used Landsat 8 imageries from USGS: http://earthexplorer.

usgs.gov/. The images are from 2015 winter season as being cloud free. Bhutan is covered with two scenes, however, a third scene is necessary (only a small part) for the Western part of Bhutan. The resolution is 30x30 m, the images user are:

- 1370412015316
- 1380412015323
- 1390412015362

Land use analysis/classification using the Software ArcGIS 10.2

For the classification of the different types of land uses comparing with the land use classes from ICIMOD 2000 & 2010, satellite images from 2015 with 8 bands were used. For the better detection of vegetation cover and soil types Google imageries were used as validation tool.

Table 22: Spectral bands of satellite image

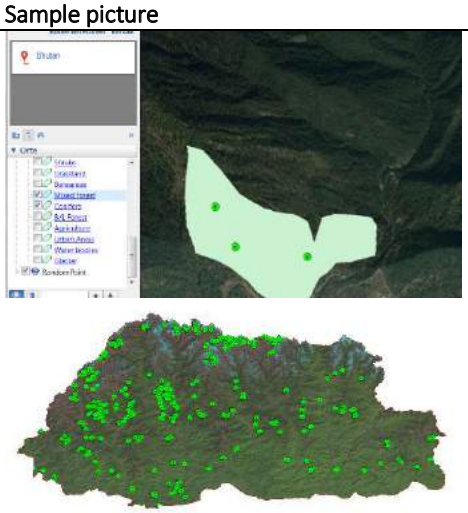
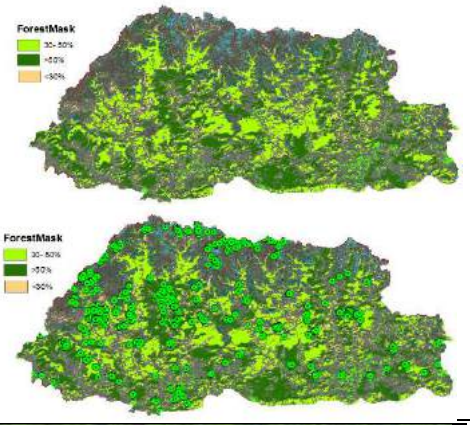
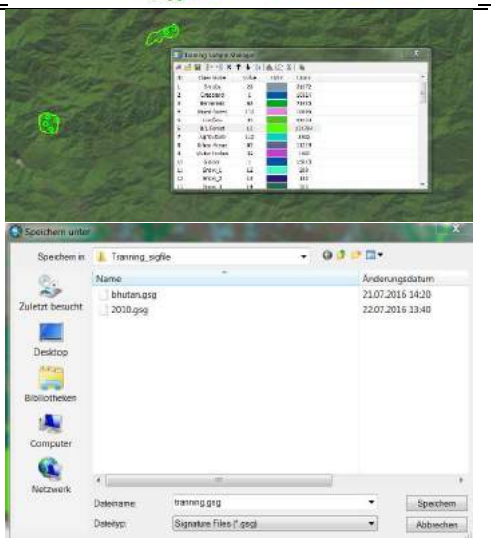
Bands	Wavelength (micrometers)	Resolution (m)
Band 1 - Coastal aerosol	0.43 - 0.45	30
Band 2 - Blue	0.45 - 0.51	30
Band 3 - Green	0.53 - 0.59	30
Band 4 - Red	0.64 - 0.67	30
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30
Band 6 - SWIR 1	1.57 - 1.65	30
Band 7 - SWIR 2	2.11 - 2.29	30
Band 8 - Panchromatic	0.50 - 0.68	15

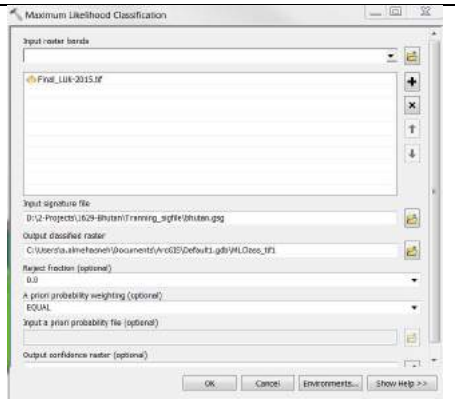
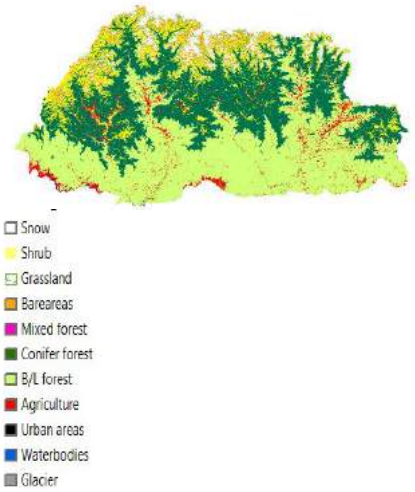
Table 23: Band combination (Image Enchantments / Channel improvement) to produce Land use classification

Image: Landsat 8/ Index	Formula	Results
Band 4: Red.	Red band	Forest
Band 5: Near Infrared (NIR)	Infra-Red band	Forest and water body
Thermal band	Thermal band	Shadow, cloud, snow, forest and grassland, shrub
NDVI* (vegetation index) Value :(-1 to 1) where (-1 to 0 water and cloud, 0-0,5 grass and agriculture, >0,5 trees and forest	NIR-R/NIR+R*100	Vegetation and non-vegetation (define Mask forest and non-forest)
SAVI	(NIR-R)/(NIR+R + L))* (1+ L)	Agriculture, grassland and others
NDSI	(G-IR)/(G+IR)	Snow and others
NDWI	(NIR-infra-red)/(NIR+Infra-red)	Water body

*the NDVI is very sensitive Index to soil colour, soil moisture, shading effects caused by solar and viewing angle geometry, vegetation cover: leaf area index, phenology and physiological status of the vegetation, vertical structure of the plant community (e.g. open grassland vs. multi-layered forest).

Creating training area with Accuracy Points

Step No.	Description	Sample picture
Step 1	Create random accuracy points for the Land use type by using Google imagery and Landsat 8 images band 1 –to 8 to increase the resolution from 30 m to 15 m with pan-sharpening.	
Step 2	Create polygon shape-file (mask for forest and non-forest area with cover in %) reference system (**WGS 84, UTM zone 45n**) (see *Procedure for ground cover analysis)*	
Step 3	Create polygon shape file as training area to define land use classes (Signature shape file). The same 11 classes from ICIMOD were used and saved as LU signature (ex. Tranning.gsg) The ArcGIS image classification toolbar gives several options for classification including: maximum likelihood, iso cluster, class probability and principal components, we used maximum likelihood which is the most common method for land use classification.	

Step 4	Start the Maximum Likelihood Classification. Define the signature file (training area shape file).	
Step 5	Save the result of Maximum Likelihood Classification, then run Majority filter and clean the boundaries. The final results is Land Use classification as Raster Layer with attribute table for all classes.	

Accuracy analysis for Ground Truthing

The accuracy of the classified maps was assessed from high resolution Google Earth Pro images and Landsat 8, band 1 –to 8 to increase the resolution from 30 m to 15 m with pan-sharpening. Finally we compared the ground truthing accuracy 2015 for each of the 11 classes with ICIMOD 2010 dataset.

Table 24: Accuracy assessment of land cover 2015

		Ground Truth:											Totals:
Predicted:		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
1	**Snow**	146					1				6	2	155
2	**Shrub**		198				20					1	219
3	**Grassland**		1	33				10					44
4	**Bare area**				113					5			118
5	**Mixed Forest**					8	2						10
6	**Conifers**		2				193	3	4	3			205
7	**BL Forest**						2	123					125
8	**Agriculture**		4				4		124	3			135
9	**Urban**									5			5
10	**Water**										34		34
11	**Glacier**	1										49	50
Totals		147	205	33	113	8	222	136	128	16	40	52	1100
Accuracy of Ground Truth		99%	97%	100%	100%	100%	87%	90%	97%	31%	85%	94%	
Accuracy of Prediction		94%	90%	75%	96%	80%	94%	98%	92%	100%	100%	98%	
Overall Accuracy:			**93.3%**										

Table 25: Comparison ICIMOD Ground Truthing 2010; ICIMOD Ground Truthing 2000 not available

Table 4
Accuracy assessment of land cover 2010.

	Broadleaved forest	Needleleaved forest	Mixed forest	Shrubland	Grassland	Agriculture	Built-up area	Water body	Barren area	Snow and glacier	Total	User's accuracy (%)
Broadleaved forest	**58**	3	1	2		2					66	**87.88**
Needleleaved forest	3	**49**	2	1							55	**89.09**
Mixed forest	2	1	**39**	2		2					46	**84.78**
Shrubland	1	2	4	**35**	2	1	1				46	**76.09**
Grassland			1	3	**30**	4	1				39	**76.92**
Agriculture	1		1	1	2	**28**	2	2	1		38	**73.68**
Built-up area					1	2	**18**		4		25	**72.00**
Water body						1		**32**		2	35	**91.43**
Barren area					1	2	4		**32**		39	**82.05**
Snow and glacier								2	1	**27**	30	**90.00**
Total	65	55	48	44	36	42	26	36	38	29		
Producer's accuracy (%)	89.23	89.09	81.25	79.55	83.33	66.67	69.23	88.89	84.21	93.10		

Crown Cover Analysis – to assess forest degradation

For the crown cover analysis and the change detection between 2000-2015 we used the same steps of classification and ground truthing as explained above. We defined the crown cover in three percent classes based on Landsat images (2015, 2010, 2000)

Table 26: Crown cover % classes

Crown cover%	Description
>50%	Dense forest
30-50%	Dense to open forest
<30	Open forest to degraded

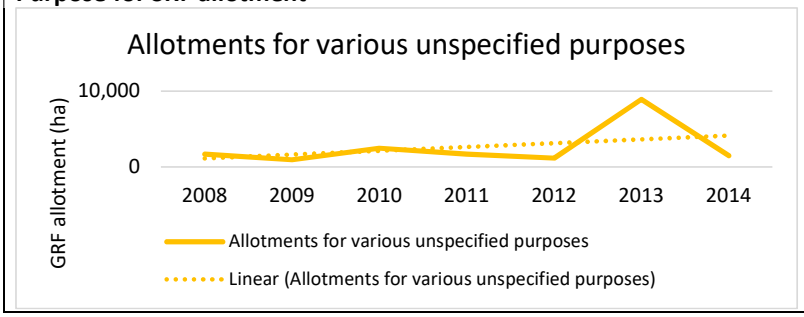
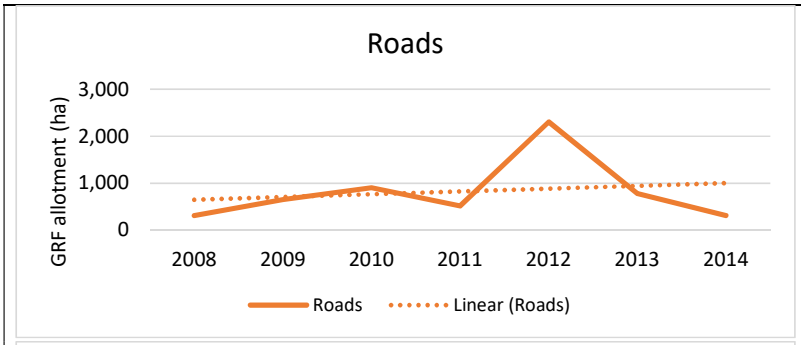
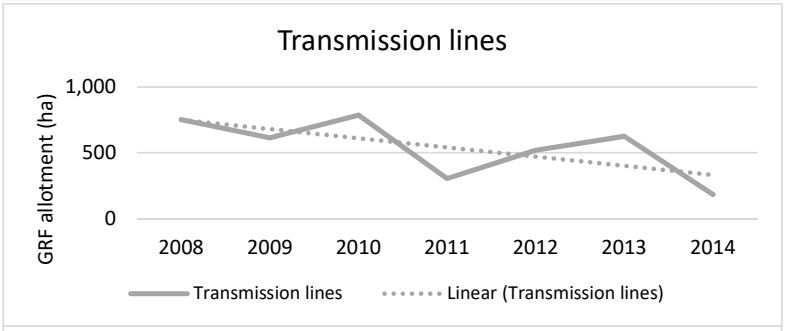
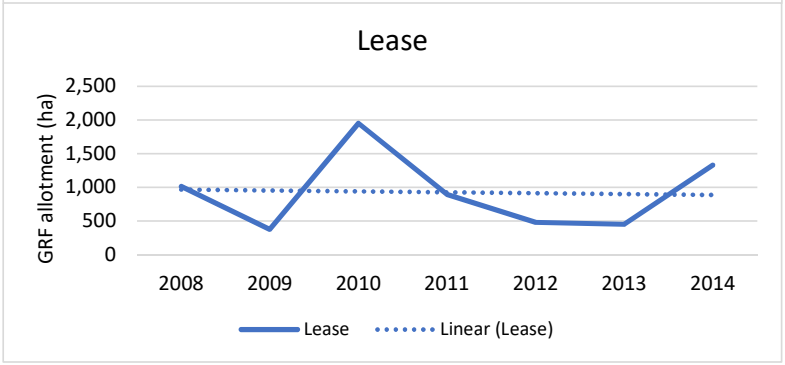
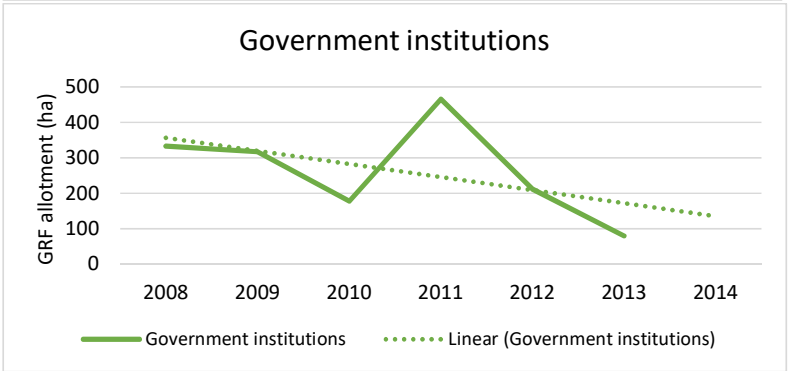
Procedure for Crown cover analysis

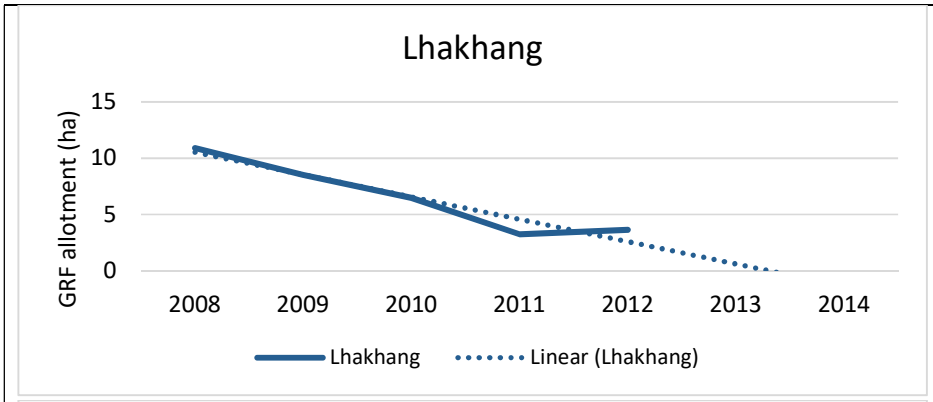
1. Create random points tool and tanning areas for forest types (conifer, broadleaf forests and mixed forests) to define Crown cover classes in each period 2000, 2010 and 2015
2. Save the training area signature file and run the max. likelihood classification
3. Extract values to points tool (from raster to polygon)
4. Add XY coordinates tool (intersection with admin units of Bhutan)
5. Edit and sort attribute table (raster value in crown cover %)
6. Export data from attribute table
7. Analyze the frequency for predicted classes und ground truth points
8. Convert shapefile to .kmz

Annex 4: Trends in SRFL allotment and indication of future trend

Trends in SRFL allotment are described below, with indication of what the historical trends indicate for the future. These figures do not reflect known development proposals, however, and thus the transmission line allotments indicate a decreasing trend, whereas according to known development plans, the opposite is the case

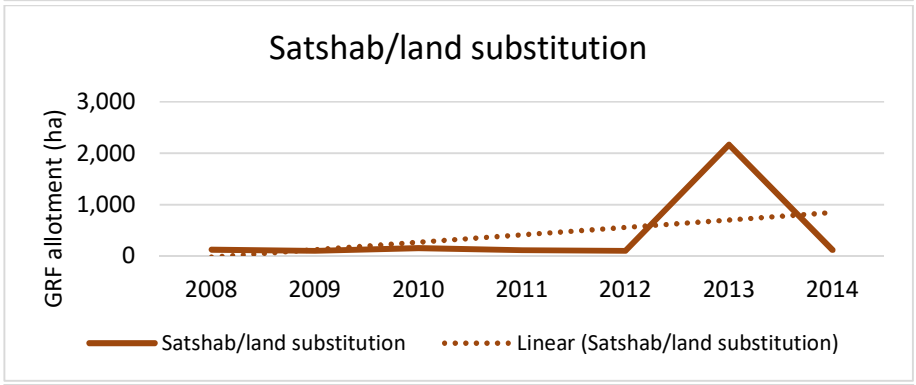
Source: Katwal et al., 2011; Department of Forest and Park Services /Ministry of Agriculture and Forests, 2013; 2014; and 2015.

Purpose for SRF allotment	Historic trend
	Increasing
	Increasing
	Decreasing
	Decreasing
	Decreasing (Note: category not reported in 2014 stats)

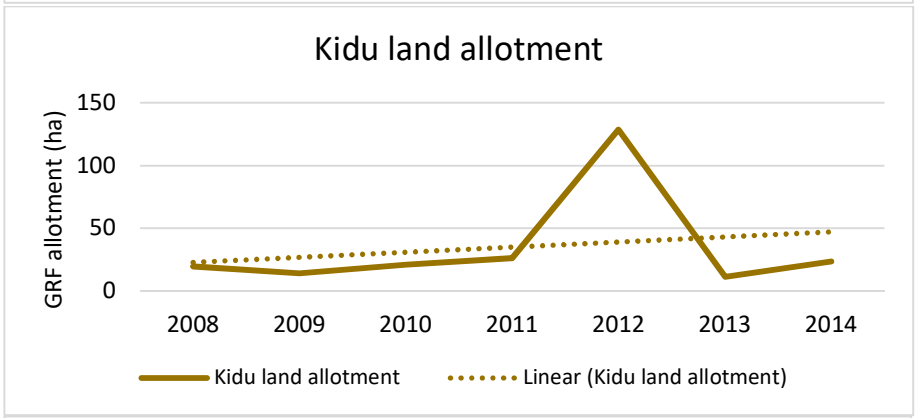


Decreasing

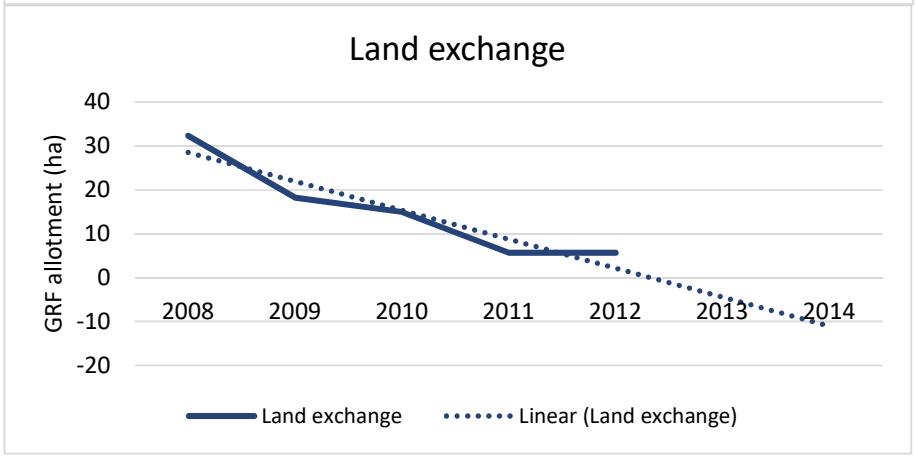
(Note: category not reported in 2013 and 2014 stats)



Increasing



Increasing



Decreasing

(Note category not reported in 2013 and 2014 stats)

Figure 40: Trends in SRFL allotments 2008-2014

Annex 5: Stratified stocking volumes applied in this study

Forest Strata	Vol/ha Scenario 1 (m3/ha)	Vol/ha Scenario 2 (m3/ha)
<30BroadleafForest5	50	58
>50BroadleafForest5	193	154
30-50BroadleafForest5	85	100
<30ConiferForest5	115	154
<30MixedForest5	62	154
30-50MixedForest5	106	303
<30BroadleafForest11	113	86
>50BroadleafForest11	222	228
30-50BroadleafForest11	187	148
<30ConiferForest11	163	166
>50ConiferForest11	332	486
30-50ConiferForest11	251	291
<30MixedForest11	62	187
>50MixedForest11	241	548
30-50MixedForest11	106	328
<30BroadleafForest12	126	154
>50BroadleafForest12	247	411
30-50BroadleafForest12	208	266
<30ConiferForest12	115	201
>50ConiferForest12	234	590
30-50ConiferForest12	208	353
<30MixedForest12	62	204
>50MixedForest12	241	600
30-50MixedForest12	106	359
<30BroadleafForest14	75	231
>50BroadleafForest14	194	678
30-50BroadleafForest14	138	405
<30ConiferForest14	125	234
>50ConiferForest14	323	688
30-50ConiferForest14	241	412
<30MixedForest14	100	189
>50MixedForest14	258	555
30-50MixedForest14	190	332
<30ConiferForest15	125	235
>50ConiferForest15	323	690
30-50ConiferForest15	241	413

<30BroadleafForest16	75	73
>50BroadleafForest16	194	194
30-50BroadleafForest16	138	126
<30ConiferForest16	125	217
>50ConiferForest16	323	636
30-50ConiferForest16	241	380
<30MixedForest16	100	175
>50MixedForest16	258	513
30-50MixedForest16	190	307
<30BroadleafForest15	75	233
>50BroadleafForest15	194	684
30-50BroadleafForest15	138	409