



National Forest Inventory of Bhutan: Shift in Role from Traditional Forestry to Diverse Contemporary Global Requirements

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Abstract

The current study was carried out to look at the processes and modality of Bhutan's national forest inventory; and show the technical ownership of a country towards implementing national forest inventory. Bhutan's NFI adopted systematic sampling grid of 4 km by 4 km spread across the country and the field surveys were conducted over a period of three and half years to collect data on forest resources. Unlike conventional inventories, Bhutan's national forest inventory was a multipurpose and holistic forest health monitoring inventory. The entire process was very scientifically and statistically rigorous and robust inventory drawing contributions from various internationally renowned experts and organisations and it is a significant milestone achieved by Bhutan to strengthen institutional capacity, generate information for further research and knowledge and for overall global environmental conservation. Besides, Bhutan's national forest inventory contributes considerably to Reducing Emissions from Deforestation and Forest Degradation (REDD+) Readiness program of the Royal Government of Bhutan. One of the standout achievements is that current national forest inventory, led by national experts unlike past inventory. As a result, Bhutan has been able to showcase its commitment to environmental conservation, build strong collaboration with government agencies and development partners, strengthen institutional capacity and contribute greatly to knowledge generation and information in the region.

Key words: Biodiversity, biomass and carbon stock, growing stock, national forest inventory, resource assessment.

INTRODUCTION

The history of forest inventories dates back to the end of middle ages when intensive use of forest resources first led to wood shortages which, in turn, forced users to begin forest planning, particularly near towns and mines (Loetsch and Haller 1973; Gabler and Schadauer 2007 as cited in Tomppo *et al.* 2010). The first inventorying was often local with the aim of assessing the available timber resources for specific purposes and were

often conducted by the timber users, for example companies (Loetsch and Haller 1973; Loetsch *et al.* 1973; Davis *et al.* 2001 as cited in Tomppo *et al.* 2010). During 20th century, systematic sample grids were used for National Forest Inventory (NFI) as a method of statistical sampling for conducting survey and assessment of forest resources (Kleinn *et al.* 2010; Tewari 2016). It soon became obvious that such inventories could not easily be used to

compile national level forest information for purposes of formulating national forest policy; thus, NFI's were initiated. Since that time, forest information has been collected via user-driven NFI's in many countries. About one tenth of plots of a state is sampled per year in western states, producing a ten year inventory cycle (Shaw *et al.* 2005).

National Forest Inventory is a part of National Forest Monitoring System (NFMS) conducted to regularly update specifications of forest collecting different information and analysing the primary statistics by countries. It is used in data provisioning for forest management and policy formulation at all geographic levels including international conventions (Tewari 2016). The national forest inventory helps in documenting the trends and condition of forest resources over a period of time. The important factor of it is in NFMS to generate carbon stock data and emission or removal factors to contribute to greenhouse gas inventory reporting and/or to assess carbon dioxide removal by forest ecosystem along with activity data generated through remote sensing.

According to United Nations Framework Convention on Climate Change (UNFCCC) 2009 report, REDD+ monitoring outlined in COP 15 emphasized methodological approaches for national monitoring system to use a combination of remote sensing and ground based forest carbon inventory approaches for measuring forest area changes and forest carbon stocks and changes (Romijn *et al.* 2012). The guidelines of Intergovernmental Panel on Climate Change (IPCC 2006) also mentions about estimation of carbon stock changes to be calculated and reported

as five carbon pools of forest land, namely above-ground biomass (AGB), below-ground biomass (BGB), dead wood, litter (DOM), and soil organic matter (SOM) in GHG inventories (IPCC 2006; Romijn *et al.* 2012).

WHY IS NATIONAL FOREST INVENTORY IMPORTANT?

As we understand, the history of undertaking NFI dates back to the end of middle ages. It was carried out mainly from the perspective of demand for timber and wood utilisation. But today the NFI has wider and greater scope and purpose. It not only assesses the timber stock, but provides information on biodiversity, forest health and disturbances, biomass and forest carbon. Multipurpose NFI, as carried out for Bhutan, also provide information on wildlife and ecosystem services amongst others.

The first national field-based forest assessment, referred to as the Pre-investment Survey (PIS) was carried out from 1974 to 1981. This was mainly focused on timber assessment for establishing wood-based industries in the country. It was driven by the need to pursue economic development in the country (FRMD 2012). The PIS was carried out with the support of Government of India. It provided the first estimate of forest cover as well as growing stock in the country. Since then, several remote sensing exercises were carried out which monitored the changes in forest cover over time.

However, remote sensing exercises did not provide quantitative information, such as changes in growing stock over time and other information required for maintaining forest resources sustainably.

Ground based inventories were limited to forest management units, which are areas designated for commercial harvesting of timber and did not provide national level forest information.

In 2008, Bhutan adopted its first Constitution. The Constitution of Kingdom of Bhutan (2008) mandated the need to maintain 60 per cent forest cover. It was also during this period that Bhutan made its commitment to remain carbon neutral at the COP 15 to UNFCCC in Copenhagen, Denmark. The need for assessing forest for parameters such as forest carbon and also the need for robust tools for monitoring the changes in forest resources was deemed crucial.

More than thirty years after the first field-based forest assessment, the Department of Forests and Park Services (DoFPS) of Bhutan thus embarked on NFI in 2009. It was designed to collect comprehensive and holistic quantitative and qualitative information on forest resources. The information included growing stock, forest carbon stock, growth and increment, forest health and disturbance, species diversity and wildlife. The National Forest Policy (NFP) adopted in 2011 further emphasised the need and mandate for periodic monitoring of forest cover over time.

Besides, Bhutan's own national requirements, the importance of NFI's globally too has grown many folds. International agreements and commitments such as Kyoto Protocol, Convention on Biological Diversity, Global Forest Resources Assessment (FRA) and National Communications to the UNFCCC have direct impacts on the

national economies and development. Since forest also plays critical role in mitigation and adaptation to impacts of climate change, the NFI has been recognised as one of the key components of REDD+. According to the UNFCCC 2009 report, REDD+ monitoring outlined in COP 15 emphasised methodological approaches for national monitoring system to use a combination of remote sensing and ground based forest carbon inventory approaches for measuring forest area changes and forest carbon stocks and changes (Romjin *et al.* 2012). It is an important tool for measuring forest carbon stocks and stock changes within Measurement, Reporting and Verification (MRV) functions of NFMS (UN-REDD Programme 2013). Under Component 3, NFI is Pillar 2 of MRV functions on measurement and is most intensive in terms of labour and information collection.

Bhutan is currently in the REDD+ readiness phase. The readiness phase draws supports from both bilateral and multilateral international development partners, chief among them being the Forest Carbon Partnership Facility (FCPF) of the World Bank. Bhutan REDD+ Readiness Preparation Proposal (RPP) was approved in 2013 (WMD 2015). The ICIMOD supports Bhutan's NFI through REDD+ Himalayas Initiative supported by the GIZ.

The main outcome of REDD+ readiness programme is to develop Bhutan's National REDD+ Strategy and implementation framework including NFMS, Forest Reference (Emission) Level, MRV mechanism, and Safeguard Information System (SIS).

MATERIALS AND METHODS

This paper is being presented to show the best practices in REDD+ focusing on National Forest Inventory of Bhutan, conducted by the Royal Government of Bhutan. Bhutan's NFI has been fully led by national experts drawing contributions from many international and regional scientists. The paper also showcases how the NFI has been customised and prioritised to fulfil Bhutan's national needs. The NFI reports, manuals, field guide books, Forest Monitoring Unit inventory guidelines and the officials involved in the process have been consulted and engaged to prepare this paper. The summarized field methodology including the implementation modality of NFI of Bhutan is described in the following sections.

National Forest Inventory Design

The DoFPS of Bhutan conducts two types of forest inventories; one for preparing forest management plans called Forest Management Unit (FMU) inventory for forests where timber is harvested based on principle of sustainable forest management and the other, the NFI. While the forest management inventories are repeated at an interval of 10 years but are confined only to a particular FMU. On the other hand, NFI covers the entire country. For the purpose of the NFI, the entire country was divided into a systematic sampling grid of 4 km by 4 km, regardless of land use or land cover classes. A total 2424 sampling cluster plots were laid spread across the country. With this design, it was targeted to obtain reliable estimates for basal area at 15 per cent margin of error within 90 per cent confidence interval at district level and greater precision at the national level.

Each cluster plot consisted of three circular plots on an L-shaped transect spaced at 50 meters apart (FRMD 2012), as depicted in figure 1. These circular plots are called as Elbow, North and East plots. Each circular plot has radius of 12.62 meters yielding an area of 0.05 hectares. Within Elbow plot, sub-plot of radius 3.57 meters is laid to collect regeneration data and is called Regeneration Plot. Another two sub-plots of radius 0.57 meters are laid within North and East plot to collect data on herb.

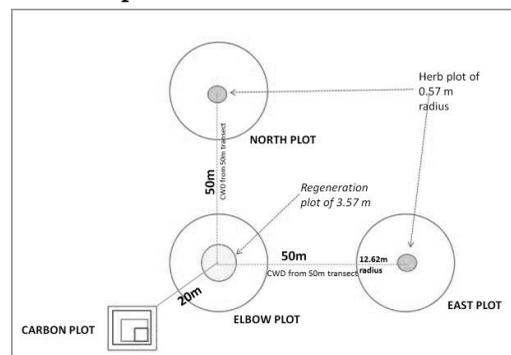


Figure 1: National Forest Inventory Plot Design

Source: FRMD (2016)

Implementation Modality

As many experts pointed out during the process of undertaking NFI, Bhutan's inventory was one of the most intensive and robust. It was intensive both in terms of financial and human resources. The field work lasted for three and half years but it would have taken longer, had it not been for a thorough planning and strategic implementation. One of the greatest strengths has been putting in place a well-worked-out implementation modality and strategy. The entire process NFI was implemented in a phased manner-preparatory phase and implementation or data collection phase. The preparatory

phase began in 2009 and lasted until 2012. During this phase, preparatory works which included resource mobilisation, developing design and methodology, developing field manuals and protocols, procuring equipment and gears, mobilising field staff, and training the nominated field staff were carried out.

The implementation modality was developed in consultation with field offices based on thorough assessment of human resource capacity of the department and also field offices. Sixty professional forestry staff were engaged in NFI as NFI crew. They were grouped into 12 crews or teams of 5 members each. Each crew or team was headed by a senior Range Officer, assisted by a young Ranger and three young foresters. The decision to engage regular technical staff instead of recruiting staff on contract was to ensure institutional capacity development and for long term needs of the department and the program itself.

Field Data Collection

One of the salient features of current NFI of Bhutan was that it was a paperless inventory, as opposed to the conventional inventory. Trimble global positioning system (GPS) device was used not only to navigate to plots but also collect data. Digital field forms were designed in pathfinder software and then transferred to GPS, thus making the data available in a single device. The inventory crew were provided with GPS, laptops and external hard drive to collect and store raw data. Each crew was provided with NFI field manual which provided step-wise instruction to plan the field work besides providing guidance on data collection and storage.

Data Management and Analysis

The data once received in head office from the field staffs were converted into required file format and then uploaded into Open Foris Collect platform. From collect platform the data was exported as comma separated values (csv) for cleaning, sorting and then prepared for final analysis. The NFI data analysis was done using Calc and statistical environment R modules. Calc is a modular browser-based tool for data analysis developed by FAO as part of Open Foris Initiative.

Soil Organic Carbon

The samples were collected from 20 per cent of the accessible cluster plots up to depth of 30 cm from the plot laid southwest of Elbow plot center by excavation method in 10 cm by 10 cm square plot from three different layers of 0-10 cm, 10- 20 cm and 20- 30 cm. The details of the sampling design and field data collection methodology is described in *A field Guide, for Aboveground Understory and Soil Carbon Assessment*, published by Forest Resources Management Division in 2014. The soil organic carbon content is analysed using Walkley and Black Method, and CHN Analyser. A detailed Soil Organic Carbon (SOC) estimation method is described in *Laboratory Manual for Aboveground Understory and SOC Analysis* published by FRMD (n.d.)

Forest Carbon Assessment

The aboveground biomass of the trees and sapling were estimated using 14 species specific biomass models and two general models for broad-leaved and conifer tree species which were developed as a part of NFI. The belowground biomass for trees and sapling were estimated using formula provided by Mokany *et al.* (2006)

$$\text{BGB} = 0.489 \times \text{AGB}^{0.8}$$

The biomass of shrubs, herbs and litters are based on oven-dried weights of the samples collected from 20 per cent accessible cluster plots and detail procedure is described in Laboratory Manual for Aboveground Understory and Soil Organic Carbon Analysis published by FRMD (n.d.).

The biomass of the coarse woody debris (CWD) was computed using estimated volume, wood density and biomass expansion factor.

$$\text{CWD Biomass} = \text{Volume} \times \text{Wood Density} \times \text{BEF}$$

Carbon estimates from biomass were then computed by applying a carbon fraction of 0.47 (IPCC 2006) to the biomass estimates.

RESULTS

The NFI results have been presented in two volumes – national forest inventory report I and II. The report volume I is intended to present up-to-date information and establish baseline information on tree resources in the country, which will serve as a tool for strengthening the science-based forest management. These statistics presented in report I are expected to promote development of effective forest governance and resources utilisation plans and programs based on sustainable forest management principles and best practices. The information contained in first volume are forest cover statistics reported at national level as well as by dzongkhags, aside from other estimates such as basal area, tree counts and growing stock being presented too. Basal area, tree count and growing stock statistics are reported at national level, followed by *dzongkhag*¹

(district) level, by different forest type and land use classes. The basal area, tree count and growing stock are also reported by forest type, diameter classes, height classes and major tree species. These are estimates which are generated through statistically robust methods of analysis. The volume I reported that the forest occupies a total of 2,730,889 ha equivalent to 71 per cent of the total country's area, with Wangdue Phodrang dzongkhag (district) having the highest forest cover of 292,824 ha and the lowest in Tsirang dzongkhag of 48,857 ha. In terms of per cent cover, Dagana, Pemagatshel and Zhemgang dzongkhags were found to have the highest forest cover per cent of 83 per cent each and Gasa dzongkhag the least with 36 per cent.

Likewise, in regards to the statistics for tree count, the volume reported that an estimated 816,524,026 trees were found in Bhutan with stem density 213 trees per ha. It also reported that Trashigang dzongkhag has the highest number of tree count with 82,773,731 trees and Gasa dzongkhag has the lowest number of tree count with 9,766,164 trees. The report also pointed out that Tsirang dzongkhag has the highest stem density with 283 trees per ha and Gasa dzongkhag has the lowest stem density with 91 trees per ha. Going by forest type, it is estimated that the Cool Broad-Leaved Forest has the highest tree count of 296,492,852 trees and the lowest in Dry Alpine Scrub Forest with 469,746 trees. Maximum tree count is found in diameter class of 10-20 cm with 287,507,073 trees and the minimum in diameter class of 90-100 cm with 10,311,675 trees, according to report I, which indicates that Bhutan's forest is fairly young forest.

¹ Dzongkhag is a *Dzongkha* (National language of Bhutan) terminology which means district in English. There are twenty dzongkhags (districts) in Bhutan.

In terms of basal area, the volume I reported that a total basal area of the forest is estimated to be 114,791,541 m² with average basal area of 30 m² per ha. Trashigang dzongkhag has the highest basal area with 9,956,439 m² and the lowest in Gasa dzongkhag with 961,167 m². The report also pointed out that Lhuntse dzongkhag has the highest basal area per hectare with 56 m² per ha and the lowest in Gasa dzongkhag with 9 m² per ha. In terms of forest type, total basal area is maximum in Cool Broad-Leaved Forest with 49,177,533 m² and the minimum in Dry Alpine Scrub forest with 19,481 m². The diameter class of ≥ 100 cm contributes to the maximum basal area with 33,040,958 m² and the minimum from diameter class of 10-20 cm with 5,235,586 m².

The volume I reported that the total growing stock of forest is 1001 million m³ and average growing stock is 261 m³ including all trees whether or not they fall under our forest definition. Looking at the growing stock by dzongkhag, Mongar dzongkhag has the highest total volume with 86,817,118 m³ and Gasa dzongkhag has the least with 7,277,898 m³. Lhuntse dzongkhag has the highest volume per hectare with 566 m³ while Gasa dzongkhag has the least with 68 m³. The Cool Broad-Leaved Forest has the highest total volume with 438,025,418 m³ and Dry Alpine Scrub Forests has the least with 95,854 m³. The diameter class of ≥ 100 cm has the highest volume estimate of 337,804,979 m³ while the diameter class of 10-20 cm has the least 26,588,104 m³.

The second volume of the NFI report contained the results and estimates on forest biomass and carbon, which are reported at

national level, by dzongkhag, forest type and by elevation. It is reported that total forest carbon stock stored in vegetative carbon pool and soil is 709 million tonnes of carbon. Trashigang Dzongkhag has the greatest total biomass with 96 million tonnes while Gasa has the lowest with 7 million tonnes. This corresponds to 45 million tonnes of carbon and 3 million tonnes of carbon in Trashigang and Gasa respectively. In terms of forest type, the total biomass stock is greater in broadleaf forest with 726 million tonnes than conifer forest of 329 million tonnes of biomass. This corresponds to 341 million tonnes of carbon and 155 million tonnes of carbon in broadleaf and conifer forest respectively. The report II also reports the biomass and carbon by elevation. The total biomass stock is greatest in 2000-3000 m elevation range with 540 million tonnes of biomass and least at elevation greater than 4000 m with 144 million tonnes of biomass. This corresponds to 254 million tonnes of carbon for forest in 2000-3000 m elevation and 68 million tonnes of carbon above 4000 m elevation.

The Significance of National Forest Inventory of Bhutan

Notwithstanding its significance, the NFI has been and will continue to remain hugely an expensive national undertaking for most countries, barring a few developed countries. Bhutan despite being a least developed country with very limited technical, financial and human resources has successfully completed its first NFI. The completion of NFI is a huge achievement. The successful completion of NFI in Bhutan showcases four important contributions:

Bhutan's Commitment to Environmental Conservation and Global Responsibility

Under the visionary leadership of the Monarchs, Bhutan has placed huge importance on environmental conservation and has followed a sustainable development policy based on the principle of Gross National Happiness, wherein environment conservation is one of the four pillars. Bhutan has been recognised as a global conservation leader for its conservation efforts, often placing greater importance of conservation than economic benefits. About 51 per cent of the country's area is designated under protected area network system and 71 per cent of the country is under forest cover.

Considering the significance of forests for its role in contribution to sustainable development goals and its role in addressing climate change concerns, NFI is another testimony of Bhutan's commitment to the global responsibility. When Department of Forests and Park Services embarked on carrying out the NFI, there was no dedicated or allocated fund for the exercise. Yet despite the lack of fund, Forest Department initiated the process and strategically planned the exercise to be carried out in a phased manner. The Royal Government of Bhutan, despite having other developmental priorities has funded more than fifty per cent of the total fund required for carrying out the NFI. This testifies the commitment of the government to protection and conservation of environment.

Successful Collaboration of Government Agencies and Development Partners Towards Common Goal

NFI is an output of successful collaboration among governmental agencies and development partners. The key challenge is achieving commitment from the government and other state or non-state actors with conflicting interests (Angelsen 2009). The successful collaboration in Bhutan highlights the foremost policy of Royal Government of Bhutan in working closely with the development partners, to align project activities including funds with the Policies, Programs and National Key Result Areas (NKRA) of Royal Government of Bhutan. This has not only avoided duplication of activities and spending of limited financial resources; but has also allowed successful implementation of project activities.

Given the huge investment required for carrying out such a mammoth exercise, the NFI has been implemented with the support of multiple development partners over course of time. With the support of SNV, Department of Forests and Park Services was able to prepare the sampling design and pilot the exercise in one of the gewogs (local administrative unit). Bhutan Trust Fund for Environment Conservation (BT FEC) provided crucial follow-up support for Preparatory Phase as well as for initiating the Enumeration Phase of NFI in 2010 through 2012.

United States Department of Agriculture Forest Service (USDA-FS) played a critical

role in providing technical support and guidance in finalising the sampling design and field methods for forest carbon assessment. The Yale School of Forestry and Environment and University of Washington engaged through USDA-FS continued to provide guidance on statistical issues associated with forest inventory and sampling.

The United Nations REDD+ program (UNREDD program) initiated the REDD+ in 2010 and through UN-REDD-TS, FAO provided technical support for building the capacity of the department for fulfilling the requirement under MRV in REDD+. Forest Resources Management Division (FRMD), the focal division under DoFPS was able to explore the various monitoring tools developed by FAO. Most importantly, FRMD was able to explore the possibilities of using OPEN FORIS, a suite of open source tools developed by FAO for data collection, management and analysis for NFI. Eventually, FRMD successfully adopted the OPEN FORIS tools (Collect and Calc) for NFI data management and analysis with the technical support of FAO. This removed the need to develop an exclusive data management system, which was initially planned.

The REDD+ Readiness Proposal (R-PP) developed in 2013 with the support of UN-REDD had identified NFI as an important exercise under MRV component for REDD Readiness and supported the field data collection. R-PP was approved by Forest Carbon Partnership Facility (FCPF) in the same year. Together with R-PP, the REDD+ Himalayas Capacity Building project initiated in 2015 supported by Federal Ministry for the Environment,

Nature Conservation and Nuclear Safety (BMUB) of Germany through GIZ and ICIMOD provided the much needed support for implementing NFI field work and biomass equation development. The support from each of these development partners were strategically planned to avoid duplication of efforts and resources. The FRMD worked closely with the Watershed Management Division, the focal office for climate change and REDD+, to implement REDD Readiness activities.

The NFI Core team, which served as the advisory committee comprised of multi stakeholder representatives. The NFI required support of other agencies for carrying out parallel exercises. The Renewable Natural Resources Research Development Centre (RNR-RDC), now part of Ugyen Wangchuck Institute for Conservation of Environment (UWICER) carried out biomass equation development exercise. This was important for generating country specific biomass allometric models for trees to estimate the biomass and carbon in trees. The soil and Plant Analytical Laboratory of National Soil Service Centre under the Department of Agriculture provided laboratory support for analysing the forest understory and soil samples for organic carbon analysis. The NFI is therefore also the result of successful collaboration among the various government and non-governmental agencies within the country.

Clear roles and responsibilities were defined for each implementing partners involved. Besides, conducting frequent meetings with partners to update the progress of the project, an operational manual was developed that defined the roles and responsibilities of each partners.

Such steps enabled each partner to know their roles and also provided them opportunity to contribute actively towards achieving project goals and outputs; and take ownership of the project itself and activities thereof.

Impact of NFI to the Institutional Capacity

Besides the resulting data and report on state of forest resources, one of the major impacts of NFI has been on the institutional capacity of the forest department. When NFI was initiated in 2009, one of the key objectives was to build the capacity of the department and people involved. Sixty professional foresters were mobilised from the field offices and engaged in NFI as crew member and have therefore been trained and are made very conversant with the use of equipment, NFI field protocols and methodology.

Besides having the knowledge and experience in carrying out the field work, at present, the Department has the capacity for data management and analysis which can be strengthened over time with recent/advanced technology, knowledge and skills. The forest inventory (data collection) and data management functions of the next NFI is being planned to be decentralised to the field offices. This would help in ensuring a continuous flow of quality information from the field to monitor REDD+ actions on the ground. These institutional capacities enables implementation of periodic NFI, which would be essential for a robust NFMS required for monitoring the changes in forest resources over time. The current initiative on NFI, while offering us the baseline information on our forest,

establishes a foundation for periodic inventories in future. The periodic inventories are imperative for monitoring 60 per cent forest cover mandate as enshrined in the constitution of Bhutan.

The parallel exercises on biomass allometric model development and forest understory and soil organic carbon analysis had led to the development of capacity in related areas. The capacity of the two laboratories, namely Forest Research Laboratory (now part of UWICER) at Yusipang and Soil and Plant Analytical Laboratory (SPAL) at Semtokha, have also been built. The relevant staffs have been trained in data collection and analysis protocols, and both the laboratories have been equipped with adequate equipment including very high-end equipment such as CHNS analyser. Thus, both these institutions now have the capacity to handle similar works in future.

Through NFI, Bhutan has also been able to create awareness and raise the level of education of general public particularly of local government leaders as well as central government leaders. The technical capacity was raised in central government through technical advisors of development partners increasing the assistance in institutional capacity building. When NFI was started in 2009, not only general public but also some of the people holding key government posts had very limited or no knowledge of importance of NFI. As part of the current NFI, meetings with local government leaders were held to educate them on NFI periodically which eased the implementation of field works. Hence, the support and cooperation received from them while field works were carried out in their jurisdiction was tremendous after such meetings.

Contribution to Knowledge on Himalayan Forests

The NFI report presenting information on growing stock, regeneration, increment, forest biomass and carbon, species diversity of Bhutan are important information on forests of eastern Himalayas. It presents opportunities for greater understanding of forests in these regions. The allometric biomass models for 20 tree species found in the country developed through the REDD+ Capacity building project supported by BMUB, ICIMOD and GIZ can be used by neighbouring countries having similar tree species. The soil organic carbon estimates generated at national level as well as by forest types and elevation ranges are valuable information for understanding the forest soil carbon dynamics in Himalayan region and more so in context of assessing the impacts of climate change.

The systematic sampling design consisting of cluster plots established at fixed distance of 4 km by 4 km and field protocols adopted for data collection would be useful for carrying out similar exercises in mountainous terrains. The experiences and lessons of carrying out the national forest inventory would be valuable for other developing countries embarking on similar exercises.

CONCLUSION

The NFI of Bhutan has been an enormous exercise undertaken by the Department of Forests and Park Services and successfully completed with the commitment of the Royal Government of Bhutan and support of multiple development partners involved; namely SNV, BTFEC, FAO, UN-REDD program, FCPF, BMUB, ICIMOD and GIZ.

The NFI of Bhutan demonstrates how the role of forest inventory can be expanded to acquire multiple information on forest resources in response to diverse national and international reporting requirements. Besides fulfilling the national need for up-to-date state of forest resources in the country for formulation of sound policies and forest management practices, it enhances the country's reporting abilities with reduced uncertainties in the data and estimates. The forest biomass and carbon estimates were used for establishing the forest reference emission level (FREL)/ forest reference level (FRL) of the country.

The NFI in Bhutan also demonstrates the impact that project has made in enhancing forest department's technical and institutional capacity in responding to the current challenges of forest management. The foundations for periodic inventory and monitoring of changes in forest resources are now established.

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