CASE STUDIES ON MEASURING AND ASSESSING FOREST DEGRADATION

FOREST DEGRADATION IN NEPAL: REVIEW OF DATA AND METHODS

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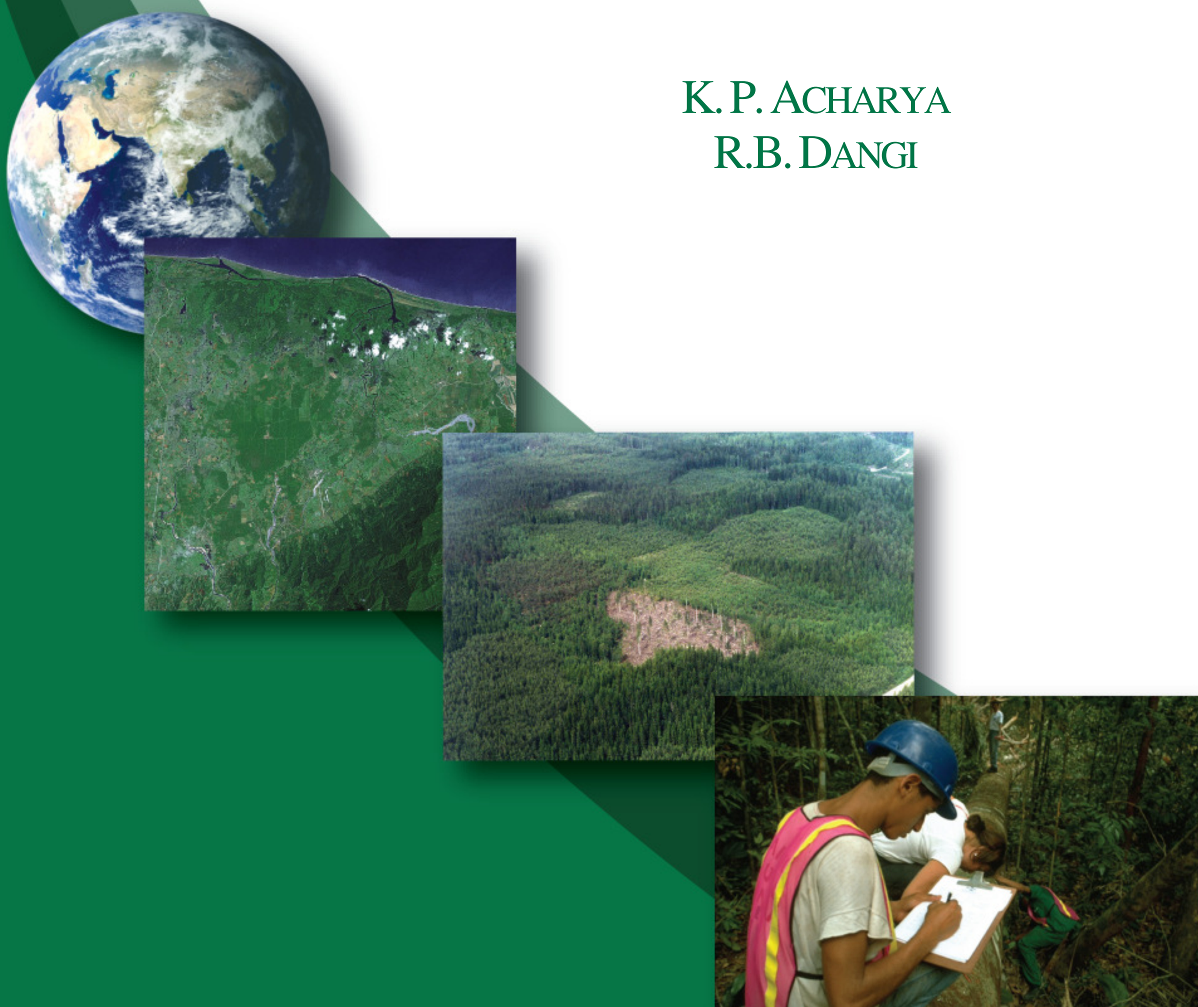

Sustainably managed forests have multiple environmental and socio-economic functions which are important at the global, national and local scales, and they play a vital part in sustainable development. Reliable and up-to-date information on the state of forest resources - not only on area and area change, but also on such variables as growing stock, wood and non-wood products, carbon, protected areas, use of forests for recreation and other services, biological diversity and forests' contribution to national economies - is crucial to support decision-making for policies and programmes in forestry and sustainable development at all levels.

Under the umbrella of the Global Forest Resources Assessment 2010 (FRA 2010) and together with members of the Collaborative Partnership on Forests (CPF) and other partners, FAO has initiated a special study to identify the elements of forest degradation and the best practices for assessing them. The objectives of the initiative are to help strengthen the capacity of countries to assess, monitor and report on forest degradation by:

- Identifying specific elements and indicators of forest degradation and degraded forests;
- Classifying elements and harmonizing definitions;
- Identifying and describing existing and promising assessment methodologies;
- Developing assessment tools and guidelines

Expected outcomes and benefits of the initiative include:

- Better understanding of the concept and components of forest degradation;
- An analysis of definitions of forest degradation and associated terms;
- Guidelines and effective, cost-efficient tools and techniques to help assess and monitor forest degradation; and
- Enhanced ability to meet current and future reporting requirements on forest degradation.

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Case Studies on Measuring and Assessing Forest Degradation

Forest Degradation in Nepal: Review of Data and Methods

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Abstract

Forests provide a wide range of provisioning, regulating, cultural and supporting services for human well being collectively known as ecosystem services. The sustainability of forest ecosystems depends on sustained management, efficient utilization and effective protection measures against deforestation and forest degradation. Present global discussions on forest degradation have been focused on reduction of emissions from source and removal of enhancement from the sink i.e. carbon services. In Nepal, the role of other ecosystem services such as water harvesting, soil conservation, biodiversity conservation are also equally important for sustaining rural livelihoods and maintaining environmental condition. Hence, it is imperative to develop common understanding on forest degradation among the forest users, professionals, policy makers, and the politicians. This will be helpful developing appropriate public policy to address the problem of forest degradation.

This paper aims to review the past forest resource assessments, methodologies and findings on forest degradation. The study observed that differentiation on forest quality was recognized since the first forest resources assessment in the early 1960s. Similarly, all forest resource assessments have identified criteria and indicators for capturing forest degradation. Forest degradation has been understood as reduction in production capacity of commercial timber volume. Change in tree canopy cover was used as a key criterion in assessments. Degradation was assessed through canopy closure, tree density, regeneration capacity, stand maturity, lopping, species dominancy, grazing, and soil surface erosion. Forest with no well defined stems has been defined as a shrub land which increased at a rate of 5.57 percent per year from 1978/79 to 1994. The assessment methodologies include field survey, satellite images, aerial photography, ground checks or a combination of these. Finally the paper concludes by offering potential methods for assessing forest degradation in Nepal.

These assessments focused on investigating the association of canopy cover with the commercial timber volume. This approach neither recognizes ongoing degradation within the dense canopy forests nor the under storey degradation. In addition, the trade off of different kinds of ecosystem services was not considered. The use of satellite images with field survey could be a suitable approach for assessing forest degradation based on the resultant outcomes of all kinds of forest ecosystem services. A participatory valuation approach using Ecosystem Service Index (ESI) to assess forest degradation is recommended rather than accounting of individual services. Finally, the paper argues that the scale of forest services should be understood comprehensively to prevent the emergence of new drivers of degradation. Hence, forest degradation should be understood as the reduction in the capacity of forests to produce ecosystem services.

Keywords: Forest, shrub, degradation, method, ecosystem valuation

1. Introduction

Forests are an integral part of the farming system in Nepal. Farmers must have access to forest products such as leafy biomass for fodder and animal bedding, fuel wood for energy, and timber for building and agricultural implements (Mahat, 1987; Gilmour and Fisher, 1991; Malla, 2000). In the high altitude Jumla area, it was estimated that maintaining of one hectare (ha) of paddy land requires up to 50 ha of forest and grazing land (Whitemand, 1980). Similarly, for middle hills, Wyatt-Smith (1982) estimated a requirement of 3.5 ha of forest to maintain one ha of agricultural land. In the whole country, fuel wood derived from forest constituted 84 percent of the total energy consumed in 2006/07 (WECS, 2006). Similarly, about 42 percent of the fodder requirement for livestock production is derived from the forests (WECS, 2006; Pandey, 1982). In addition, a number of forest resources such as high value medicinal and aromatic plants are facing excessive and unsustainable harvest pressure and degradation (MoEST, 2008). The forestry sector contributes 9.45 percent from direct products and 27.55 percent including indirect services to the national gross domestic product. On the other hand, over 28 percent of the country's land is estimated to be in degraded condition (DFRS, 2008; MoEST, 2008).

The Ministry of Forests and Soil Conservation, Department of Forest Research and Survey (DFRS) and Government of Nepal have carried out a number of forest resource assessments since the 1960s. The resource assessment ranges from national level to community level. These inventories differ in objectives and methodology. The paper reviewed strategic level forest inventories from Nepal. In addition, two economic studies in Nepal were evaluated. This paper aims to discuss major findings of different methodologies used and to offer a potential approach that could be utilised for assessing forest degradation.

The next part of this section presents a brief review on the forest assessment studies conducted in the past indicating linkages with the thematic elements of sustainable forest management. Section 2 begins with an examination of methodologies, criteria and indicators used for assessing forest degradation. Section 3 focuses on results of different assessments; it describes the advantages and disadvantages of various methodologies with respect to cost and accuracy of information. The discussion section highlights the lesson learned in relation to the drivers of degradation and detectability of the methods used. It further discusses appropriate methods for assessing forest degradation such as Ecosystem Service Index (ESI). The paper concludes with a recommendation that forest degradation should be understood as resultant outcomes of the different services available from the forest.

Forest resource assessment in Nepal

1. Forest Resources Survey Office (FRSO)1963/64

The forest resource survey office conducted the first forest inventory during the period of 1963-67 using 1953-58 and 1963-64 aerial photography. It used visual interpretation of aerial photographs and mapping combined with field inventory. The land categories include forest, crop, grass, urban, water, badly eroded and barren lands. The forest land was subdivided into commercial and non-commercial forest (HMG 1961; 1969; 1973). The inventory was concentrated only on assessing extent of forest area, growing stock/ha up to 10 cm top diameter. It does not cover high altitude forests areas.

2. Land Resource Mapping Project (LRMP)1978/79

The LRMP was jointly implemented by the Government of Nepal and Kenting Earth Sciences Limited Canada with financial support from the Government of Canada. The objectives were to develop appropriate forest land use maps based on forest types, composition, structure and land degradation status. The project was implemented during 1977 to 1884 (LRMP 1985; 1986). The forest resource assessment was made through the combined use of aerial photographs (1977-79), extensive ground truth checks by helicopter, land surveys and topographic maps.

3. Master Plan for the Forestry Sector (MPFS)1986

The Master Plan for the Forestry Sector (MPFS) was implemented by the Ministry of Forests and Soil Conservation. The data were based on LRMP information and forest inventory data from Forest Survey and Research Office (MPFS 1989a; MPFS 1989b). The aim was to update resource information changes that occurred during the intervening period of LRMP.

4. National Forest Inventory (NFI)1994

The National Forest Inventory (NFI) was started in the early 1990s and completed in 1998 with a base year of 1994. The programme was implemented by the DFRS with support from the Government of Finland. The NFI used satellite image analysis - Landsat, aerial photographs and field measurements.

5. Forest Cover Change Analysis of the Terai Districts (DoF) 2005

The study estimated extent of forest cover and annual rate of change of 20 terai districts. It was commissioned by the Department of Forests. The forest cover change was estimated by analysing satellite images of different time periods, supported by ground verification (DoF 2005).

6. Economic Valuation of Ecological Goods and Services (ESE) 2005

The study was commissioned by the Ministry of Forests and Soil Conservation, Government of Nepal. The study estimated the value of goods and services of forest ecosystems representing different ecological zones and management regimes (MoFSC 2005). However, the study could not cover all the ecological regions.

7. Contribution of Forestry Sector to Gross Domestic Product in Nepal (GDP) 2008

The DFRS conducted this study to estimate the actual contribution of forestry sector in national GDP. Both, use and non-use values had been taken in to consideration in estimating the contribution. The use values include consumptive goods like timber, fuel wood, grass/fodder/bedding materials, NTFPs, sand and boulders. Similarly, non use value includes recreation, eco-tourism, soil conservation and green carbon sequestration (DFRS 2008).

Resource Assessment and the thematic elements of Sustainable Forest Management

A summary of major resource assessment studies and their linkages with thematic elements of Sustainable Forest Management (SFM) is presented in Table 1. The information reveals that not all elements of SFM were covered in these measurements. The table shows that resource assessments were focused to investigate extent of forest area and estimation of timber volume. Two recent economic studies on the valuation of forest services have added carbon, biodiversity and protective function of the forests in assessments. The forest health and vitality has yet to be considered in the assessment.

Table 1: Strategic level forest assessment in Nepal and SFM linkages

S.N.	Study	Year	Responsible Organisation	SFM thematic element
1.	Forest Resources Survey	1974	FRSO(DFRS)	1, 5
2.	Land Resource Mapping Project	1978/79	LRMP/WECS	1, 5
3.	Master Plan for the Forestry Sector	1986	MoFSC/DFRS	1, 5, 7
4.	National Forest Inventory	1994	DFRS	1, 5
5.	Forest Cover Change Analysis of the Terai Districts	2005	DoF	1
6.	Economic Valuation of Ecological Goods and Services	2005	MoFSC	2, 4,5, 6, 7
7.	Contribution of Forestry Sector to Gross Domestic Product in Nepal,	2008	DFRS	2, 4, 5, 6, 7

Thematic elements of sustainable forest management are. 1. Extent of forest resources; 2. Contribution to the Carbon cycle, forests and climate change; 3. Forest health and vitality; 4. Biological diversity; 5. Productive functions of forests; 6. Protective functions of forests; and 7. Socio-economic functions of forests. (Source: FAO 2009)

2. Assessment Methodology

Assessment and tools

It is commonly agreed that measuring forest degradation is more complex and difficult than deforestation (Panta *et al.*, 2008; Lambin, 1999; Souza *et al.*, 2003). Table 2 summarises the criteria and methods used in defining and assessing forest degradation. The table reveals that all reviewed assessments have accepted differences in forest quality. The tree canopy stocking level was found to be the main criterion used in all assessment. Hence, common acceptance on forest degradation of a forest in these assessments is the reduction in production capacity of timber volume. The stocking level was linked with forest productivity. Proxies used include canopy closure, number of mature trees, the number of preferred trees, density, cut stump, growing stock, regeneration capacity, stand maturity, lopping, species composition, grazing, and soil surface erosion.

The table shows that 10 percent canopy cover was used to distinguish forest and non-forest areas. However, there was confusion among the definition of forest and shrub land, shrub lands and scrub, forest and degraded forests. The most commonly used indicators are crown closure and number of regeneration sized trees per unit areas. In addition, some qualitative indicators such as lopping and encroachments were considered as a factor for degradation.

Table 2: Review on methodology of forest assessment studies

Study	Degradation criteria	Indicators	Methods	Procedure
1. FRSO	Stocking class (Crown cover <10 % as a non forest area) and density class) Scrub and shrub	• Crown closure and number of reproduction size trees/ha (well stocked- >70 % and above 799 reproduction size tree/acre, Medium 40-69% or 400-699 reproduction size tree/acre; 10-39 % or 100-399 reproduction size tree/acre) • Lands with unmerchantable tree and shrub species growing in bush-like clumps.	• Means estimator • Visual interpretation of aerial photographs • 1:12,000 to 1:60,000 aerial photographs • Dot counting • Area rectification and adjustment • Field inventory in	• 1"= 1 mile land use map prepared using aerial photographs, • Physiographic regions divided • Forest, Cropland, Grass, Urban, Water, Badly eroded and Barren • Forest subdivided into commercial/non commercial forest • Area rectification • Forest mapping 3"=1 mile Forest inventory for volume and growth information

	Encroached forest	• Heavy and repeated fuel wood cuttings • Lands 10 % or more covered by tree crown and containing commercial timbers but currently being cultivated, unlikely to remain as forests • No legitimate ownership	commercial forest	• Systematic grid of 3.2 km x 16.1 km • Cluster of 5, 800 m² rectangular plot • Stumps recorded with species & size • Location of measured trees mapped • 5 circular sub-plots of 5.27 ft radius used to record reproduction and dominant crown cover. • Conifer growth estimated by borings
2. LRMP	Stand stocking Soil surface erosion	• Crown density is % of ground area covered by tree crowns as viewed on the photograph or from air (Crown density < 10 % as non-forest, crown cover <40 % with an average of 25%) • Few scattered trees • Grazing -number of livestock • Forest fire	• Visual interpretation of aerial photographs (black and white 1: 20,000 to 1:50,000) • Ground truth checks by helicopter • Land surveys • Topographic maps	• Land utilisation classification in 4 physiographic regions • Aerial and ground reconnaissance • Forest reconnaissance, ground check • Forest, cultivated, grass lands, shrub lands and other lands, • Forest classification • Interpretation and typing • Topographic maps and transferring, • Field work and data collection • Drafting, planimetry & compilation
3. MPFS	Crown closure Regeneration	• 10 to 40 % under stocking or degraded • 10 to 40 % crown closure or, if immature containing 250 to 999 regeneration sized trees/ha • If immature containing 999 or less regeneration sized trees/ha • Stands with mature or over mature trees	• Desk review • Visual interpretation of aerial photographs and field verification	• Creation of data base from LRMP and FSRO research plots, five physiographic regions • Field verification using aerial photographs • Modelling to update information
4. NFI	Crown cover - stand density	• <10% crown cover or well defined stems not found	• Satellite images, GIS, topographic maps, vector data-boundary • Ground based inventory • Visual interpretation of aerial photographs of scale 1:50,000	• Land use categories, forest & shrub • Forest area into reachable, non -reachable and encroached, field verification, data transfer manually onto planimetric sheets, digitisation • Development regions separation • Satellite image analysis - Landsat TM, NDVI used District Forest, Churiya forest and remaining hills districts inventory • Photo point sampling, two stage cluster designing, 4x4 km, manual transfer, stereoscope for land use
5. DoF	Crown cover	• Degraded forest means sparsely distributed trees or forest land with < 10 % crown cover including shrub	• GIS, Satellite images analysis and ground verification	• Satellite image analysis and field verification • Landsat TM 1990/91 and 2000/01 • Districts level outputs
6. ESE	Crown cover Use value of ecosystem services	• <10 % crown cover as degraded forest or shrub land	• Forest inventory • Questionnaires • Market price • Market price of substitutes • Benefits transfer • Total net stock	• Terai, siwaliks and middle hills regions in 12 districts covering Sal, Terai hardwood, Pine, Sub-temperate forest and shrub land. • Community forests, protected area system and government managed regimes surveyed
7. GDP	Crown cover	• <10 % crown cover and shrub as degraded forest	• Ground based forest inventory • Questionnaire • Market price • Market price of substitutes • Benefits transfer • Total net stock	• High-Hills, Mid-Hills & Terai regions • Sal, Terai Mixed Hardwood, Khair/ Sissoo, Lower Slope Mixed Hardwood, Chir pine, Upper Slope Mixed Hardwood, Oak / *Castanopsis* and others forest types, • Management regimes – Leasehold, Government managed, Religious, Community & protected areas.

3. Results

Table 3 highlights the extent of forest and shrub categories while more details are presented in Annex 1. The FRSO survey recognised the forest quality differentiation primarily based on stand size, density classes, crown closure, merchantable volume, although, there is no clear definition and assessment of forest degradation. It was characterised by fewer number of trees, lopped trees, unwanted species (i.e. not commercial tree species), heavy grazing pressure, unpalatable species, and bushy species. However, it has identified encroached forest as a kind of degraded forest.

Table 3: Extent of forest and shrub land cover in Nepal

Study	Year	Forest		Shrub		Forest and Shrub total	
		Area '000 ha	%	Area '000 ha	%	Area '000 ha	%
1. FSRO	1964	6,402	45.5	-	-	6,402	45.5
2. LRMP	1978/79	5,616	38.1	689	4.7	6,285	42.8
3. MPFS	1985/86	5,424	37.4	706	4.8	6,210	42.2
4. NFI	1994	4,268	29	1,560	10.6	5,828	39.6

Table 4: Estimation of forest degradation rate in terms of increase in shrub land

Study	Year	Shrub land		Forest degradation % per year (1978/79 to 1994)
		Area 000 ha	%	
LRMP	1978/79	689	4.7	5.57
NFI	1994	1,560	10.6	

Tables 3 and 4 revealed that the total forest area has not changed very much, although the forest cover has been degrading. Table 3 shows that shrub was not included as a separate land use category until LRMP, since then it is one of the important land use categories. From the definition of shrub land (DFRS, 1999) and the above tables, it is clear that shrub lands are those forest areas from where tree stems were removed but the area still meets other criteria of forests such as canopy closure. It leads to a conclusion that shrub land is an outcome of forest degradation or is a kind of degraded forest. The forest and shrub area analysis (DFRS, 1999) result is presented in Box 1.

Box 1: Forest and shrub area results

- Forest covers 29 % and shrub covers 10.6%, both forest and shrub together cover 39.6%.
- In Terai plains, forest area has decreased at annual rate of 1.3% from 1978/79 to 1990/91.
- In the Hilly Area, forest area has decreased at an annual rate of 2.3% from 1978/79 to 1994, whereas forest and shrub together have decreased at annual rate of 0.2%.
- In the whole country, from 1978/79 to 1994, forest area has decreased at an annual rate of 1.7%, whereas forest and shrub together have decreased at an annual rate of 0.5%.

Box 1 indicates that deforestation and degradation have been understood in terms of forest and shrub areas. A comparison of NFI with LRMP shows that the area under shrub land increased by 126 percent during 1978/79 to 1994 or at a minimum rate of 5.57 percent per year. However, the result shows that there is no substantial change in the total of forest and shrub land area. The degradation estimate does not include the degradation that remains within the forest category i.e.

above 10 percent crown cover. The DoF (2005) definition on degraded forest also includes shrub land as a part of degraded forests. Other elements among different inventories are less comparable due to different definition and coverage.

Degradation assessment methods

The methodologies used in past assessments can be grouped into Aerial Photography, Field Survey, Satellite Image and Ecosystem Service Valuation. The following table compares the strengths and weakness among these methodologies and accuracy level. In the table, the analysis indicates that forest degradation assessment accuracy increases if it is supported by the ground based information.

Table 5: Relevancy of different forest degradation assessment methodologies in Nepal (Based on Photographs 1:12,000 to 1: 60,000 and Landsat TM images experiences)

Methodology	Advantageous	Disadvantageous	Accuracy level	Costs	Implications for Nepal
Aerial photography	• Easy to understand to local community • Visible to demonstrate forest degradation such as crown cover change, shifting cultivation, forest fragmentation • Long experience • Infrastructure exits • Require low input on technology	• Difficulty in mountain area • High costs, • High time requirement, • Nearly abandoned and replaced by new technologies. • No latest aerial photographs available • Degradation elements such as grazing, fire damage, forest NTFPs and understorey damage, encroachment is not completely detectable	High	High	No recent aerial photographs available - less useful
Field survey	• Data available for comparison • More accurate, • Widely understood, • Cheap labour • Considerable experience • Simple technology • Capture all kinds of ecosystem services • National to local scale possible • Scattered case study and academic, research data available	• More resources, • Long time requirement • Difficult in mountain terrain • No recent data available	High (Std. Error for the top 4 "volume ranged from 2.61% to 6.66 %).	Medium	Considerable experience exists, labour is cheap- still a good option, community involvement is available, proposed FINNIDA assistance survey will generate new data
Satellite image analysis and GIS	• Global uniformity • Rapidly advancing technology • Easy interpretation in high resolution images • High resolution images usable as a map for demonstration • Requires low forest inventory	• Technical capacity and infrastructure demanding, • Cloud, shadow and slope in hilly areas, • Few control plots for ground verification, • Seasonal images availability, • Limited data to replace ground inventory • Difficult to assess under storey including NTFPs.	Medium to high (67 to 98% to distinguish in different stocking class)	Free to moderately expensive (Landsat to IKONOS) Low or medium	Difficult terrains support it. Needs capacity development, if combined with field survey, is one of the best option
Ecosystem service valuation	• Recognizes broader value of forest ecosystem	• Technically demanding • Outside forestry discipline	Medium to High	Low to Moderate	Community participation, true valuation of forest services.

4. Discussion

Nepal has a substantial experience on ground based forest inventory which has established considerable data sources. However, inventories seem to be focused to investigate commercial timber volume of the forest and not designed for forest degradation assessment in particular. Further, compared with forest inventory, recent economic studies are much wider, incorporating concepts of ecosystem services. The average rate of forest conversion to shrub land (5.57 percent/year) is significantly higher than deforestation (1.7 percent/year) for the same period of 1978/79 to 1994. It indicates that the forest degradation is more important for countries like Nepal for carbon emission or ecosystem services accounting. Although the factors responsible for forest degradation in Nepal are not clearly understood, a list of possible factors and their detectability is presented in Table 6.

The most commonly used methods are ground based forest inventory, aerial photography, and satellite image analysis and a combination of these. Crown cover is taken as a proxy of degradation, which is unable to address forest degradation until it remains as forest or in under storey. Canopy reduction will reduce biomass but may enhance watershed conservation and carbon removal or biodiversity. Table 6 shows that under storey loss is also a fundamental way of forest degradation. Crown cover base assessment alone is unable to account for many of the drivers of degradation. Similarly, the table reveals that, field survey combined with image analysis will be able to capture the key degradation elements and their consequences.

The NFI defined shrubland as an area the same as forests but well-defined stems cannot be found. By contrast the DoF study defined degraded forest to mean sparsely distributed trees or forest land with less than 10 percent crown cover including shrub. These definitions indicate that shrub land is a degraded forest. However, in some cases, these studies have used different definition of degraded forests and shrub lands, creating confusion. Fuzzy boundaries between land cover categories need to be removed by providing clear, simple and consistent definition for all assessments.

Table 6: Drivers of degradation and detectability of different methods

Drivers of degradation	Level of significance	Key degradation element	Detectability (low to high, 1 - 3)		
			Field survey	Aerial Photographs	Images
Fuel wood removal	High	Biomass, understorey	3	2	1
Timber removal	High	Crown cover, biomass	3	2	1
Fodder, leaf litter removal	High	Biomass, understorey	3	2	1
Over extraction of medicinal & other species	High	Understorey, biomass, biodiversity	3	1	1
Encroachment	High	Crown cover, habitat, biomass, understorey	3	2	2
Overgrazing	High	Understorey, soil, habitat	3	1	1
Development activities- Road	High	Crown cover, habitat, biomass, fragmentation	3	3	2
Wild fire	Medium	Understorey, biomass, soil, biodiversity	2	1	2
Settlements to landless	Medium	Crown cover, habitat, biomass	3	2	2
Invasive species	Low	Biomass, understorey, habitat, biodiversity	3	1	1
Rot disease	Low	Biomass	3	1	1
Floods	Medium	Biomass, understorey, biodiversity	2	1	2
Wind throw	Low	Biomass, species	3	2	2

Past assessments have done spatial and temporal mapping of forest conditions of Nepal which suggest that forest degradation is causing changes in the forest structure, composition, stocking and forest types, change of the vertical structure or alteration of other attributes. Sharma and Suoheimo (1995) found that about 45 percent of trees are affected by the rot diseases in Makawanpur and Rautahat districts. Similarly, Acharya (2000) stated that there is degradation on existing forest stock due to repeated logging practices resulting in lower quality forest types. It was illustrated through conversion of Sal forest (>60 percent of basal area) to Sal Terai Hardwood and finally to Terai Hardwood (sal basal area <20 percent).

Nepal is suffering acutely from different sources of forest degradation. Forest encroachment is a serious problem in the Terai plains. An estimate shows that 100,000 ha of forest is under encroachment in the Terai and many more coming under threat of encroachment by illegal squatters. High altitude forests are degraded due to the stocking of livestock units 9 times higher than their carrying capacities (MoEST, 2008; NBS, 2002). Table 6 illustrates that degradation can be the result of a single factor or a combination of multiple factors. It is highly significant for maintaining subsistence economy which is based on the exploitation of natural resources as a major source of livelihoods. The detection of such drivers is extremely limited with remote sensing unless it reaches to serious level or it is supported by ground based information. Any methodological innovations should consider the ground reality. Forest degradation may occur in following ways:

1. Reduction in biophysical attributes of forests such as crown cover in such a way that forest remains as forest, up to10 percent.
2. Reduction of crown cover from shrub land or degraded forest until it is converted to other land use. It has implications for services including carbon sequestration.
3. National area statistics will show both 1 and 2 on forest or shrub/degraded forest category undermining the degradation.
4. Degradation may occur in under storey canopy due to removal of NTFPs and other resources.

The proposed field based inventory, with the assistance from the Government of Finland, will generate substantial spatial and temporal information in Nepal. In addition, regional cooperation through South Asian Association for Regional Cooperation (SAARC) could be a very practical solution for such assessment specifically for small developing countries such as Nepal.

There is a need for the development of a comprehensive methodology to understand and value forest degradation from ecosystem services perspectives. It could be based on the use of satellite images combined with field survey. In addition, a participatory ecosystem services valuation approach (PESVA) is recommended for understanding ecosystem services comprehensively to capture degradation factor as shown in Table 6. This is simple but manageable by community institutions for community forest management and will clearly help understanding forest degradation. The PESVA requires expert inputs on the methodological template development, index development, default value; key and simple procedure. In addition, satellite images supported by ground observations could be the most efficient way to estimate rates of forest degradation by locations to know where and how forests are being degraded.

The conceptual clarity on issues such as what is forest degradation, its impacts on ecosystem services, fragmentation, local drivers of degradation, and opportunity costs is essential. The use of satellite images and field based inventory requires additional capacity development, data sharing mechanisms, permanent field plots, biomass studies, NTFPs and wildlife inventory. Likewise, research to assess under storey vegetation in different conditions using images needs special consideration.

4. Conclusions

Forest degradation is a unique process affecting forest ecosystem services (MEA, 2005). These drivers are different in across and within the countries. A detailed and more specific understanding of these drivers is necessary to address forest degradation. There is a need for a comprehensive methodology to understand and value forest degradation from ecosystem services perspectives for subsistence economy, poor people and forest dwellers depending on ecosystem services for daily needs.

Nepal has a substantial experience on ground based forest inventory which has established considerable data sources on forest stock. The methods used are aerial photographs, field inventory and satellite images analysis. The further development of methodologies in assessing degradation will largely depend on definitions. Different organizations have used different definitions and a consensus definition is needed. Similarly, the clear distinction between shrub land and degraded forest and methods to assess shrub lands are required. Similarly, several policy documents have used forest degradation differently, which needs to be resolved. It should consider full ranges of biophysical and socio-economic conditions. Nevertheless, in Nepal, a robust methodology which can capture a range of drivers causing forest degradation (Table 6) is necessary. The present methodologies can be improved in two ways. First, the use of satellite images supported by ground based inventory. It should cover major forest types, physiographic regions and management regimes. The use of satellite images and field based inventory is suitable to assess biomass, growing stock, basal area, species composition, structure and forest type related assessment. This approach will combine the strengths of both methods.

A second approach would be PESVA which will be based on the concept of forest ecosystem services index (ESI). The ESI approach should consider use value (UV) concept instead of total economic value (TEV). It should consider direct use value (DUV) and indirect use value (IUV) concept, which have more critical influence on forest degradation. ESI is sum of different components of ecosystem service indexes. For a particular forest, it may ranges from 0 to 1. Periodic monitoring and comparison of indexes with base line index (Box 2) will provide information about the extent of forest degradation or enhancement.

However, there is a need for capacity development, data base management system at national and local levels. Pilot studies are required to test and generate more information on forest degradation. Such evidence will have positive influence in national resources allocation for forest management.

Box 2: Ecosystem Service Index (ESI)

ESI is a summary index of ecosystem services of a forest. It measures the average performances of use values of the forest. It is estimated against ecosystem services as defined by MEA. Some of the indicators for discussion could be as follows:

- Services-trend index: it is estimated by total number of ecosystem services of the forest, number of services in increasing trend, number of services in decreasing trend
- Service-value index: it is estimated by optimum values for a given type of forest, value presently provided by the forest.

The better understandings of forest degradation needs commitments at political and bureaucratic level, infrastructure, legal measures of forest monitoring and national strategy, coordination of agencies using remote sensing data, understanding diverse nature of local drivers of degradation and measurement and opportunity cost. Similarly, there is a strong need for establishing an effective degradation monitoring system.

Nepal can move ahead with the development of guidelines for forest monitoring, clear definition, procedure for consistency, piloting covering major ecological zones and forest types, and management regimes. Regional cooperation with India through SAARC could be a practical option for cost effective assessment of forest degradation and its periodic monitoring every five years. Nepal may request for remote sensing data from India and produce a periodic report based on ground inventory by DFRS. PESVA needs additional exercises on creating default values developed through available information and expert consultation. A programme framework that can be applied at community level, especially in Nepal, where communities are managing forests is essential. It also needs the development of simple format, guidelines and procedures. The paper concludes that isolated approaches such as carbon sequestration to perceive forest degradation will create new problems or drivers of forest degradation. Therefore, this paper concludes that forest degradation is the reduction in ecosystem services capacity of forest.

Figure: Foresters undertaking a ground based inventory. (Source: WWF, Nepal)

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Annex 1: Findings of the past assessments in Nepal

Study	Key findings related to forest degradation	Inferences
1. FRSO	**Area** 45.5 % of land covered by forest, out of which 47 % is commercial. Whereas in hills 58.1 % forest lands, commercial forest area in the hill 34.4 % **Composition** Sal covers 20.7%, sawn timber stands 77 % and 23 % pole/sapling/regeneration stand **Stocking** Average volume 63 m3/ha. In Hills, 35.1 % of commercial forest is well stocked, 28.5 % medium and 8.7 % is poorly stocked, over storey poor with understory medium 7.6, overstorey poor understory well stocked well stocked 3.3% and overstorey medium with understory well stocked 16.8 % **Tree distribution** In hills, 47 % of tree below 22 inch diameter class are from undesirable species (not used for industrial wood, desirable species are sal, Asna, Khair, Chirpine, Blue Pine, Spruce, Fir and Hemlock) **Non commercial forest** In hills, encroachment: 0.06 percent of non commercial forest area (5,236 acre); Scrub and shrub: 5.28 % (797,203 acre)	Focus was on total merchantable volume of selected species in commercial forest area. Forest encroachment was recognised due to fuelwood extraction and lopping.
2. LRMP	**Area** Forest area 5,616,800 ha (38.01 %), shrub 689,900 ha (4.68 %), >40 % crown cover is 28.1%, **Stocking** 34% (excluding High Himal) of forest is under stocked degraded forests; 55% of forest is in very poor condition in middle mountains;	Forest areas are converting into degraded forest-shrub.
3. MPFS	**Area** Forest 37.4 %, Shrublands and degraded forests: 5 % (706,000 ha) P 24, MPFS **Composition** 59 % hardwoods, 17 % conifers and 24 % mixed forests. Pole reproduction size constitutes only 1% of volume/ha, whereas small timber 65.2% and remaining 1/3rd by large timber. **Stocking and Degraded forest** Only 15% of forest area has >70 % crown cover, <40 % crown cover is in 26.3% of the total forest, 59% have 40-70%. Per ha growing stock is 96 m3 whereas total forest biomass is 628 million ton.	Shrublands increased due to over cut for fuel wood and lopping for fodder. Other causes of degradation are fire, cross border timber smuggling, almost 60% shrub lands are in middle mountains. Rate of conversion of forest area into degraded forest/shrub not reduced. Some of deforested area remains as degraded forests.
4. NFI	**Area** Forest 29 % (4,268,800), shrub 10.6 % (1,559,200 ha), In terai, forest has decreased at annual rate of 1.3% from 1978/79 to 1990/91. In the hilly area, forest area has decreased at an annual rate of 2.3 % from 1978/79 to 1994, whereas forest and shrub together have decreased t an annual rate of 0.2%. In the whole country, from 1978/79 to 1994, forest area has decreased at an annual rate of 1.7 %, whereas forest and shrub together have decrease at an annual rate of 0.5%. **Composition** 28.2 % of total stem volume is occupied by sal followed by Quercus – 9.3 %. All together 229 species identified in inventory. **Stocking** Mean stem volume is 178m3/ha in 408 stem/ha bigger than 10	Rate of conversion of forest area into degraded forest-shrub is significantly increased. There is higher degradation rate in hilly region whereas deforestation is prominent in the terai. Forest degradation rate is double than the deforestation rate for 1978/79 to 1994. (Degradation is 3.5 % per year compared to 1.7 % per year of deforestation) NFI assumed no shrubland in terai, would have been higher rate of degradation. Please refer to DoF study.

	cm dbh. Total stem volume of reachable forest is 387.5 million m3 and biomass is 428.5 million ton **Non reachable forest** About 51.5 % of the forests of Nepal are reachable. **Forest degradation** The shrub land area is result of forest degradation, which has increased from 689,900 ha in 1978/79 LRMP estimates to 1,559,200 ha in NFI. It is an increase of 869,300 ha in 16 years at a rate of 56 % or at an annual rate of **3.5 %.** The degradation within the forest category is not accounted in the estimate.	
5. DoF	Total forest area in 20 terai districts is 1,149,494 ha (excluding protected area). Out of the total, 88 % (1,011,362 ha) is forest and 12 % (138,132) is degraded forest.	Decreasing trend in land cover change in erai plains during 1990/91 to 2000/01. Encroachment has profound effects on forest decline.
6. ESE	The highest absolute value per ha was found in the Sal forest (Nrs 3 million). Within the Terai forest ecosystems, the absolute value of shrub land (Nrs 0.76million is half than Terai Mixed Hardwood Forest (Nrs 1.5 million). The shrub lands have lower per ha values compared to forests ecosystems in respected region. Pine forest has lowest values within the forest ecosystems. There is variation in TUV per ha in six research sites. It is mainly due to variation in existing stock of the forest.	The ecosystem services vary accordingly land use, physiographic regions and forest types. Values of all three terai ecosystems are higher than hills Forest ecosystem services can be valued by use value of the ecosystem services
7. GDP	Forestry sector contribution to GDP in the past was generally estimated 4.4% compared to 9.45%, whereas it is 27.55% including intangible benefits.	Forests contribute significantly on national gross production. Indirect use value of forest ecosystem must be valued to realise forest benefits.