# Chapter 5

# Feasibility of reducing emissions from deforestation and forest degradation in the Terai Arc Landscape, Nepal

**Abstract**

Countries need to evaluate the cost efficiency and possible benefits of participating in the proposed REDD+ mechanism. This chapter summarized earlier three essays and further elaborated the feasibility of REDD+ in one of the world's biodiversity hotspots based on the drivers of deforestation and forest degradation, emissions reduction potential and estimates of opportunity costs. The study on drivers of deforestation suggests that strong, effective and efficient forest institutions supported by clearly defined property rights are the key goals to address deforestation along with increased agricultural yield. The estimated total opportunity cost of avoided deforestation in the Terai Arc Landscape is 6.7 million US$ per year to reduce 749,000 Mg $CO_2$e emissions. $CO_2$ emissions reduction by addressing forest degradation is more cost effective than those from deforestation. Total of 914,000 Mg $CO_2$e per annum can be reduced through addressing forest degradation in the landscape during the next 30 years period at the opportunity cost of 3.4 million US$ per year. Shifting from state-owned and managed forestry to community-managed forestry activities in the Terai Arc Landscape to address forest degradation has enormous significance both on net emissions reductions and economic efficiency.

***Keywords:*** Opportunity cost, emission reduction, Sub-national REDD+, Terai Arc Landscape, Nepal

## 5.1 Rationale

Research suggests that the role of forests in regulating global climate might be bigger than previously thought and will likely become even more important as other carbon sinks become saturated (LeQuere et al., 2007; Stephens et al., 2007). Rapid conversion of forested land to agriculture and other land uses has been concentrated on the biodiversity and carbon rich ecosystems of the tropics (MEA, 2005; Turner et al., 2003). However, compensation for even a small portion of the global benefits standing forests provide like carbon storage, climate regulation and biodiversity, might be sufficient to greatly reduce deforestation (Stern, 2007).

A proposed compensation mechanism called 'Reducing emissions from deforestation and forest degradation, conservation, enhancement of forest carbon stocks and sustainable management of forests (REDD+)' has been one of the key elements in international climate negotiations. A final mechanism is yet to be in place but the COP-19 held in November 2013 adopted a number of decisions and provides guidance for full implementation of REDD+. Issues of this proposed incentive mechanism have been the subject of extensive debate since it entered the negotiations in COP-11 in Montreal, 2005 and will continue to be debated. In current UNFCCC negotiations processes, developing countries of the tropics have made it clear that their ability to participate in this newly proposed mechanism would depend on obtaining sustained-sufficient funding. A major challenge for the scientific community is to accurately estimate the cost of emissions reductions which determines level of funding required to implement REDD+.

Nepal is fully committed to integrate REDD+ into its wider development agenda, national priorities and policies (MFSC, 2014). REDD+ is one of the strongest pillars of low carbon economic development strategy that is being developed as envisioned by Climate Change Policy, 2011. The country is currently implementing numbers of REDD+ readiness activities [see (MFSC, 2013)].These activities are guided by the Readiness Preparation Proposal (R-PP) and co-ordinated by REDD Cell. A step ahead, the government of Nepal also keen to participate World Bank's Emissions Reduction Program as performance based sub-national REDD+ in the Terai Arc Landscape and preparing reference level (RL). In this context, feasibility of emissions reduction in the landscape considering drivers of deforestation and forest degradation, emissions reduction potential and cost of emissions reduction is

expected to be an important contribution to design a sub-national REDD+ for this forest and biodiversity rich region.

## 5.2 Deforestation: drivers, $CO_2e$ emissions and opportunity cost

### 5.2.1 Forest and forest area change

The Terai Arc landscape is one of the priority landscape in Nepal, both for the conservation of its biodiversity and the protection of the ecological services it provides. The landscape recently declared additional protected area in Banke district as Banke National Park. Forest covers 47.7 % of total 22,129 sq. km area of TAL with agriculture and grassland (44.4 %), shrub cover (4.4 %), barren land (2.7 %) and water body (0.8 %) and remaining others (Karki, 2011). Forest of the landscape has been deforested in alarming rate. It has observed 1.3% annual loss of forest cover during the period of 1991-2001 (DoF, 2001). According to more recent estimate based on WWF/Winrock data, 29,000 ha forests have been converted into other land use during the period of 1990 to 2009 (Figure 5.1).

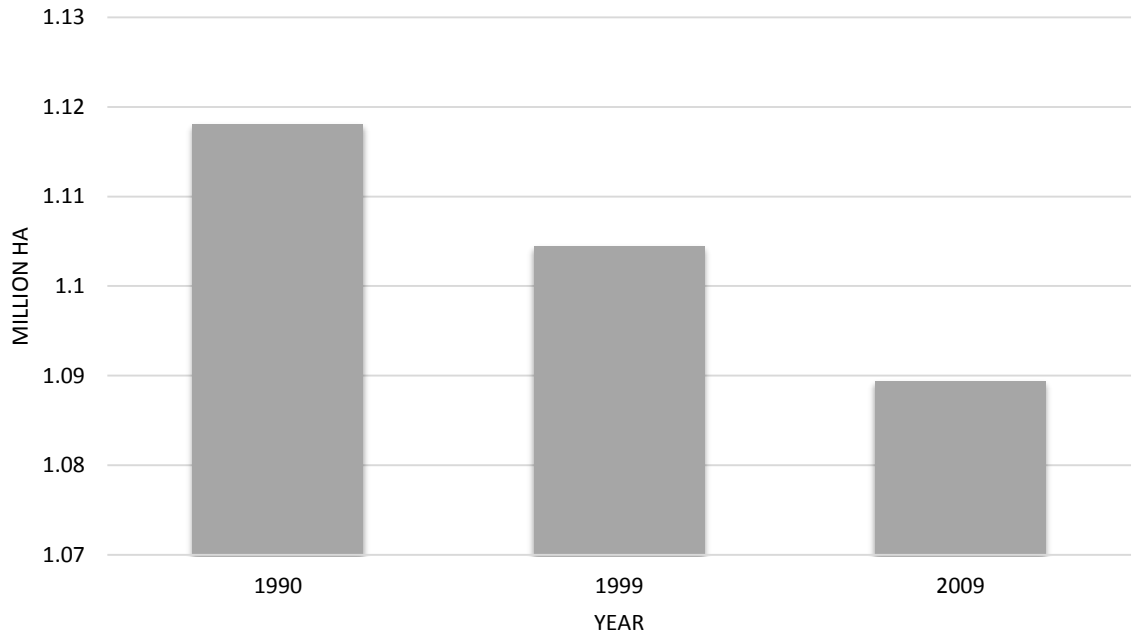


**Figure 5.1 Decline in forest area in the Terai Arc Landscape, 1990-2009** (authors' calculation based on WWF, 2010)

### 5.2.2 Drivers of deforestation

Chapter 2 elaborates the drivers of deforestation and forest degradation. The results suggest that agricultural growth is one of the most important drivers of deforestation along with property right and population growth. The result shows that increased agricultural yield facilitated to reduce deforestation in the Terai Arc Landscape of Nepal. The trend of agricultural crop yield in the districts of the landscape is presented in Table 5.1. This study assumed that increased food production per unit of land decreases the pressure towards deforestation. The research indicated that future deforestation can be avoided if more intensive agriculture increased yield per hectare, and hence reduce levels of C emissions.

**Table 5.1 Percentage changes (annual) in agricultural yield (weighted) during the two period***

| Sn | District | 1990-99 | 1999-09 |
|---|---|---|---|
| 1 | Rautahat | -2.43 | 12.54 |
| 2 | Bara | -0.84 | 1.49 |
| 3 | Parsa | -0.14 | 0.84 |
| 4 | Makwanpur | 4.13 | 4.19 |
| 5 | Chitwan | 1.85 | 5.15 |
| 6 | Nawalparasi | -6.34 | 11.06 |
| 7 | Rupendehi | -0.60 | 5.32 |
| 8 | Palpa | -1.57 | 4.79 |
| 9 | Kapilvastu | 6.34 | 2.70 |
| 10 | Arghakhanchi | 0.07 | 0.20 |
| 11 | Dang | 4.27 | 0.26 |
| 12 | Banke | 7.23 | 1.35 |
| 13 | Bardia | 10.16 | 4.10 |
| 14 | Kailali | 4.17 | 2.14 |
| 15 | Kanchanpur | 8.69 | 1.22 |
| | Mean | 5.00 | 5.74 |

**Calculation based on MoAD data*

The fertile soil of the landscape offers huge potential to increase agricultural yield. Rice is the major cereal crop of the landscape. Current average yield of rice is 2510 kg per hectare. According to Agribusiness Promotion and Marketing Development Directorate (APMDD, 2013), rice yield can be increased up to 3834 kg per hectare in the Terai which is almost 53 percent higher than current yield. This indicates that there is a huge potential of emissions reduction through avoided deforestation with the help of improved agricultural practices.

Property right is one of the important drivers of deforestation in the study area. Our result confirmed the earlier studies of Deacon (1995), Bhattarai et al.(2001), Culas(2007), Nguyen-

Van et al. (2007) and Southgate et al. (1991) that security of tenure is negatively related to deforestation. The degree of local communities' access and control over forest resources and enforceability of forest management and protection activities, however, diverge according to management regimes implemented in the forests of the landscape. The tenure security, clear ownership, local authority and strong and effective enforcement of rules and regulations among others attributes of community forestry have contributed to retard deforestation.

On the other hand, increased deforestation observed with increased protected areas may be due to leakage effect. Forest products extraction activities may have concentrated in the limited forest areas available outside these protected areas. Therefore, increasing protected areas has the negative net effect to reduced emissions through avoided deforestation in the landscape. The desired outcome of REDD+ under the current policy of limiting access and strict control of protected areas in the landscape, appears elusive mainly because of a growing demands for agricultural and forest products, particularly given the absence of alternative sources for those products.

### 5.2.3 Carbon stocks and emission factor

Monitoring of changes in C stock of the forest to quantify reduced emissions for the purpose of REDD+ payment will require current and future C stocks data. More accurate estimation of C stocks potentially will lead to higher financial returns under the proposed mechanism because buyers will be more confident and willing to pay higher price (IPCC, 2006). Accurate and reliable C density data for forests is the key challenge to be able to quantify C emissions from deforestation and forest degradation. Estimated emissions based upon global land use observations and biome average data sets have huge uncertainty bands (Sathaye, Andrasko, & Chan, 2011).

While C density of the forest is one of the major determinants in assessments of costs and benefits to REDD+ participating countries, cost estimates of emissions reductions based on global model C data are also highly uncertain. In this site-specific study, focus was on quantifying C stock and emission factors to estimate cost of emissions reduction. To ensure accuracy on C stock data, the Inter-governmental Panel on Climate Change (IPCC, 2006) has suggested a three-tier approach to estimation; use of biome average values (tier I)for rough

approximation, country specific values (tier II) and measurement-based forest inventory combined with predictive relationships (tier III) for higher levels of accuracy.

In this study, we applied field measurement-based forest inventory method combined with the best predictive tree allometric model available to achieve a high level of accuracy in the C stock estimation. Biomass data and samples were collected from 113 plots distributed throughout four different management regimes of 1.1 million ha of forest in the landscape.

The mean C stock in the forest of the Terai Arc Landscape was found to be 228.76±19.61 Mg $ha^{-1}$. Aboveground biomass constituted the largest portion (46 %) of total C stock followed by SOC (42 %) and BGB (11 %). Shrub and litter pools contributed less than one percent of total C stock. The value of total C stock varied from 291.55±42.51 Mg $ha^{-1}$ in Protected Areas to 237.15±32.54 Mg $ha^{-1}$ in Community forests to 189.16±26.46 Mg $ha^{-1}$ in Government-managed forests and to 126.76±56.36 Mg $ha^{-1}$ in other forest land uses. The forest of TAL stored 252,000±22,000 Gg C at 95 % confidence interval.

To estimate per unit opportunity cost of emissions reduction, the study requires emission factor which is how much carbon will be emitted when the forest changes from one class to another. This study assumed the difference between mean carbon stock of the forest of TAL and carbon stock in other forest land use as an emission factor for deforestation. This means, if one hector of forest converted into other forest land use, 102 Mg C (374.34 $CO_2e$) will be emitted into the atmosphere. Recent study in the landscape suggests that improved land use planning alone will prevent deforestation of approximately 2,000 ha per year in the Terai Arc Landscape (MFSC, 2014). If we use this data, the forest of the landscape has potential to reduce 749,000 $CO_2e$ emissions per year from avoided deforestation.

### 5.2.4 Opportunity cost of emissions reductions through avoided deforestation

Before embarking on REDD+ program, countries need information on the costs and benefits to conserve the forest for emissions reductions. Incentive from the proposed mechanism is expected to make many efforts to avoid deforestation and forest degradation in the tropics attractive, but not all. Participation on REDD+ program is attractive when the payment per ton of emissions reduction outweigh the costs associated with the program. These two variables; costs and payments per ton of emissions reductions, determine the economic feasibility of the mechanism at national or sub-national scale. This information is important for both investors and policy makers; because it helps both parties assess how much benefit

is received in return for investments made. Estimation of the foregone benefits or opportunity costs of avoided deforestation and forest degradation under REDD+ is the crucial step to understand the cost component of REDD+.

Opportunity cost is usually the single most important and largest element of REDD+ costs (Pagiola & Bosquet, 2009). Opportunity cost estimates at a global scale using highly aggregated data mostly from forest carbon rich countries in the tropics do not reflect the economic conditions, agro-ecology, farming system, land productivity and forest carbon densities prevalent in South Asian sub-continent such as Nepal. Those studies tend to under-estimate the cost of REDD+ in sites and countries which have lower forest carbon densities but higher returns from alternative land uses. Opportunity cost of conserving forest for the purpose of REDD+ was calculated as the net present value (NPV) for each possible alternative land use, assuming a constant stream of future revenues and discount rate of 10% for the period of next 30 years period. The discount rate used is in line with most of the earlier estimates of REDD+ opportunity costs. The study highlights the importance of site specific, bottom-up studies that includes widely neglected aspects of forest degradation when examining and comparing the costs of REDD+ in specific sites.

Reported mean NPV for the next 30 years period from traditional agricultural practice in the landscape is US$ 2953.81 per hectare with a standard deviation of US$ 639.51. Traditional farming practice in the Terai region of Nepal shows cultivation of three crops per unit area of land within a year. In the current crop composition, rice is the major crop, followed by wheat or maize and pulse crops. While traditional practice also includes some livestock, additional NPV of US$ 911.89 per hectare can be derived from livestock farming. The fertile land of the landscape has scope to increase yield substantially through use of improved agricultural technologies. Cultivation of high yielding crop varieties can increase crop yield up to 52.73 percent resulting 62.92 percent increased NPV during the period.

Average return per unit area from traditional agricultural practices easily surpass the return from forestry business that includes timber, fuel wood sales and revenues from protected areas. The study estimated NPV of US$ 514.11 per hectare from forestry that included timber, fuel wood and revenue from national parks as a biodiversity benefit (See appendices C.4, C.5 and C.6). The landscape generates US$ 503.00 net return (NPV) during the 30 year period from timber harvesting and merely US$ 5.88 per hectare from fuel wood harvest.

However, forest revenue varies greatly from district to district; from NPV of US$ 74.84 per hectare in Palpa district to US$ 2097.29 per hectare in Kanchanpur district. Revenue from national parks as a proxy of biodiversity benefit, contribute just 1.02 percentage of total forest revenue in the landscape.

Converting forests of the landscape into agricultural land with current crop composition has a marginal opportunity cost of avoiding deforestation over the 30 years period of US$ 8.95 per Mg of CO2e. Using the value of emissions reductions potential of the landscape mentioned in *section 5.2.3*, total opportunity cost of REDD+ in the Terai Arc Landscape is estimated to be 6.7 million US$ per year. The additional 25 percent costs of project implementation, transaction and administration is recommended (Potvin, Guay, & Pedroni, 2008), would augment the overall cost of avoided deforestation by 8.4 million US$ per year.

## 5.3 Forest degradation: drivers, emissions factor and opportunity cost

### 5.3.1 Drivers of forest degradation

To estimate the net emissions reduction from the forestry sector, reporting of emission reductions from both, deforestation and forest degradation is required. The study incorporated both components of emissions sources; the latter one largely overlooked in earlier studies. Identification of important drivers of forest degradation is the first key step to evaluate the cost efficiency of emission reductions under the proposed REDD+ mechanism.

Timber and fuel wood extraction are the most important proximate causes of forest degradation in the landscape. The results indicate that timber and fuel wood harvesting from the Terai Arc forests is not sustainable. The rapidly increasing population of more than 7 million people in the region is heavily reliant on fuel wood for cooking and timber for construction. Sales of fuel wood and timber are important sources of livelihoods of the forest dependent communities. Over exploitation of the forests for timber and for fuel wood has reduced the stock of total biomass and resulted in degradation of the forest.

### 5.3.2 Emission factor

The results show that C stocking was influenced by the management regime in place at each site. The more strict conservation or protection oriented management a regime, the higher the stocking of C. For example, forests in the protected areas stored 102.40 Mg $ha^{-1}$ more C

than those in government managed forest, which have timber production as one of the major objectives of management. Compare to protected areas forests, government managed forests have relatively poor enforcement of protection. Community forests also reserved 48 Mg $ha^{-1}$ more C than did government managed forest.

Evidence of strong association of C stock with management regime provides valuable information for policy makers who need to make informed choice of management regime for the landscape, including C benefits among others. Higher stocking of C was found in the protected areas where strict restriction on exploitation of forest products is enforced, rather than community, government-managed and other forests where timber harvesting is recurrent.

Increasing trend of community managed forestry has been observed since community forestry programme started in 1990. During the 1990-1999 period, only 6 percent of total forest areas were managed under community forestry in the landscape. In the later period (1999-09), the community forest users groups significantly increased to 1300, managing almost one third of the total forest area. Community forestry seems to be more effective than government managed forestry in terms of stocking of carbon. Further promotion of these community based resource management programme will help to reduce emissions under the proposed REDD+ mechanism.

On the basis of C storage, if we assume government managed forest as degraded forest in compare to intact forest inside protected areas, forest of the landscape had potential of reducing 375.79 Mg $ha^{-1}$ $CO_2e$ through avoided forest degradation. Shifting from state-owned forestry to community-managed forest will reduce emissions 176.14 CO2e Mg $ha^{-1}$ through greater retention of C stocks. If we assume that half of the total forest area were managed under the community forestry during the next 30 years period, 914,000 Mg CO2e emissions will be reduced.

### 5.3.3 Opportunity cost of forest degradation

Cost of avoiding forest degradation is cheaper than avoiding deforestation. Emissions from forest degradation can be avoided with the opportunity cost of only US$ 3.77 per Mg of CO2e. Across districts, opportunity costs of avoiding such forest degradation, varies from as low as US$ 1.77 per Mg of CO2e in Parsa district to as high as US$ 8.55 per Mg of CO2e in Kanchanpur district. Total of 914 thousand Mg CO2e per annum can be reduced through

addressing forest degradation in the landscape during the next 30 years period at the opportunity cost of 3.4 million US$ per year.

The findings of the study indicate the role of forest degradation to reduce emissions under the proposed REDD+ mechanism. A huge amount of C emissions from forest degradation, particularly from the government-managed forest, has been observed. Shifting management from state-owned and managed forestry to community-managed forestry activities in the Terai Arc Landscape to address forest degradation has enormous significance both on net emissions reductions and economic efficiency.

## 5.4 Conclusion

Before embarking on REDD+, countries need to evaluate cost efficiency at national or sub-national scale and possible benefits of participating in the proposed mechanism. The study identified drivers of deforestation and forest degradation and quantified C stock and emissions reduction potential to estimate total cost of emissions reductions in one of the world biodiversity hotspots.

From the analysis of panel data, we found that agricultural growth and property rights are the major drivers of deforestation. Increased crop yield facilitates reducing deforestation. The fertile soil of the landscape offers huge potential to increase agricultural yield as higher as 53 percent than current yield. This indicates that there is a huge potential of emissions reduction through avoided deforestation with the help of improved agricultural practices.

Similarly, the tenure security, clear ownership, local authority and strong and effective enforcement of rules and regulations among others attributes of community forestry have contributed to retard deforestation in the Terai Arc Landscape. The current policy reform is urgently needed of forest governance; strong, effective and efficient forest institutions supported by clearly defined property rights to achieve the goals of emissions reductions through avoided deforestation.

Timber logging and fuel wood collection are the proximate causes of forest degradation in the landscape. The results indicate that timber and fuel wood harvesting from the forests is not sustainable. Evidence of strong association of C stock with management regime provides valuable information for policy makers who need to make informed choice of management regime for the landscape, including C benefits among others.

The estimated emissions reduction potential from addressing forest degradation is found to be higher than those from avoiding deforestation. In addition, $CO_2e$ emissions reduction by addressing forest degradation is cost effective as well. Shifting from state-owned and managed forestry to community-managed forestry activities in the Terai Arc Landscape to address forest degradation has enormous significance both on net emissions reductions and economic efficiency.