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ORIGINAL ARTICLE

Reducing emissions from deforestation and forest degradation plus (REDD+) in the Philippines: will it make a difference in financing forest development?

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Abstract There is a high level of interest in reducing emissions from deforestation and forest degradation plus (REDD+) carbon (C) financing as a way to accelerate forest conservation and development. However, there is very limited information on the potential costs and benefits of REDD+ in developing countries like the Philippines. In this paper, we estimated the range of likely financial benefits of REDD+ implementation in the country under various forest degradation and mitigation scenarios. Our findings show that reducing the rate of forest degradation by a modest 5 to 15 % annually while increasing the doubling the rate of reforestation to 1.5 % annually could reduce C emissions by up to about 60 million t C by 2030. These are equivalent to US$ 97 to 417 million of mean C credits annually at US$ 5 per ton C. These figures are much higher than the total budget of the government and official development assistance for forestry activities in the country which amounted to US$ 46 million in 2005 and US$ 12 million in 2006, respectively. We conclude that REDD+ C credits could be a significant source of financing for forestry projects in developing countries like the Philippines.

Keywords Carbon · Financing · Forest · Mitigation · Philippines · REDD+

1 Introduction

Terrestrial ecosystems are vital to the global carbon (C) cycle. It is estimated that about 60 gigaton (Gt) C is exchanged between terrestrial ecosystems and the atmosphere every year, with a net terrestrial uptake of about −0.9±0.6 Gt C per year for 2000 to 2005 (Denman et al. 2007). The world's tropical forests are estimated to contain 428 Gt C in vegetation and soils.

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The loss of tropical forests is the major driver of carbon dioxide (CO_2) flux caused by land use changes during the past two decades. The best estimate of the United Nations Intergovernmental Panel on Climate Change (IPCC) is that land use, land-use change and forestry (LULUCF) activities, mainly tropical deforestation, contributed 1.6 Gt C/year of anthropogenic emissions in the 1990s (Denman et al. 2007). There is still much uncertainty on the size of the contribution of land use processes to greenhouse gas (GHG) emissions in general. Indeed, the land use C source has the largest uncertainties in the global C budget. The United Nations Food and Agriculture Organization (FAO) forest resources assessment showed that globally, C stocks in forest biomass decreased by 1.1 and 0.5 Gt of C annually between 1999–2005 and 2005–2010, respectively owing to continued deforestation and forest degradation. This is partly offset by forest expansion through planting that accounted for a 7 % (264 Mha) increase in forest cover from 2005 to 2010 (FAO 2006 and 2010). More recently, Harris et al. (2012) using satellite observations of gross forest cover loss and a map of forest C stocks, estimated gross C emissions across tropical regions between 2000 and 2005 at 0.81 Gt C/year with a 90 % prediction interval of 0.57 to 1.22 Gt C/year.

Deforestation, degradation and poor forest management reduce C storage in forests, but sustainable forest management, planting and rehabilitation, can increase C sequestration (FAO 2005). The tropical region has the largest potential for climate change mitigation through good forestry activities. It is difficult to quantify the total potential of the world's tropical forest to mitigate climate change. Available studies about mitigation options differ widely in basic assumptions on C accounting, costs, land areas, baselines, and other major parameters (Nabuurs et al. 2007). There is a need for more detailed estimates of economic or market potential for mitigation options by region or country in order for policy makers to make realistic estimates of mitigation potential under various policy, C price, and mitigation program eligibility rule scenarios. The largest potential is in avoiding deforestation and enhancing afforestation and reforestation, including bio-energy.

It is estimated that US$17–33 billion must be invested annually to halve GHG emissions from deforestation by 2030 (Viana 2009). One scenario calculates that the global C markets could supply around US$7 billion per year to reduce deforestation by 2020. This means a shortfall of about US$11–19 billion per year. This gap could be filled by Annex I countries such as for example under a future United Nations Framework Convention on Climate Change (UNFCCC) agreement or under some bilateral agreements. For instance, Norway's Climate Change and Forestry mechanism has an initial budget of US$2.5 billion for the next 5 years.

The Philippines emitted a total of 107,738 kiloton (Kt) of GHG in 1994 (PINC 1999). The energy sector had the greatest contribution (49 %), followed by the agriculture sector (33 %), industry (11 %) and wastes (7 %). On the other hand, land-use change and forestry (LUCF) accounted for 126 Kt of sequestered CO_2, which is just about 1 % to total national emission. This can be attributed to the high deforestation rate between 1980 and 1990 which was used to estimate GHG emissions. However, subsequent studies indicate that the net absorption of the LUCF sector could be as much as the total 1994 GHG emission (Lasco and Pulhin 2001). A number of analyses have shown the potential of forest lands in the Philippines to store and sequester C (Lasco et al. 2010; Lasco and Pulhin 2009). In addition, the potential of forestry projects for C credits under the UN FCCC Kyoto Protocol and the voluntary C market in the country have been analyzed (Villamor and Lasco 2009).

The Philippines is one of 18 mega biodiversity countries due to its geographical isolation, diverse habitats and high rates of endemism (PAWB 2009). It is ranked 5th globally in terms of the number of plant species and maintains 5 % of the world's flora. Species endemism is very high covering at least 25 genera of plants and 49 % of terrestrial wildlife. At the same time, the Philippines is one of the world's most threatened hotspots as it continues to lose its rich biodiversity resources (Conservation International 2011). The key drivers of biodiversity loss are many: deforestation due to logging, mining, land conversion and introduction of exotic species (Conservation International 2011; PAWB 2009). With forests dwindling, logging has recently been banned in all natural forests. However, illegal cutting of trees still persist. There are more than 10 million people, mostly very poor, who depend on forest resources and agriculture production in the uplands.

In the last few years, there is rising interest in reducing emissions from deforestation and forest degradation and other activities that increase C stocks (REDD+) as a strategy to mitigate climate change. Still under negotiations are the exact scope, modalities, and rules for REDD+. In the Philippines, there is widespread interest in REDD+ both in government and civil society. A national REDD+ strategy has been is completed (The Philippines REDD-plus Strategy Team 2010). The potential scope and benefits of REDD+ components have been analyzed for smallholder communities (Lasco et al. 2011) and at a sub-national level (Phelps et al. 2010). Support from the highest levels of government is present. However, there is still a large amount of data gaps that need to be filled. One of the key gaps is up to what extent can C financing help the forestry sector of the country? In other words, is it worth all the efforts to prepare for REDD+? The main objective of this paper is to assess the potential size of C credits that can be generated under REDD+ in the Philippines by modeling a business as usual scenario and comparing it to a REDD+ scenario. We then compare the results to current investments in the forestry sector.

2 Deforestation and reforestation in the Philippines

2.1 Rate of deforestation in the Philippines

The Philippines possessed a vast area of tropical forests and about 90 % of the whole archipelago was composed of forests when the early colonizers arrived in the 16th century (Liu et al. 1993). Due to rapid colonization during the 1800's, there was an increasing level of deforestation in the country. The Americans introduced the modern logging system in the country and by 1920, only 64 % (19 million ha) of the country was covered with forests (Moya and Malayang 2004 and ACIAR 2000). This rapid deforestation continued especially after World War II with only 36 % (10.9 million ha) and 22 % (6.46 million ha) of forests remaining by 1969 and 1988, respectively (Chokkalingm et al. 2006; Bautista 1990 and FAO 1989). There was an average of 162,000 ha of forests being cleared per year and the most recent data on land cover of the Philippines indicated that there are only 23.9 % (7.17 million ha) remaining forest cover in the country (Forest Management Bureau (FMB) 2007). The main drivers of deforestation in the Philippines are demand for timber, increasing population, agricultural expansion, and urbanization (Rebugio et al. 2005; Pulhin 2002; Borlagdan et al. 2001, Lasco et al. 2001, Sajise 1998; Liu et al. 1993 and Kummer 1992).

Demand for timber Early literatures reported that deforestation in the Philippines was mainly due to increase in demand for wood especially during the American colonization (Pulhin 2002 and Borlagdan et al. 2001). During that time, licenses for forest exploitation was controlled by the government and this led to formulation of policies that favored the privileged few and later on resulted in the destruction of the country's vast forested areas. More timber licenses proliferated during the 1950's when timber concessions almost doubled from 4.48 million ha in 1959 to 10.59 million ha in 1979 (Gould 2002, unpublished paper).

Increasing population Rapid deforestation in the country could also be attributed to increasing population over the last 30 years which parallel the years of rapid decline in forest cover. There was a rampant increase in population from 37 million in 1970 to 92 million in 2009 (NSO 2009). Due to the increase in population, people living in the lowlands tend to migrate in the uplands to seek greater space (Borlagdan et al. 2001 and Sajise 1998). This movement towards the uplands led to clearing of lands for housing and for basic necessities such as food and income.

Agricultural expansion The increase in population led to increased demand for one of the basic needs of society which is food. As more and more people settled in upland areas, they also established small farms where they get their daily needs for food and also served as their source of income. Furthermore, due to commercial logging, roads were built in mountainous areas which paved the way for surging population in the uplands (Rebugio et al. 2005; Liu et al. 1993 and Kummer 1992).

Commercialization and urbanization Economic development of the country entailed establishment of industries and commercial buildings. This led to a decline in areas for human settlement and agriculture in the lowlands. As a result, people were driven to upland areas to seek more lands for settlement and agricultural purposes (Kummer 1992). Ultimately, this trend led to fragmentation of intact forests in uplands areas for the purpose of meeting human needs.

2.2 Reforestation in the Philippines

As early as 1866 to1887, one of the royal decrees from Spain prohibited shifting cultivation in the country (Chokkalingm et al. 2006 and Sajise 1998). Such early efforts showed that forest land degradation was already happening at that time. By 1910, small-scale reforestation projects mostly funded by the national government were being implemented in the Philippines. The Forestry School located at the University of the Philippines in Los Baños initiated the reforestation activities in the country, with 600 species of planting materials.

From 1937 to 1941 several reforestation projects followed at the heels of the initiative of the Forestry School as more funds were allotted by the government (Chokkalingm et al. 2006). After the World War II, there was an evident decrease in the areas reforested and the funds available for such activities. Only after the ratification of Republic Act 115 in 1947 that reforestation activities were given renewed support by the government.

The late 1980s and early 1990s saw the largest area reforested with 131,404 ha in 1989 and 191,663 ha in 1990 (Moya and Malayang 2004). This can be attributed to the paradigm shift in implementing reforestation projects in the country, with greater participation of local communities. This period was also the time when most of the timber license agreements signed in the 1950's expired and the lands covered by these agreements were then transferred to other forestry programs.

The idea of incorporating community-based forestry programs in reforestation activities started in the early 1970's with three major programs namely (Harrison et al. 2004):

- Forest Occupancy Management (FOM), 1974—this program was intended to stabilize the farming systems of shifting cultivators and enhance their socio-economic status.

- Family Approach to Reforestation (FAR), 1979—local families were integral in the implementation of this program since they participated in the establishment of trees in public lands with maximum area of 5 ha.
- Communal Tree Farming (CTF), 1979—this program established tree farms and plantations with local communities serving as protectors of the plantations. Initially, families acquired 1-year land titles that can be converted to a 25-year land titles, renewable for another 25 years.

In the succeeding years, other people-oriented programs followed:

- Integrated Social Forestry Program (ISFP), 1982—the main goal was to enhance ecological stability, maximize land productivity and improve the socioeconomic status of communities in the upland areas. Two stewardship certificates were issued for this program, namely: Certificate of Stewardship Contract (CSC) for families and Certificate of Community Forestry Stewardship (CCFS) for communities that participated in the program.
- Community-Based Forestry Management (CBFM), 1995—formed through the Executive Order No. 263 and served as the national strategy to ensure the sustainable development of the country's natural resources. Communities are entitled to occupy, possess, use and develop an area greater than 1,000 ha of forest lands and its other resources.
- Community-Based Resource Management (CBRM), 1998—the Department of Finance was the lead agency for this program. Reduction in rural poverty and environmental degradation was the main goal of this program. Furthermore, the program enhanced the capacity of LGU's to sustainably develop their natural resources with the help of central government systems.

According to the latest statistics on reforestation in the country, in 2007 a total of 27,837 ha were reforested by both the government and private sector in the country (Fig. 1).

3 REDD+ in the Philippines

Under the UNFCCC negotiations, there is an emerging consensus to pursue activities under REDD+. This covers activities on reducing emissions from deforestation; reducing emissions from forest degradation; conservation of forest C-stock; sustainable management of forests; and enhancement of forest C stocks (Hoang et al. 2012; Westholm et al. 2011). The UN FCCC Copenhagen Accord (2009) recognized the crucial role of reducing emission from deforestation and forest degradation. The parties to the Accord supported the immediate establishment of a REDD+. The UN FCCC Cancun Agreements (2010) officially launched the REDD+ mechanism under the UNFCCC (La Vina et al. 2011).

Many developing countries including the Philippines are participating in some form of REDD+ readiness projects under such programs as the UN-REDD and the Forest Carbon Partnership Facility of the World Bank. The Philippines received a US$ 0.5 million grant from the UN-REDD program in 2011 with the aim of increasing the capacity of forestland, protected areas and ancestral domains managers and support groups to implement REDD+ projects and activities (UN-REDD Programme 2010).

In 2010, the Philippine National REDD plus Strategy (PNRPS) was prepared (The Philippines REDD-plus Strategy Team 2010) and endorsed to the Climate Change Commission (CCC). Drafted by a pool of writers from various civil society groups, the academe, research

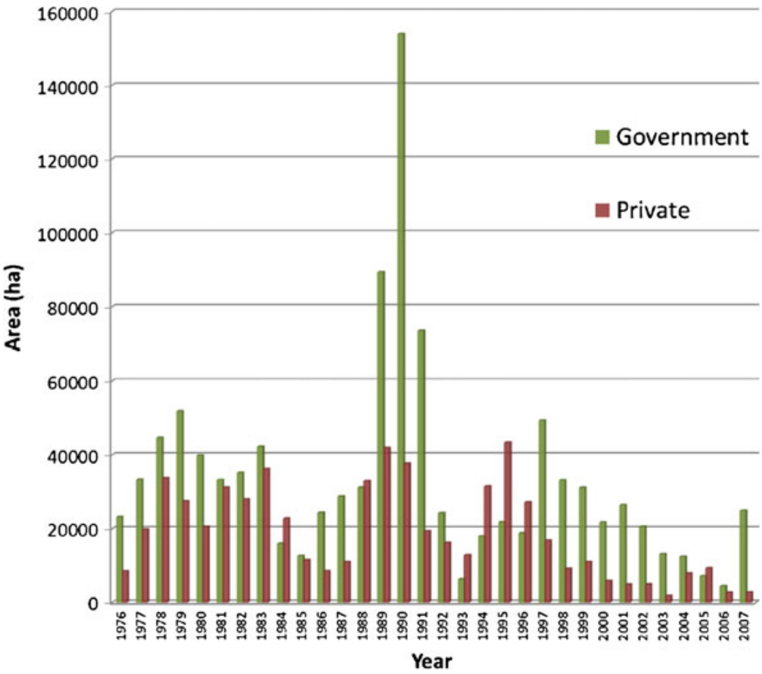

Fig. 1 Rate of reforestation in the Philippines from 1976 to 2007

institutions, local government, and the Department of Environment and Natural Resources including its bureau representatives (Forest Management Bureau, Ecosystems Research and Development Bureau, Parks and Wildlife Bureau, National Commission on Indigenous Peoples (NCIP), National Mapping and Resources Information Authority (NAMRIA), etc.), the PNRPS offers a number of strategies and corresponding activities over a 10 year time period (2010–2020). The PNRPS has seven components: enabling policies; governance; resource use, allocation and management; research and development; measurable, reportable and verifiable (MRV) conditions; capacity building and communication; and sustainable financing.

Initial analyses show that REDD+ activities can implemented in the country and could potentially benefit local communities and the environment (Phelps et al. 2010; Lasco et al. 2011; Lasco et al. 2010). At present, a number of pilot REDD+ projects are underway with sites located in the provinces of Palawan, Quezon, Leyte, Cagayan and Nueva Viscaya. In various forums in the country, there seem to be very high expectations on REDD+ as a source of financing for forest conservation. However, no analysis has been done on the potential C credits that could come from REDD+.

4 Potential carbon benefits from REDD+ in the Philippines

In this section, we present our analysis of the potential C benefits from REDD+ in the Philippines. We first estimated a baseline scenario C emissions from lands actually covered with forests. Then, we estimated the GHG emissions from several REDD+ mitigation scenarios. The net C benefits of REDD+ was then calculated by getting the difference between C benefits from REDD+ scenarios and the baseline scenario.

4.1 Baseline GHG emissions

There were 7.1 million hectares of forest in the Philippines as of 2003 based on official government data (Table 1). We calculated the rate of change of each forest type based on data from the latest FAO Forest Resource Assessment (FRA) report for the Philippines (FAO 2010). Closed canopy forests are protected and so we assume their area coverage do not change. Other forest types have positive change so that overall, forest area in the Philippines has been increasing in the last few years. On the basis of these rates of change, we estimated the forest area in 2010 and projected it till 2030 (Fig. 2).

The following definition of forest and forest types are used in the study (from FAO 2010):

- Forest- Land with tree crown cover (or equivalent stocking level) of more than 10 % and area of more than 0.5 ha
- Closed Broadleaf- Forest with predominance (more than 75 % of tree crown cover) of trees of broadleaved species; total ground forest cover of equal to or more than 40 %.
- Closed Mixed- Forest in which neither coniferous, nor broadleaved, nor palms, bamboos, account for more than 75 % of the tree crown cover; total ground forest cover of equal to or more than 40 %.
- Closed Conifer- Forest with predominance (more than 75 % of tree crown cover) of trees of coniferous species; total ground forest cover of equal to or more than 40 %.
- Open Broadleaf- Forest with predominance (more than 75 % of tree crown cover) of trees of broadleaved species; trees form a discontinuous layer covering between 10 and 40 % of ground.
- Open Mixed- Forest in which neither coniferous, nor broadleaved, nor palms, bamboos, account for more than 75 % of the tree crown cover; trees form a discontinuous layer covering between 10 and 40 % of ground.
- Open Conifer- Forest with predominance (more than 75 % of tree crown cover) of trees of coniferous species; total ground forest cover of equal to 10 to 40 % of ground.
- Mangrove- The type of forest occurring on tidal mudflats along the sea coast extending along the streams where the water is brackish
- Plantation- Forest stands established by planting or/and seeding in the process of afforestation or reforestation.

Carbon emissions/sequestration by above ground biomass was estimated following the principles of the IPCC national GHG inventory guidelines (Houghton et al. 1997) using

Table 1 Forest area in the Philippines as of 2003 (from FMB 2007) and their rate of change based on the FAO Forest Resource Assessment report (FAO 2010)

Forest type	Area in 2003 (in million ha)	Rate of change per year (in %)
Closed broadleaf	2.449	0
Closed mixed	0.025	0
Closed conifer	0.087	0
Open broadleaf	3.847	0.008489291
Open mixed	0.070	0.008489291
Open conifer	0.113	0.008489291
Mangrove	0.247	0.008489291
Plantation	0.330	0.007394304
Total	7.168	

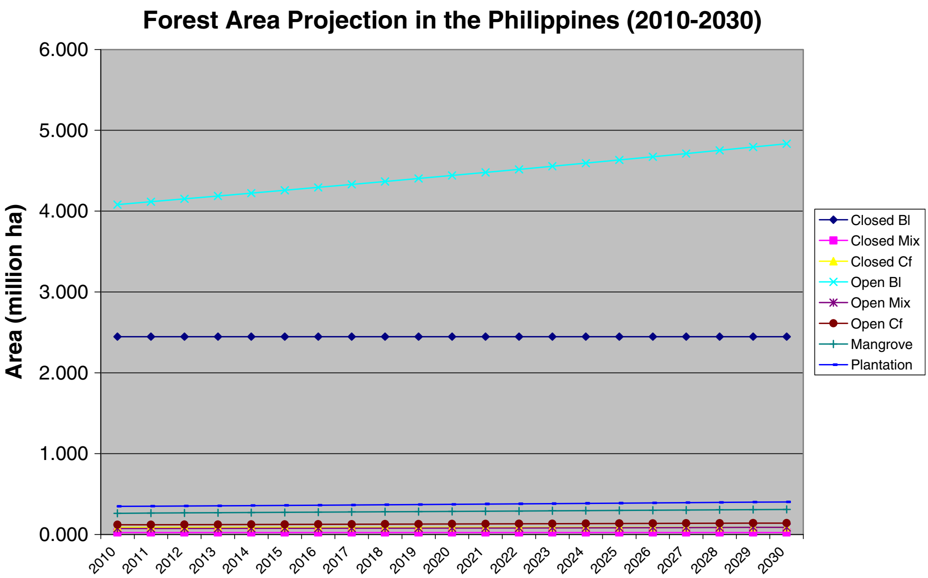

Fig. 2 Projected forest area by types from 2010 to 2030

Microsoft Excel worksheets. Unlike the IPCC, we did not take into account change in C due to harvesting and non-CO2 gases. However, change due to biomass degradation was considered. Annual growth rates and biomass density of each forest type was obtained from literature (Table 2). Net C emissions/sequestration as a result of forest growth and deforestation was calculated using the following formula:

$$\text{Net } \Delta \text{ in Carbon(C)} = \Delta \text{ in C as a result of growth rate} + \Delta \text{ in C as a result of deforestation}$$

$$\Delta \text{ in C as a result of growth rate} = \text{Area of forest type in year n} * \text{Annual biomass growth rate} * 0.45$$

$$\Delta \text{ in C as a result of deforestation} = (\text{Area of forest type in year}_{n} + \text{Area of forest cover in year}_{n-1}) * (\text{Biomass at year}_{n} - \text{Biomass at year}_{n-1}) * 0.45$$

$$0.45 = \text{carbon content in biomass}$$

Table 2 Annual growth rates and biomass density of Philippine forests

Forest type	Annual growth rate t dm/ha/year	Biomass before conversion (t dm/ha)
Closed broadleaf	1.5	520
Closed mixed	1.5	370
Closed conifer	1.5	185
Open broadleaf	3.5	260
Open mixed	3.5	185
Open conifer	3.5	93
Mangrove	3.5	132
Plantation	9.1	132

Growth rates and biomass for Philippine forests from Lasco and Pulhin (2003) except for closed broadleaf forest which was from IPCC (Houghton et al. 1997)

There are no comprehensive data on forest degradation rates in the Philippines. However, there are numerous anecdotal reports that illegal cutting of trees is on-going in many parts of the country (Durst 2005). We assumed three possible degradation scenarios: 5 %, 10 %, and 20 % removal of biomass per unit of forest area which we believe are on the conservative side (Table 3). These assumptions could be checked for accuracy once data on forest degradation becomes available in the near future since some forest inventory work are underway or are being planned by the government.

Net C emission as a result of biomass degradation was calculated using the following formula:

$$\text{Net } \Delta \text{ in Carbon(C)} = \text{Forest area in year}_n * \Delta \text{ in biomass as a result of degradation} * 0.45$$

Under the baseline scenario and without considering forest degradation, the forests of the Philippines are a slight sink with about 1 M tC sequestered every year equivalent to about 3.7 Mt CO_2 (Fig. 3). This is consistent although lower that the figures obtained in GHG inventory conducted for the second national communication (Manila Observatory 2010). The main reason for this is that we considered only forested lands and did not consider non-forest lands which sequester C at very high rates.

In contrast, under even the most moderate degradation scenario, forest ecosystems of the Philippines shifts from a net sink to a large source of C emissions. This shows that without factoring in biomass removal or forest degradation (as in the GHG inventory of the national communications), we are grossly underestimating C emissions from Philippine forests. For example, logging operations in southern Philippines are removing as much 50 % of total biomass (Lasco et al. 2006) yet these areas are still classified as forests.

4.2 GHG emissions under REDD+ mitigation scenarios

For this study, we assessed two REDD+ mitigation options: reducing forest degradation and enhancing C stocks through reforestation. The following mitigation options are considered: reducing rate of degradation by 5, 10 and 15 % every year and an increase in the rate of reforestation from about 0.7 % per year currently to 1.5 % per year. There are nine

Table 3 Biomass of forests at three degradation scenarios with data on Table 1 as baseline

Forest type	Biomass at 5 % degradation	Biomass after 10 % degradation	Biomass at 20 % degradation
Closed broadleaf	494	468	416
Closed mixed	352	333	296
Closed conifer	176	167	148
Open broadleaf	247	234	208
Open mixed	176	167	148
Open conifer	88	83	74
Mangrove	125	119	106
Plantation	125	119	106

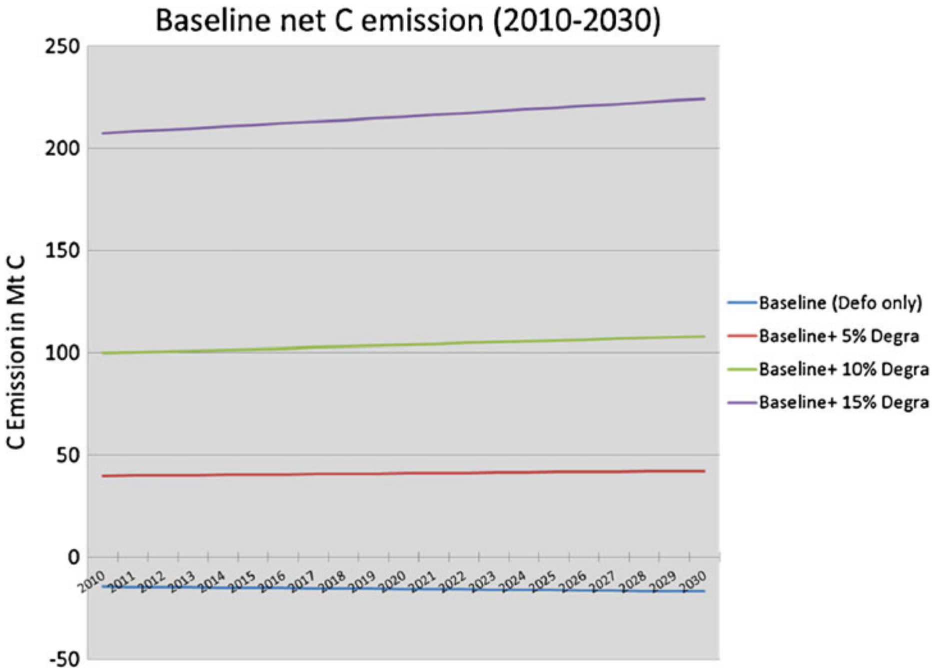

Fig. 3 Projected carbon (C) emissions under baseline scenario (deforestation only; no degradation) and under three forest degradation scenarios

combinations of forest degradation intensity considered in the analysis with the same increase in reforestation rate for all mitigation options:

Baseline degradation scenario	Degradation reduction rate (Mitigation)
5 %	5 %, 10 %, and 15 %
10 %	5 %, 10 %, and 15 %
15 %	5 %, 10 %, and 15 %

This means for example that in the first combination, it is assumed that in forested lands suffering 5 % biomass degradation, the rate of degradation will be reduced by 5 % annually. This combination will give the lowest mitigation potential. While in the last combination, it is assumed that in forested lands experiencing 15 % biomass degradation, the rate of degradation will be reduced by 15 %. This combination represents the highest mitigation potential.

Under the various REDD+ mitigation options, net C emissions are positive i.e. there is net C sequestration (Fig. 4). As expected, the less degradation and deforestation rates, the more C is sequestered. Doubling the rate of tree plantation establishment has very little effect on the total net C sequestered. This suggests that there is higher potential in controlling forest degradation than in establishing new plantations.

The estimates given here are likely to be on the upper end of what is possible. As such, they provide the maximum potential given the scenarios used. The actual mitigation potential could be much lower given physical, socio-economic and governance constraints in the country.

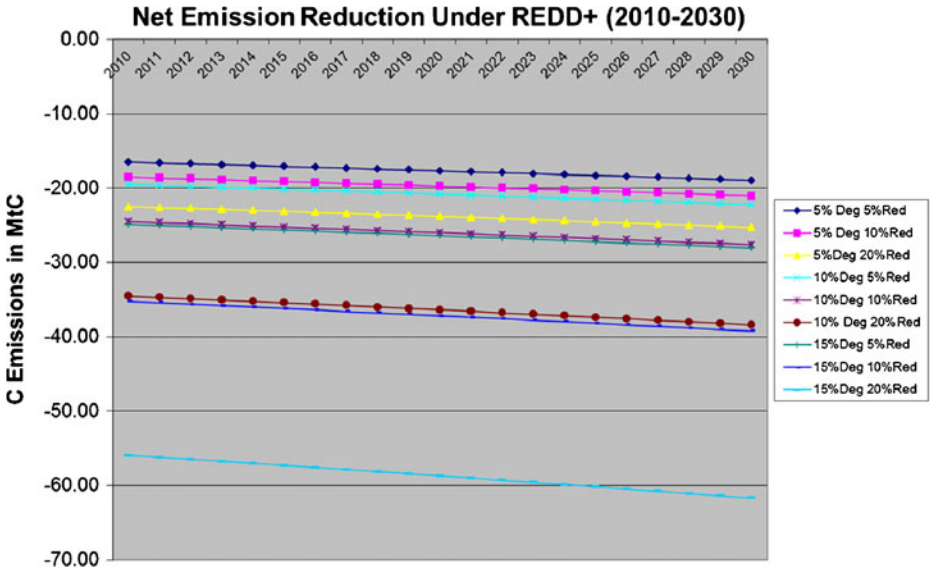

Fig. 4 Net carbon (C) emissions under REDD+ with three degradation reduction scenarios (5 %, 10 %, 20 % reduction) and 10 % increase in tree plantation establishment

4.3 Potential C credits

The various mitigation options can generate from US$ 1.94 to 8.33 billion from 2010 to 2030 with an annual average of US$ 97.25 to 416.50 million (Table 4). Most of the credits will come from reducing biomass degradation. A two-fold increase in baseline reforestation will have little difference in total C credits compared to reducing the rate of biomass degradation by even 5 %. One implication of this is that the Philippines stand to gain much more through reducing the rate of forest degradation than in accelerating its rate of reforestation. More so when the higher cost of reforestation is taken into consideration as discussed below.

We estimated the how much it will cost to implement the mitigation options outlined above (Table 2). There were several possible ways to do this. First is to use the budget of the

Table 4 Potential carbon (C) credits (in million US$) from REDD+ under various degradation reduction scenarios at US$5 per ton C

Mitigation option	Annual average	Total 2010–2030
1.5 % reforestation only	2.18	43.69
5 % deg 5 %red	97.25	1,944.97
5 % deg 10 %red	108.03	2,160.53
5 %deg 20 %red	129.58	2,591.66
10 %deg 5 %red	140.97	2,819.40
10 %deg 10 %red	195.47	3,909.39
10 % deg 20 %red	195.47	3,909.39
15 %deg 5 %red	143.06	2,861.28
15 %deg 10 %red	292.54	5,850.75
15 %deg 20 %red	416.50	8,330.07

All forest degradation options include the reforestation. Carbon credits paid annually. All values not discounted government of the Philippines for forest protection. In 2005, the Philippines allocated Philippines Peso (PHP) 400 million (US$ 9.3 million at PHP 43 per US$) for forest protection activities nationwide (FAO 2011). Using this amount, the cost of forest protection is about US$ 1.28 per ha for the 7.246 million ha of forests. Second, we assumed that the total natural resources budget Department of Environment and Natural Resources (DENR) amounting to US$ 46.1 million in 2005 were used for forest protection (FAO, 2011). The cost of forest protection then becomes US$ 6.37 per ha. The main deficiencies of this estimate are that: (a) the budget of DENR is not all spent on forest protection, (b) the amount cannot be correlated to results on the ground; and so (c) they are just rough approximation of the baseline expenditures of the government to the whole natural resources sector. In other words, actual expenses on forest protection could be much lower which is exactly the reason why we believe forest degradation is going on.

Alternatively, it is better to use the cost of protecting a relatively large tract of forested land with some success, if such were available. Fortunately, this is the case with forested lands under the care of government-controlled utilities. These forests are much better protected than forests under the care of the government. For example, the Energy Development Corporation (EDC) manages forested lands as part of their geothermal reservation. One of these is in Leyte Island in central Philippines. The whole watershed covers 20,438 ha and we earlier estimated that the company spent PHP 861 per ha (US$20 at P43 per USD) to protect this forest (Lasco et al. 2002). This amount is much higher that the two previous estimates above and seems more realistic considering it is based on a demonstrated success of protecting a forest reserve.

Thus, we used US$20 per ha for the cost of reducing by 5 % forest degradation in the scenario where forests nationwide are experiencing 5 % degradation. Then we progressively raised the cost of preventing degradation on a pro-rated basis as shown in Table 5. In other words, the higher the degradation going on and the higher the rate of reducing the degradation the more costly it would be. Using this cost estimates, the total cost of REDD+ mitigation ranges from US$ 200 to 1,168 million (Table 5). These costs are much lower than income from C credits that could be generated from the REDD+ (Table 4). This suggests that REDD+ has a potential to add new resources to forest conservation in the Philippines.

In terms of the unit cost for C, the various mitigation options will cost US$ 0.51 to 1.21 per tC (equivalent to US$ 1.87 to 4.44 per t CO2). This is within the range of our earlier estimates for forestry projects in the Philippines with life-cycle cost of potential forestry

Table 5 Estimated cost of REDD+ mitigation options for the period 2010 to 2030

Mitigation option	Cost per ha (US$)	Degradation (million US$)	Reforestation (million US$)	Total (million US$)	Cost per t C (US$)
5 % deg 5 % red	20	149	51	200	0.51
5 % deg 10 % red	40	298	51	349	0.81
5 % deg 15 % red	60	447	51	497	0.96
10 % deg 5 % red	40	298	51	349	0.77
10 % deg 10 % red	80	596	51	646	1.15
10 % deg 15 % red	120	894	51	944	1.21
15 % deg 5 % red	60	447	51	497	0.87
15 % deg 10 % red	90	670	51	721	0.90
15 % deg 15 % red	150	1,117	51	1,168	0.93

projects ranging from about US$0.12 per tC to US$7.60 per tC (Lasco and Pulhin 2001). On the other hand, the cost of protecting EDC geothermal forest reservation cited above was US $2.94 per tC (Lasco et al. 2002). The values we obtained in this study are consistent with global estimates. The Stern Review estimates that approximately US$1–2 per tCO_2 is needed to avoid deforestation in countries responsible for 70 % of global deforestation (Stern 2007). Kindermann et al. (2008) estimated that a 10 % reduction of emissions from deforestation from 2005 to 2020 would cost US$2–5 per tCO_2. These amounts are much smaller than forestry projects in industrialized countries. For example, a systematic comparison of sequestration supply estimates from national studies in the US produced a range of US$25 to US$75 per tC for a program size of 300 million tons of annual C sequestration (Stavins and Richards 2005).

One important implication of the results of the study is the huge potential of REDD+ to bring in new funding for forest conservation. In 2005, the total budget of the DENR for all activities in natural resources management is about US$46 million (FAO, 2011). In contrast, even the lowest REDD+ mitigation scenario in this study can bring in about US$ 100 million annually effectively doubling funding for forest conservation activities. In 2006, total Official Development Assistance (ODA) support for forestry activities is about US$ 12.74 million (Foreign-Assisted and Special Projects 2006). This is less than 15 % of the potential C credits obtained in this study. These results imply that for smaller forest countries like the Philippines, REDD+ could make a significant contribution.

5 Conclusion

While there is high global interest on the role of forests to climate change mitigation, there are limited information on how REDD+ can impact forest financing at the country level. In this paper we were able to show that modest reduction in forest degradation can lead to a significant increase in forest financing through C credits.

Our findings show that reducing the rate of forest degradation by 5 to 15 % annually while increasing the rate of reforestation to 1.5 % annually could reduce C emissions by up to about 60 million tC by in 2030. These are equivalent to US$ 97 to 417 million of mean C credits annually at US$ 5 per ton C. These figures are much higher than the total budget of the government and official development assistance for forestry activities which amounted to US$ 46 million in 2005 and US$ 12 million in 2006, respectively. We conclude that REDD+ C credits could be a significant source of financing for forestry projects in developing countries like the Philippines.

However, the figures discussed above are preliminary estimates of the potential credits from REDD+ in the Philippines. Further studies accounting for other sources of income from the various mitigation options can be done. In addition, analyzing opportunity costs of forest degradation could lead to a better estimate of the cost of stopping forest degradation. There is also a need have more precise data on the rate of forest degradation in the country.

Many developing countries whose forests and rate of deforestation are not as large as Indonesia or Brazil are uncertain of how REDD+ could benefit them. The case of the Philippines has illustrated that significant C credits could be possible from reducing forest biomass degradation. Unfortunately, there is much less information in many countries on the extent of forest degradation. The study suggests that more research attention should be focused on quantifying the rate of forest degradation in tropical countries where forests are under threat. The drivers of forest degradation need to be identified and management strategies need to be developed to counteract their impacts.

Finally, it should be recognized that there are sectors which have strong reservations regarding the potential effectiveness of REDD+ in its current form as a way to mitigate climate change. Among the risk factors that could impede the success of REDD+ in countries where it is likely to be implemented include: weak forest governance systems, lack of enabling policy environment, graft and corruption, neglect of indigenous and local people's rights, and accelerated biodiversity loss (Barr and Sayer 2012; Phelps et al. 2012; Llanos and Feather 2011). These issues must be adequately addressed if REDD+ will succeed beyond the hype that surrounds it at present.

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