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EVALUATING PUBLIC PLANTATION AND COMMUNITY PLANTED FORESTS UNDER THE CDM AND REDD+ MECHANISM FOR CARBON STOCK IN NEPAL

Ram Asheshwar MANDAL[1*], Ishwar Chandra DUTTA[2], Pramod Kumar JHA[3], Sidhibir KARMACHARYA[1], Samshul Mohammad HAQUE[4]

[1] Department of Botany, Trichandra College, Nepal
[2] Tribhuvan University Service Commission, Nepal
[3] Department of Botany, Tribhuvan University, Nepal
[4] Institute of Forests, Hetauda Campus, Nepal

Abstract

Public plantations (PPs) and Community planted forests (CPFs) are inimitable types of participatory forest management practices in Nepal, but their eligibility issues under the framework of clean development mechanism (CDM) and reducing emission from the deforestation and forest degradation mechanism (REDD+) are not evaluated. So, to explore the management system of PP and CPF, we compared forest carbon stocks in plantations and evaluated these plantations under these mechanisms as objectives of this research. The relevant documents were revised and altogether 55 samples were collected from Shreepur, Banauta and Bisbity PPs and Sita, Ramnagar and Jogikuti CPFs, in Mahottary district, Nepal. The equation of Chave et al was used to calculate the biomass, which was further converted into carbon. Meanwhile, management practices were evaluated under the framework of CDM and REDD+. The PPs are public land managed, especially by disadvantaged communities, while CPFs are the patches of national forest managed by users. The variation in carbon stock was found to be highest (148.89 ton ha^{-})^{1} in Sita CPF and lowest (30.34 ton ha^{-})^{1} in Bisbitty PP. In fact, it is difficult to certify plantations under CDM, due to its complexity, but they can easily be candidate to the REDD+ mechanism, if they are bundled with large forest blocks.

Keywords: *CDM; REDD+; community; public plantation; carbon stock; bundling*

Introduction

The greatly strengthened scientific case of global warming is taking place and radical actions are needed to avert its most severe effects. Forestry can make a very significant contribution to a low-cost global mitigation portfolio that provides synergies with adaptation and sustainable development [1]. So, developing countries have been working on a clean development mechanism (CDM) and a "reducing emission from deforestation and forest degradation" (REDD+) mechanism. In this context, eligibility criteria of CDM are so complex that the plantation projects are quite impossible to qualify under it. Thus, the REDD+ mechanism becomes a key concern for developing countries and Nepal is also working to be ready for this.

* Corresponding author: ram.mandal@gmail.com

The net global change of forest area was estimated to -5.2 million ha annually, between 2000 and 2010. Southeast Asia experienced a more than 0.9 million ha shrink in its forest area in the last 10 years [2]. Similarly, the estimated annual deforestation area, between 1991 and 2001, was 84,000 ha in Nepal. Yet, the total global plantation area was estimated to 264 million ha in 2010. A net gain of forest was reported in Asia, more than 2.2 million ha per year, in the period 2000 to 2010, due to the large-scale afforestation in China. That was approximately 7,046ha between 2000 and 2005. There are about 3,543ha of public plantations in different parts of Tarai, Nepal [3]. Those plantations help store the carbon and ultimately support decrease the people's pressure on national forests, a concept which is aligned with the main purpose of the REDD+ mechanism.

More than one billion people, one sixth of the world population, live on less than 1 US $/day. South Asia has about 423 million inhabitants, the highest number of people living in absolute poverty, which makes up about 40% of the world’s poor people and that region holds about 23% of the world population [4]. About 25% of the population lives under the poverty line and out of that 80% of people depend on forest products in Nepal [5]. Around 10 million people are employed in forest management and conservation in the world, but many more are directly dependent on forests for their livelihoods. Thus managing forest-dependant people is a great challenge, but there are no alternative ways to alter the deforestation and forest degradation, immediately.

One of the ways of managing jobless poor citizens in Tarai, Nepal is income generation through agro-forestry i.e. public plantation (PP), which has been helping to lessen the pressure on the forest. Here, community planted forests (CPF) are different, but this also helps to take pressure off the national forest. Such types of users of small scale plantations may have high expectations from REDD+ rewards, but for their eligibility under either REDD+ or CDM, the record of forest carbon is mandatory.

It is a fact that the community knows about the social benefit of afforestation, but they are unaware of environmentally benign aspects, especially the benefit from carbon credit. Thus, several queries were made to know what the quantity of carbon stock in such plantations is? What is the mean annual carbon increment (MACI) in these plantations; what are the scopes of these plantations under the REDD+ and CDM mechanisms? This research tries to find the answers to these questions, so our research objectives are: to explore the management system of community planted forests and public plantations, to show and compare forest carbon stock in community planted forests and public plantations and to evaluate the community planted forests and public plantations under the CDM and REDD+ framework

Materials and Method

***Research site**:* The research sites were selected in Mahottary district of Nepal, which is situated 26° 36' to 28° 10' N and 85° 41' to 85° 57' E. The average annual temperature ranges between 20 and 45^0 C and the average annual rain fall was recorded between 1100 and 3500 mm. Three CPF and three PP areas in Mahottary district were selected as study sites (Fig. 1), because the community plantations Sita (5.42ha), Jogikuti (8.60ha) and Ramnagar (4.92ha) were planted in 2006, 2007 and 2008 respectively. Similarly, the Bisbitty (7.6ha), Banuata (8.8ha) and Shreepur (10.5) public plantations were also made in 2006, 2007 and 2008, respectively. These studies sites were planted with pure *Eucalyptus camaldulensis*. Some other natural species were *Cynodon dactylon* and *Mimosa pudica*.

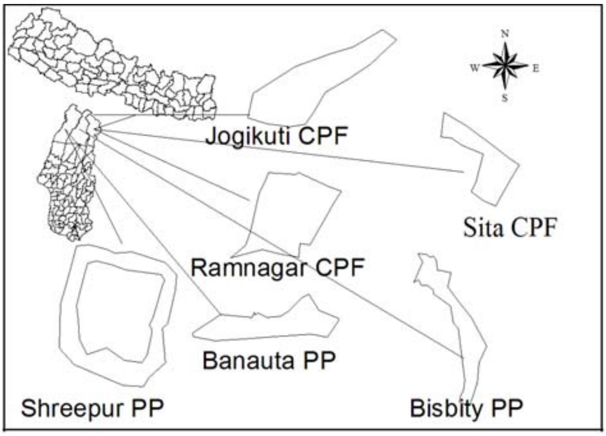

Fig. 1. Map of Research Site

Data collection

The bio-physical data and documents associated with plantations, CDM and REDD+ were collected as follows:

Bio-physical data: The maps of these plantation areas were prepared by using the coordinates taken by Geographical Positioning System (GPS), with the ArcGIS software. Simple random sampling was used, maintaining 1% of sample intensity [6]. Altogether 55 samples were taken from plantation sites. Out of that, 11, 11 and 9 sample points were fixed at Banauta, Shreepur and Bisbitty plantation sites respectively, while 6,7 and 11 sample points were set at Sita, Jogikuti and Ramnagar community planted forests, respectively, to collect the data. Next, centre point coordinates of sample points were taken from the map and uploaded to the GPS and navigated the points, to establish the nested points in the field. The plantations are generally pole size, so 10m x 10m for this and 1m x 1m for litter and grasses were laid out, while soil samples were taken from the centre at depths from 0 - 0.1m, 0.1 - 0.3m and 0.3 - 0.6m [7]. Height and diameter at breast height (DBH) of poles and sapling (DBH > 5cm) were measured, but samples of sapling (DBH < 5cm), grasses, litter and soil were taken out for lab analysis.

Moreover, 12 additional samples were taken from neighboring areas of the plantation site, in order to determine the carbon stock of the study site before plantation. The neighboring site was normally covered with long grasses, such as *Themeda triandra*, *Cynodon dactylon*, *Mimosa pudica*.

Other Data

Apart from the above mentioned, plans of community planted forests and public plantations and policy documents of CDM and REDD+ were collected. In addition, a small group meeting was also conducted to know the practice of plan implementation in these plantations.

Data Analysis

The biophysical data and collected documents were analyzed by applying simple statistics.

The biophysical data were analyzed by applying the Statistical Package of Social Science (SPSS) software version 17. The biomass of plants with DBH > 5cm and DBH < 5cm was calculated by using the allomatric equation of Chave *et al* [8] and Tamrakar [9], respectively, but the equation of Tamarakar provides only the fresh weight, so collected samples were dried in the lab. At the same time samples of litter and grasses were also dried. Moreover, the root biomass was calculated by multiplying by conversion factor 0.125 of shoot biomass. Then, wood carbon was calculated by multiplying it with 0.47 of dry biomass [10]

Moreover, soil bulk density and carbon content were calculated by using the Walkley and Black method [11, 12]. The mean annual carbon increment was also calculated by using the formula below. Then, the value was changed into CO_2 multiplying conversion factor 44/12, in order to show the CO_2 removal from atmosphere.

Mean Annual Carbon Increment (MACI) = Sum of Carbon stock of Pole and Sapling/Age of plantation

Stock difference = Carbon stock of plantation - Carbon stock of neighboring site (control site) [13].

Preparation for analysis

The identified 6 outliers in the biomass of public plantations and community planted forests were removed for testing under the normality, for further statistical analysis. Then a homogeneity test was carried out, to apply one way ANOVA test, to compare whether the MACIs in these plantations were different [14].

Apart from that, the collected plans and practices adopted by community planted forests and public plantations users were compared. Then, these documents were evaluated within the policy framework of CDM and REDD+ for the eligibility.

Results and Discussion

Management practices in community planted forests and public plantations: Community planted forests or community forests are patches of forest protected, developed and utilized by the nearest community, while public plantations are the common land of public institutions, such as schools, village development committees, which is leased by poor and disadvantaged communities for plantation, protection and utilization. The users of CPFs are living nearby the plantation, whether they are rich or poor. Nevertheless, only disadvantaged poor households are members of public plantations. Generally, the number of users of PPs is 7 to 15 households, but there is no limitation thereof in CPFs. Some management differences are listed below (Table 1).

Table 1. Differences in management aspects between community planted forests and public plantations

Description	Community planted forest		Public plantation	
	Provision	**Practice**	**Provision**	**Practice**
Protection	Users participate in protection Prohibition of grazing, fire, encroachment and logging	Only benefitted persons participate	Individually users participate in protection Protection from grazing, fire, encroachment and logging	Users sincerely to care the plantation
Development	Silvicultural operations: clearing, pruning, cleaning, weeding, replanting and lastly harvesting for pole applied	Generally users like to harvest the pole without applying other operations	Intercropping doesn't need cleaning, weeding in plantation. Casualty replacement. Moreover, natural pruning is helpful for growth of plantation	Users completely follow the operations prescribed in the plan
Utilization activities	Users use the grass and they have plan to use the pole in future	Generally committee members are more benefitted	Inter cropping is common (vegetables and Non-timber forest products) and users have right to use the intermediate yield. The pole can be sold and income will be shared	Users have income from inter cropping Users can buy or sell pole in the market and income is shared
	Users are equally benefitted	Sometimes bias for poor in benefits sharing	Lease in benefit sharing of timber (40-60% benefit to users)	Only sharing of timber not for intercropping
Intercropping	NTFPs & grasses are allowed	Users applied	Cash crops and NTFPs are allowed	Applied for starting of 3 years
Responsibility	All users involve to manage the plantation	Equal participation is difficult job	Plantation site is allocated to individual house hold for management	Local people feel pride to manage the plantation

Carbon Stocks and Mean Annual Carbon Increment (MACI) in Community Planted Forest and Public Plantations

Carbon stocks in community planted forests and public plantations

The carbon stocks of plantations varied from site to site. The highest carbon stock was 148.89t·ha^{-1} in Sita CPF, while it was lowest, about 30.34t·ha^{-1}, in Bisbitty PP. The estimated total carbon stock of those plantations was 3683.78t (Table 2).

Table 2. carbon stock in community planted forests and public plantations

Plantation	Pole & Sapling C (t·ha^{-1})	Root C (t·ha^{-1})	Grass & litter C (t·ha^{-1})	Soil C (t·ha^{-1})	Total C (t·ha^{-1})	Total C (t)
Shreepur PP	54.34	6.79	0.06	79.13	140.32	1473.33
Banauta PP	11.48	3.74	0.07	37.00	70.71	622.29
Bisbitty PP	12.03	1.50	0.065	16.74	30.34	230.60
Sita CPF	68.89	8.61	0.06	71.33	148.89	807.29
Ramnagar CPF	22.00	2.75	0.05	33.00	57.80	284.66
Jogikuti CPF	13.65	1.71	0.08	15.44	30.88	265.61

The research done by Dutta *et al* [15] showed about 84.07t·ha^{-1} and 87.42t·ha^{-1} C of 10 and 11 years of *Eucalyptus camaldulensis* in Indrakali community forests and in Newardanda Kamidanda community forest respectively [15]. Those values were contrary to the present research, because of the plantation age. Meanwhile, the values of soil carbon were 76.27t·ha^{-1} in Indrakali, quite similar to the values of Shreepur PP.

Mean Annual Carbon Increment (MACI) of Plantations

The value of the mean annual carbon increment (MACI) varied according to plantation site. The highest value (11.36t·ha^{-1}) was found in Sita CPF, while the lowest (3.41t·ha^{-1}) in Jogikuti CPF. The total estimated capacity of CO_2 removal from the atmosphere of these plantations was 1135.21t (Table 2). The MACI depends on the quality of the plantation site.

Amatya *et al* [17] showed that the values of MAI of 4 years old *Eucalyptus Camaldulensis* plantations at a poor site was 5.8 m^3 ha^{-1} and of a 6 years old plantation at a fair site was 19.4 m^3·ha^{-1}, which means that the estimated values of MACI, which is equal to MAI (m^3) x wood density x 0.47 (wood density of *Eucalyptus Camaldulensis* is 0.96g·cm^{-3}), were 2.63t·ha^{-1} and 8.75t·ha^{-1} respectively [17]. These values were nearly close to the MACI values of our research site. We should mention that the growth of *Eucalyptus camaldulensis* is better on non-saline soil than on moderately saline soil [16].

Table 3. Mean Annual Carbon Increment and CO_2 removal by the plantations

Plantations	No of stems	MACI (Poles + sapling) (t•ha^{-1})	Annual removal of CO_2 (based on MACI t•ha^{-1})	Annual removal of total CO_2 (t)
Shreepur PP	3618	10.20	37.40	392.65
Banauta PP	2013	6.58	24.12	183.28
Bisbity PP	1756	4.54	16.63	146.33
Sita CPF	2211	11.36	41.65	225.84
Ramnagar CPF	1733	4.40	16.15	79.52
Jogikuti CPF	1833	3.41	12.51	107.59

ANOVA of MACI in Community and Public Plantations

The one way ANOVA showed that there were significant differences in MACI among the plantations, at 5% significant level (Table 3).

Table 3. ANOVA showing differences in MACI among the plantations

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	431.12	5	86.22	429.12	.000
Within Groups	8.44	42	0.20		
Total	439.56	47			

The Posthoc Test Homogeneous subset, Tukey B showed that there was a variation in the value of MACI in each plantation at 5% level of significant, except at Ramnagar CPF and Bisbity PP (Table 4).

Table 4. Posthoc Test Homogeneous subset, Tukey B

Plantation	Subset for alpha= 0.05					
	N	Category 1	Category 2	Category 3	Category 4	Category 5
Jogikuti CPF	9	3.41				
Ramnagar CPF	6		4.40			
Bisbity PP	8		4.53			
Banauta PP	8			6.58		
Shreepur PP	11				10.19	
Sita CPF	6					11.36

Addition in Carbon Stocks after Plantation

The value of carbon stock varied in different plantation areas and their neighboring sites. The carbon stock of the neighboring site of Shreepur PP was the highest ($77.71t{\cdot}ha^{-1}$), while it was lowest ($32.11t{\cdot}ha^{-1}$) for the Ramnagar community plantation. In the case of carbon value of plantation, it was highest ($148.89t{\cdot}ha^{-1}$) in Sita CPF and lowest ($30.34t{\cdot}ha^{-1}$) in Bisbity PP. The stock differences ranged from 14.41 to $62.61t{\cdot}ha^{-1}$ in PP while it ranged from 16.44 to $80.56t{\cdot}ha^{-1}$ in CPF (Fig. 2.). Overall, the increase in carbon stock was 1792.25t in those afforested areas. The variation of carbon stock depends on the soil nutrients, the number of plants per ha, the silvicultural operations [15]. The growth of *Eucalyptus camaldulensis* in a 7 years old plantation showed $35t{\cdot}ha^{-1}$ in a very good site [17].

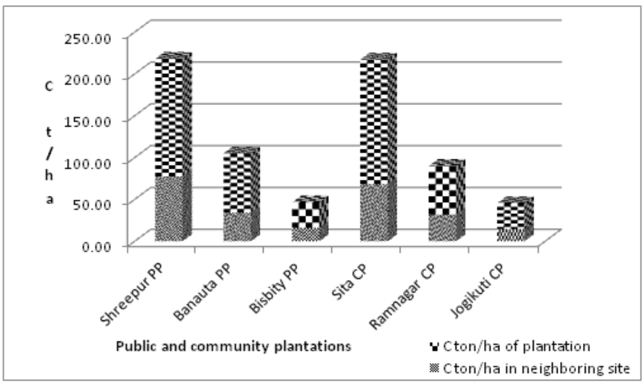

Fig. 1. Carbon stock in plantation and neighboring sites - $t{\cdot}ha^{-1}$

Clean Development Mechanism and REDD+ Framework and Community and Public plantations

Additionality, leakage, permanency, baseline or reference scenario and monitoring reporting verification (MRV system) are the basic components of the CDM and REDD+

mechanism. Above records of carbon in CPF and PP showed additionality, however it is essential to evaluate them under both the CDM and the REDD+ frameworks.

Basically, a base line and reliable method of monitoring systems is a key technical element of CDM. Nevertheless, reference emission level and designing the Monitoring, Reporting and Verification (MRV) system, are major elements of REDD+. However, these two elements are quite similar in function. The plantation projects under CDM must result in real, measurable and long term emission reductions on top of a baseline that should be certified and regularly monitored by the operational entities. In the case of REDD+, a country itself can set the reference emission level but the MRV system should be based on third party verifications. In this context, both public and community plantations can be eligible under the REDD+ mechanism, but in the case of CDMs, only public plantations may qualify (Table 5.).

Table 5. Evaluating CPF and PP under the framework of CDM and REDD+ Mechanism

Technical elements	CDM	REDD+	Community planted forests	Public plantation
Additionality	Addition in carbon stock: planted by post 2000	Certified emissions reduction (CER) proves that emission from D & D reduce through performance based +ve stock change	Based on carbon stock differences	Based on carbon stock differences
Leakage	The project must address and account for potential leakage	Activity & market leakage should be addressed	Reduce leakage by altering D & D	Reduce leakage by altering D & D
Permanency	Minimum 40 yrs rotation	Reducing emission from atmosphere as long as possible through reducing D & D	Rotation of *Eucalyptus* is only 7yrs & other 2 consecutive rotations from coppice are for 7+7 yrs	Same CPF so, after 21 year, next plantation period starts
Baseline & reference level	Plantation site be unfrosted since 1990 and project started from 2000 or onward	Developing countries can set national, sub national or hybrid approach. Nepal chooses hybrid approach	Carbon stock of starting year of plantation can be considered as baseline	Carbon stock of starting year of plantation can be considered as baseline
Monitoring Reporting and Verification system	Reliable method of carbon monitoring system is applied	MRV system must be scientific and sound	Expect user friendly MRV system	Expect user friendly MRV system

Modified from: Satyanarayana (2003), Cortez and Stephen (2009) [19, 20]

Another remarkable uncertainty of such plantations is the 40-years of permanency under a CDM plantation project, which is quite impossible to achieve, but the permanency is not yet decided under the REDD+ mechanism [18]**.**

Indeed, REDD+ will be cost effective by working with large blocks of forests which public plantations and community planted forests do not possess. Thus, the concept of bundling such a project with other large forest blocks would be efficient and effective to be credited under the reward system of the REDD+ mechanism. Undoubtedly, plantation projects should be bundled with blocks of forest to certify under the REDD+ mechanism. The consequences would be dual benefits, such as increasing the carbon stock and reducing the pressure on national forest and ultimately a reduction of emissions, as well.

The present research offers the option of a bundling approach for small scale plantations with large blocks of natural forests, to diminish the monitoring and evaluation cost required to qualify for the REDD+ mechanism. This idea was also inline with the REDD+ piloting done by the International Centre for Integrated Mountain Development (ICIMOD), Asia Network for Sustainable Agriculture and Bioresources (ANSAB) and the Federation of Community Forest Users, Nepal (FECOFUN), as well as the World Wildlife Fund (WWF), Nepal. Here, the former REDD+ pilot project focused on the bundling of different forests management regimes under one watershed management, while a later one highlighted on the bundling of different forest management types under the Terai Arc Landscape, as a sub national approach [21, 22]. The concept behind it is that forests within one watershed boundary are single units of the REDD+ project and vice versa for forests within the boundary of Terai Arc Landscape.

Conclusions

Community planted forests and public plantations have different types of users and benefit sharing. The carbon stocks and MACIs also varied according to plantation type and site. Such types of plantations may be certified under the REDD+ mechanism, but bundling with block forest is a compulsory requirement.

Thus, it is recommended to assess the carbon stocks of such plantation to other areas, such as private plantations, and start the practice of bundling of carbon stock for monitoring and evaluation.

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