Smallholders' Contribution on Climate Change Mitigation and Water Quality: The Case of the CBFM Project in Midwestern Leyte, Philippines

Arturo E. Pasa
Department of Agroforestry, College of Forestry and Natural Resources
Visayas State University, Visca, Baybay, Leyte, 6521-A Philippines

ABSTRACT

The study assessed carbon storage and water quality within the 2,236-ha Community-Based Forest Management (CBFM) Project in Cienda, Gabas, Baybay, Leyte, Philippines. Results revealed that the CBFM project area stored an average amount of 333.28 Mg/ha carbon from aboveground biomass down to the soil complex (0-1mdepth). The upperstorey biomass had an average carbon density of 166.146Mg/ha while 1.94 Mg/ha for the understorey biomass. Floor litter carbon density ranged from 1.27 Mg/ha to 2.69 Mg/ha, root carbon density from 11.03 to 17.43, and soil carbon density from 111.14 to 221.73 Mg/ha. On the average, streamflow velocity was 0.30m/sec, streamflow volume 0.32m^3/sec, turbidity 2.96 ntu and the associated sediments 16.0 mg/L. Odor and taste were unobjectionable. pH ranged from 7.50 to 7.0 while total hardness from 7.84 to 15.16 mg/L. The average nitrite (NO_2) content was 11.115mg/L while nitrate (NO_3) was 1.05 mg/L. The concentration of nutrients was also very low except for Phosphorous (P). P ranged only from 2.20 to 4.46 mg/kg or parts per million (ppm) while potassium (K) ranged from 3.71 to 3.90 ppm. Sodium (Na), calcium (Ca), and magnesium (Mg) concentrations were also very low. Heavy metals were detected but also at low concentrations. The huge amount of stored carbon and the superior condition of water within the CBFM project is attributed to the smallholders protecting the area against illegal logging, slash and burn farming and river poisoning.

KEYWORDS: Smallholders, CBFM, Watersheds, Environmental Services, Carbon Sequestration, Water Quality

INTRODUCTION

Forests within the watershed ecosystems provide enormous environmental services to various societies on earth. However, in many countries − including the Philippines − the undue pressure imposed on forests by the growing number of people has relentlessly damaged these ecosystems. Population pressure has gradually deprived people of the environmental services that they used to enjoy everyday as a result of forest depletion due to increased demand in timber for construction and timber products. The Philippines was the world's leading tropical hardwood producer in 1975, but became a timber-importing nation in 1994 (Chiong-Javier 2001). Hence, the Philippine Government designed various programs to protect and conserve the remaining forest[1]. The Community-Based Forest Management (CBFM) Program introduced in 1995 in particular recognized the indispensable role of the local people or smallholders[2] in managing the remaining

[1] These include the Integrated Social Forestry Program (ISFP), Upland Development Program (UDP), National Forestation Program (NFP), Forest Land Management Program (FLMP), Low Income Upland Communities Project (LIUCP), Community Forestry Program (CFP), Regional Resources Management Project (RRMP), Forestry Sector Project (FSP), and Community-Based Forest Management Program (CBFMP) (Harrison *et al.* 2005).

[2] Smallholders refers to people whose income is within or below the poverty line, whose voices are less heard in policy making and with less access to natural resources.

forest resources as well as keeping the watersheds in the country resilient to climate change and destructive water and land use systems. Therefore, the CBFM Projects in the Philippines like the particular project under this study are expected to contribute to climate change mitigation and water quality management.

Carbon Storage

One of the environmental services of a CBFM project is the sequestration and storage of carbon dioxide (CO_2) that is known as one of the gases responsible for the warming of the atmosphere. As scientific authorities have revealed, climate change or the increase of the earth's atmospheric temperature (global warming), is one of the most pressing issues today. Greenhouse gases (GHGs) like CO_2, methane, nitrous oxides and chlorofluorocarbons (CFCs) absorb thermal radiation emitted by the earth's surface. Thus, rising concentration of GHGs in the atmosphere could lead to changes in the world's climate. Among GHGs, CO_2 is the most abundant. According to best scientific estimates, CO_2 concentration will reach the equivalent of 560 parts per million by the year 2030, which is double than the natural level. With the increasing concentration of this gas together with other GHGs, temperature of the earth's surface will also increase. Experts reporting during the May 1990 United Nations Intergovernmental Panel for Climate Change estimated that by 2020 the world will, on the average, be 1.3 ^{0}C warmer than now and rising to 3 ^{0}C by 2070. Sea level will rise because the heat will melt polar ice and expand the water in oceans. Over the next century, water levels are expected to increase by a meter or more. Many more people are in peril from the flooding of deltas and other-low-lying coastal areas. Some areas are already subsiding, making them doubly vulnerable to the rising sea. On this crowded planet, divided by national frontiers, it will be hard to find anywhere to go (Lean et al., 1990).

The recorded CO_2 concentration in the atmosphere in 2005 was 379 ppm which exceeds by far the natural range of the last 650,000 years (180 to 300 ppm) and warming in the last 100 years has caused about a 0.74 °C increase in global average temperature. The best estimate for surface air warming for a 'high scenario' is 4.0 °C with a likely range of 2.4 to 6.4 °C (IPCC, 2007). Thus, efforts to mitigate climate change are underway, including the greenhouse gas inventory for the LUCF sector in the Philippines, Thailand, and Indonesia, as reported by Magcale-Macandog (2000). Currently, the Philippines have three World Bank-supported greenhouse gas (GHG) emission reduction projects. These include the watershed rehabilitation project of Laguna Lake focusing on reforestation and agroforestry, the Laguna de Bay watershed project focusing on methane emission reduction from waste management projects and the North Wind Bangui Bay project in the northern tip of Luzon designed for carbon–free energy generation (www.carbonfinance.org, 2007). Likewise, the CBFM projects in the Philippines including the project where this study was conducted are anticipated to partly mitigate climate change by sequestering CO_2 from the atmosphere.

Water Quality

Water is the central to many national concerns, including energy, food production, environmental quality and regional economic development. Yet, most people continue to use water with little concern for the prescribed perils (Dzurik, 2003). In the recent past, Lean et al. (1990) pointed out that everywhere it seems surface waters are being polluted with a frightening assortment of municipal, industrial and agricultural wastes. Even in industrialized countries, where water quality legislation has taken hold, pollution is still a nagging problem. For much of the developing world, rivers and lakes are often clogged with a virulent mixture of industrial toxins, untreated sewage, and agricultural chemicals. Most residents of Canada and the US take a supply of fresh, pure water for granted. But a growing number of people are getting worried about contaminants in their water and are beginning to buy bottled spring water: some even install home purifying systems (Press and Siever, 1994).

Toxic substances from municipal, industrial and agricultural wastes have detrimental effects to the society. For example, nitrites can combine with natural amines and amides in the food or in the human body to form nitrosamines. High levels of nitrites/nitrosamines in the diet are thought to be contributory to the high incidence of esophageal cancer in northern China and Iran (Encarta, 2005). Lean et al. (1990) pointed out the findings from the World Resources Institute (1988-1989) that nitrates in drinking water may cause blood poisoning in infants, hypertension in children, gastric cancer in adults, and fetal malformations. The combination of high nitrates with pesticides is carcinogenic (cancer-forming) and mutagenic (causing birth defects). The high concentration of nutrients in rivers or lakes is known to cause the abnormal growth of aquatic plants that will deplete the amount of oxygen present causing aquatic animals die. High nutrient concentration will also cause periodic outbreak of toxic blue-green algal blooms (Encarta, 2005).Thus, high concentration of these substances in water is hazardous to both freshwater fauna and the consuming public.

Agenda 21 Chapter 13 stated that nearly half of the world's population is affected in various ways by the degradation of watershed areas (FAO, 2006) and one of which is obviously potable water supply. Watersheds which are common sources of water for various societies on earth are the sites for settlements, agricultural production, industrial centers and commercial complex. In the coming years, if unabated, these areas will no longer provide the potable water for the diverse users in view of the relentless degrading land uses by various entities. The world's supply of freshwater therefore depends largely on people's capacity to manage upstream-downstream flows (FAO, 2006).

The Philippine watersheds also suffer similar anthropogenic pressures as sadly manifested by the Ormoc, Southern Leyte and Quezon Province flashfloods. At present, there is only a remaining 0.80 million ha of old growth dipterocarp forest (Rebugio et al., 2005) due to commercial logging and land use conversions. Due to the current forest condition and the subsequent soil erosion, reforestation of the denuded watersheds and protection of the remaining forest lands has been intensified not only to ensure sustainable supply of various goods and services but also potable water for all Filipinos. To enhance its success, the smallholders were given the noble task of protecting the uplands and conserving the resources therein through the Community-Based Forest Management (CBFM) scheme. Thus this study was conducted to obtain baseline information on the CBFM scheme of protecting the remaining watersheds with particular reference to carbon storage and water quality. Data generated from this study is anticipated to provide valuable information for policy formulation involving smallholders, watersheds, climate change and water quality.

RESEARCH METHODS

Study Site

The site of this study was the west-oriented watershed ecosystem within the 2236 ha Community-Based Forest Management (CBFM) in Cienda, Gabas, Baybay, Leyte, the Philippines. The site is rugged and mountainous with slope ranging from 30 to 80 percent and lies between $124^0 50'$ longitude and $10^0 44'$ latitude having a climatic type IV with more or less evenly distributed rainfall throughout the year (Figure 1). On average, June to January are wet months while February to May are relatively dry. Average annual rainfall is 2500 mm while the average annual minimum temperature is 22.3^0C and maximum is 33.67^0C (PAGASA 2007). The monthly average wind velocity is 2.17 m per second with the highest occurring during February to March and July that is attributed to the northeast and southeast monsoon (CRMF, c2002).

Field and Laboratory Methods

1. Carbon Stocks Assessment

1a. Upperstorey Biomass Carbon

A total of 27 (20 m x 20 m) purposive sampling plots were laid out within the study sites: 9 plots within the protected zone, 9 within the buffer zone, and 9 within the multiple-use zone of the CBFM project. Tree heights, diameters, and local names were recorded. The biomass of trees with at least a diameter at breast height (dbh) of 10 cm and above (after Brown, 1997 and Lasco and Sales, 2003) was calculated using the allometric equation below (adopted from Brown, 1997):

$$Y=\exp[-2.134 + 2.530*\ln(D)] \qquad \text{(equation 1)}$$

Where: Y=biomass per tree (kg) D=diameter at breast ht. (cm)

Biomass of palms was calculated using the formula of Frangi and Lugo (1985) cited by Brown (1997):

$$Y=10.0 + 6.4 * TH \qquad \text{(equation 2)}$$

Where: Y=plant biomass (kg) TH=total height (m) 10 + 6.4= constant

Carbon density was calculated by multiplying the biomass value with 45 percent as suggested by Lasco (2003) and Sales-Come (2004).

1b. Understorey Biomass

To determine the understorey biomass, three subplots measuring 2m x 2m were randomly laid out (nested) within plots 1, 5, and 9 in each zone. All individual trees below 10 cm dbh as well as woody vegetation found within were harvested. Fresh weights of leaves, twigs, branches, and stems were determined and representative samples were separated for oven-drying.

A kg of freshly cut and mixed stems, twigs, and branches and a kg of fresh leaves were obtained from the field for air-drying. After a week of air-drying, 100-g samples from each biomass group were obtained for oven-drying. The oven-dried weight of the original biomass samples was then obtained through ratio and proportion.

1c. Forest Litter Carbon

Forest litters were collected from the three randomly laid out (1 m x 1 m) subplots within the 27 main plots. Collected litter samples from the three subplots were mixed together, fresh weights determined in the field, and representative samples obtained for oven-drying.

1d. Root Biomass

Three soil pits measuring 1 m x 1 m x 1 m were dug within the randomly selected plots 1, 5, and 9 under each zone. From these pits, all plant roots visible to the naked eyes were collected. Fresh weights of the said roots were determined in the field and representative samples for oven-drying were obtained.

The mathematical model of Cairns et al. (1997) below was also used to calculate the carbon stock found in the root biomass for comparative purposes.

Root biomass =Exp [-1.0587+0.8836ln (AGB)] (equation 3)

Where: AGB= aboveground biomass

All biomass samples were oven-dried for four days at constant temperature of 103 ^{0}C. When the constant dry weights were attained, biomass samples were brought to the International Rice Research Institute's (IRRI) Analytical Service Laboratory at Los Baños, Laguna for grinding and carbon analyses. The Stainless Cross Beater Grinder and the Vibrating Sample Mill were used to grind the samples thoroughly while the Elemental Analyzer was used for carbon analyses.

1e. Soil Carbon

The soil organic carbon dynamics were analyzed along the various depths (0-30, 30-60, 60-100 cm) of the soil pits. Soil bulk density (BD) was determined within the plot before digging using the core sampling method. The soil organic carbon (SOC) was analyzed through the Walkley-Black method and calculated using the equation below:

Total SOC(Mg ha $^{-1}$)= SOC x specified soil depth x BD (equation 4)

The BD used in calculating the soil carbon stock from the soil surface down to 30 cm depth (0-30 cm) was based from the results obtained through core sampling method. From 30 cm down to 100 cm, the BD used was based on the assumed value of 1 Mg/m^3. Core samples for BD determination were not obtained at these depths due to soil compaction caused by digging operation. The assumed value was based from the observation that soil particles at such depth were higher than the ground surface due to the downward movement of clays.

2. Water Quality Assessment

Water samples were collected, employing stratified sampling technique, at strategic locations within the river system of the study site (Figure 1) using sterilized plastic bottles. Samples were immediately brought and analyzed for the associated nutrients, sediments, hardness, turbidity, and heavy metals at the Central Analytical Service Laboratory of the Visayas State University, Baybay, Leyte. Sample collections for physico-chemical properties were replicated three times while streamflow discharge and velocity were determined seven times within the study period from June (relatively dry period) to November (relatively wet period) 2005.

RESULTS AND DISCUSSION

1. Carbon Storage

The various strata within the different zones of the study site showed varied trends in carbon storage. The buffer zone had the highest upperstorey biomass carbon density because it had the highest volume of standing trees among the three zones. The multiple-use zone having the lowest upperstorey carbon stock had less volume of standing trees among the three. According to the key informants, the multiple-use zone had been subjected to small-scale logging operation in the past by the local people for building houses and other light structures because of the area's accessibility. What remains are naturally regenerating, small- to medium-sized plants.

The understorey biomass carbon only showed slender variation as compared with the upperstorey biomass carbon. The multiple-use had slightly more carbon stocks among the three zones which could be attributed to some sturdy understorey plants. However, the stock of leaf biomass carbon within the understorey vegetation of the multiple-use zone was the least among the three zones. The leaves in the said zone appeared to be succulent compared to plants in the other zones although during the double grinding process at IRRI, all leaf samples came out with closely similar appearances and texture.

The floor litter carbon stocks also showed varied trends. This time, the buffer zone had the highest amount of carbon among the three zones which could be due to the degree of decomposition and the type of floor litter present in the site. During the actual sampling period, the buffer zone had the thickest and driest floor litters among the three zones. Floor litters from the other zones were thinner and showed higher degree of decomposition particularly in the protected zone which could be the reason for the high amount soil carbon in that particular zone (Figure 1).

In addition, the multiple-use zone had the highest root biomass carbon density. However, using equation 3, the estimated root biomass carbon density did not corroborate with the actual results obtained. The protected zone had 34.08 Mg/ha, the buffer zone had 41.65 Mg/ha, and the multiple-use zone had 20.10 Mg/ha carbon density. Because of such significant variation, there seemed to be a need to further study the root biomass and carbon density of the site by increasing the number of sampling pits. The researcher failed to obtain more root biomass samples from the site because of the restrictions imposed by the people's organization.

The soil carbon which is a significant portion of forest carbon was also determined. Results showed that soil carbon was higher compared with the biomass carbon, except in the buffer zone where the volume of standing trees was very high. Obviously, soil carbon is higher than the aboveground biomass because falling debris or litter as well as animal wastes and dead remains will ultimately decompose and join the soil complex. The same result was corroborated by the findings of Batjes (1996) that soil carbon was four times more than that of the aboveground biomass. However, a large portion of this carbon was mostly present only within the 0-30 cm of the soil horizon (Figure 1).

Overall, the protected zone contained the highest total carbon stocks among the three zones (Figure 2 and Table 1). Houghton et al. (1997) estimated the aboveground biomass carbon of the Philippine old-growth and secondary dipterocarp forests to be 370-520 and 300-370 Mg/ha, respectively. Results from this study showed average aboveground biomass carbon storage of only 169.99 Mg/ha which is closer to the estimates of Lasco and Pulhin (2000) for protection and secondary forests.

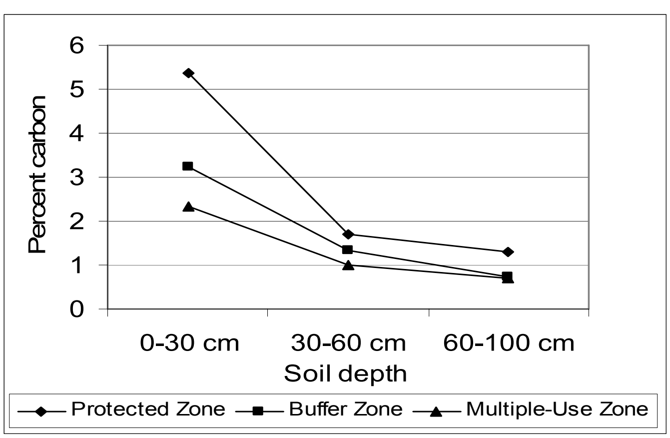

Figure 1.Percent carbon found at various soil depths within the different zones of the study site

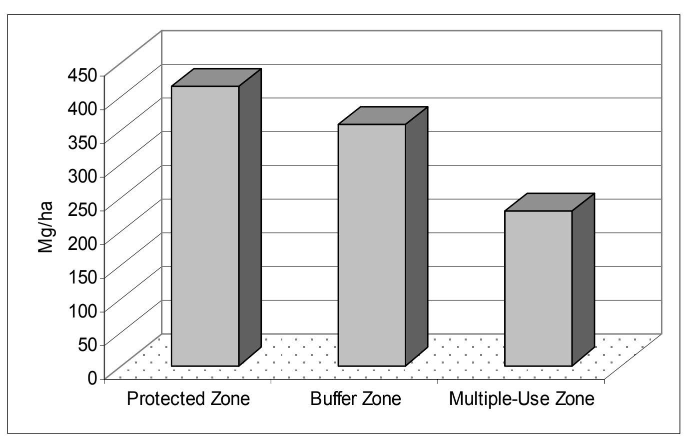

Figure 2. Total carbon density within the different zones of the study site

Table 1. Total carbon stocks within the different zones of the CBFM Project (2005)

CARBON POOLS	LOCATION/ CARBON STOCKS (Mg/ha)+		
	Protected Zone	Buffer Zone	Multiple-Use Zone
Upperstorey Biomass	177.89a	223.73a	96.82a
Stem/Twigs (Understorey)	1.34a	1.49a	1.72a
Leaves (Understorey)	0.54a	0.37a	0.35a
Floor Litter	1.38b	2.75a	2.31a
Roots (actual density)	11.03a	13.57a	17.43a
(estimated using eq.3)*	34.08	41.65	20.10
Soil	221.73a	114.96b	111.14b
Total	413.91	356.87	229.77

*Not accounted in the total carbon density calculation
+Number followed by a common letter is not significantly different based on HSD at 5%

2. Water Quality

The average streamflow velocity of the watershed was 0.303m/sec which ranged from 0.230 to 0.344 m/sec while the average streamflow volume was 0.318m^3/sec. Site 3 as the lowermost sampling location is the point of convergence of all water from upper and middle sampling sites, thus having the highest volume. Turbidity values varied from 2.65 to 3.26 ntu with site 3 as the least turbid. Based on WHO (1993), the turbidity of water in the watershed is still within the acceptable maximum limit of 5 NTU. The associated sediments (assessed as Total Suspended Solids) on streamflow was very minimal ranging only from 11.0 to 21.0 mg/L (Table 2) which was lower compared with the maximum limit of 25 mg/L set under DAO34-S 1990.

Odor and taste of water within the three sampling sites were unobjectionable while pH readings varied from 7.50 to 7.61 but still falling within the allowable range for class AA waters based from DAO 34 (S 1990) and WHO (1993). This means that the river water within the CBFM project area is in superior condition in terms of odor, taste and pH. Contrary to the pH value of soil (i.e. 5.10-6.57), the pH of the river water within the study site was higher. This condition could be due to basaltic geochemistry of the parent material of the site as reported by Asio (1996) as well as to the absence of factories, mining operations, and other possible contributory agents of acidity.

Table 2. Average physical properties of surface water within the CBFM Project site

PHYSICAL PROPERTIES	LOCATION		
	Site 1 Upper	Site 2 Middle	Site 3 Lower
Velocity (m/sec)	0.336	0.230	0.344
Volume (Q=m^3/sec)	0.162	0.319	0.474
Turbidity (NTU)	3.260	3.250	2.650
TSS (mg/L)	21.00	12.00	11.00

Total hardness ranged from 7.843 to 15.164 mg/L which are lower than the standard criteria of the WHO (1993). Too hard water, which is caused largely by calcium and magnesium salts, is undesirable as it could lead to human disorders. Results from this study however showed that hardness of water within the site is still tolerable. The nitrite (NO_2) content varied from 6.906 to 15.32mg/L while nitrate (NO_3) ranged only from 0.82 to 1.28 mg/L all of which were below the WHO (1993) maximum levels, implying that the water in the site is of good quality.

Furthermore, the concentration of nutrients within surface water was also very low except for Phosphorous (P). P ranged from 2.20 to 4.46 ppm, higher than the allowable limit for surface water nutrients (see Tomar, 1999). This could be due to the natural P from the soil and parent material since there is neither mining company nor fertilizer application by farmers within the site. Together with nitrogen, P could cause algal bloom which will eventually result to eutrophication. So far, there was no reported case of such phenomenon within the site. On the other hand, Potassium (K) varied from 3.71 to 3.90 ppm. Sodium (Na), calcium (Ca), and magnesium (Mg) concentrations were very low (Table 3). This indicates the good quality of water in terms of nutrient level along the site's river system. As mentioned earlier, the hardness of water was also very low, implying the low concentration of nutrients mentioned above. With the smallholders protecting the site, algal bloom and other associated detrimental effects is not a threat within the watershed.

Table 3. Average chemical properties of surface water within the CBFM Project site

CHEMICAL PROPERTIES	LOCATION		
	Site 1 Upper	Site 2 Middle	Site 3 Lower
Odor	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Unobjectionable
pH	7.510	7.504	7.610
Total Hardness (mg/L)	7.843	8.172	15.164
NO_2 (ug/L)	7.740	6.906	15.321
NO_3 (mg/L)	1.282	1.696	0.820
Total P (ppm)	3.120	2.200	4.460
Total K (ppm)	3.904	3.708	3.884
Total Na (ppm)	4.753	3.969	4.902
Total Ca (ppm)	5.138	5.944	4.894
Total Mg (ppm)	2.057	1.545	1.879

Table 4. Average concentration of heavy metals within the river system of the study site

HEAVY METALS	LOCATION		
	Site 1 Upper	Site 2 Middle	Site 3 Lower
Total Cd (ppm)	0.003	0.004	0.006
Total Cu (ppm)	0.058	0.026	0.029
Total Zn (ppm)	0.088	0.077	0.079
Total Ni (ppm)	nil	0.002	0.001

Cadmium (Cd) content of water ranged from 0.003 to 0.006 mg/L which is within the acceptable level set under DAO 34-S 1990. High Cd can cause diarrhea as well as liver and kidney disorder (Encarta, 2005), hence its high concentration in water is undesirable. In addition, there were lower concentrations of copper (Cu), zinc (Zn), and nickel (Ni). Cu content varied only from 0.026 to 0.058 mg/L while Zn ranged from 0.077 to 0.088 and Ni from 0.00 to 0.002 mg/L. The quantitative analyses of the three heavy metals showed that their concentrations were far below the limit set under DAO 34-S 1990 and WHO 1993 and 2004 at 1.00 mg/L for Cu and Zn, and 0.02mg/L for Ni, respectively (Table 4).

POLICY IMPLICATIONS

Watersheds are important ecosystems that store high quality water for domestic and commercial uses of our society. They are also important ecosystems that sequester carbon, through their vegetation, thereby partly mitigating climate change. Watersheds therefore of every country need to be protected against all forms human-induced destructions. While many watersheds in the Philippine are degraded, the watershed in Cienda, Gabas, Baybay, Leyte protected by smallholders has been storing carbon, providing clean air and irrigating rice farms and vegetable gardens in the lowlands sustaining the livelihood opportunities of the local people in the agriculture sector. The same watershed provides superior quality water for domestic uses and recreational activities. This becomes possible due to the effort of the smallholders in safeguarding said watershed. In fact, the said project was nominated as one of the “exemplary forest management in Asia and the Pacific” (see RAP Publication 2005/02). However, sustaining the enthusiasm of smallholders to continue doing so remains a great challenge. Experiences from the past showed that delayed releases of wages led to the declining attendance and support of participants to various CBFM project activities. Rewarding smallholders for their environmental services is viewed as an important element for that purpose. Hence, it is suggested that the government would consider rewards or livelihood opportunities of smallholders in relation to watershed protection and water quality.

Rewarding − or as commonly known in South America − *payment for environmental services* (PES) is a newly emerging initiative in forestry and agroforestry development programs. For example, the program for ‘*Rewarding the Upland Poor for their Environmental Services (RUPES)*’ explores new ways of addressing poverty (Van Noordwijk 2007). The goal of the program is to enhance livelihood and resource security for the upland poor in Asia, and maintain or enhance environmental functions (De los Angeles 2007). Opportunities exist for local farmers to maintain or restore local agro-ecosystem functions that protect watersheds, conserve biodiversity and sequester carbon. These include financial incentives and resource security that promote conservation. In addition, new market mechanisms that have the potential to reward the upland poor communities for effective and sustainable natural resources management, are emerging. These opportunities are supported by the global political commitment of halving poverty by 2015 (RUPES c2002). Similar topic is currently reviewed by FAO (2006).

A PES program was implemented in Costa Rica in 1996 where a range of environmental services (including carbon fixation, hydrological services, biodiversity protection and scenic beauty enhancement) derived from natural forests, tree plantations and agroforestry systems were identified (Subak 2000). Payments were made for these services, which obviously widens the livelihood opportunities of the local farmers. Redondo-Brenes and Welsh (2006) reported that as a component of PES program, private companies support the program through signed agreements with FONAFIFO that promotes watershed conservation in Costa Rica. The hydroelectric power company Energia Global is paying US$10/ha/yr for the protection of 1818 ha near the San Fernando River watershed and 2493 ha around the Volcan River. Plantanar, another hydroelectric power company, is paying between US$15/ha/yr and US$30/ha/yr to protect 3654 ha in the Plantanar watershed. The State Power Producer (CFNL) is paying US$40/ha/yr to protect 10,900 ha around the Balsa Superior River, the Aranjuez River and the Cote Lake (Redondo-Brenes and Welsh 2006). If similar program would be established in the Philippines, there will be supplementary financial opportunities for smallholders protecting watersheds-a situation where both the watersheds and smallholders are benefited.

CONCLUSION AND RECOMMENDATIONS

The stored carbon was really huge and water quality of the study site was indeed superior. While the average carbon storage of the Philippine grasslands is roughly 5MgC/ha., the site has 333.29 MgC/ha. The physico-chemical properties and naturally occurring heavy metals of surface water are within the acceptable range of the WHO (1993, 2004) and DAO 34 S1990. Therefore, algal bloom and heavy metal toxicity are not a threat to the local people dependent on water from the watershed. This impressive condition was made possible through the effort of the smallholders who are protecting the watershed against slash and burn farming, illegal logging and river poisoning. However, sustaining the enthusiasm of smallholders to keep protecting the watershed remains a great challenge. It is suggested that the government would consider rewards or livelihood opportunities for smallholders in relation to watershed protection. The government may also consider the emerging opportunities under the PES program as well as the global political commitment of halving poverty by 2015.

The smallholders are approximately 47% of the total population in the province of Leyte and roughly 46% in the entire country. Their contribution is therefore essential and substantial to bring back the critical watersheds in the Philippines into life-supporting ecosystems. This task is indeed enormous and complex and the involvement of the various stakeholders is indispensable. There is no other way for all the stakeholders or even the global community but to agree and devise ways and means to make watersheds resilient to degrading water-utilization schemes and climate change.

ACKNOWLEDGMENT

The author is grateful to the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), German Academic Exchange Service (DAAD) of the Federal Republic of Germany, and the Commission on Higher Education (CHED) of the Republic of the Philippines for the financial support. He is also indebted to Teodoro R. Villanueva, Wilfredo M. Carandang, Myrna G. Carandang, Juan M. Pulhin, Luz Asio and Cynthia Godoy for their technical assistance. Likewise, to the people's organization (CSVFA) for allowing the author conduct research in their CBFM project.

LITERATURE CITED

Asio, V.B., 1996. Characteristics, weathering, formation, and degradation of soils from volcanic rocks in Leyte, Philippines. PhD Dissertation. Institut Fur Bodenkunde und Standortslehre, Universitat Hohenheim (310), Stuttgart, Germany.

Brown, S. 1997. Estimating biomass and biomass of tropical forest: a primer. FAO Forestry Paper No. 134, Rome: Food and Agriculture Organization. 55p.

Cairns, M.A., S. Brown, E.H. Helmer and G.A. Baumgardner. 1997. Root biomass allocation in the world's upland forests. Oecologia. 111: 1-111.

Chiong-Javier, M. (2001), 'Local organizations in the upland natural resources management in the Philippines: Country Overview', a paper presented to the SANREM Conference on Local Governance of Natural Resource Management in Southeast Asia, Manila, 28−30 May 2001.

CRMF, c2002. Community-based forest management project profile. Cienda-San Vicente Farmers Association, Cienda, Gabas, Baybay, Leyte.

De Los Angeles, M. (2007), Personal communication, Environmental Economic Consultant, World Bank Institute, Washington DC.

DENR Administrative Order 34 S 1990. Revised water usage and classification. Water quality criteria amending section numbers 68-69, chapter III of the NPCC rules and regulations. Visayas Avenue, Diliman, Quezon City.

Dzurik, A.A. 2003. Water resources planning. Rowman and Littlefield Publishers, Inc.

ENCARTA ENCYCLOPEDIA, 2005. Nutrients and heavy metals in water. All rights reserved.

FAO, 2006. Better Forestry, less poverty: a practitioners guide. FAO Forestry Paper 149. Viale delle Terme di Caracalla, 00100 Rome, Italy.

FAO, 2006. The new generation of watershed management programmes and projects. FAO Forestry Paper 150. Viale delle Terme di Caracalla, 00100 Rome, Italy.

Harrison, S.R., Emtage, N.F. and Nasayao, B.E. (2005), 'Past and present forestry support programs in the Philippines, and lessons for the future', Small-scale Forest Economics, Management and Policy, 3(3): 303-317.

Hougthon, J.T., F.L.G. Meira, B. Lim, K. Treanton, I. Mamaty, Y. Bonduki, D.G. Griggs and B.A. Callander (Eds.). 1997. Greenhouse Gas Inventory Workbook. Intergovernmental Panel on Climate Change. Paris, France: Organization of Economic Co-operation and Development (OECD) and the International Energy Agency (IEA).

IPPC (Intergovernmental Panel on Climate Change) (2007), 4th Assessment Report, 'http://en.wikipedia.org/wiki/IPCC_Fourth_Assessment_Report', accessed 23 April 2007.

Landon, J.R. 1991. Booker tropical soil manual. Longman Scientific and Technical. Longman Group UK Ltd.

Lasco, R.D. 2003. Laboratory Guide on Forest Soils and Climate Change. Los Baños: Institute of Renewable Natural Resources. College of Forestry and Natural Resources. UP Los Baños, Laguna, Philippines.

Lasco, R.D. and F.B. Pulhin 2000. Forest land-use change in the Philippines and climate change mitigation. Mitigation and Adaptation Strategies to Global Change Journal 5: 81-97.

Lasco, R.D. and R.F. Sales. 2003. Estimating carbon storage and sequestration of Philippine forest ecosystems. Smallholder Forestry Research Paper Series. Los Banos: College of Forestry and Natural Resources, Leyte State University, Baybay, Leyte.

Lean, G., Hinrichsen, D. and Markham A. (1990), *WWF Atlas of the Environment*, Prentice Hall, New York.

Magcale-Macandog, D.B. (2000), 'Status of the GHG inventory for the LUCF sector in the Philippines, Thailand, and Indonesia', Proceedings of the IGES/NIES Workshop on GHG inventories for Asia-Pacific Region, Institute for Global Environmental Strategies, Japan.

PAGASA (Philippine Atmospheric, Geophysical and Astronomical Service Administration) Agrometeorology Station (2007), 'Average annual rainfall and temperature in midwestern Leyte', Leyte State University, Baybay, Leyte.

Press, F. and R. Siever, 1994. Understanding earth. WH Freeman and Co.

RAP Publication 2005/02. In Search of Excellence: Exemplary Forest Management in Asia and the Pacific. P. Durst, C. Brown, H.D. Tacio and M. Ishikawa Eds. Asia-Pacific Forestry Commission. FAO Regional Office for Asia and the Pacific, Bangkok.

Rebugio, L.L., et al. 2005. Forest Restoration in the Philippines: A Review for Research and Development Initiatives. Los Baños: College of Forestry and Natural Resources, UPLB. ASEAN-KOREA Environmental Cooperation Project.

Redondo-Brenes, A. and Welsh, K. (2006), 'Payment for hydrological environmental service in Costa Rica: The Procuencas Case Study', in *Tropical Resources Bulletin*, Vol. 25, Yale Tropical Resources Institute, Yale School of Forestry and Environmental Studies, Yale University, New Haven, Connecticut.

RUPES (c2002), 'Primer on Developing Mechanisms for Rewarding the Upland Poor in Asia for Environmental Services They Provide', World Agroforestry Centre, Los Baños, Laguna, the Philippines.

Sales-Come, R. F. 2004. Personal communication. Researcher, Environmental Forestry Program (ENFOR), University of the Philippines Los Baños. Laguna, Philippines.

Subak, S. (2000), 'Forest protection and reforestation in Costa Rica: Evaluation of a clean development mechanism prototype', *Environmental Management*, 26(3): 283−297.

Tomar, M. 1999. Quality assessment of water and wastewater. Lewis Publishers.

Van Noordwijk, M. (2007), Personal communication, ICRAF Regional Coordinator for Southeast Asia, Bogor, Indonesia.

World Health Organization, 1993. Revised guidelines for drinking water quality (184). Geneva, Switzerland.

World Health Organization, 2004. Guidelines for drinking water quality. Third Edition. Geneva, Switzerland.

www.carbonfinance.org, 2007, World Bank-Supported GHG emission reduction projects in the Philippines, accessed September 5, 2007.