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Environmental Services from a Smallholder-Protected Forest Ecosystem in Midwestern Leyte Province, Philippines

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The Community-Based Forest Management (CBFM) Project in Midwestern Leyte Province was studied to assess the following environmental services: 1) carbon storage, 2) biodiversity conservation, and 3) soil and water conservation. 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. A total of 1,903 plants belonging to 325 species and 94 animal species were recorded based from actual survey and ethno-faunal assessment. Soil and water resources of the site were in good condition. Soil had an average bulk density of 0.70 Mg/m3, while infiltration rate ranged from 326.10 ml/min during the dry season to 68.09 ml/min during the wet season. Surface runoff was 10 m3/ha and sediment yield 0.17 Mg/ha. Water quality was in superior condition though trace amount of heavy metals were detected.

Introduction

Forests 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 has designed various programs to protect and conserve the remaining forest[1]. The Community-Based Forest Management Program (CBFMP) introduced in 1995 in particular recognized the indispensable role of the local people in managing the remaining forest resources in the country.

In recent years, the focus on forest management and conservation has shifted from the highly technical commercial forestry to a more people-oriented social forestry. Gone are the days when forestry was looked upon as solely management and utilization of trees by large-scale timber product-oriented logging corporations to meet demands for wood and wood-based products. The more recent scenario is a paradigm shift in the forestry sector to small-scale, multiple-product-based, people-oriented, and community-based sustainable forest management (Mangaoang 2002). The concern to improve the socio-economic condition of the rural populace and particularly the smallholders, however, still remains a challenging issue for the Philippine Government. Despite the effort of the Philippine Government to improve the per capita income of the Filipinos, many are still within the poverty line. In selected barangays in Baybay, Leyte, the mean annual income of small-scale farmers ranged only from PHP46,434 to PHP76,217 (Pasa 2006). In Leyte Province, average annual family income from 1994 to 2000 ranged only from PHP51,042 to PHP93,251 while the per capita poverty threshold for rural areas as of 2000 was PHP9,725 with a poverty rating of 47.6%. This implies that nearly half the people in rural areas of the province can be

[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).

considered poor (Emtage and Suh 2005). This also implies some challenges to improve their level of income.

Based on the four Barangays surveyed by Emtage and Suh (2005), households manage on an average of 2.91 ha of farmland, and own about 1.44 ha of this land. With the limited land area, small-scale farmers in Leyte are left behind in the socio-economic race. Adding value to their goods and services is viewed as an important element in enhancing socio-economic status of Philippine farmers (Aggangan and Faylon 2005). Another opportunity where farmers could increase their annual income is through some form of payment for the environmental services they provide (positive externalities of spillover benefits), since vegetation in their small-scale forest farms, agroforestry farms and Community-Based Forest Management Projects undoubtedly sequester and store carbon, enhance biodiversity as well as conserve soil and water resources.

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). However, the assessment of environmental services from smallholder-protected forest ecosystems, particularly in the Province of Leyte remains a challenging task, hence this study. The research was aimed to contribute information to policy makers for facilitating payments for environmental services to widen the livelihood opportunities of smallholders and promote sustainable land management in the Province of Leyte, Philippines.

Research Method

Study Site

The site of this study was the 2236 ha Community-Based Forest Management (CBFM) project, located in the contiguous area of Barangay Gabas and Barangay Kilim in Baybay, Leyte, Philippines. The site lies between 124°48' longitude and 10°43' latitude, having a climatic type IV with more or less evenly distributed rainfall throughout the year. 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°C and maximum is 33.67°C (PAGASA 2007).

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):

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

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):

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

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.

$$\text{Root biomass} = \text{Exp}\,[-1.0587 + 0.8836\ \ln\,(\text{AGB})] \qquad \text{(equation 3)}$$

Where: AGB= aboveground biomass

All biomass samples were oven-dried for four days at constant temperature of 103°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 eluvation and illuviation processes.

2. Biodiversity Assessment

Biodiversity assessment under this study focused only on the macro-floral and macro-faunal species of the site.

2a. Flora

The 27 (20m x 20m) main plots used for carbon stocks assessment were used to determine the biodiversity of macro-flora in the study site. All plants (except for seedlings 15 cm and below in height which are very difficult to identify) were identified and their frequency of occurrence recorded. Sample specimens for unidentified species were collected and brought to the herbaria of the College of Arts and Sciences and the College Forestry and Natural Resources at the Visayas State University for identification. Other unidentified specimens were brought to UPLB, Laguna and identified by Mr. Blass Hernaez of the College of Arts and Sciences. Plant taxonomy books and other related illustrated references which included Salvosa (1963), de Guzman *et al.* (1986), de Guzman and Fernando (1986), Santos (1986), Zamora and Co (1986), Fernando *et al.* (2004), were also used to identify unknown specimens. The remaining unidentified specimens were labeled according to their local names or chronological numbers for biodiversity index calculation.

The following formulas were adopted with modifications from Caldas *et al.* (2000):

a. Population density = $\frac{\text{Number of individuals per species in sampling area}}{3600 \text{ m}^2}$ (equation 5)

Where: 3600 m^2 = aggregate area of the nine sampling plots in each zone

b. Relative density = $\frac{\text{Number of individuals per species}}{\text{Total number of individuals for all species}}$ (equation 6)

c. Shannon-Weiner Index of Diversity (H)

$$H' = -\sum_{i=1}^{S} Pi(\ln Pi)$$ (equation 7)

Where: S = number of species

Pi = proportion of total sample belonging to ith species (use relative density)

d. Shannon-Weiner Index of Evenness (J)

$$J = \frac{H'}{H'max} = \frac{H'}{\log_e S} = \frac{H'}{\ln S}$$ (equation 8)

e. Simpson Index of Dominance (C)

$$C = \sum_{i=1}^{S} Pi^2$$ (equation 9)

f. Simpson Index of Diversity (D)

$$D = \frac{1}{C}$$ (equation 10)

2b. Fauna

Primary data for the different mammals, birds, reptiles and amphibians in the study site were gathered through actual survey while secondary data were gathered through key informant interviews (i.e. triangulation approach). Photographic guides and illustrated references of different Philippine faunal species which included Buckles (undated), Rabor (1986), Alcala (1986), Fisher and Hicks (2000), Bartlett *et al.* (2001) and Lastica (2005) were used as references during the interviews.

3. Soil and Water Conservation Assessment

3a. Soil Physico-Chemical Properties

Soil samples were obtained from the randomly selected 1, 5, 9 plots within each zone. The said samples were brought to the Soil Science and Analytical Service Laboratory of the Philippine Root Crops Research Center (ASL-PRCRTC) and analyzed for texture, pH, bulk density, organic matter, carbon (10-20 cm), nitrogen, phosphorus, potassium, calcium, magnesium, and sodium content.

3b. Infiltration Rate

Infiltration rate was assessed using the single-ring infiltrometer made of galvanized iron (GI) pipe. One-third of its total height (10 cm) was driven unto the ground and a measured volume of water (300 ml) was poured into it. Time spent for water infiltration was read simultaneously. The first assessment was done during summer (month of May) while the second assessment was conducted during the rainy season (month of November).

3c. Surface Runoff and Sediment Yield Analyses

Surface runoff and the associated sediment yield were assessed using the runoff plots described by Cruz (1994), Kelly and Gomez (1998), and Ciesiolka and Rose (1998). In each zone, three runoff plots measuring 4 m x 8 m were laid out parallel to the slopes. Thirty-cm wide plane galvanized iron (GI) strips were used as boundary on all its sides with the lower portion strategically opened and connected to a gutter directed towards a receiving 100-L drum or container.

About half of the width of GI sheets (15 cm) was buried into the soil while the remaining half extended above the soil surface to prevent the outflow and inflow of water from and to the plots. These runoff plots were established along the three zones with homogenous slopes to facilitate the comparative analyses.

Surface runoff produced after rainfall event was measured from the receiving drum or container below each plot. Eroded soil sediments from the said plots were determined (volumetrically and gravimetrically) at the end of every rainfall event. One-L aliquots from the thoroughly agitated runoff from the receiving drums were taken for sediment determination and analyses. All the receiving drums were then drained of runoff water for the next runoff and sediment samplings.

The sediment yield from the 1-L aliquots was determined at the Soil Science Analytical Services Laboratory of the Visayas State University. The Whatman micro-fiber filter paper was used to sieve the soil sediments from the samples. The filtered soil sediments were oven-dried and weighed. The total amounts of sediments per plot and per ha were calculated using simple ratio and proportion. Nutrients associated with surface runoff were also determined using water from the 1-L aliquot obtained from the agitated runoff sample. The analyses included nitrogen, phosphorus, potassium, calcium, magnesium, and sodium.

3d. Water Yield Analyses

Water samples were collected, employing stratified sampling technique, at strategic locations within the river system of the study site using sterilized plastic bottles. Samples were immediately brought and analyzed for the associated nutrients, sediments, hardness, turbidity, and heavy metals at the ASL-PRCRTC. Samplings were undertaken three times within the research period from June to November of 2005. The analyses included nitrogen, phosphorus, potassium, calcium, magnesium, sodium and heavy metals.

Results and Discussion

1. Carbon Stocks Assessment

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 cause 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.

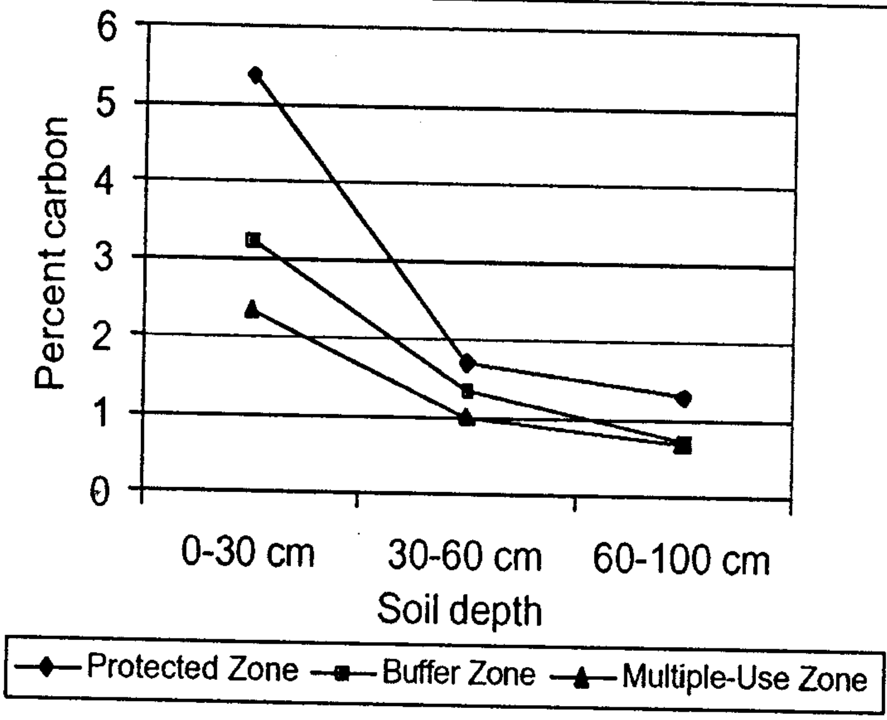
The understorey biomass carbon only showed slender variation as compared with the upperstorey biomass carbon. The multiple-use had slightly more carbon stocks among the three zones, which could be attributed to some sturdy understorey plants. However, the stock of leaf biomass carbon within the understorey 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).

Figure 1: Percent Carbon Found at Various Soil Depths Within the Different Zones of the Study Site



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 2: Total Carbon Density Within the Different Zones of the Study Site

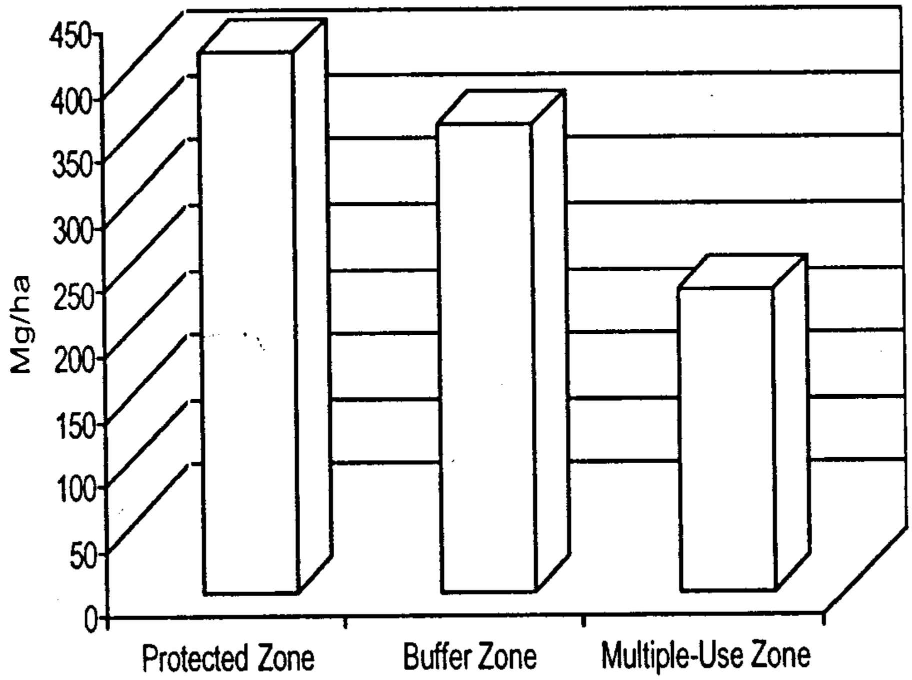


Table 1: Total Carbon Stocks Within the Different Zones of the CBFM Project (2005)

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 equation3)*	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

+ Number followed by a common letter is not significantly different based on HSD at 5%

2. Biodiversity Assessment

2a. Flora

The assessment of floral diversity within the different zones of the CBFM Project showed that the site contained various species of plants. A total of 1,903 plants belonging to 325 species were recorded during the actual field data collection from three zones. The protected zone contained the most number of trees per ha followed by the buffer zone and then the multiple-use zone. On the other hand, there were more shrubs found in the multiple-use zone than in the other zones (Table 2) which could be due to the previous cutting operation. However in a per hectare basis, there were more plants in the buffer zone followed by the protected zone and then the multiple-use zone.

Table 2: Total Count by Category of Floral Species Recorded Within the Different Zones of the CBFM Project (2005)

Plant Category	Location/Plant Count		
	Protected Zone	Buffer Zone	Multiple-Use Zone
Trees	477	455	355
Shrubs	38	34	62
Herbs	42	52	52
Palms	18	34	16
Vines/Liana	23	31	51
Grasses/Sedges	5	14	12
Ferns	42	56	31
Epiphytes/Orchids	3	0	0
Total (within nine plots)	648	676	579
Total (per ha)	~1800	~1878	~1609

~rounded to nearest whole number.

In terms of species richness, the multiple-use zone contained the most numerous species followed by the buffer zone and then the protected zone (Table 3). It appeared that a certain site like the multiple-use zone under this study would become more diverse if it is subjected to some form of disturbance and then allowed to regenerate naturally. As mentioned earlier, the multiple-use zone was the most disturbed among the three zones but amazingly it contained more plant species.

The buffer zone, which ranked second in species richness, had also undergone some degree of perturbations but lesser in intensity compared to the multiple-use zone. Some portions along the slopes were actually slashed and burnt before. It was quite fortunate that the considerable distance of that zone from the lowland and the presence of wild pigs that consumed the root crops and bananas in all farms have discouraged the local people from expanding their farming system. Some farmers have also migrated to other places looking for better livelihood opportunities, thus abandoning some cultivated areas in the said zone. These situations have given the vegetation the opportunity to regenerate naturally.

The protected zone had the least number of species among the three zones. This could be due to the absence of disturbance compared to the other two zones or to the presence of more dominant species that have limited the opportunity of other species to occupy and flourish within the site.

In terms of diversity using both Shannon-Weiner and Simpson indexes, the multiple-use zone showed the highest value followed by the buffer zone and then the protected zone. On the other hand, the Simpson index of dominance showed an opposite trend. The dominance value for the multiple-use zone was the lowest while the protected zone was the highest (Table 3).

Table 3: Diversity Indices per Category of Floral Species Found in the Different Zones of the CBFM Project (2005)

Biodiversity Indexes	Protected Zone	Buffer Zone	Multiple-use Zone
Number of Species	174	182	193
Population Density (plants per ha)	1800	1878	1609
Shannon-Weiner Index of Diversity	1.097	1.192	1.306
Shannon-Weiner Index of Evenness	0.213	0.229	0.248
Simpson Index of Dominance	0.655	0.473	0.407
Simpson Index of Diversity	1.526	2.113	2.455

2b. Fauna

The site is a haven to various species of mammals, birds, amphibians, and reptiles. A total of 94 species were recorded throughout the conduct of this research, namely: 1) mammals with 11 species belonging to nine families, 2) birds with 40 species belonging to 20 families, 3) reptiles with 16 species belonging to nine families, and 4) amphibians with 27 species belonging to five families.

Observed during the survey included the Philippine monkey (*Macaca fascicularis*), Philippine flying fox (*Pteropus vampyrus*), water monitor (*Varanus salvator*), common field rats (*Rattus rattus*), endangered rufous (*Bucerous hydrocorax*) and tarictic (*Penelopides panini*) hornbills, swiflets (*Collocalia esculenta*), flying lemur (*Cyanocephalus volans*), reticulated python (*Python reticulata*) and venomous viper (*Trimeresurus flavomaculatus*). Ethno-faunal assessment also revealed that indeed the site is a refuge to various species of animals (Table 4).

Table 4: Faunal Species Observed and Ethno-faunally Assessed Within the CBFM Project Site

Common Name	Scientific Name	Family Name	Basis
Mammals			
Philippine Monkey	Macaca fascicularis	Cercopithecidae	O
Philippine Deer	Cervus mariannus	Cervidae	E
Philippine Flying Lemur	Cyanocephalus volans	Cyanocephalidae	O
Philippine Field Rat	Rattus rattus	Muridae	O
Philippine Flying Fox	Pteropus vampyrus	Pteropidae	O
Fruit Bat	Rousettus sp.	Pteropidae	O
Tree Squirrel	Sundasciurus philippinensis	Sciuridae	E
Philippine Warty Pig	Sus barbatus	Suidae	E
Philippine Tarsier	Tarsius syrichta	Tarsiidae	E
Malay Civet	Viverra tangalunga	Viverridae	E
Common Palm Civet	Paraduxuros philippinensis	Viverridae	E
Avian/Birds			
Osprey	Pandion haliaetus	Accipitridae	E
Philippine Hawk Eagle	Spizaetus philippinensis	Accipitridae	E
Philippine Falconet	Microhierax erythrogenys	Accipitridae	E
Crested serpent eagle	Spilornis cheela	Accipitridae	E
Philippine dwarf kingfisher	Ceyx melanurus	Alcedinidae	E
Swiftlet	Collocalia esculenta	Apodidae	O
Rofous Hornbill	Bucerous hydrocorax	Bucerotidae	O

Contd...

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Tarictic hornbill	Penelopides panini	Bucerotidae	O
Philippine Nightjar	Caprimulgus manillensis	Caprimulgidae	E
Emerald Dove	Chalcophalps indica	Columbidae	O
White-eared brown dove	Phapetriron leucotis	Columbidae	O
Zebra dove	Geopelia striata	Columbidae	O
Reddish coco dove	Macropygia phasianella	Columbidae	E
Pompadour green pigeon	Treron pompadora	Columbidae	E
Spotted dove	Stretopelia chinensis	Columbidae	O
Common crow	Corvus macrorhynchos	Corvidae	O
Philippine coucal	Centropus viridis	Cuculidae	O
Philippine Fairy Bluebird	Irena cyanogaster	Irenadae	O
Olive backed sunbird	Nectarinia jugularis	Nectariniidae	O
Gray-hooded sunbird	Aethopyga primigenius	Nectariniidae	O
Metallic-winged sunbird	Aethopyga pulcherrima	Nectariniidae	O
Black-naped oriole	Oriolus chinensis	Oriolidae	O
Wild chicken	Gallus gallus	Phasianidae	E
White-bellied Woodpecker	Dryocopus javensis	Picidae	E
Frogmouth	Batracostomus septimus	Podargidae	O
Guaiabero	Bolbopsittacus lunulatus	Psittacidae	E
Collasisi /Parakeet	Lariculus philippinenesis	Psittacidae	O
Blue crowned racquet tail	Prioniturus discurus	Psittacidae	O
Blue-crowned Racquet	Prioriturus discursus	Psittacidae	O
Yellow vented bulbul	Pycnonotus goiaver	Pycnonotidae	E
Philippine bulbul	Hypsipetes philippinus	Pycnonotidae	O
Common moorhen	Gallinula chloropus	Rallidae	E
White-breasted waterhen	Amaurornis phoenicurus	Rallidae	E
Asian glossy starling	Aplonis panayensis	Stumidae	O
Coleto	Sarcops calvus	Stumidae	E
Streaked ground babbler	Ptilocichla mindanensis	Timaliidae	E
Leyte Tit Babbler	Macronous leytensis	Timaliidae	E
Philippine Eagle Owl	Bubo philippinensis	Tytonidae	E
Grass owl	Tyto capensis	Tytonidae	E
Philippine Scops-owl	Otus megalotis	Tytonidae	E

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Reptiles			
Leyte Catsnake	Bioga angulata	Colubridae	E
Elongated-headed tree snake	Ahaetulla prasina	Colubridae	E
Arboreal rat snake	Gonyosoma oxycephalum	Colubridae	O
Sailfin Water Lizard	Hydrosaurus pustulatus	Agamidae	O
Common Flying Lizard	Draco spiloptera	Agamidae	O
Yellow-gray banded snake	Calliophis calligaster	Elapidae	O
Common Cobra	Naja naja	Elapidae	O
King Cobra	Ophiophagus hannah	Elapidae	E
Fresh-water Turtle	Cuora amboensis	Emydidae	E
Common Gekko	Gekko gecko	Gekkonidae	O
Common House Gecko	Hemidactylus frenatus	Gekkonidae	O
Reticulated Python	Python reticulatos	Pythonidae	O
Common Mabouya	Mabuya multifaciata	Scincidae	O
Green Tree Skink	Lamprolipes smaragdina	Scincidae	O
Water Monitor	Varanus salvator	Varanidae	O
Pit Viper	Trimeresurus flavomaculatus	Viperidae	O
Amphibians			
Common Toad	Bufo marinus	Bufonidae	O
Truncate-toad narrow mouthed frog	Kaloula conjuncta	Microhylidae	O
Slender digit narrow mouthed frog	K. picta	Microhylidae	E
Narrow mouthed frog	K. walteri	Microhylidae	E
Malayan horned frog	Megoprys montana	Pelobatidae	O
Pelobatid frog	Leptobrachium visayanus	Pelobatidae	O
Corrugated forest frog	Platymantis corragatus	Ranidae	E
Common forest ground frog	P. dorsalis	Ranidae	E
For further identification	P. luzonensis	Ranidae	E
Isolated forest frog	P. insulatus	Ranidae	E
Negros cave frog	P. spelaeus	Ranidae	E
For further identification	P. sp	Ranidae	E
Giant Philippine frog	Rana magna magna	Ranidae	E
Variable back frog	R. signata	Ranidae	E
For further identification	R. vittigerra	Ranidae	E

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Contd...			
Woodworth's frog	R. woodworthi	Ranidae	E
Green Paddy Frog	R. earythraea	Ranidae	O
Common Green Frog	R. everitti	Ranidae	E
For further identification	R. mangyanurum	Ranidae	E
For further identification	R. similis	Ranidae	E
For further identification	R. sp	Ranidae	E
Small-headed Frog	Occidozyga laevis	Ranidae	O
Common Tree frog	Polypedates leucomystax	Rhacophoridae	E
Rough-armed tree frog	Rhacophorus apendiculatus	Rhacophoridae	E
Variegated tree frog	Philautus bimaculatus	Rhacophoridae	E
Gliding Tree Frog	R. pardalis	Rhacophoridae	E
Spiny tree frog	Edwardtayloria spinosa	Rhacophoridae	O
O=Observed; E=Ethno-faunally assessed.			

The floral and faunal diversity in the area was maintained through the relentless effort of the people's organization to guard the project site. Although the site is already a secondary forest (but with lesser degree of perturbations as compared with the mountain ecosystems of Southern Leyte and large portion of Northern Leyte), the results from this study revealed the astounding ecological condition of the area. Hence, the said area at present is a rich gene bank of various species of plants and animals that can regenerate the nearby environs as the need arises. Some Japanese and Filipino scientists who made a short scientific investigation of the site were impressed by the local people's efforts in protecting the forest. They subsequently published their findings under the United Nations University Press (edited by Velasquez *et al.* 2005) to attract more agencies to support the sustainable management of said CBFM project. The same project was nominated as one of the exemplary forest management in Asia and the Pacific (see RAP Publication 2005/02 by Durst *et al.* of FAO).

3. Soil and Water Conservation Assessment

3a. Soil Physico-Chemical Properties

The site had a moderately acidic soil pH ranging from 5.10 to 6.57 based from the pH category of Landon (1991). The study of Asio (1996) on the soils of the adjacent mountain ecosystem corroborates such findings. In his analysis, he obtained acidic pH values ranging from 4.0 to 5.20. Worldwide observation also revealed that tropical soils are usually acidic due to organic acid formation from plant and animal debris as well as the occurrence of high rainfall that removes basic substances through leaching, surface runoff, and soil erosion.

Soil texture ranged from silt loam, sandy loam to clayey. The protected zone contained the highest percentage of silt; the multiple-use zone had the highest percentage of sand; and the buffer zone had the highest percentage of clay. Bulk density ranged only from 0.61 to 0.78 Mg/m^3 implying that the area was not subjected to various forms of compaction-enhancing perturbations. The protected zone contained the highest percentage of carbon and organic matter followed by the buffer zone and then the multiple-use zone. Since the presence of organic matter is also indicative of the nitrogen present in the soil, it was noticed that nitrogen level within the different zones showed the same trend as the organic matter. Other nutrients were also present at variable concentrations but sufficient enough to support the growth of plants (Table 5).

Table 5: Physico-Chemical Properties of Soil within the Different Zones of the Study Site

Parameters	Location		
	Protected Zone	Buffer Zone	Multiple-Use Zone
pH	5.97	5.10	6.57
Texture			
Upper slope	Silt loam	Clay	Sandy loam
Middle slope	Loam	Silt loam	Clay loam
Lower slope	Silt loam	Loam	Sandy loam
Bulk Density (Mg/m^3)	0.72	0.61	0.78
Carbon%(10-20 cm depth)	5.80	4.59	2.98
Organic Matter%	10.00	7.92	5.14
Total N%	0.67	0.58	0.29
P (mg/kg)	144.00	162.00	265.00
K (mg/kg)	627.83	260.97	269.05
Na (mg/kg)	159.80	125.79	136.77
Ca (mg/kg)	2107.50	1354.25	5208.25
Mg (mg/kg)	471.53	359.95	848.54

3b. Infiltration Rate

The different zones showed different infiltration rates. The protected zone had an average infiltration rate of 498.58 ml/min during the summer period but only 86.34 ml/min during the wet season. The buffer zone had the lowest infiltration rate among the three zones possibly because of the high clay percentage of the soil in the area. Clay has finer particles characterized by high cohesion and retention of water molecules, therefore limiting the movement of such substance into and within the ground. The multiple-use zone, on the other hand, which had sandy loam to clay loam, had higher infiltration rates than the buffer zone (Table 6).

Table 6: Infiltration Rate of the Ground Surface Within the Different Zones of the Study Site

Parameters	Location		
	Protected Zone	Buffer Zone	Multiple-Use Zone
Dry Season			
Infiltration Rate (ml/min)	498.58	110.28	369.43
Soil moisture%	51.42	62.23	22.07
Wet Season			
Infiltration Rate (ml/min)	86.34	6.89	111.04
Soil moisture%	69.59	77.37	34.36

3c. Surface Runoff and Sediment Yield

The buffer zone generated the highest amount of surface runoff among the three observation sites (Table 7) followed by the protected zone and then the multiple-use zone. As surmised earlier, the clayey soils in the buffer zone could have impeded the infiltration process, thus causing more surface runoff. The high surface runoff from the buffer zone also carried the highest yield of sediments amounting to 23.83 g/L. Basically, the higher the rainfall, the higher the surface runoff as shown in Figure 3. The amount of sediments associated with surface runoff also showed a similar trend except for the protected zone which generated only a very trace amount (Figure 4). The presence of plant debris on the forest floor as well as the stratification of vegetation could be responsible for the diverse results.

Table 7: Infiltration Rate of the Ground Surface Within the Different Zones of the Study Site

Parameters	Location		
	Protected Zone	Buffer Zone	Multiple-Use Zone
Surface Runoff (L/plot)	25.14	57.10	17.16
Surface runoff (m^3/ha)	7.86	17.84	5.36
Sediment Yield (g/L)	0.51	23.83	14.53
Sediment Yield (Mg/ha)	0.004	0.425	0.078

Figure 3: Rainfall and the Resultant Surface Runoff Within the Three Zones

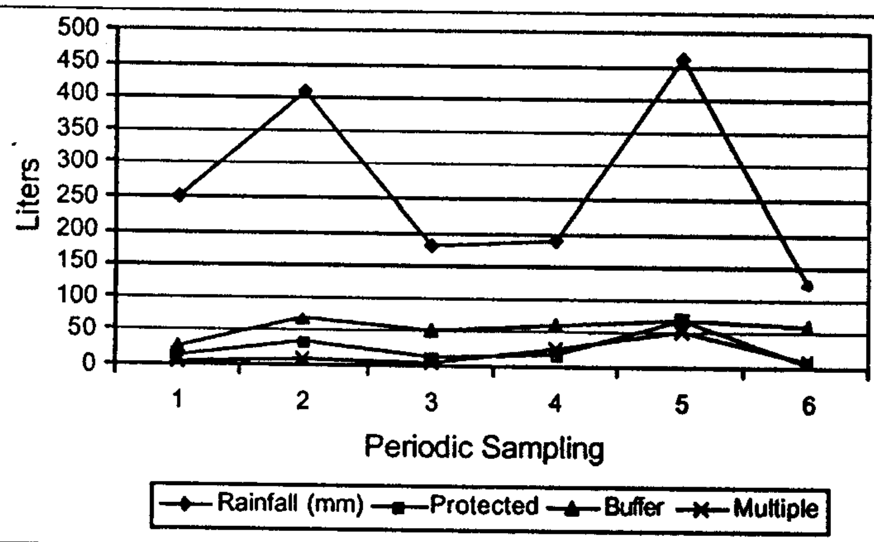
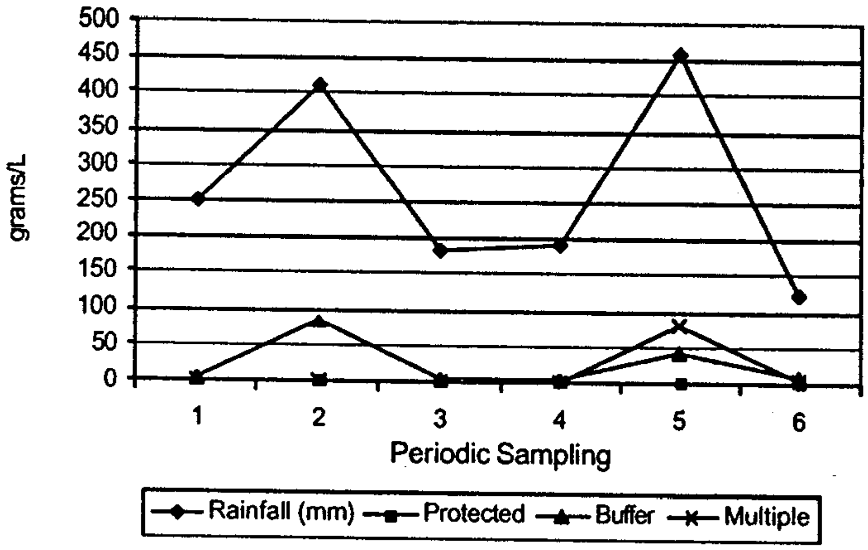


Figure 4: Rainfall and the Associated Sediment Yield of Surface Runoff



Based on the result, the lowest surface runoff occurred within the multiple-use zone followed by the protected zone and then the buffer zone. As to the soil type, the multiple-use zone was dominated largely by sandy loam soil which is expected to absorb or infiltrate considerable volume of water, hence the lesser surface runoff. The protected zone, on the other hand, had silty loam soil with lesser infiltration but with higher surface runoff than the soil in the multiple-use zone. The buffer zone, having the highest amount of clay, showed the highest amount of surface runoff and least infiltration rate. Such findings corroborated the observations of Ward (1967).

The pH of runoff water ranged from 7.05 to 7.12, a bit higher than the soil pH values. The nitrogen present was very low (Table 8). Nitrogen is a volatile substance and its concentration is expected to be lower compared to the soil nitrogen content. Within the soil, nitrogen is largely stored in the organic matter or decaying debris. Hence, the soil nitrogen was higher compared with the nitrogen in the runoff water. Phosphorus, potassium, sodium, calcium, and magnesium also had lower concentration in runoff water compared with that in the soil.

Table 8: Chemical Properties of Surface Runoff Water Within the Different Zones of the Study Site

Parameters	Location		
	Protected Zone	Buffer Zone	Multiple-Use Zone
pH	7.12	7.07	7.05
Total N%	0.010	0.011	0.019
Total P (mg//kg)	0.194	0.039	0.178
Total K (mg/kg)	54.725	16.478	18.314
Total Na (mg/kg)	2.822	1.208	1.980
Total Ca (mg/kg)	12.596	5.969	10.623
Total Mg (mg/kg)	1.984	1.015	2.096

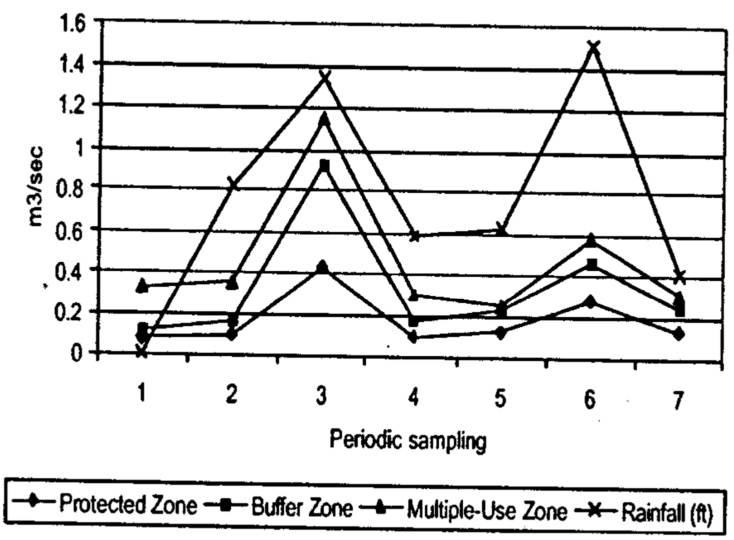
3d. Water Yield

The pH value of water along the river system ranged from 7.504 to 7.610 (Table 9). Based from DAO 34 (S 1990) and WHO (1993), such value is still within the allowable range for class AA waters. This means that the river water within the study site is in superior condition in terms of pH. Contrary to the pH value of soil within the study site, the pH of the river water samples was higher.

Such condition could be attributed to basaltic geochemistry of the parent material of the site as revealed by Asio (1996) as well as to the absence of factories, mining plants, and other possible contributory agents of acidity and pollution.

The odor and taste of water were unobjectionable and turbidity level was below the maximum limit at 5 NTU. Average velocity was 0.303 m/sec and average volume of 0.318 m^3/sec (Figure 5). Figure 6 showed the average volume of streamflow within the three zones. It was obvious that the multiple-use zone had the highest volume because of the accumulation of water from the upper tributaries. In addition, the associated sediment yield on streamflow ranged only from 0.011 to 0.021 g/L while total hardness ranged only from 7.843 to 15.164 mg/L (Table 9). Based on DAO 34-S 1990 and WHO 1993, the site's sediment yield and hardness of water are still within the acceptable level. This means that the water quality of the site in terms of sediment yield and total hardness is in superior condition.

Figure 5: Rainfall Events and Streamflow Dynamics Along the River System of the Study Site



The nitrite (NO_2) content of streamflow ranged only from 6.906 to 15.321 ug/L which is far below based on the WHO's 1993 acceptable levels while nitrate (NO_3) ranged from only 0.820 to 1.282 mg/L, which is also far below from the WHO's 1990 standards. According to the World Resources Institute (1988-1989) cited by Lean *et al.*, (1990), 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). Thus, high concentration of such substance in water is hazardous to the consuming public. Fortunately, this study confirmed the safe quality of water from nitrite and nitrate content in the study site.

Figure 6: Streamflow Volume and the Associated Sediment Yield Along the River System of the Study Site

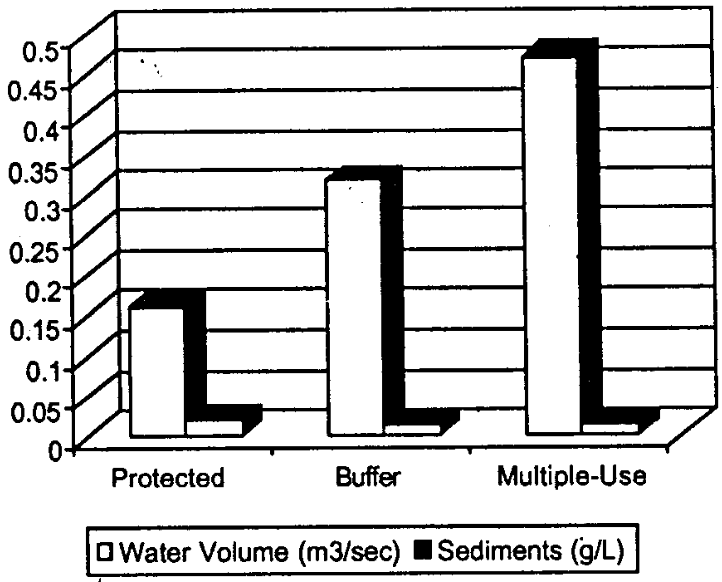


Table 9: Physico-Chemical Properties of Surface Water Along the River System of the Study Site

Parameters	Location		
	Protected Zone	Buffer Zone	Multiple-Use Zone
pH	7.510	7.504	7.610
Odor	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Unobjectionable	Unobjectionable	Unobjectionable
Turbidity (FTU)	3.260	3.250	2.650
Velocity (m/sec)	0.336	0.230	0.344
Volume (m3/sec)	0.162	0.319	0.474
Sediments (g/L)	0.021	0.012	0.011
Total Hardness (mg/L)	7.843	8.172	15.164

Contd...

Contd...			
NO_2 (ug/L)	7.740	6.906	15.321
NO_3 (mg/L)	1.282	1.696	0.820
Total P (mg/kg)	3.120	2.200	4.460
Total K (mg/kg)	3.904	3.708	3.884
Total Na (mg/kg)	4.753	3.969	4.902
Total Ca (mg/kg)	5.138	5.944	4.894
Total Mg (mg/kg)	2.057	1.545	1.879
Total Cd (mg/L)	0.003	0.004	0.006
Total Cu (mg/L)	0.058	0.026	0.029
Total Zn (mg/L)	0.088	0.077	0.079
Total Ni (mg/L)	nil	0.002	0.001

The amount of nutrients along the streamflow was also very low. Phosphorous (P) ranged only from 2.20 to 4.46 mg/kg or parts per million (ppm) while potassium (K) ranged from 3.708 to 3.904 ppm. Sodium (Na), calcium (Ca), and magnesium (Mg) concentrations were also very low (Table 10). This indicates the good quality of water in terms of nutrient level along the site's river system. As pointed earlier, the hardness of water was also very low, implying the low concentration of nutrients/ minerals. Algal bloom therefore is not a threat within the study site.

Trace amount of naturally occurring heavy metals were detected under this study. Cadmium (Cd) content of water ranged from only 0.003 to 0.006 mg/L which is within the acceptable level set under DAO 34-S 1990. High Cd can cause internal human disorders particularly liver and kidney, hence its high concentration is undesirable in water. In addition, there were lower concentrations of copper (Cu), zinc (Zn), and nickel (Ni). Cu content ranged 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.

Conclusion and Recommendations

The smallholder-protected forest ecosystem under this study revealed significant environmental services to society. Results from the investigations clearly showed the huge amount of carbon stock being stored at the various strata of the said ecosystem, thereby keeping such element from contributing the global warming phenomenon. There was also enormous, rare, and endangered species of flora and fauna maintained through the relentless efforts of the people's organization to guard the project site. Hence, the said area at present is a rich gene bank of various species of plants and animals that can sustainably regenerate the nearby environs. As mentioned, the site is already a secondary forest (but with lesser degree of perturbations as compared with the mountain ecosystems of Southern Leyte and large portion of Northern Leyte) but results from this study revealed the astonishing ecological condition of the area. The condition of both vegetation, soil and water resources was superior, thereby maintaining an impressive microclimate; balancing food webs, energy circuits and material cycle; and sustaining the essential and indispensable needs of society. Should local people under CBFM be rewarded then, to boost their enthusiasm in safeguarding the forests and sustain the associated environmental services? Who will give the rewards?

Further studies should be undertaken to determine whether selling of forest environmental services could really provide financial benefits to smallholders. One possible study using economic models is to make a comparative research (scenario-building) among or between carbon payments, biodiversity service payments, and/or water payments against the annual income from agronomic crops or pasture. This study can help identify what land use would enhance smallholders' income taking into consideration the sustainable generations of forest environmental services. At present, carbon trading is one of the promising developments in relation to environmental services program. Recently the World Bank reported that carbon market grew in value and carbon prices are getting higher. But there seem to be many trading impediments that need to be uncovered along this line. If properly implemented coupled with equitable and transparent trading mechanisms, both smallholders and the environment will obviously obtain benefits from these mechanisms.

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