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CARBON UPTAKE OF SAMAR ISLAND'S FOREST/BIOMASS: A PRELIMINARY ESTIMATION[1]

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CARBON UPTAKE OF SAMAR ISLAND'S FOREST/BIOMASS: A PRELIMINARY ESTIMATION[1]

by

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CARBON UPTAKE OF SAMAR ISLAND'S FOREST/BIOMASS: A PRELIMINARY ESTIMATION

1. BACKGROUND

The protection of the climate system, which sustains life on Earth, has become one of the paramount objectives of the global community as exemplified in the United Nations Framework Convention on Climate Change (UNFCCC). The continuing destabilization of the climatic balance, manifested in the progressive rise of greenhouse gases (GHGs) in the atmosphere, is traced to anthropogenic activities such as, among others, fossil fuel combustion, land use conversion and deforestation. It has been acknowledged that such human interference with the climate system may increase the likelihood of certain climatic events to occur at an accelerated rate, affecting the intrinsic capacity of the biosphere to adapt for survival. To arrest this trend that is brought about by unsustainable modes of development, the preservation of tropical forests has been identified as one of many ways that provide a high potential to sequester carbon and thus reduce global atmospheric levels of one of the most potent GHGs – carbon dioxide.

Forests can absorb and release carbon dioxide through the natural processes of photosynthesis, respiration and decomposition. Considering the inherent balance of these processes, it has been demonstrated that about 50 percent of organic matter is composed of carbon (Lasco, 1999). Castro (2000) likewise reports that the carbon content of a whole-tree biomass is 50 percent. The same report also assumes that timber harvesting releases about 75 percent of carbon in tree biomass back into the atmosphere. Deforestation, therefore, eliminates a potentially significant means of suppressing the rise in GHG concentrations.

The conservation of the forest and other biological resources is one of the management options being explored for the Samar Island Forest Reserve (SIFR), which would consequently preserve the associated ecological services it provides. In view thereof, it is the objective of this paper to make a preliminary estimation of the indirect use value of carbon sequestration of forests and other biomass types within the SIFR. The results of this exercise will serve as an input into the benefit-cost analysis of various land use alternatives for the SIFR, in an effort to provide guidance in the implementation of an efficient management strategy for the said Reserve.

2. METHODOLOGY

In estimating the contribution of the SIFR as a carbon sink, the methodology and coefficients used for calculating the gross annual uptake of carbon associated with biomass growth were adopted from the GHG inventory manual and workbook designed by Villarin, Narisma, Reyes, Macatangay and Ang (1999).

Villarin et al (1999) states that the total amount of carbon absorbed by biomass growth in a year is a function of the land area covered by a particular vegetation type, the rate of biomass growth, and the fraction of carbon present in dry (biomass) matter. The equation is given as follows:

$$G = A \times B \times C$$

where:

G = gross annual carbon uptake by biomass growth (in t C)
A = land area of a particular vegetation type (in ha)
B = biomass growth rate (in tons of dry matter/ha/year)
C = fraction of carbon resident in dry matter

An accurate tally of actual forest/biomass cover is a critical parameter in determining the precise amount of carbon sequestered by forest and non-forest vegetation types. However, due to inherent difficulties in data gathering and processing, this paper is limited to an approximation of the area size based on secondary information. The data sources are discussed as follows:

- ***Table 1*** presents the land cover statistics of the Japan Forest Technical Association (JAFTA) for the year 1996 from which the areas of different forest / biomass stocks in Samar Island were derived. (The JAFTA data were used in ***Tables 5a*** and ***5b***.)

- Mr. Augusto Villa-Real, the SAMBIO GIS Mapping Specialist, provided the area estimates for old growth and residual forests within SIFR based on his assessment of the land use maps of the Samar Island Biodiversity Project (SIBP), as shown in ***Table 2***.

- The estimated area under agriculture within the SIFR was based on the total cultivated area reported by the Bureau of Agricultural Statistics of Region VIII (BAS-8) as shown in ***Table 3***. Taking a conservative approach, due to observed land clearing activities at the site and the limitations of map digitization, it is assumed that the computed area devoted to agriculture is a subset of the total area covered by residual forests, which was estimated by the GIS Mapping Specialist. (These SIFR area data were employed in ***Table 6***.)

As can be gleaned from the above formula, the uptake of carbon is also dependent on the biomass growth rate, expressed in terms of tons of dry (biomass) matter per hectare per year (t dm/ha/yr). Villarin et al (1999) adopted the values presented in the study by Lasco and Pulhin (1998) since these closely correspond to the estimates of UNDP-ESMAP (1992). However, this paper settled upon the values from a more recent study by Lasco (1999), as presented in ***Table 4***.

Aside from the biomass growth rates, the carbon fraction present in different biomass types is an important parameter in accounting for the amount of carbon absorbed by forests and other types of vegetation. Villarin et al (1999) used the locally derived values of Lasco and Pulhin (1996). Similarly, carbon fraction values from the more recent Lasco study (1999) were used in this paper (also in ***Table 4***).

To roughly estimate the economic value of the gross annual carbon uptake of SIFR, a factor of US$20 to one ton of carbon (1 t C) is used, which reflects the damage cost avoided by

maintaining the land under forest[3] (Fankhauser's estimate (1995) as cited by Adger et al (1995) in Bishop (1999)). Based on current foreign exchange rates, an average of PhP50 to a dollar (US$) is applied to the conversion.

3. RESULTS

3.1 Gross Annual Carbon Uptake of Samar Island Forest / Biomass Stocks

The estimated gross annual carbon uptake based on the statistics provided by JAFTA (1996) for the three provinces of Samar Island (Eastern Samar, Northern Samar and Western Samar) is presented in ***Table 5a***. The whole Samar Island, represented by 831,550 hectares of forest and other biomass stocks, accumulates a total of 2,041,180 tons of carbon annually, with a total economic value of approximately PhP2.041 billion. The results show that brushlands accumulate the most carbon compared to other forest / biomass types, contributing about 82.16% of the total carbon uptake. The 393,856 hectares of brushland in Samar Island accumulates a gross total of 1,677,118 tons of carbon per year or an annual increment of 4.26 tons of carbon per hectare. This translates to a total economic value of PhP1,677,117,619 for carbon absorbed by brushlands or PhP4,258.20 per hectare.

Residual dipterocarp forest places a far second in terms of gross annual carbon uptake followed by old growth dipterocarp forest, contributing 8.72% and 7.84% of the total, respectively. The total carbon assimilated by the 189,577 hectares of residual or second growth forests is estimated at an annual rate of 177,956 tons of carbon or 0.94 ton of carbon per hectare per year. This total carbon uptake increment is valued at PhP177,955,930. The old growth forest, with an estimated total area of 106,696 hectares, accumulates a total of 160,044 tons of carbon per year or an annual rate of 1.5 tons of carbon per hectare. This annual carbon uptake has a total economic value of PhP160,044,000. It is interesting to note that on a per hectare basis, the economic value of carbon accumulated by old growth forest is higher at PhP1,500 compared to residual forests, which is estimated at PhP938.70.

Although grassland is the third largest in terms of land area (15.1%) after residual dipterocarp forest (22.8%) and brushland (47.4%), no value was assigned for both its annual biomass growth rate and carbon fraction of dry matter, which results in a value of zero in terms of the carbon absorbed. The assumption is that the total carbon released from the periodic burning of grassland areas balances the total carbon assimilated by the said biomass type, resulting in zero net sequestration of carbon [Villarin et al, 1999]. However, it has been demonstrated that grassland areas have a potentially significant ability to sequester carbon if these were left undisturbed and allowed to regenerate forest trees [Lasco and Pulhin (1998) as cited in Villarin et al (1999)].

[3] The same 'central' value was also used by Pearce and Moran (1994) to illustrate the cost of minimum economic damage for every ton of carbon released as a result of converting forests to other land uses, noting that the resulting damage cost estimates allow for carbon fixation in the subsequent land use.

3.2 Gross Annual Carbon Uptake of Samar Island (by different tree plantation species)

Based on the JAFTA statistics of 1996, the estimated gross annual carbon uptake of Samar Island's three (3) provinces according to different tree plantation species is presented in ***Table 5b***. Since the JAFTA data did not distinguish area size per species, the total area for tree plantation, at 961 hectares, is used in the calculation of carbon uptake by mahogany, gmelina and mangium wood.

Applying the locally derived values of Lasco (1999) for annual biomass growth rate and carbon fraction of dry matter of each of the species mentioned, the results show that when mangium wood is used in tree plantations, an annual total of 2,055,321 tons of carbon is accumulated by the forest and other biomass stocks of Samar Island. This amounts to a total economic value of about PhP2.055 billion. An equivalent total of 18,000 tons of carbon per year amounting to PhP18 million is attributable to mangium tree plantations.

Gmelina tree plantations contribute much less at 7,823 tons of carbon annually, the value of which is estimated at PhP7.823 million. This brings the gross annual carbon uptake of Samar Island's forest and other biomass stocks to 2,045,154 tons with an equivalent value of about PhP2.045 billion.

Mahogany tree plantations come in at third, contributing a total of 3,164 tons of carbon per year, with an estimated value of PhP3.164 million. This puts the gross total carbon absorbed by Samar Island's forest and other biomass stocks at 2,040,495 tons per year, equivalent to a total worth of PhP2.040 billion.

3.3 Gross Annual Carbon Uptake of Samar Island Forest Reserve (SIFR)

Using the area estimates of the SAMBIO GIS Mapping Specialist, the gross annual carbon uptake of the different land uses within SIFR is calculated and presented in ***Table 6***. The results show that old growth dipterocarp forests, covering about 38.65% of the total area of forest / biomass stocks within SIFR, accumulate the most carbon compared to other land uses. The 132,408 hectares of old growth forests are found to absorb carbon at a yearly increment of 198,613 tons or 1.5 tons of carbon per hectare per year. The total economic value of this carbon share is approximated at PhP199 million or PhP1,500 per hectare of old growth forest.

Residual dipterocarp forests covers more than half, at 51.62%, of the total area of forest / biomass stocks within the SIFR. It is assumed that the area devoted to agriculture is a subset of the total area covered by residual forests. The total agricultural area, therefore, is subtracted from the 208,050 hectares of residual forests approximated by the GIS Mapping Specialist to obtain the net area covered by residual forests. Using this net area, equivalent to 176,861 hectares, residual forests are found to accumulate an estimated 166,019 tons of carbon annually. This translates to an annual carbon absorption rate of 0.94 ton per hectare of old growth forest, which is the same rate as the gross annual uptake of the same forest type using the JAFTA statistics. The total economic value of this carbon uptake is calculated at PhP166 million or PhP938.70 per hectare of residual forest.

The estimated area for agricultural land, at 31,189 hectares, is based on the total cultivated area obtained from BAS-8. The agricultural area accumulates 84,211 tons of carbon

annually or a yearly carbon uptake of 2.70 tons per hectare. This amounts to a total economic value of PhP84 million or PhP2,700 per hectare of agricultural land within the SIFR.

In summary, the entire SIFR comprising 342,609 hectares of forest and other biomass stocks, accumulates a total of 458,000 tons of carbon annually, equivalent to about PhP458 million.

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Table 1
Samar Island Land Cover Statistics

PROVINCE	TOTAL AREA (In hectares)	CLASSES: OLD GROWTH	RESIDUAL	MOSSY	BRUSH-LAND	MANGROVE	PLANTATION FOREST	GRASS-LAND	shadows & clouds	OTHERS	TOTAL FOREST	% FOREST
E. Samar	417,102	70,645	71,279	1,437	123,843	4,043	141	12,582	48,437	84,695	271,388	65.07
N. Samar	349,664	20	23,023		137,162	1,208	466	19,805	59,348	108,632	161,879	46.30
W. Samar	549,050	36,031	95,275		132,851	8,121	354	93,264	104,627	78,527	272,632	49.66
TOTAL	**1,315,816**	**106,696**	**189,577**	**1,437**	**393,856**	**13,372**	**961**	**125,651**	**212,412**	**271,854**	**705,899**	**53.65**

Source: Japan Forestry Technical Association (JAFTA), 1996
Note: no data for the agroforestry, pine and submarginal forest classes

Table 2
Land Use Inside the Samar Island Forest Reserve (SIFR)

Classes	Description	Area (has)
EC	Cultivated area including brushland & grassland	2,150.52
EDC	Closed canopy forest (old growth + residual)	132,408.46
FDO	Open canopy forest	208,050.04
IC	Arable lands & crops	59.88
IMC	Cropland mixed with coconut	4,477.84
	TOTAL	**347,146.74**

Source: Mr. Augusto Villa-Real, SAMBIO GIS Mapping Specialist, December 2000
Note: Results of the digitization of the SIBP Land Use Maps

Table 3
Total Physical Area Devoted to Production of Agricultural Crops, Samar Island, CY 1999

CROP	INSIDE SIFR			OUTSIDE SIFR		TOTAL
	AREA (ha)	%	RANK	AREA (ha)	RANK	
Coconut	15,099.92	48.41	1	171,692.87	1	186,792.79
Palay	8,169.55	26.19	2	61,916.58	2	70,086.13
Abaca	961.06	3.08	5	19,534.94	3	20,496.01
Banana	1,523.94	4.89	4	8,919.33	4	10,443.27
Corn	1,963.28	6.29	3	6,464.63	5	8,427.90
Camote	541.10	1.73	6	5,389.15	6	5,930.25
Cassava	478.08	1.53	7	5,376.87	7	5,854.95
Gabi,ginger, etc.	2,452.20	7.86		21,343.48		23,795.68
TOTAL	**31,189.13**			**300,637.85**		**331,826.98**

Source of basic data: Bureau of Agriculture Statistics (BAS), Region VIII

Table 4
Carbon Content, Biomass Density and Biomass Accumulation Data for Land Use Conversion and Forestry (LUCF) in the Philippines

Forest Land Use	Carbon Content of Biomass (%)	Total Above-ground Biomass (t/ha)	Rate of Above-ground biomass change (t/ha/yr)	Source of Data
Protection Forest Old-growth forest Mossy forest Pine Submarginal	Assumed to be 50	OGF assumed to be 350. All others 50% of OGF.	Assumed to be 3.0	Brown et al. (1991) Lasco (1998a)
Second-growth Forest (SGF)	43 (Luzon) 44.7 (Visayas)	279 in Luzon 446 in Visayas 261.8 in Mindanao	7.81 in Luzon 2.1 in Visayas 5.2 in Mindanao	Lasco et al. (1999) New data Kawahara et al. (1981)
Brushlands	45.3 for wood (Visayas)	65 in Visayas	9.4 in Visayas	New data
Grasslands	44.5 (Visayas)	28.5 in Visayas	0 (because regularly burned)	New data
Tree Plantations	45 (Luzon) Visayas: 39.2 for mahogany wood 43.3 for gmelina wood 45.0 for mangium wood	In Visayas: S. macrophylla: 66.9 G. arborea: 180 A. mangium: 245.3 In Mindanao: G. arborea: 133 Paraserianthes falcataria: 81.5, 108.2 and 34.6 S. macrophylla: 260.5	In Visayas: S. macrophylla: 8.4 G. arborea: 18.8 A. mangium: 41.6 In Mindanao: G. arborea: 10.8 P. falcataria: 6.0 and 9.8	New data Lasco et al. (1998b) Kawahara (1991)
Agroforestry	45 *Cliricidia sepium* - based alley cropping (Luzon) 45 *Gmelina arborea* and cacao multistorey system (Luzon)	235.6: Multistorey system (Luzon) 67.5: Alley cropping (Luzon) 32: Fallow system (Visayas)	6.0: Improved fallow (Visayas)	Lasco et al. (1998a,b) Kungu (1993)

Source: R. Lasco, *Quantitative Estimation of Carbon Storage and Sequestration of Forest Ecosystems*, Paper presented at the UNFCCC Workshop on Emission Factors and Activity Data, Accra, Ghana, August 4-6, 1999.

Table 5a
Gross Annual Carbon Uptake of Samar Island Forest/Biomass Stocks

	A	B	C	D	E	F	G	H
	Area of Forest/Biomass Stocks (ha)	Annual Growth Rate (t dm/ha/yr)	Annual Biomass Increment [x 1 yr] (t dm)	Carbon Fraction of Dry Matter	Total Carbon Uptake Increment (t C / yr)	Total CO_2 Uptake Increment (t CO_2 / yr)	Economic Value of Carbon Uptake (PhP)	Economic Value of Carbon Uptake per Hectare (PhP)
			C = A x B		E = C x D	F = E x 44/12	G = E x 1000	H = G / A
Forest								
Dipterocarp								
Old Growth	106,696	3.00	320,088.00	0.50	160,044.00	586,828.00	160,044,000	1,500.00
Residual	189,577	2.10	398,111.70	0.45	177,955.93	652,505.08	177,955,930	938.70
Mossy	1,437	3.00	4,311.00	0.50	2,155.50	7,903.50	2,155,500	1,500.00
Mangrove	13,372	3.00	40,116.00	0.50	20,058.00	73,546.00	20,058,000	1,500.00
Tree Plantation	961	8.90	8,552.90	0.45	3,848.81	14,112.29	3,848,805	4,005.00
Brushland	393,856	9.40	3,702,246.40	0.45	1,677,117.62	6,149,431.27	1,677,117,619	4,258.20
Grassland	125,651	0.00	0.00	0.45	0.00	0.00	0	0.00
TOTAL	831,550				2,041,179.85	7,484,326.13	2,041,179,854	2,454.67

Source of formulas and worksheet: Villarin, J.T., Narisma, G.T., Reyes, M.S., Macatangay, S.M. and Ang, M.T. 1999. Tracking Greenhouse Gases: A Guilde for Country Inventories. Manila Observatory and the Inter-Agency Committee on Climate Change. A GEF Project Implemented by UNDP.

Note:

1. Area of forest/biomass stocks is based on the land cover statistics of JAFTA (1996). (Please see Table 1.)
2. Annual growth rate of biomass and carbon fraction of dry matter for dipterocarp (old growth and residual) and mossy forest, brushland, grassland types are based on Lasco, R. (1999). (Please see Table 4.)
3. Annual growth rate of biomass and carbon fraction of dry matter for mangroves are based on Lasco and Pulhin (1998) as cited in Villarin, et al (1999), in the absence of values for mangroves in Lasco (1999).
4. Annual growth rate of biomass for tree plantation is based on Lasco and Pulhin (1998) as cited in Villarin, et al. (1999). (Value absent in Lasco, 1999)
5. Carbon fraction of dry matter for tree plantation is based on Lasco and Pulhin (1996) as cited in Villarin, et al. (1999). (Value absent in Lasco, 1999).
6. A factor or US$20 to one ton of Carbon (1 t C) is used to derive the total economic value of annual carbon uptake based on Fankhauser's estimate (1995), which is used by Adger, et al. (1995) as cited in Bishop (1999). An exchange rate of PhP50 to US$1 is used in the conversion.
7. No forest statistics for pine, submarginal and agroforestry classes.

Table 5b
Gross Annual Carbon Uptake of Samar Island Forest/Biomass Stocks – By Different Tree Plantation Species

	A	B	C	D	E	F	G	H
	Area of Forest/Biomass Stocks (ha)	Annual Growth Rate (t dm/ha/yr)	Annual Biomass Increment [x 1 yr] (t dm)	Carbon Fraction of Dry Matter	Total Carbon Uptake Increment (t C / yr)	Total CO_2 Uptake Increment (t CO_2 / yr)	Economic Value of Carbon Uptake (PhP)	Economic Value of Carbon Uptake per Hectare (PhP)
			C = A x B		E = C x D	F = E x 44/12	G = E x 1000	H = G / A
Forest								
Dipterocarp								
Old Growth	106,696	3.00	320,088.00	0.50	160,044	586,828	160,044,000	1,500
Residual	189,577	2.10	398,111.70	0.45	177,956	652,505	177,955,930	939
Mossy	1,437	3.00	4,311.00	0.50	2,156	7,904	2,155,500	1,500
Mangrove	13,372	3.00	40,116.00	0.50	20,058	73,546	20,058,000	1,500
Tree Plantation	961							
Mahogany wood (S. macrophylla)		*8.40*	*8,072.40*	*0.39*	*3,164*	*11,603*	*3,164,381*	*3,293*
Gmelina wood (G. arborea)		*18.80*	*18,066.80*	*0.43*	*7,823*	*28,684*	*7,822,924*	*8,140*
Mangium wood (A. mangium)		*41.60*	*39,977.60*	*0.45*	*17,990*	*65,963*	*17,989,920*	*18,720*
Brushland	393,856	9.40	3,702,246.40	0.45	1,677,118	6,149,431	1,677,117,619	4,258
Grassland	125,651	0.00	0.00	0.45	0	0	0	0
TOTAL AREA	**831,550**		(mahogany wood)		**2,040,495**	**7,481,817**	**2,040,495,430**	**2,454**
			(gmelina wood)		**2,045,154**	**7,498,898**	**2,045,153,974**	**2,459**
			(mangium wood)		**2,055,321**	**7,536,177**	**2,055,320,969**	**2,472**

Source of formulas and worksheet: Villarin, J.T., Narisma, G.T., Reyes, M.S., Macatangay, S.M. and Ang, M.T. 1999. Tracking Greenhouse Gases: A Guilde for Country Inventories. Manila Observatory and the Inter-Agency Committee on Climate Change. A GEF Project Implemented by UNDP.

Note:

1. Area of forest/biomass stocks is based on the land cover statistics of JAFIA (1996). (Please see Table 1.)
2. Annual growth rate of biomass and carbon fraction of dry matter for dipterocarp (old growth and residual) and mossy forest, tree plantation species, brushland, grassland types are based on Lasco, R. (1999). (Please see Table 4.)
3. Annual growth rate of biomass and carbon fraction of dry matter for mangroves are based on Lasco and Pulhin (1998) as cited in Villarin, et al (1999), in the absence of values for mangroves in Lasco (1999).
4. A factor or US$20 to one ton of Carbon (1 t C) is used to derive the total economic value of annual carbon uptake based on Fankhauser's estimate Adger, et al. (1995) as cited in Bishop (1999). An exchange rate of PhP50 to US$1 is used in the (1995), which is used by conversion.
5. No forest statistics for pine, submarginal and agroforestry classes.

Table 6
Gross Annual Carbon Uptake – Samar Island Forest Reserve

	A	B	C	D	E	F	G	H
	Area of Forest/Biomass Stocks (ha)	Annual Growth Rate (t dm/ha/yr)	Annual Biomass Increment [x 1 yr] (t dm)	Carbon Fraction of Dry Matter	Total Carbon Uptake Increment (t C / yr)	Total CO_2 Uptake Increment (t CO_2 / yr)	Economic Value of Carbon Uptake (PhP)	Economic Value of Carbon Uptake per Hectare (PhP/ha)
			C = A x B		E = C x D	F = E x 44/12	G = E x 1000	H = G / A
Forest								
Dipterocarp								
Old Growth	132,408.46	3.00	397,225.38	0.50	198,612.69	728,246.53	198,612,690.00	1,500.00
Residual	176,860.91	2.10	371,407.91	0.45	166,019.34	608,737.57	166,019,336.22	938.70
Agricultural area w/in residual forest	31,189.13	6.00	187,134.78	0.45	84,210.65	308,772.39	84,210,651.00	2,700.00
Brushland/Grassland	2,150.52	9.40	20,214.89	0.45	9,157.34	33,576.93	9,157,344.26	4,258.20
TOTAL	342,609.02				458,000.02	1,679,333.41	458,000,021.48	1,336.80

Source of formulas and worksheet: Villarin, J.T., Narisma, G.T., Reyes, M.S., Macatangay, S.M. and Ang, M.T. 1999. Tracking Greenhouse Gases: A Guilde for Country Inventories. Manila Observatory and the Inter-Agency Committee on Climate Change. A GEF Project Implemented by UNDP.

Note:

1. Annual growth rate of biomass and carbon fraction of dry matter for dipterocarp (old growth and residual), agriculture and brushland are based on Lasco, R. (1999). (Please see Table 4.)
2. Area estimates of forest/biomass stocks for old growth and residual forests are based on the rough assessment of the SIBP land use maps by Mr. Augusto Villa-Real, SAMBIO GIS Specialist. (Please see Table 2.)
3. Area estimate for agricultural land is based on the total cultivated area obtained from the Bureau of Agricultural Statistics-Region 8 (Table 3). The assumption is that the estimated area devoted to agriculture is a subset of the total area for residual forests (the total area covered by residual forests is 208,050.04 ha, per the estimation of the SAMBIO GIS Specialist).
4. A factor or US$20 to one ton of Carbon (1 t C) is used to derive the total economic value of annual carbon uptake based on Fankhauser's estimate (1995), which is usedby Adger, et al. (1995) as cited in Bishop (1999). An exchange rate of PhP50 to US$1 is used in the coversion.
5. No forest statistics for pine, mossy, submarginal and tree plantation classes.