APPENDIX 4.

Valuation of Ecosystem Services of Biodiversity Conservation Corridor, Attapeu, Champasak, and Xekong Provinces, Lao PDR (ADB R-PPTA 7459)

A. Introduction

1. The value of forest resources has traditionally been measured in terms of direct benefits from extraction of timber. This value does not reflect the true value of forest resources to society or to the national economy, since natural forests have many positive externalities and intangible benefits. Most of the forest ecosystem services are difficult to quantify or put a value in money terms. Although timber, non-timber forest products are tradable in the market, the price mechanism often fails to reflect the real value of those ecosystem services because their valuation is based on the cost of extraction (labor, equipment, and transport) and raw material only. This does not take into consideration the ecosystem service values, such as watershed protection, soil fertility, carbon sequestration, and biodiversity conservation. Therefore, market failures often occur in ecosystem management as markets and economic development planning rarely reflect the full social costs or benefits of environmental goods or services. The valuation of ecosystem services is essential in correction of market failure and supports economic planners in reflecting true costs in policy and decision-making.

2. The valuation of ecosystem services of the Biodiversity Conservation Corridor in Lao PDR serves as a basis for identifying real costs and reflection of economic values of forests in government planning and underlines the importance of biodiversity corridor establishment and management.

B. Forest cover and status in the Corridor area

3. The proposed Biodiversity Conservation Corridor in Lao PDR is connecting 4 National Protected Areas (Xe Pian – Dong Hua Sao - Dong Ampham – Xe Sap) spread over 69 target villages in three provinces (Attapeu, Champasak and Xekong) with an aggregate area of 696,100 ha, of which 417,660 ha or 60% may be estimated as forested area. Within the corridor area, Mixed Deciduous (217,629.52 ha) makes up more than 50% of the forest area, while Dry Dipterocarp (128,445 ha) and Dry Evergreen (51,007ha) account for 30% and 12% respectively (detail forest cover and types see table 1 below).

Table 1. Forest cover and types in the Biodiversity Conservation Corridor (in ha)

Land use/Forest Type	Total Area (ha)	Champasak	Attapeu	Xe Kong
Dry Dipterocarp	127,431.74	64,044.72	55,781.83	8,618.53
Lower Dry Evergreen	2,748.90	2,340.87	122.70	-
Upper Dry Evergreen	49,772.31	12,111.70	10,131.83	26,299.85
Lower Mixed Deciduous	65,789.58	38,681.88	26,778.96	-
Upper Mixed Deciduous	150,128.83	39,918.73	57,824.76	54,425.19
Gallery Forest	1,552.83	1,071.54	414.11	-
Coniferous	4,880.31	876.72	-	3,687.31
Mixed Coniferous and Broadleaved	15,355.50	439.84	-	14,088.92
Forest Area	**417,660.00**	**159,486.00**	**151,054.20**	**107,119.80**
Total	**696,100.00**	**265,810.00**	**251,757.00**	**178,533.00**

Source: Forest Cover Assessment 2002 DOF (2005)

C. Valuation method for selected ecosystem services

4. The Total Economic Value of an ecosystem is the sum of the direct use values, indirect use values and non-use values, the types of ecosystem services under each category are listed in table 2 below. In practice, it is not possible to quantify all of these values in monetary terms in a robust way. This assessment focuses on the values of non-timber forest products (NTFP), carbon storage/sequestration, watershed protection, water quality regulation, soil erosion control.

Table 2. Types of forest ecosystem services

Use Values		Non-use value
Direct use values	**Indirect use values**	
Timber	Watershed protection	Existence value
Non-timber forest product (NTFP) (i.e. food, medicine, fuel wood, material, etc.)	Climate regulation (carbon sequestration, oxygen generation)	Culture/ spiritual value
Recreation and tourism	Soil erosion control	Biodiversity
Education	Nutrient retention	Bequest
Animal fodder	Micro climate regulation	Heritage

Source: GMS Biodiversity Conservation Corridors, ADB R-PPTA 7459

5. Valuation methods of ecosystem services can be classified into two broad economic categories based on demand and supply: 1) stated preference methods by asking people for their willingness to pay for a certain ecosystem service; 2) revealed preference methods by using a relation with a market good or service to estimate the willingness-to-pay for the service. Specific method[1] for estimating particular ecosystem services according to the nature of goods or services and proxy function availability usually list contingent valuation method (CVM), hedonic prices, direct estimation of opportunity costs, replacement costs, cost savings, threshold values etc. Methods used in this valuation are shown in the table below.

Table 3. Valuation methods for selected ecosystem services

Ecosystem services	Valuation Method	Data considered in the valuation
Non-timber Forest Products	Market analysis	Biophysical data; market demand, quantity collected and traded; product prices
Carbon Storage	Market prices Damage cost	Carbon biomass density; area of different forest types; international carbon price;
Water Regulation - Watershed protection - Water purification	Cost saving	Reservoir construction cost and water treatment cost; annual precipitation in project area; annual evaporation in forest of all climate types; area of relevant (coniferous or broadleaf) forest types

[1] Thampapillai, D. J. (2002). Environmental Economics: Concepts, Methods and Policies, Oxford University Press, Melbourne.

Ecosystem services	Valuation Method	Data considered in the valuation
Soil erosion, prevention	Damage cost	Rate of erosion of different types of forest land and non-forest land; Area of different forest types; cost of 1 ton sediment removal; ratio of sediments entering river or reservoir to total soil loss

6. The valuation has been conducted using the following steps: i) determining geographic focus to understand the characteristics of the ecosystem and socio-economic conditions of the project area; ii) identifying potential ecosystem services to be valued through field study and consultation with stakeholders and experts; iii) defining valuation methods of the selected ecosystem services, and collecting required data for valuation through field surveys and secondary literature review of local studies; iv) applying the valuation methods and calculating the value for each selected ecosystem service; and v) conducting scenario analysis based on different land use options and sensitivity analysis for dealing with uncertainties of the results.

1. Non-Timber Forest Products (NTFP)

7. NTFPs play an essential role in local livelihoods and are one of the major income sources in the biodiversity corridor area. The most important NTFPs currently being collected are: 1) Malva nut (local name: Mak Chong); 2) Bamboo and rattan; 3) Resin (i.e. *Vatica harmandiana and Diptercapaceae spp.*); 4) Palm leaf and grass leaf / broom grass flower; 5) Medicinal plants/herbs (i.e. *Rhododendro simsii,* local name: Kheua Haem,); 6) Food (i.e. vegetables, bamboo shoot, rattan shoot etc.); and 7) Fuel wood. Food and fuel wood from the forests are the major consumption goods for local people.

8. It is difficult to estimate exact quantity of NTFPs available and how much is being collected from the forested areas in the corridors. Data has been collected based on sample surveys in 7 villages in the three provinces. As many NTFPs are not marketed and for household consumption only, this valuation mainly focuses on marketed NTFPs (i.e. Malva nut, rattan, bamboo, medicinal plants, resin, mushroom, etc.). In particular, Malva nut is one of the major products in the corridor area that seems to have a well-established market. It is reported that on average, one household can harvest 30kg/year. The market price varies from Kip 4,500/kg to Kip 6,000/kg[2] (US$5.6 – $7.5) and the average annual harvesting per village in three provinces is estimated at 5 - 6 tons; Resin has been collected for fuel energy on an average of 36 kg/HH/yr and selling at Kip 2,500/kg ($0.3/kg); Bamboo, rattan, palm leaf, and medicinal plants are also widely collected in the corridor area but at a relatively small scale compared with Malva nut. NTFP value is estimated at 343million Kip ($42,876) on average per village annually. If we include household consumption goods and other minor products, the values may be higher but information on these NTFPs is scattered as their collection and marketing by households is not well documented. Sustainable harvesting and threat of overexploitation in the Corridor area were also taken into consideration.

2. Carbon Storage

9. Discussion at COP 15 (2009) and COP 13 (2007) of the United Nations Framework Convention on Climate Change (UNFCCC) made the Reduction of Emissions from Deforestation and Land/Forest Degradation an important platform for boosting investments to enhance carbon sequestration potential of natural forests and plantations and reduce emissions from land use change and forest destruction. Carbon sequestration capacity is assumed to be 50% of the biomass carbon density, 1 ton of carbon can be further converted to about 3.6 tons CO2. In Lao PDR there have been few studies of carbon stocks, but Table 4 below shows the

[2] Exchange rate Kip 8,000 to 1 US$. http://coinmill.com/LAK_USD.html#USD=1

range of carbon stocks that have been measured and are used in the provisional baseline for R-PP. The formula is written as: **V=Q*P*S**

Where: V - service value of carbon storage (US$)
Q - carbon storage capacity of the ecosystem (t/ha)
P - International carbon price (US$/t)
S - Area of each forest type (ha).

Table 4. Comparison of carbon stocks for different forest quality classes in Lao PDR

Well-stocked (> 70%)	Medium (40 - 70%)	Degraded (20 - 40%)	Fallow (6 years)	Plantation (Teak/ 6 years)
~ 220 t C/ ha	~ 62 t C/ ha	~ 20 t C/ ha	32 t C/ ha	51 t C/ ha
~ 792 t CO2/ ha	~ 223 t CO2/ ha	~ 72 t CO2/ ha	~ 115 t CO2/ ha	~ 184 t CO2/ ha

Source: REDD concept note under R-PPTA 7459

10. The prices estimated for carbon sequestration varies in different sources. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC 2007) suggests prices ranging between US$20-US$50 per ton of CO_2, while the average price in the Clean Development Mechanisms (CDMs) in general is US$10.5 per ton of CO_2. In 2009, carbon prices for forest management and agro-forestry projects in voluntary carbon markets ranged from $5 - $16 per ton of CO_2[3]. US$5/ton of CO_2 is taken for estimation of value of carbon storage in this assessment.

3. Water regulation services (storage and purification)

11. The mechanism of **watershed protection (storage)** of forest is manifested in the retention of water by the crown, trunk, undergrowth vegetation, forest litter and soil through which water is relocated to regulate availability of surface water and runoff. The forest is often referred to as a "sponge" and "green reservoir" for its immense osmosis effect and watershed protection capacity. By regulating runoffs, forests can contribute to delay in flood peaks and reducing flood volumes; in dry seasons, forests gradually release absorbed water that maintains river flow and relieves droughts. One commonly adopted valuation method is the rainfall storage method.

$$\mathbf{V=Q*C_{yt}}$$
$$\mathbf{Q=S*J*R}$$
$$\mathbf{J=J_O*K}$$
$$\mathbf{R=R_O-R_g}$$

Where: Q - Increase in water preserved in forest (meadow) ecosystems, compared to bare land (m^3);

S - Area of the forest (ha);

J - Annual average precipitation runoff yield of the study area (mm);

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[3] Source: Katherine Hamilton, Milo Sjardin, Molly Peters-Stanley and Thomas Marcello, 2010, Building Bridges: State of the Voluntary Carbon Markets 2010, Ecosystem Marketplace & Bloomberg New Energy Finance.

Jo - Annual average precipitation of the study area (mm):

K - Ratio of precipitation runoff yield to total precipitation of the study area;

R - Benefit coefficient of reduced runoff in forests (meadow) compared to bare land (or non-forested area)(%);

R_0 - Precipitation runoff rate under precipitation runoff condition in bare land (%);

R_g - Precipitation runoff rate under precipitation runoff condition in forests (%);

Cyt - Investment cost of reservoir construction per m^3

V - Annual economic value of forest ecosystems in watershed protection.

12. Average annual precipitation in the Corridor area is estimated at 2,345 mm (Attapeu), 1,908 mm (Champasak), and 1541 mm (Xekong), thus J_O=2.3, 2.0 and 1.4 are taken for calculation. The ratio of precipitation runoff yield is 0.6 in relation to total precipitation of the project area. The reference of R parameters are listed in Table 5 below; R=0.39, 0.36 and 0.34 have been selected for subtropical evergreen broadleaf forest, subtropical, tropical evergreen coniferous forest, and subtropical evergreen deciduous forest and broadleaf forest categories.

Table 5. R value of the various forest ecosystems

Type of forest ecosystems	R value
Cold-temperate larch	0.21
Temperate evergreen coniferous forest	0.24
Temperate, subtropical deciduous broadleaf forest	0.28
Temperate deciduous, lobular sparse forest	0.16
Subtropical evergreen deciduous forest and broadleaf forest	0.34
Subtropical evergreen broadleaf forest	0.39
Subtropical, tropical evergreen coniferous forest	0.36
Subtropical bamboo forest	0.22
Tropical forest, monsoon forest	0.55

Source: Zhao Tongqian, 2004, Assessment and Valuation of Forest Ecosystem Services in China's Natural Resources Journal, 2004, 19(4):480-490

13. The investment cost of reservoir construction is based on the data from Xekong 4 and 5 Hydropower development projects; the cost of reservoir construction is estimated as US$ 0.16 per cubic meter on average.

14. Rainwater retained by forests can reach drinking water quality (Yu Xinxiao etc, 2002)[4]. One possible method to value the **water purification function** is as follows:

$$\mathbf{V=Q^{*}P}$$

Where: V—Value of water purification by forest

Q—Amount of water preserved in the ecosystems

P—Unit price of water treatment or price of water supply.

15. The price of water supply is taken as KIP 1,350 /cu.m (US$0.168)[5] for residential and commercial use in Vientiane.

4. Soil erosion prevention

[4] "The forest ecosystem services and their valuation of Beijing mountain areas", Yu Xinxiao, Qin Yongsheng, Chen Lihua and Liu Song, *Acta ecologica sinica*, 2002, 22(5):783-786.

[5] Data source: Vientiane Times, Vientiane Water Supply Enterprise, available at: http://laovoices.com/2010/05/21/joint-venture-turns-on-tap-for-vientiane-water-supply/

16. As a protection layer of the ground, forest helps to prevent soil erosion and minimize sedimentation in reservoirs and rivers, thus extending reservoir life. The ability of forest in rainwater retention and reduction of rainfall volume and velocity reaching the ground serves to regulate runoff quantity and speed and minimize soil loss. One method of estimating the value of reduction in soil loss is equivalent to the cost of sediment removal from rivers and reservoirs. The formula for calculating the value of soil erosion prevention by forests is as follows:

$$\mathbf{V_k = K \cdot G. \sum S_i * (d_i - d_o)}$$

Where: V_k — Economic value of soil conservation;

K — Cost of 1 ton of sediment removal;

S_i — Area of all types of forest (ha)

G — Ratio of amount of sediments entering rivers or reservoirs to total soil lost;

d_i — Rate of erosion of all types of forest(t/ha);

d_o — Rate of erosion of non-forest land (t/ha).

17. The average cost of 1 ton of sediment removal is US$2.5. The estimated ratio of sediments entering rivers or reservoirs to total soil loss is 50% or G=0.5. The rate of soil erosion[6] in a non-forested area is 319.8tons/ha/yr and soil erosion from broadleaf forests and coniferous are estimated at 0.5 ton/ha/yr and 7.8 ton/ha/yr.

D. Values of ecosystem services in Biodiversity Conservation Corridors, Lao PDR

18. The total value of ecosystem services assessed in the Biodiversity Corridor area amounts to $1.5 billion, which translates into just over $4,600 per ha. Carbon storage function provides the highest values followed by water regulation services. NTPF value comes out low ($7 million per year) due to insufficiency of available data for marketed products. Livelihoods of local communities depend also on forest ecosystem goods and services; hence, the valuation in this case is a conservative estimate. The actual importance of NTFPs must be rated higher than its nominal value. Values of soil erosion control may also be under-estimated as damage cost of landslides due to soil erosion has not been taken into account in this valuation. These ecosystem service values need to be maintained and enhanced.

Table 6. Summary values of ecosystem services in Biodiversity Corridor, Lao PDR (in '000 US$)

Ecosystem Services	Champasak	Attapeu	Xe Kong	Total Value	Unit Value (USD/ha)
NTFP	1,130	1,070	759	2,958	7
Carbon Storage	294,340	278,779	197,696	770,815	1,846
Watershed protection	111,740	120,708	51,774	284,222	1,069
Water purification	117,851	127,309	54,605	299,765	1,128
Soil erosion control	62,723	60,128	35,821	158,673	597
Total Value	**587,784**	**587,994**	**340,655**	**1,516,433**	**4,647**

Source: GMS Biodiversity Conservation Corridors (ADB R-PPTA 7459), Aug 2010

19. The 4th National Report[7] to the Convention on Biological Diversity of Lao PDR presents the total economic benefits to the industry derived from the various forest resource amounts to US$ 436.85 million. Carbon sequestration value of climate change mitigation can reach

[6] Data source: The Fifth Forestry Inventory, 1999, Forestry Science Data Center, China

[7] WREA, 2010, Assessing Progress towards the 2010 Biodiversity Target: The 4th National Report to the Convention on Biological Diversity, Lao Peoples' Democratic Republic.

29.71million annually. Fuel wood, both for domestic and commercial purpose, are estimated at over US$ 500,000 annually as market value. Further, it is estimated that water resources for irrigation produced an average gross return for rice cultivation of approximately US$ 317/ha per year (MAF & STEA, 2004).