Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos, Phase III, Cambodia Component

INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINABLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST

FORESTRY ADMINISTRATION

TECHNICAL REPORT

INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST

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Preface

The Preah Vihear Protected Forest (PVPF) in Cambodia is situated within the Indo-Burma Biodiversity Hotspot, which is one of 35 Hotspots that are recognized globally and one of nine important Biodiversity Corridors in the Greater Mekong Sub-region. There are two primary rivers, the Mekong and the Ro Pov, which are located to the northeast of the PVPF, that assume important roles in the region, not only for transportation, but also in the social and economic sectors. The area provides habitats for 57 mammal species and about 255 species of birds, 58 species of reptiles, and numerous species of amphibians, including several globally-threatened species. It is probably the most important site world-wide for the critically-endangered Giant Ibis (*Pseudibis gigantean), which is the national bird of Cambodia,* and the most important site in Southeast Asia for three critically-endangered species of vultures. The PVPF is recognized as one of the most biodiversity rich areas in Cambodia, as well as throughout the region, but information on its forest biodiversity and local communities remains incomplete.

The purpose of developing this Technical Report on *"Integrating Forest Biodiversity Resource Management and Sustainable Community Livelihood Development in the Preah Vihear Protected Forest"* is to strengthen the technical foundation for sustainable conservation and resource use to enhance local community livelihoods and contribute to economic growth. This Technical Report has been prepared under the people-centered, socially oriented, forest ecosystem integrity theme of '*Forests for People and Sustainable Development.'*

This Technical Report has been organized around six interrelated subjects, including (1) Forest Cover Trends in the Preah Vihear Protected Forest; (2) Preliminary Assessment of Carbon Stocks; (3) Land Use and Land Cover Change Scenarios; (4) Floral Diversity; (5) Distribution of Landscape Wildlife Species; and (6) Sustainable Livelihoods.

The Forestry Administration expresses its sincere appreciation for the financial and specialized technical support for preparing this Technical Report that was provided through the International Tropical Timber Organization (ITTO) project PD 577/10 Rev.1 (F): "Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos (Phase III)" – Cambodia Project Component.

The long term collaborative efforts of the Forestry Administration of the Kingdom of Cambodia and the International Tropical Timber Organization have supported on-site research, promoted sound management of forest resources, strengthened technical capacities, and expanded the sharing of scientific and technical information and publications. I congratulate the Cambodia Project Component Team for producing this Technical Report on *"Integrating Forest Biodiversity Resource Management and Sustainable Community Livelihood Development in the Preah Vihear Protected Forest."*

It is of critical importance with the elaboration of this Technical Report to recognize the continued requirements for active commitment from, and participation of, local and national stakeholders, as well as the cooperation and support of our international development partners.

DR. CHHENG KIMSUN
Delegate of the Royal Government in charge as
Head of the Forestry Administration

ACKNOWLEDGEMENTS

The Cambodia Project Team expresses its appreciation to everyone involved in facilitating the preparation of this Technical Report on *"Integrating Forest Biodiversity Resource Management and Sustainable Community Livelihood Development in the Preah Vihear Protected Forest,"* and reviewing and commenting on drafts of the report.

The production of this Technical Report on *"Integrating Forest Biodiversity Resource Management and Sustainable Community Livelihood Development in the Preah Vihear Protected Forest"* was funded through the ITTO PD 577/10 Rev.1 (F) project on "Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos (Phase III)" - Cambodia Project Component and the financial support received from the government and the people of Japan, as well as the support and encouragement that has been provided by Mr. Takeshi Goto, Assistant Director, Division of Forest Management, and Dr. Hwan Ok Ma, Projects Manager, of ITTO is acknowledged.

Our sincere appreciation is also extended to Mr. Hiroshi Nakata, Technical Advisor to the Head of the Forestry Administration and his staff - Ms. Naomi Matsue, Project Administrative Coordinator of the JICA-funded CAM-REDD Project, and Ms. Ches Sopheap, Office Manager. Their support, advice, and assistance provided during the course of this endeavor is much appreciated.

This Technical Report would not have been possible without the support and encouragement of the Forestry Administration in Phnom Penh, especially H.E. Dr. Chheng Kimsun, Delegate of the Royal Government in charge as Head of the Forestry Administration, as well as Senior Officials of the Forestry Administration.

It is also important to recognize the Governor of Preah Vihear province, provincial military and police commanders, and other relevant authorities for their assistance and cooperation, as well as the many local people who assisted the project team in organizing and implementing field activities during the course of this phase of the project.

We acknowledge, as well, the active participation of local Forestry Administration Officers of the Preah Vihear Forestry Administration Cantonment; Chhep, and Choam Ksant Forestry Administration Divisions and the Forestry Administration Triage, especially Mr. Khim Pann, Mr. Ith Phoumara, Mr. Mak Panha, and Mr. Tan Setha.

The collective efforts of the ITTO PD 577/10 Rev.1 (F) Cambodia Project Team in preparing the Technical Report on *"Integrating Forest Biodiversity Resource Management and Sustainable Community Livelihood Development in the Preah Vihear Protected Forest,"* including Mr. Chheang Dany, Dr. Dennis J. Cengel, Mr. Nhan Buthan, Ms. Lim Sopheap, Mr. Kim Sobon, Mr. Pang Phanit, Mr. Pheng Sopheak, Mr. Say Sinly, Mr. Yinarom, and Mr. Sem Sinoun, are also recognized

Finally, we would like to express our appreciation to all of the other specialists who took their time to advise, review, and comment on various different aspects that were associated with producing this Technical Report.

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TABLE OF CONTENTS

CHAPTER III

LAND USE AND LAND COVER CHANGE SCENARIOS

CHAPTER IV

FLORAL DIVERSITY

CHAPTER V

THE DISTRIBUTION OF LANDSCAPE WILDLIFE SPECIES

CHAPTER VI

SUSTAINABLE LIVELIHOODS ASSESSMENT

Annexes:

List of Tables

List of Figures

List of Maps

ACRONYMS AND ABBREVIATIONS

cm. : centimeter
ha : hectare
m : meter
ns : not statistically significant

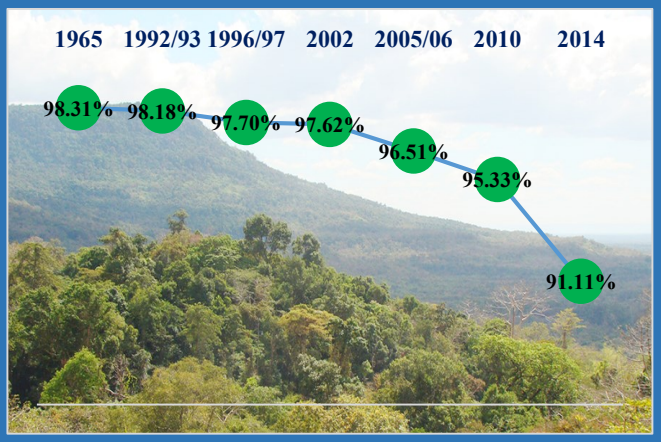
AGB : Above Ground Biomass
AUC : Area Under Curve
BGB : Below Ground Biomass
CBD : Convention on Biological Diversity
CLUP : Commune Land Use Planning
CMDG : Cambodia Millennium Development Goals
CUCR : Community Use, Cultural Heritage, and Religious Forests
CTSP : Cambodia Tree Seed Project
DANIDA : Danish International Development Agency
DBH : Diameter at Breast Height
DEM : Digital Elevation Model
EGF : Evergreen Forest
FA : Forestry Administration
FAO : Food and Agriculture Organization of the United Nations
FR : Forest Restoration
GIS : Geographic Information System
GPS : Global Positioning System
IPCC : Intergovernmental Panel on Climate Change
IINAS : International Institute for Sustainability Analysis and Strategy
ITTO : International Tropical Timber Organization
IUCN : International Union for the Conservation of Nature
JICA : Japan International Cooperation Agency
LULC : Land Use and Land Cover Change
NbT : Nature-based Tourism
NCDD : National Committee for Sub-national Democratic Development
NFI : National Forest Inventory
NGO : Non-Governmental Organization
NTFPs : Non-Timber Forest Products
OLI : Operational Land Imager
PLUP : Participatory Land Use Planning
PTWRC : Phnom Tamao Wildlife Refuge Center
PVPF : The Preah Vihear Protected Forest
REDD : Reducing Emissions from Deforestation and Forest Degradation
RFSE : Reserve Forests for Special Ecosystems
RGC : Royal Government of Cambodia
RIL : Reduced Impact Logging
RUA : Royal University of Agriculture
SLC : Social Land Concession

SMART	: Spatial Monitoring and Reporting Tool
TM	: Thematic Mapper
UN	: United Nations
UNEP	: United Nations Environment Programme
UNFCCC	: United Nations Framework Convention on Climate Change
USGS	: United States Geological Survey
UTM	: Universal Transverse Mercator coordinate system
WCS	: Wildlife Conservation Society
WCMC	: World Conservation Monitoring Centre
WP	: Watershed Protection

Zoning Categories

CUCR	Community Use, Cultural Heritage, and Religious Forests
NbT	Nature-based Tourism
RFSE	Reserve Forests for Special Ecosystems
WP	Watershed Protection
FR	Forest Restoration Site
PVPF	Preah Vihear Protected Forest

INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST



CHAPTER I

FOREST COVER TRENDS IN THE PREAH VIHEAR PROTECTED FOREST

KIM SOBON, SAY SINLY,

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SUMMARY

The primary objectives of this study were to assess the forest cover of each forest cover type, as well as forest cover changes between 2002 and 2014, in the Preah Vihear Protected Forest and to conduct a ground assessment of forest conditions in 2014. The assessments were conducted using SPOT satellite image data of the LANDSAT Thematic Mapper (TM) 5 and LANDSAT 8 OLI with high resolution pixels (30 m x 30 m). Four bands (3-4-5-6) of the 11 bands that were available were used for forest classification. Seven land use classes were used in the assessments, including those of evergreen forest, semi-evergreen forest, deciduous forest, open deciduous forest, grassland, agricultural land, and water surfaces. ArcView 3.3, ArcGIS 10.1, and ERDAS Imagine 2014 software were used in the interpretation process. The interpretation of the 2014 imagery delineated two vegetation classes, forest and non-forest, consistent with the national definition of forest under the Forest and Agriculture Organization of the United Nations (FAO) and the Cambodia Forestry Law (2002). There were 280 points used for ground truth verification and reinterpretation was performed by the GIS and Remote Sensing Unit of the Watershed Management and Forestland Office of the Forestry Administration.

The results of the 2014 assessment in the Preah Vihear Protected Forest indicated a forest cover of 173,134 hectares, representing 91.11% of total land area. The composition of that forest cover revealed that dry deciduous forest had the most extensive forest coverage (59.19%), followed by evergreen forest (17.81%) and semi-evergreen forest (8.62%). Site assessments of 280 satellite imagery interpretation sample points in the Preah Vihear Protected Forest were conducted to confirm forest classifications. The results of the ground truthing revealed that 266 of the 280 ground truthed points were correct and the accuracy of the forest classifications was significant at 95%. The results of the current forest cover assessment in the Preah Vihear Protected Forest indicate a progressive decline in forest cover from 97.62% in 2002 to 96.51% in 2006, 95.33% in 2010, and 91.11% in 2014, equivalent to an average annual deforestation rate over that period of 0.715% of the land area of the Preah Vihear Protected Forest. That rate is, however, lower than the country-wide average of annual forest cover loss of 1.055% during that same period.

The lower rate of decrease of forest cover in the PVPF is, nevertheless, a critical concern, especially in the context of efforts to mitigate the impacts of climate change. One of the primary reasons for the loss in forest cover is the increase in demand for the use of land for agriculture and agro-industrial endeavors, especially the conversion of forestland to Social Land Concessions and illegal forestland encroachment by the military and migrants with respect to which land use policy reforms would not be able to compensate sufficiently to achieve either the Cambodia Millennium Development Goals or the Sustainable Development Goals. In order to maintain the percentage of forest cover in the Preah Vihear Protected Forest as it was in 2002 (187,282 hectares) would require 14,148 hectares of non-forest land to be converted to man-made forest and agroforestry plantations.

CHAPTER I

FOREST COVER TRENDS IN THE PREAH VIHEAR PROTECTED FOREST

1.1 Introduction

The Preah Vihear Protected Forest (PVPF) is located between 13º51'19" and 14º25'01" of latitude north and 104º51'42" and 105º47'04" of longitude east. It has an area of 190,027 hectares that encompasses a land surface covering two districts, Chhep and Choam Ksan, in Preah Vihear province and shares its boundary with Thailand and Lao PDR to the North (Forestry Administration 2010). The new settlements that have been granted as Social Land Concessions established along the road from Teuk Krahum to Mumbei since 2010 have had a significant negative effect on forest cover changes in the area.

The primary objectives of this study were to assess the forest cover of each forest cover type, as well as forest cover changes between 2002 and 2014, in the Preah Vihear Protected Forest and to conduct a ground assessment of forest conditions in 2014.

1.2 Methodology

1.2.1 Satellite images

The forest cover assessments of the Preah Vihear Protected Forest were conducted using SPOT satellite image data of the American LANDSAT Thematic Mapper (TM)5 and LANDSAT 8 Operational Land Imager (OLI) (Table 1.1 and Figure 1.1) with high resolution pixels (30 m × 30 m). The assessments were conducted by the Geographic Information System and Remote Sensing Unit of the Cambodia Forestry Administration. In the assessments, imagery from the dry season - from December to March - was used to ensure greater contrast between forest and non-forest areas and incorporate lower cloud cover (Rainey et al. 2010).

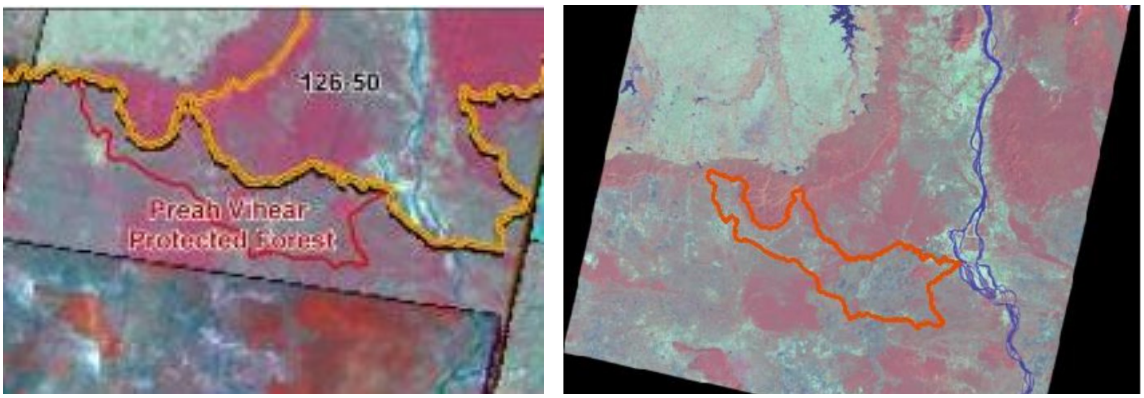


Figure 1.1. Satellite imagery (Landsat TM5 and Landsat 8 OLI).

Table 1.1. Path/Row and date of acquisition of satellite imagery.

No.	Path/Row	Date of acquisition	LANDSAT
1	126/50	18 February 2010	LANSAT TM5
2	126/50	28 January 2014	LANSAT 8 OLI

1.2.2 Classification method

There were only 4 bands (3-4-5-6) of the 11 bands that were available that were used for forest classification. The classification of land use types followed the guidelines for forest classification produced by the Cambodia Department of Forest and Wildlife (1996). Seven land use classes were used in the assessment, including those of evergreen forest, semi-evergreen forest, deciduous forest, open deciduous forest, grassland, agricultural land, and water surfaces. ArcView 3.3, ArcGIS 10.1, and ERDAS Imagine 2014 software were used in the interpretation process. In the classification of land cover, a semi-automated technique developed by the Wildlife Conservation Society Cambodia Programme was used to capture the boundaries of non-forest patches that were identified using a combination of techniques in the Area of Interest (Rainey et al 2010).

The assessments of the forest cover of the entire landscape in 2002, 2006 and 2010 used datasets from the GIS and Remote Sensing Unit of the Forestry Administration. The best data available in 2014, however, were from Landsat 8 (OLI). The interpretation of the 2014 imagery delineated two vegetation classes, forest and non-forest, consistent with the national definition of forest under the Forest and Agriculture Organization of the United Nations (FAO) and the Cambodia Forestry Law (2002). Forest is represented by land covering at least 0.5 ha with at least 10% cover of trees taller than 5 m, while non-forest is represented by land with a forest canopy less than 10%, which includes natural grassland, bare land, water, areas of shifting cultivation, rice paddy, other agriculture land, settlements and deforested areas (Brun 2009; Royal Government of Cambodia 2002).

1.2.3 Image interpretation process

The image pre-processing and interpretation processing were accomplished using the ERDAS IMAGINE software package. Subsequent data analysis was performed using ArcGIS 10.1. The methodological steps that were used in the analysis are provided in Table 1.2. Images were geometrically corrected to an image from a reference year, which was, in turn, corrected to the rivers in the national hydrology dataset (Rainey et al. 2010).

Table 1.2. Step-by-step methodological process.

Step	Process
1	Collection of available comparative datasets, including satellite imagery, aerial photographs, road and settlement locations, and field parcel maps with the selection of master and supporting images for each point in time.
2	ERDAS IMAGINE used for geometric correction and adjustment of projection. Error gaps closed.
3	Visual identification of non-forest patches followed by capture of boundaries using a semiautomatic approach with the “Seed Tool” extension in ArcGIS 10.1.
4	Peer review, visualization, editing, and topology corrections.
5	Application of geo-processing to finalize non-forest polygons.
6	Mapping and map production.

1.2.4 Forest change rate

The annual rate of change of forest cover, in this study, was derived from the formula used for computing compound interest (Puyravaud 2003).

$$r = (1/(t_2\text{-}t_1) \times \ln(A_2/A_1) \text{ or } q = ((A_2 / A_1)^{1/(t_2 - t_1)}) - 1$$

Where r or q is the annual forest change rate, A_1 is the forest area in the starting year, A_2 is the forest area in the ending year, and t_2 - t_1 is the time period. The rate r will always be higher than q, but in most cases the difference between the two quantities will be lower than the sampling error. The rate r will be significantly higher than q only when deforestation is excessive.

1.2.5 Ground truth assessment

There were 280 points used for ground truth verification. The ground truthing was conducted by Forestry Administration officers, a student researcher from the Royal University of Agriculture conducting his thesis research supported under the project, and project field staff. Reinterpretation was performed by the GIS and Remote Sensing Unit of the Watershed Management and Forestland Office of the Forestry Administration.

1.3. Results

1.3.1 Forest cover in 2014

The results of the 2014 assessment in the Preah Vihear Protected Forest revealed a forest cover of 173,133.61 hectares, representing 91.11% of its land area. The composition of that forest cover, which is provided in Table 1.3, as well as in Figure 1.2, and depicted on Map 1.1, indicates that dry deciduous forest has the most extensive forest coverage (59.19%), followed by evergreen forest (17.81%) and semi-evergreen forest (8.62%).

Table 1.3. Composition of forest cover in the Preah Vihear Protected Forest in 2014.

No.	Forest Type	Area	
		ha	%
1	Evergreen forest	33,836.48	17.81
2	Semi-evergreen forest	16,387.71	8.62
3	Deciduous forest	112,480	59.19
4	Other forest	10,119.19	5.33
5	Wood and shrub dry	310.23	0.16
Total Forestland		**173,133.61**	**91.11**
6	Non-forest	16,893.39	8.89
Total Area		**190,027**	**100**

Source: Imagery interpretation using 2014 satellite images from Landsat 8 OLI.

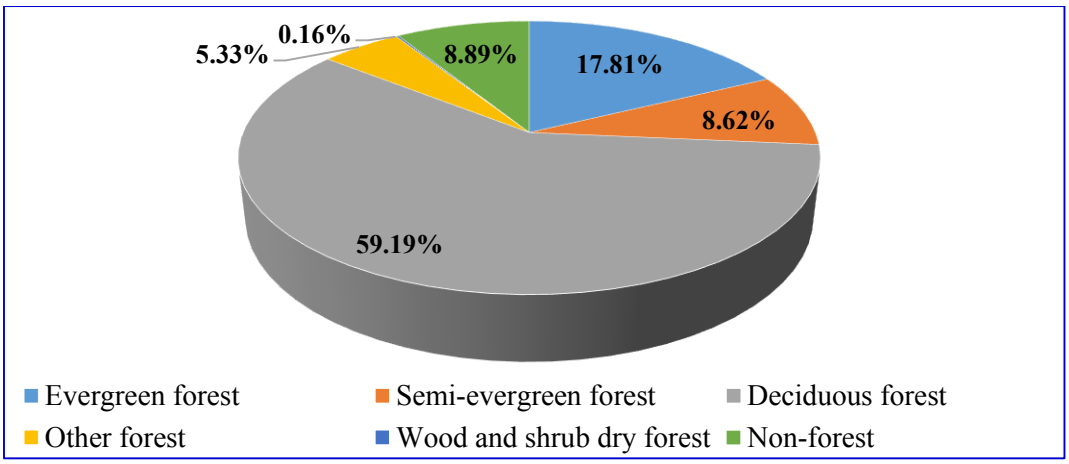
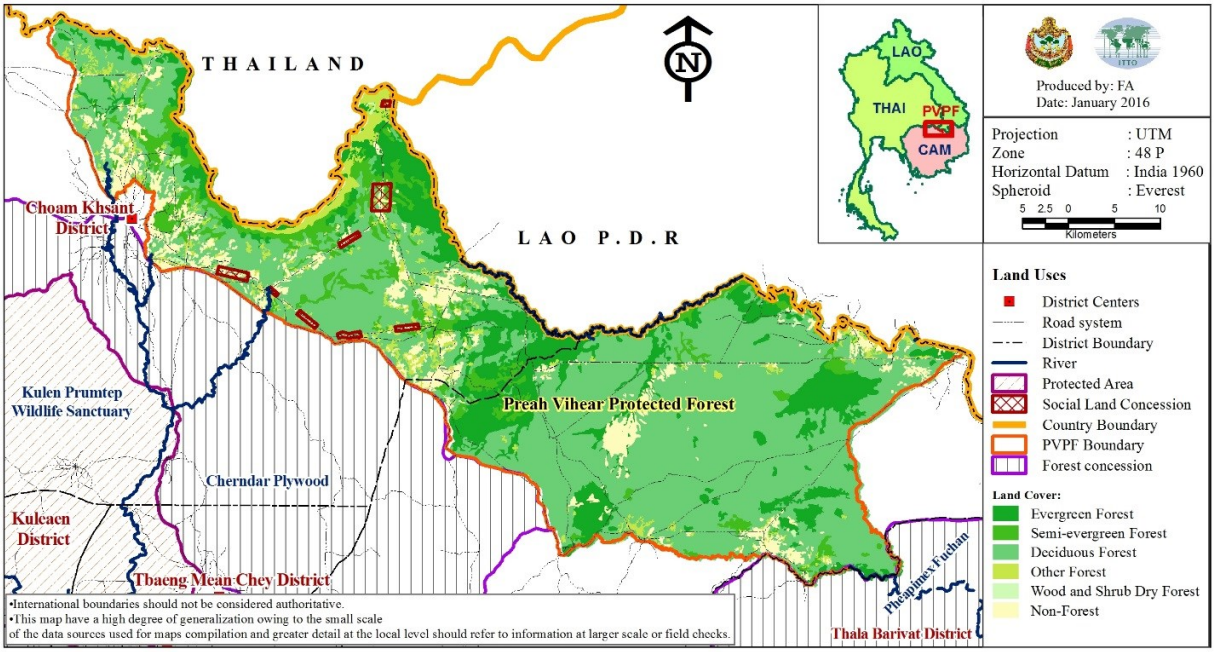


Figure 1.2. Percentages of forest and non-forest cover in the Preah Vihear Protected Forest in 2014.



Map 1.1. Forest cover in the Preah Vihear Protected Forest in 2014.

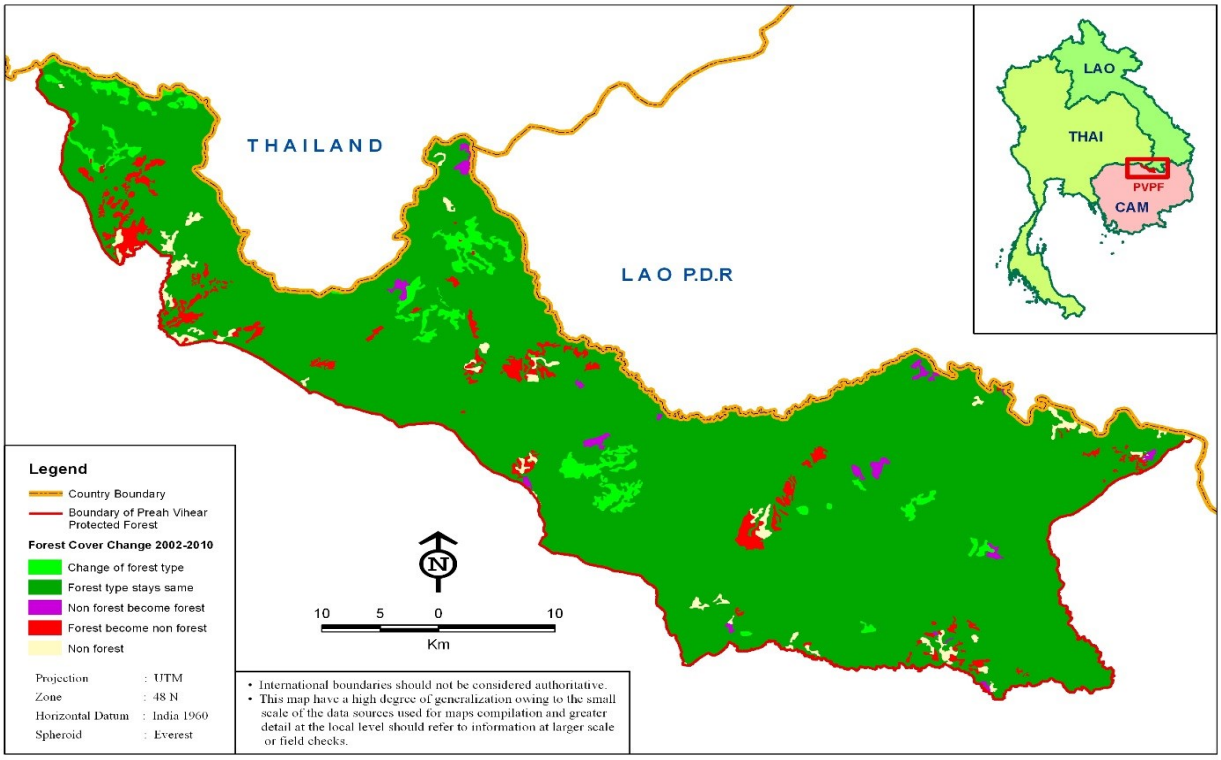
1.3.2 Forest cover changes between 2002 and 2010

Consolidating the information available on forest cover changes between 2002 and 2006, as well as between 2006 and 2010, reveals that forest cover in the Preah Vihear Protected Forest decreased from 97.62% to 95.33% between 2002 and 2010, representing an average annual decline in forestland of 0.3% (Table 1.4). This was associated with the loss of 4352.33 ha of forestland, or an average annual loss of forestland of about 548 ha. The most striking changes in forest and non-forest cover were those associated with deciduous forest, which decreased by 0.41%; non-forest, which increased by 0.3%; and evergreen forest, which increased by 0.14%, although that increase occurred primarily during the period between 2002 and 2006. The decline in the percentage of forest cover between 2002 and 2010 represented an average annual deforestation rate of 0.3% of the land area of the Preah Vihear Protected Forest. There is a pictorial representation of those changes based on the comparison of overlaid GIS land cover maps for 2002 and 2010 provided in Map 1.2.

Table 1.4. Forest cover changes in the Preah Vihear Protected Forest between 2002 and 2010.

No	Forest Type	Forest Cover Area						Annual Deforestation Rate	
		2002		2006		2010		2002-2010	
		ha	%	ha	%	ha	%	ha	%
1	Evergreen forest	33,586.37	17.68	35,708.86	18.79	35,673.88	18.78	2,087.51	0.14
2	Semi-evergreen forest	18,511.64	9.74	18,230.85	9.59	18,188.95	9.57	-322.69	-0.02
3	Deciduous forest	130,949.2	68.91	127,196	66.94	125,004	65.78	-5,945.19	-0.41
4	Other forest	2,455.85	1.29	2,256.9	1.19	2,283.89	1.2	-171.96	-0.01
Total Forestland		**185,503.1**	**97.62**	**183,392.6**	**96.51**	**181,150.72**	**95.33**	**-4,352.33**	**-0.30**
5	Non-forest	4,523.95	2.38	6,634.39	3.49	8,876.28	4.67	4,352.33	0.30
TOTAL AREA		190,027	**100**	**190,027**	**100**	**190,027**	**100**		

Source: Cambodia Forestry Administration 2014.



Map 1.2. Locations of forest cover changes in the Preah Vihear Protected Forest between 2002 and 2010.

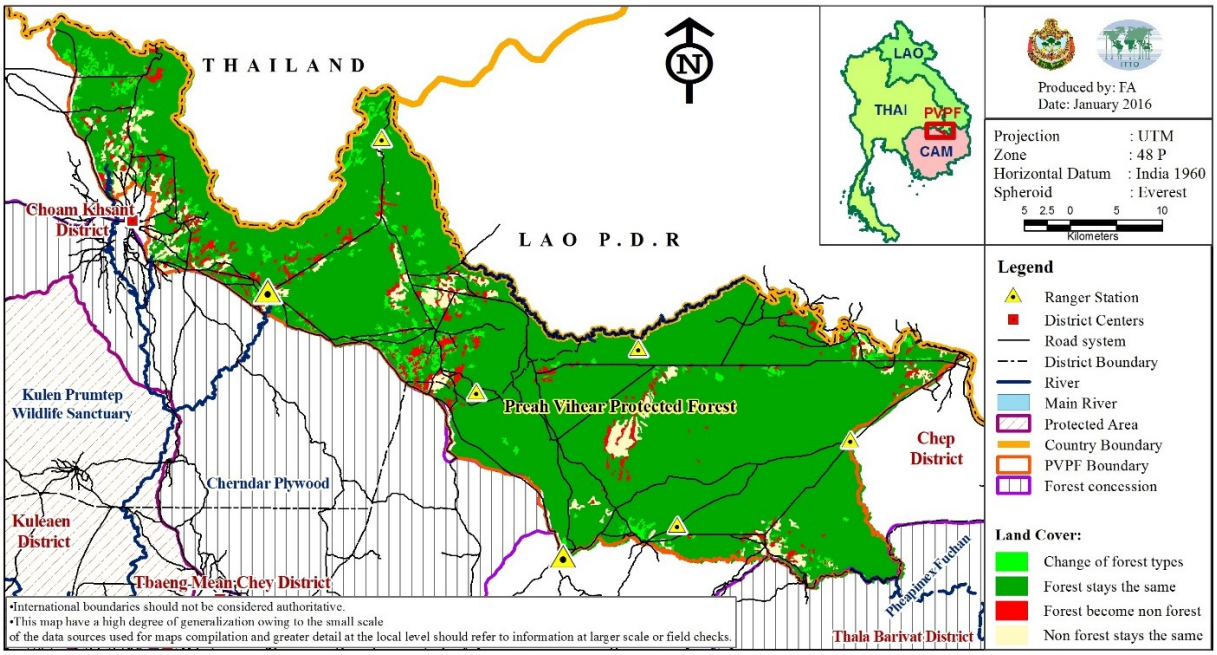
1.3.3 Forest cover changes between 2010 and 2014

Forest cover in the Preah Vihear Protected Forest decreased from 95.33% in 2010 to 91.11% in 2014. This represented an increasing rate of decline in the percentage of forest cover as the result of the loss of 8,017.11 ha of forestland during that period (Table 1.5). The average annual rate of deforestation in the Preah Vihear Protected Forest was estimated to be 1.13%. In those areas where deforestation was relatively low, forest degradation should still be recognized, however, since illegal logging and other degradation activities may have a greater impact on greenhouse gas (GHG) emissions than does forest clearing (Halperin and Turner 2013).

The representation of those changes was concentrated, especially, in deciduous forest, which declined by 1.76%, but also in evergreen and semi-evergreen forest, which declined by 0.26% and 0.25%, respectively. There was a comparable increase in the percentage of non-forest of 1.13%, other forest of 1.10%, and wood and shrub dry forest of 0.04%. There is a pictorial representation of the changes associated with the comparison of overlaid GIS land cover maps for the start and end of the period provided in Map 1.3.

Table 1.5. Forest cover changes in the Preah Vihear Protected Forest between 2010 and 2014.

No.	Forest Type	Forest Cover Area				Annual Deforestation Rate	
		2010		2014		2010-2014	
		ha	%	ha	%	ha	%
1	Evergreen Forest	35,673.88	18.78	33,836.48	17.81	-1,837.40	-0.26
2	Semi-evergreen Forest	18,188.95	9.57	16,387.71	8.62	-1,801.24	-0.25
3	Deciduous Forest	125,004	65.78	112,480	59.19	-12,524.00	-1.76
4	Other Forest	2,283.89	1.2	10,119.19	5.33	7,835.30	1.10
5	Wood and shrub dry forest	0	0	310.23	0.16	310.23	0.04
Total Forestland		**181,150.72**	**95.33**	**173,133.61**	**91.11**	**-8,017.11**	**-1.13**
6	Non-forest	8,876.28	4.67	16,893.39	8.89	8,017.11	1.13
Total Area		190,027	100	**190,027**	**100**		



Map 1.3. Locations of forest cover changes in the Preah Vihear Protected Forest between 2010 and 2014.

1.3.4 Patterns of forest cover change

a) Patterns of forest cover change between 2002 and 2010

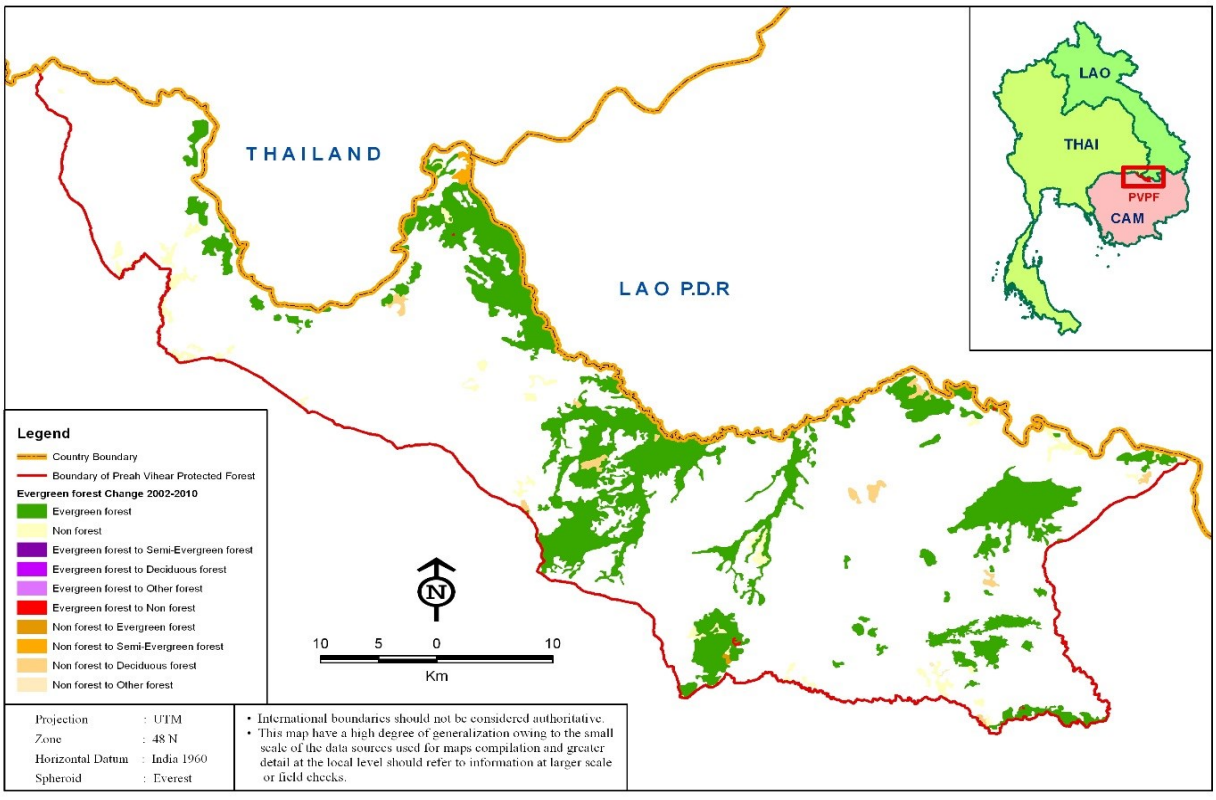
The matrix derived from forest cover GIS map overlays in Table 1.6 combines the patterns of forest cover changes in the Preah Vihear Protected Forest between 2002 and 2006 with those between 2006 and 2010. The matrix indicates that the greatest changes in the areas of the forest and non-forest land cover classifications between 2002 and 2010 were associated with

evergreen forest, deciduous forest, and non-forest. The pictorial representations of those changes in evergreen forest, which were primarily associated with net 'gains' of 1,897 ha from semi-evergreen forest, are provided in Map 1.4. The pictorial representations of those changes in deciduous forest, which were primarily associated with net 'losses' of 1,071 ha to semi-evergreen forest and 1,149 ha to non-forest, are provided in Map 1.5. The representation of those changes in non-forest were primarily associated with net 'gains' of 5,586 ha from deciduous forest. The largest percentage change in area between 2002 and 2010 was associated with non-forest, the area of which expanded, although from a much smaller base, by 96%, primarily as the result of the net 'gain' of 5,586 ha from deciduous forest.

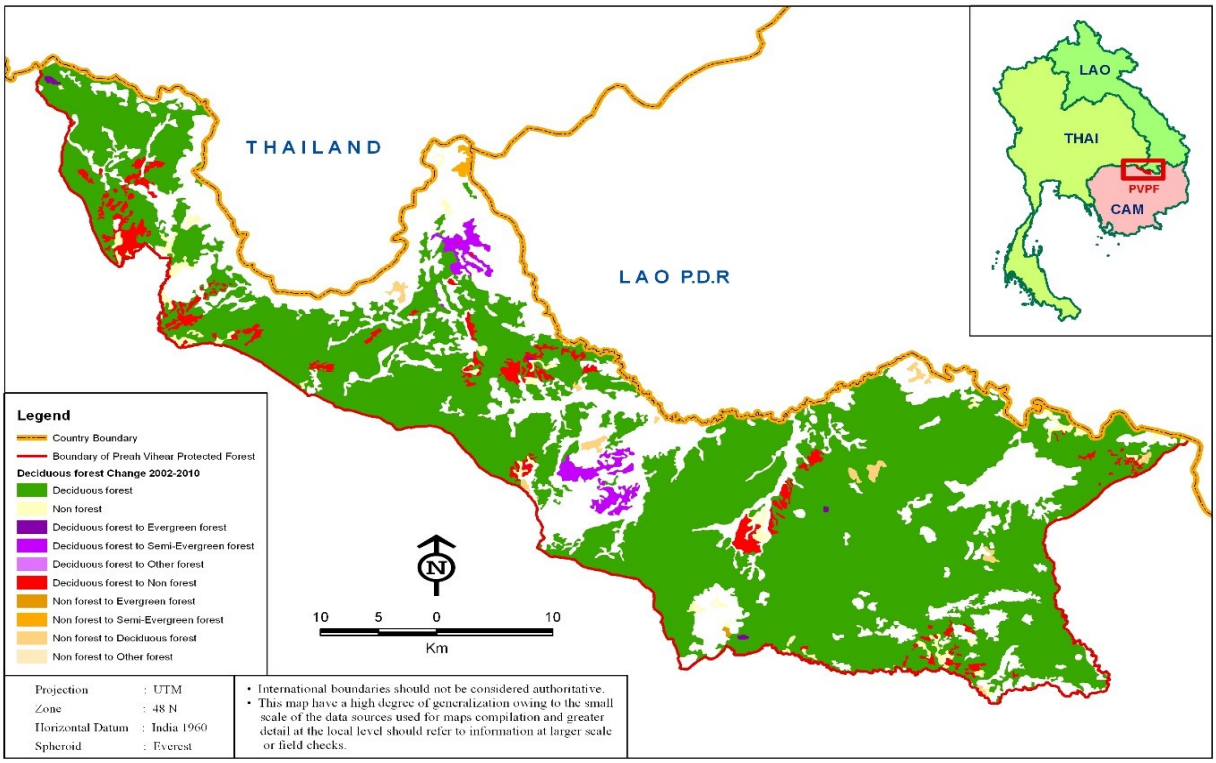
Table 1.6. Forest cover changes by forest types between 2002 and 2010.

Forest type		Change of forest type					Total 2002 (ha)
		EF	SE	DF	OF	NF	
Change of forest type	Evergreen forest (EF)	**33,528.48**	0.06	0	0.13	57.70	33,586.37
	Semi-evergreen forest (SE)	1,896.90	**15,358.30**	1,071.19	0	185.25	18,511.64
	Deciduous forest (DF)	150.46	2,429.36	**122,783.32**	0	5,586.05	130,949.19
	Other forest (OF)	53.91	145.17	0	**2,256.77**	0	2,455.85
	Non-forest (NF)	44.13	256.06	1,149.49	26.99	**3,047.28**	4,523.95
Total 2010 (ha)		35,673.88	18,188.95	125,004.00	2,283.89	8,876.28	**190027**

Note: The matrix table is based on forest cover 2002 and 2010 geodatabase analysis using GIS applications. EF = Evergreen forest; SF = Semi-evergreen forest; DF = Deciduous forest; OF = other forest; and NF = non-forest.



Map 1.4. Change in evergreen forest between 2002 and 2010.



Map 1.5. Change in deciduous forest between 2002 and 2010.

b) Patterns of forest cover change between 2010 and 2014

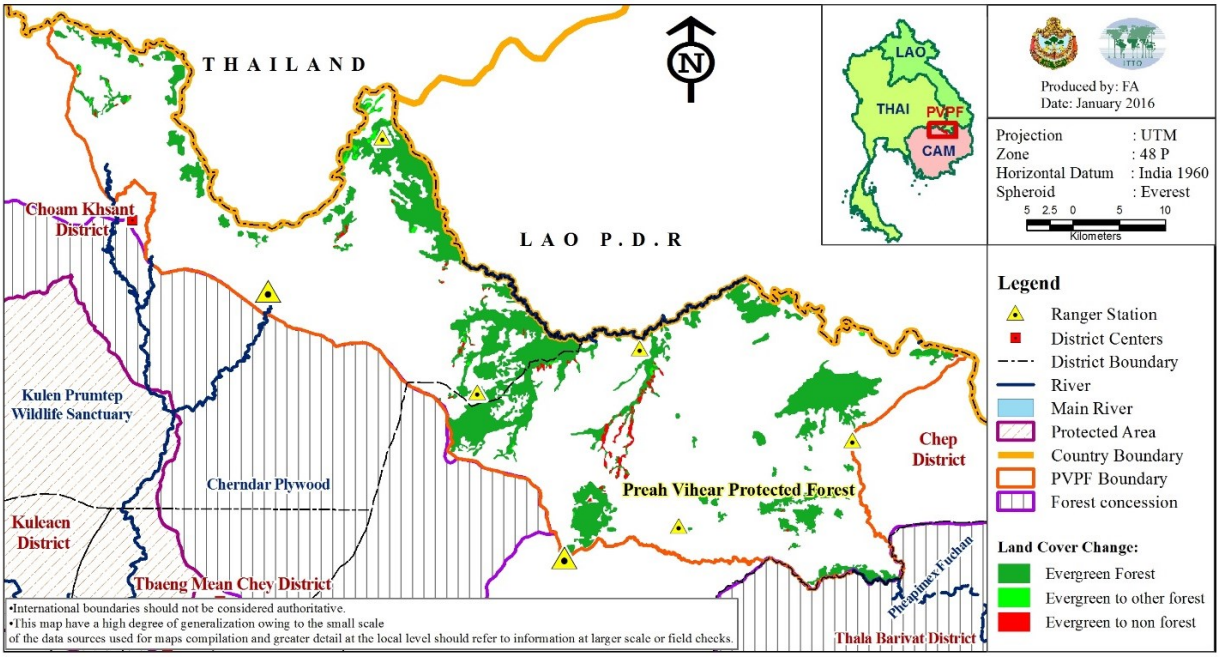
The matrix provided in Table 1.7 is derived from the GIS assessment using overlays of forest cover maps for 2010 and 2014 to discern the patterns of forest cover change in the Preah Vihear Protected Forest. The results indicate that the greatest changes in the Preah Vihear Protected Forest during that period were associated with evergreen forest, deciduous forest, and non-forest. The pictorial representations of those changes in evergreen forest, which were primarily associated with net 'losses' of 768 ha to degraded forest (other forest) and 1070 ha to non-forest are depicted in Map 1.6. The representations of those changes in semi-evergreen forest were associated with net 'losses' of 982 ha to degraded forest (other forest) and 819 ha to non-forest. Other changes that occurred in deciduous forest, which were primarily associated with net 'losses' of 6058 ha to degraded dry dipterocarp forest (other forest) and 6466 ha to non-forest are depicted in Map 1.7. The pictorial representation of those changes in non-forest, which were primarily associated with the net 'gains' of 1070 ha from evergreen forest, 819 ha from semi-evergreen forest, 6466 ha from deciduous forest and 17 ha from other forest, are depicted in Map 1.8. The largest percentage change in area between 2010 and 2014 was associated with non-forest, the area of which expanded, although from a much smaller base, by 90%, primarily as the result of the net 'gain' of 6466 ha from deciduous forest.

Table 1.7. Forest cover changes by forest types between 2010 and 2014.

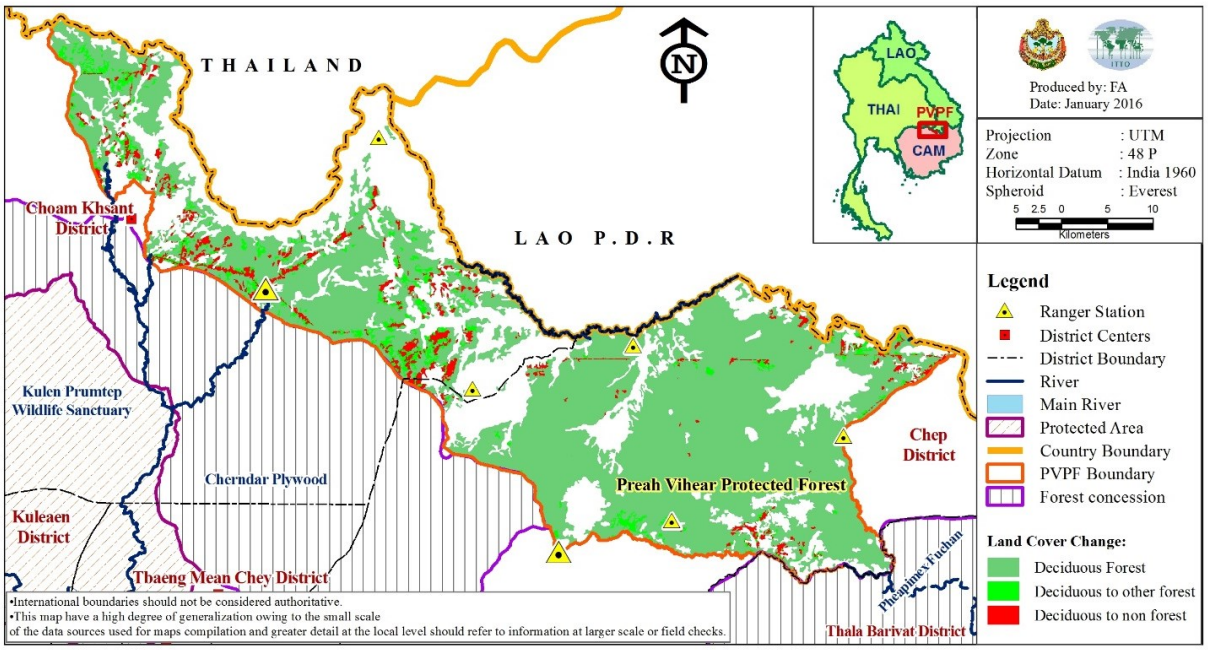
Forest types		Change of forest type						TOTAL 2010 (ha)
		EF	SE	DF	OF	WD	NF	
Change of forest type	Evergreen forest (EF)	**33836.48**	0	0	767.7	0	1069.7	35673.88
	Semi-evergreen forest (SE)	0	**16387.71**	0	982.48	0	818.76	18188.95
	Deciduous forest (DF)	0	0	**112480**	6057.79	0	6466.21	125004
	Other forest (OF)	0	0	0	**2266.9**	0	16.99	2283.89
	Wood and shrub dry forest (WD)	0	0	0	0	0	0	0
	Non-forest (NF)	0	0	0	44.32	310.23	**8521.73**	8876.28
Total 2014 (ha)		33836.48	16387.71	112480	10119.19	**310.23**	16893.39	190027

Note: The matrix table is based on forest cover 2010 and 2014 geodatabase analysis using GIS applications. EF = Evergreen forest; SF = Semi-evergreen forest; DF = Deciduous forest; OF = other forest; and NF = non-forest.

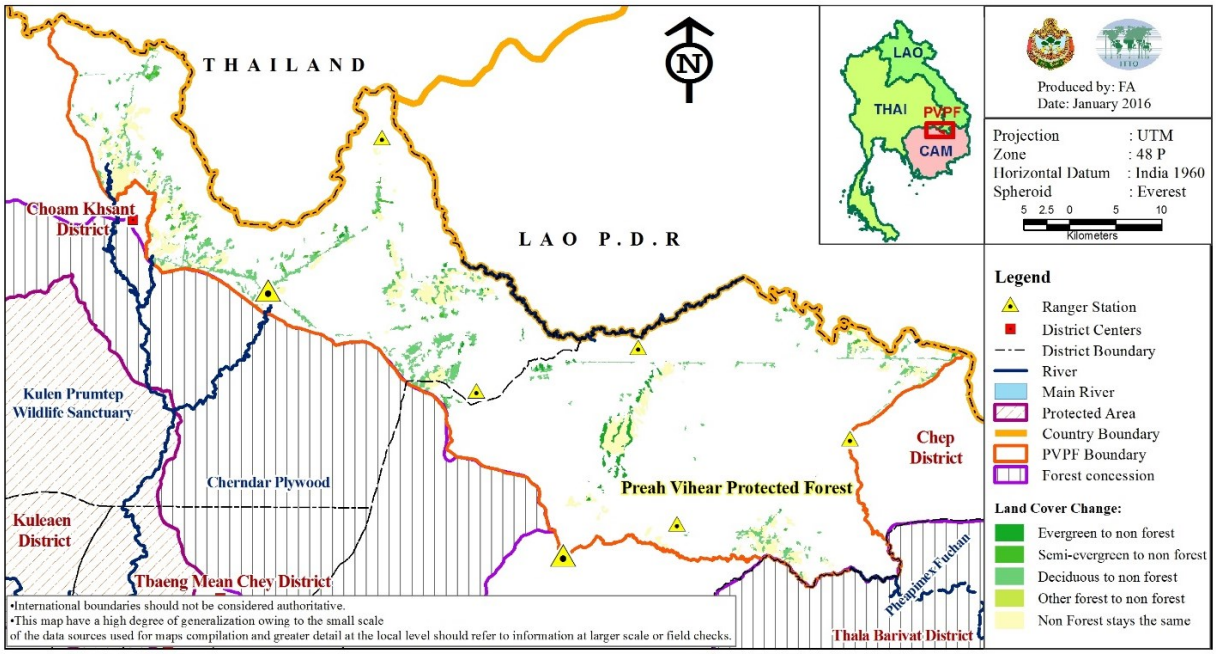
The most significant loss of forests has occurred in the northwestern part of the Preah Vihear Protected Forest located in Chaom Ksan district where the government sanctioned the allocation of land for Social Land Concessions.



Map 1.6. Change in evergreen forest between 2010 and 2014.



Map 1.7. Change in deciduous forest between 2010 and 2014.



Map 1.8. Change in non-forest between 2010 and 2014.

1.3.5 Validation of data

Site assessments were conducted to confirm forest classifications by project staff and student researchers from the Prek Leap National School of Agriculture and the Royal University of Agriculture supported under the project in collaboration with the GIS and Remote Sensing Unit in the Forestry Administration. The ground truthing of 280 satellite imagery interpretation sample points in the Preah Vihear Protected Forest was achieved. The results of the ground truthing, which are summarized in Table 1.8, revealed that 266 of the 280 ground truthed points were correct and the accuracy of the forest classifications was significant at 95%.

Table 1.8. Field verification of satellite imagery interpretation sample points.

Forest Type	Forest Classification					Total	Accuracy rate (%)
	EF	SF	DF	OF	NF		
Evergreen forest (EF)	39					39	100
Semi-evergreen forest (SE)		38				38	100
Deciduous forest (DF)			95	2		97	98
Other forest (OF)			4	31		35	89
Non-forest (NF)				8	63	71	89
Total	39	38	99	41	63	280	
Accuracy rate (%)	100	100	96	76	100		95

Note: EF = Evergreen forest; SF = Semi-evergreen forest; DF = Deciduous forest; OF = other forest; and NF = non-forest.

1.3.6 Drivers of deforestation and forest degradation

The forest cover in the PVPF in 1965 was 98.31%. It had declined to 98.18% in 1992/1993 and it continued to decrease marginally to 97.70% in 1996/1997. In 2002, the starting point of this assessment, forest cover was 97.62%, decreasing to 96.51% in 2005/2006, 95.33% in 2010, and 91.11% in 2014, the end point of this assessment (Table 1.9 and Figure 1.3).

Table 1.9. Forest cover changes in the Preah Vihear Protected Forest between 1965 and 2014.

No	Year of Assessment	Land				Total Area (ha)
		Forestland		Non-forest Land		
		ha	%	ha	%	
1	1965	186,813.68	98.31	3,213.32	1.69	190,027
2	1992/93	186,560.86	98.18	3,466.14	1.82	190,027
3	1996/97	185,664.57	97.70	4,362.43	2.30	190,027
4	2002	185,503.05	97.62	4,523.95	2.38	190,027
5	2005/06	183,392.61	96.51	6,634.39	3.49	190,027
6	2010	181,150.72	95.33	8,876.28	4.67	190,027
7	2014	173,133.61	91.11	16,893.39	8.89	190,027

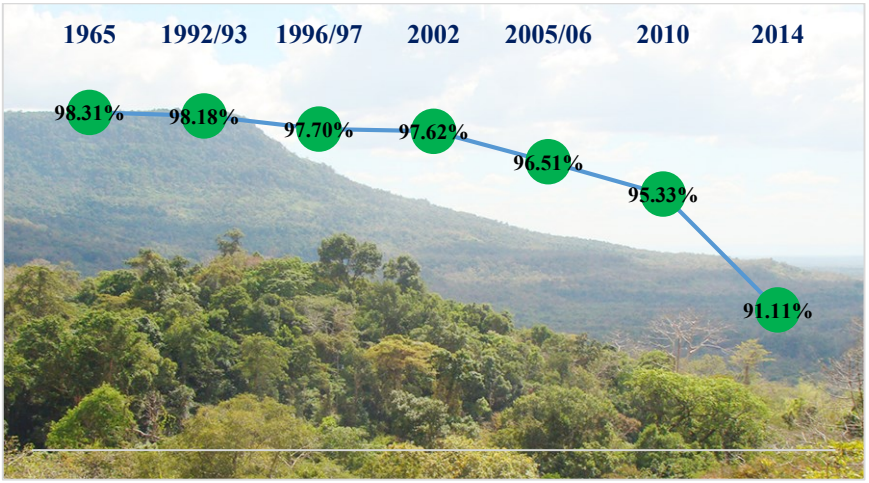


Figure 1.3. Forest cover trends between 1965 and 2014.

The forest cover loss between 2010 and 2014 represented 4.22% of the area of the Preah Vihear Protected Forest. That change was primarily associated with the implementation of the government settlement and land allocation program through Social Land Concessions, as well as attributable to population growth and agricultural expansion.

The largest part of deforestation and forest degradation in the Preah Vihear Protected Forest is associated with the land use policy changes through which the government has allocated land along the border of the Preah Vihear Protected Forest to develop infrastructure and construct settlements for military households. Other drivers of forest degradation have included unsustainable and illegal logging, unregulated fuelwood collection, and forest fires (Cambodia Forestry Administration 2010).

The domestic use of forests for fuelwood had not previously been considered to be a direct driver of forest degradation (Cambodia Forestry Administration 2011), but increased commercial demand for fuelwood is now resulting in forest degradation and it should be considered to be one of its more important drivers (Top et al. 2004; Top et al. 2006).

Fire is a natural ecosystem process in some of Cambodia's forests, as well, particularly in deciduous forests (Wharton 1966; Jones 1998; Cambodia Forestry Administration 2011). It was estimated in one assessment that 60% of all deciduous forests in Cambodia had experienced at least some burning in the previous 3-6 months and it was established that fire, as an agent of vegetation change, has an extended history in the country (Maxwell 2004). During the ground truthing verification conducted in this study, there was evidence of fire in deciduous and semi-evergreen forest observed in the form of charred wood residues, burned scars on trees, and burned non-woody vegetation. If fire intervals have become more frequent than indicated through assessments of the historical record, this could result in alterations in understory vegetation, reduce tree regeneration, and increase the cover of bamboo in riparian areas, with a corresponding decrease in biomass. Other assessments have described the impact of fire on forests more equivocally. The differences in these assessments reflects the recognition that fire regimes and forest successional dynamics have not yet been intensively investigated in Cambodia (Forestry Administration 2011).

1.4. Conclusions and recommendations

1.4.1 Conclusions

The review and updating of Forest Cover Assessments in the Preah Vihear Protected Forest is essential to monitor the current state of its forest resources and provide fundamental information for the preparation of long-term Strategic Protected Forest Management Plans. It also provides benchmark indicators for achieving sustainable forest management objectives. The results of the current forest cover assessment in the Preah Vihear Protected Forest indicate a progressive decline in forest cover from 97.62% in 2002 to 96.51% in 2006, 95.33% in 2010 and 91.11% in 2014, equivalent to an average annual deforestation rate over that period of 0.715% of the land area of the Preah Vihear Protected Forest. That is, however, lower than the country-wide average of annual forest cover loss of 1.055% during that same period.

The lower rate of decrease of forest cover in the PVPF is, nevertheless, a critical concern, especially in the context of efforts to mitigate the impacts of climate change. One of the primary reasons for the loss in forest cover is the increase in demand for the use of land for agriculture and agro-industrial endeavors, especially the conversion of forestland to Social Land Concessions and illegal forestland encroachment by the military and migrants with respect to which land use policy reforms would not be able to compensate sufficiently to achieve either the Cambodia Millennium Development Goals or the Sustainable Development Goals. Indeed, to be able to maintain the percentage of forest cover in the Preah Vihear Protected Forest as it was in 2002 (187,282 hectares) would require 14,148.39 hectares of non-forest land to be converted to man-made forest and agroforestry plantations.

1.4.2. Recommendations

- Promote agroforestry practices in degraded forests areas of the Preah Vihear Protected Forest.
- Ensure coherence of forestland management and forest land tenure policies.
- Strengthen cooperation with local authorities and local communities to deter illegal logging and the incidence of forest clearing and encroachment.
- Expand the use of the Spatial Monitoring and Reporting Tool (SMART) to strengthen the planning of law enforcement patrols in accordance with observed threats and the establishment of measurable responses to those threats.
- Increase law enforcement patrols in critical habitats and in areas in which illegal logging, wildlife poaching, and forest clearing and encroachment are more prevalent.
- Intensify campaigns against illegal logging and the incidence of forest clearing and encroachment and promote environmental education to strengthen understanding and increase awareness of those activities.
- Strengthen the capacities of rangers by allocating more equipment, including vehicles and field communication and enforcement equipment, as well as more staff, to achieve the Forestry Administration recommended number per unit cost of 8 rangers per station.
- Increase the number of informal and formal meetings with government officials to strengthen bonds of political support to strengthen biodiversity conservation in the PVPF.
- Engage local communities regarding the importance of Biodiversity Hotspots in the PVPF.
- Install entrance gates, cement boundary posts, and road signs to strengthen infrastructure development in the PVPF.
- Promote forest enrichment planting in natural forest areas of native forest trees provided from nurseries in the PVPF.
- Encourage household and community investments to support restoration efforts and the establishment of forest plantations to rehabilitate degraded and encroached reclaimed forests, especially in those instances in which natural succession is inadequate to secure the ecological recovery of those areas.

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INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST

CHAPTER II

PRELIMINARY ASSESSMENT OF CARBON STOCKS

KIM SOBON, DENNIS CENGEL, THUCH PHALLA, SAY SINLY, NHAN BUNTHAN, CHHEANG DANY, LIM SOPHEAP, and PANG PHANIT

SUMMARY

The primary purpose of this study was to establish preliminary estimates of carbon stocks in the evergreen, semi-evergreen, and deciduous forests of the PVPF as a means of providing measures of those stocks prior to a more extensive assessment of the practicability of establishing REDD+ activities in the PVPF. The sampling area consisted of eighty nine (89) plots (30 m x 50 m) that were established in evergreen (33), semi-evergreen (17), and deciduous forests (39) in the PVPF. Individual plot locations within each of those forest cover types were determined by random selection of GPS coordinates. The assessment was conducted in accordance with National Forest Inventory recommendations with rectangular plots established to increase the accuracy of sampling intensity. Under this structure, there were three levels of sub-plots in each plot, including (1) a sub-plot for measuring large trees (DBH≥30cm.); (2) a sub-plot for measuring medium size trees (15cm.≤DBH≤30cm.); and (3) a sub-plot for measuring small trees (5cm.≤DBH<15cm.).

The results indicated that there were 5,723 trees in the 89 sample plots with an estimated above ground biomass of 1,524 mt, which is equivalent to approximately 762 mt of carbon biomass. The maximum carbon biomass (288 mt) was present in the 31-60 cm DBH class and the second most biomass (258 mt) was present in the 0-30 cm DBH class. The least carbon biomass (104 mt) was present in the 61-90 cm DBH class. The sum of the above ground and below ground biomass was 322.859 ± 36.721 mt/ha in the evergreen forest; 259.086 ± 36.611mt/ha in the semi-evergreen forest; and 130.479 ± 10.299 mt/ha in the deciduous forest. The sum of the above ground and below ground carbon stocks in the evergreen forest was 161.43 ± 18.36 mt/ha; 129.54 ± 18.31mt/ha in the semi-evergreen forest; and 65.24 ± 5.15 mt/ha in the deciduous forest. The differences of biomass and carbon stocks between evergreen, semi-evergreen and deciduous forest were primarily related to differences in tree densities and volumes. The assessment of the correlation between DBH and tree biomass resulted in a correlation of 0.8526 in the evergreen forest, 0.8737 in the semi-evergreen forest, and 0.8781 in the deciduous forest. This confirmed the positive correlation and strong linear relationship between DBH and biomass in each of the forest cover types in the Preah Vihear Protected Forest.

The extent to which the relatively low estimates of carbon stocks in the deciduous forest cover type were the result of the random selection of more cutover sampling sites in deciduous forests in the PVPF or the use of the more general, and perhaps less applicable, allometric equations for moist tropical forests and tropical forests in deciduous forests is uncertain. The lower estimates of carbon stocks in deciduous forests suggest the efficacy of conducting further sampling to increase the accuracy of the estimates in deciduous forests and provide the means to facilitate a more inclusive and accurate evaluation of the feasibility of establishing REDD+ activities in the PVPF.

CHAPTER II

PRELIMINARY ASSESSMENT OF CARBON STOCKS

2.1 Introduction

In recent years, concerns with the potential impacts of climate change have been increasing. There appears to be mounting evidence that estimates of average increases in worldwide temperatures during the past century may have been caused at least to some extent by human-induced activities. Those activities include the burning of fossil fuels, unsustainable use of natural resources, and clearing of forests for agricultural crops and cattle ranching. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change indicated a warming of 0.85 (0.65 to 1.06) °C over the period from 1880 to 2012 in the globally averaged combined land and ocean surface temperature calculated using a linear trend (IPCC, 2014).

Tropical forests constitute a significant carbon sink, accounting for 1,664 million ha of forest, or about 42%, collectively, of the area of forests worldwide in 2010 (Sasaki 2012). The results of a recent assessment by Saatchi et al. (2011), moreover, indicated that tropical forest biomass contained 247 gigatons of carbon, of which 193 gigatons, or almost 80% of that amount, were stored above ground (Chaturvedi et al. 2011). Those evaluations are comparable with estimates developed by Pan et al. (2011) of 264 ± 52 gigatons of carbon stored in the live biomass (above ground and below ground) of tropical forests.

The reported substantial storehouses of carbon coupled with increasing concerns with climate change underpin the significance of observations of the rates of deforestation of the world's tropical forests. Indeed, the annual rate of deforestation worldwide averaged some 10-13 million ha between 2000 and 2010, although that represented a decline from an annual rate of some 16 million ha during the previous decade (FAO 2010; 2015). In Cambodia, the annual average rate of deforestation was 0.5% between 2002 and 2010 during a period of accelerated economic growth that was driven, in part, by the development of large-scale agro-industrial plantations (Forestry Administration, 2011).

The maintenance and enhancement of Cambodia's forest carbon stocks in its tropical forests are regarded as effective measures to contribute to mitigation of the impacts of climate change. This is especially the case under the evolving United Nations Framework Convention on Climate Change (UNFCCC) Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism that extends actions under the 'plus' component of REDD+ in accordance with 'supporting forest conservation, strengthening the sustainable management of forests, and enhancing forest carbon stocks.' The evaluation of potential REDD+ applications in the Preah Vihear Protected Forest (PVPF) introduces consideration of an important supplemental source of financing to support the effective implementation of sustainable forest management strategies that recognize the importance of local livelihoods, as well as deliver significant biodiversity conservation benefits. The realization of those efforts in the PVPF would provide a replicable structure to influence actions in each of the countries participating in the International Tropical Timber Organization - Convention on Biological Diversity (ITTO-CBD) project on 'Management of the Emerald Triangle Protected Forests Complex to Promote

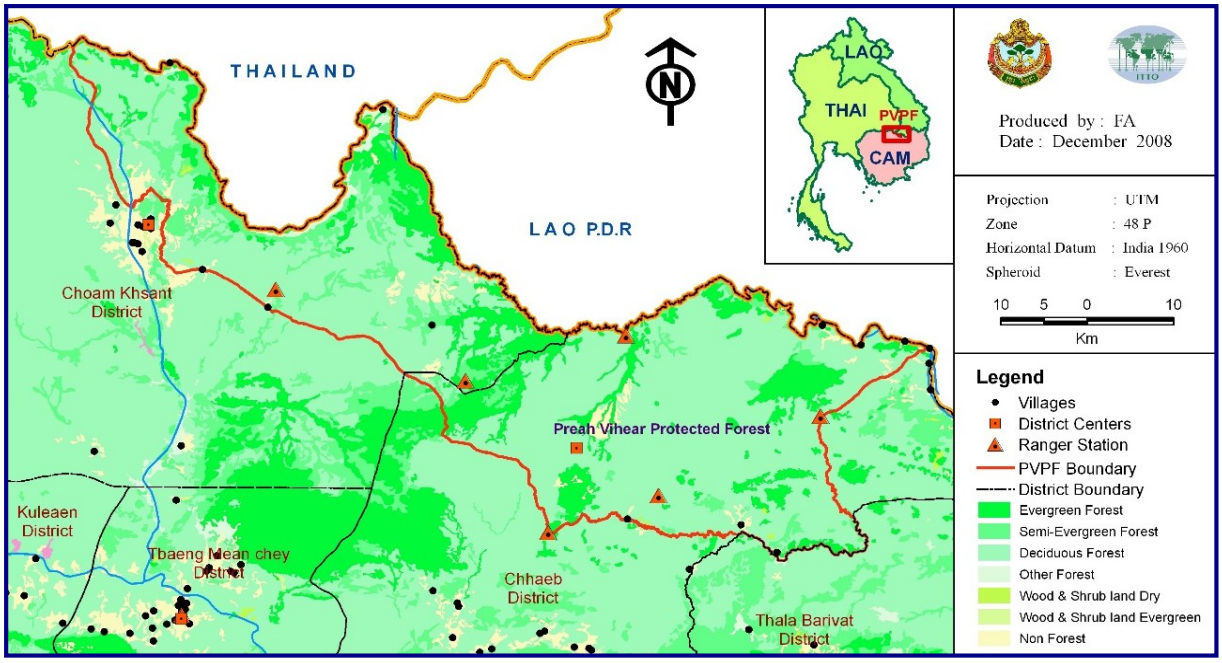
Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos (Phase III) to strengthen forest management planning practices and conserve trans-boundary biodiversity throughout the Emerald Triangle Protected Forests Complex.

The primary purpose in initiating these processes through this study was to establish preliminary estimates of carbon stocks in the evergreen, semi-evergreen, and deciduous forests of the PVPF as a means of providing measures of those stocks prior to a more extensive assessment of the practicability of establishing REDD+ activities in the PVPF. The carbon pools that were incorporated into our measures comprised live biomass, both above ground (ABG) and below ground; they did not include soil, which according to Pan et al. (2011) accounts for 32% of the total stored carbon in tropical forests, nor dead wood or litter.

2.2 Methods

2.2.1 Study area

The PVPF was established through the Royal Government of Cambodia Sub-degree No.76 on July 30, 2002 as the 'Preah Vihear Protected Forest for Forest and Wildlife Genetic Resources Conservation.' It is located in the northern part of the country and includes parts of two districts, Chhep and Choam Ksan. It shares borders with Thailand and Lao PDR in the north; Kampong Sralou Mouy and Chheb Pi communes in Chhep district in the southeast; the previously suspended Chendar Plywood forest concession area in the south; and Chom Ksan and Toeuk Kraham communes in Choam Ksan district in the southwest (Map 2.1). The PVPF constitutes an important part of the Indo-Burma Biodiversity Hotspot, which is one of 35 Global Hotspots in the world (Myers et al; 2000). The area is crucial to the conservation of several species of large mammals, including the Asian Elephant (*Elephas maximus*), Banteng (*Bos javanicus*), and Gaur (*Bos gaurus*). It also provides critical habitat for other endangered, vulnerable, and near-threatened mammals, including the Dhole (*Cuon alpinus*), Fishing Cat (*Prionailurus viverrinus*), Eld's Deer (*Rucervus eldii*), Sambar (*Cervus unicolor*), and Leopard (*Panthera pardus*). The PVPF also supports the largest global breeding population of the critically endangered Giant Ibis and is an important nesting site, as well as habitat, of other bird species, including the Green Peafowl (*Pavo muticus*), White-winged Duck (*Asarcornis scutulata*), White-shouldered Ibis (*Pseudibis davisoni*), Greater Adjutant (*Lepoptilos dubius*), Sarus Crane (*Grus antigone*), and Lesser Adjutant (*Leptoptilos javanicus*).



Map 2.1. Location of the Preah Vihear Protected Forest.

The PVPF contains 173,134 ha of evergreen, semi-evergreen, deciduous, wood & shrubland dry, and other forests (Table 2.1). The dominant forest cover type in the PVPF is dry deciduous forest, which accounted in 2014 for 59% of the PVPF's land area. The results of assessments conducted by the Cambodian Forestry Administration, which have classified the PVPF into several different land cover categories, indicate that the areas of, especially, deciduous forest, but also semi-evergreen forest, which collectively account for 68% of the PVPF's total forest cover, decreased between 2002 and 2006, and again between 2006 and 2014, as non-forest land increased.

Table 2.1. Forest cover changes in the Preah Vihear Protected Forest between 2002 and 2014.

Forest Type	**2002**		**2006**		**2010**		**2014**	
	(ha)	**(%)**	**(ha)**	**(%)**	**(ha)**	**(%)**	ha	%
Evergreen Forest	33,586	17.68	35,709	18.79	35,674	18.77	33,836.48	17.81
Semi-Evergreen Forest	18,512	9.74	18,231	9.59	18,189	9.57	16,387.71	8.62
Deciduous Forest	130,949	68.91	127,196	66.94	125,004	65.78	112,480	59.19
Wood & Shrubland Dry	1,714	0.90	438	0.23	350	0.18	310.23	0.16
Wood & Shrubland Evergreen	65	0.03	0	0.00	0	0.00		
Other Forest	2,456	1.29	2257	1.19	2,284	1.20	10,119.19	5.33
Total Forest Land	**187,282**	**98.55**	**183,831**	**96.74**	**181,501**	**95.5**	**173,133.61**	**91.11**
Non Forest	2,738	1.44	6190	3.26	8,519	4.48	16,893.39	8.89
Total	**190,020**	**100**	**190,020**	**100**	**190,020**	**100**	**190,027**	**100**

Source: Cambodia Forestry Administration 2011.

2.2.2 Sampling procedures

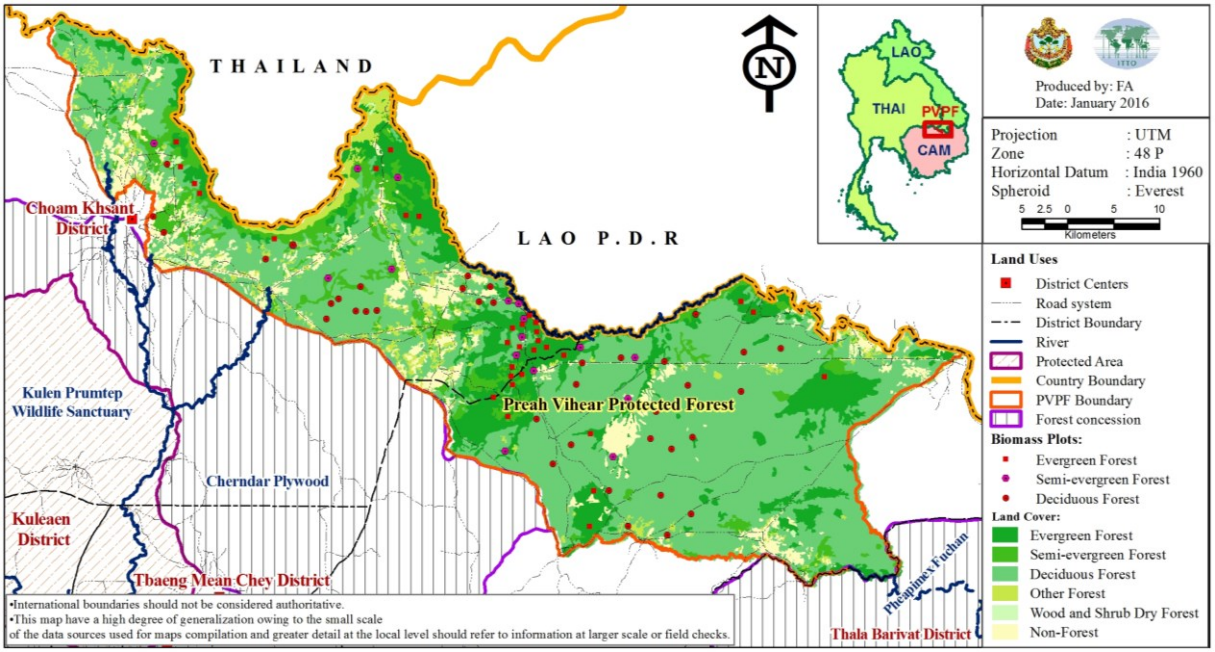
The sampling area was stratified by forest cover type and individual plot locations within each of those cover types were determined by random selection of GPS coordinates (Map 2.2). Eighty Nine (89) plots (30 x 50 m) were established in evergreen (33), semi-evergreen (17) and deciduous forests (39). The selection of the number of plots to sample in each of those forest cover types was based on estimates of sample size using the Winrock Terrestrial Sampling Calculator (Equation 1) (Walker et al. 2007).

$$n = \frac{\left(\sum_{h=1}^{L} N_h * s_h\right)^2}{\left(N * \frac{E}{t}\right)^2 + \left(\sum_{h=1}^{L} N_h * s_h{}^2\right)} \qquad \textit{Equation 1}$$

where: E is the allowable error, i.e., mean carbon stock * 0.1 (for 10% precision); N_h is the number of sampling units for stratum h (equal to the area of the stratum in hectares / the area of the plot in hectares); t is the sample statistic from the student's t-distribution for the 90% confidence level; s_h is the standard deviation of a stratum; and N is the number of sampling units in the population.

The Winrock Terrestrial Sampling Calculator automates the use of standard statistical procedures to estimate required numbers of plots to sample on the basis of previous estimates of the means and standard deviations of carbon stocks in evergreen, semi-evergreen and deciduous forest types, as well as specified confidence and error levels, which were selected in this study to be 90% and 10%, respectively, and allocates those plots to each of the three forest cover types. Each of the sampled plots was subdivided into quadrats at 10 m gridline intervals to facilitate tree measurement within each of those plots. In some of the more densely vegetated areas, in which the establishment of sample plots was constrained to some extent because of difficult access, it was not possible to establish plots in every part of the sampling area.

The GPS position of each plot was recorded to facilitate the marking of the points on GIS and remote sensing images and locating plot boundaries. Individual live trees with diameter at breast height (DBH) ≥ 5 cm were measured in each plot using calibrated diameter tapes; dead trees were not measured. The methodology used for carbon stock sampling was based on protocols established by Walker et al. (2012), which provide standard operating procedures for selecting sampling design, establishing sample plots, and measuring trees and other sources of carbon to estimate the carbon stored in the various organic pools within a landscape.



Map 2.2. The location of sample plots in the Preah Vihear Protected Forest.

2.2.3 Plot design

In accordance with National Forest Inventory (NFI) 2014 recommendations, rectangular plots were established since the resulting nesting of plots increases the accuracy of sampling intensity, especially for recording larger trees, and ensures the more efficient use of time (Vesa et al. 2014). Under this structure, there are three levels of sub-plots in each plot, including (1) a sub-plot for measuring large trees (DBH≥30cm.); (2) a sub-plot for measuring medium size trees (15cm.≤DBH≤30cm.); and (3) a sub-plot for measuring small trees (5cm.≤DBH<15cm.) (Table 2.2).

Table 2.2. Plot design and sub-plot specifications.

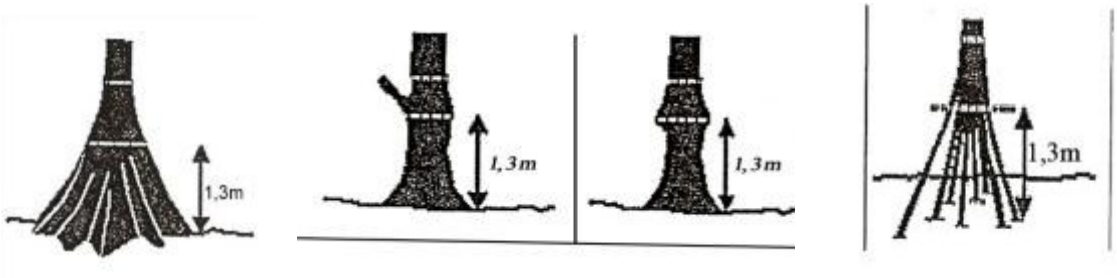
Plot & Sub-plots	Dimensions	Area (m^2)	Sizes of Trees to be Counted and/or Measured
Subplot 1: Large Trees	30 m × 50 m	1500	DBH≥30cm
Subplot 2: Medium Trees	30 m × 25 m	750	15cm.≤DBH≤30cm.
Subplot 3: Small Trees	10 m × 10 m	100	5cm.≤DBH<15cm.

Source: Vesa, et al., 2014.

2.2.4 Measuring techniques

The local and scientific names of every tree species were recorded. If a species was unknown, a photograph was taken and shown to local plant 'experts' and/or villagers to enlist their assistance in naming the unknown species. The DBH of every tree with DBH ≥ 5cm was measured with a measuring tape at a height of 1.3 m above the ground using a 1.3 m long stick. The DBH of every tree was measured twice to ensure accuracy. The following figures illustrate the applications of measurement techniques under various conditions.

If a fork of a tree originated at a height of 1.3 m or more above the ground, the tree was considered to be a single tree and its DBH was measured below the fork. If a fork originated below 1.3 m, each trunk was considered to be a single tree and its DBH was measured at a height of 1.3 m above the ground. If a tree had an irregular shape at a height of 1.3 m above the ground because of bulges, wounds, hollowed out trunks, or branches, its DBH was measured above the deformation (Cambodia Forestry Administration 2010; Vesa,et al. 2014).



Source: Cambodia Forestry Administration 2010.

2.2.5 Data analysis

The purpose of this study was to estimate carbon stocks in each of the forest cover types to provide preliminary measures of the amounts of carbon currently stored in the PVPF. General allometric equations for moist tropical forests and tropical forests (Table 2.2) were used to convert DBH measurements to estimates of above ground and below ground biomass, respectively, of each standing live tree. It was assumed that the carbon content of each measured tree was 50% of its biomass estimated from the allometric equations (Chave et al., 2005; Cairns et al. 1997). Estimates of above ground and below ground biomass of each tree were determined, as were average above ground and below ground biomass in each forest cover type.

Random sampling was used for sampling above ground biomass, which was determined using the following formula:

$$AGB = p \times \exp(-1.499 + 2.148 \times \ln(dbh) + 0.207 \times (\ln(dbh))^2 - 0.0281 \times (\ln(dbh))^3) \quad \textit{Equation 2}$$

The p value used for wood density was the standard average value of 0.57 gm/cm3.

The formula used in determining below ground biomass, which includes the biomass of live roots, excluding fine roots < 2 mm diameter, is:

$$BGB = e^{(-1.0587+0.8836*\ln(AGB))} \quad \textit{Equation 3}$$

The total biomass of trees was calculated by summing AGB and BGB

The correlation between DBH and tree biomass in different forest types was determined using the following formulas, which were calculated using R programing:

$$Cor(x,y) = \frac{cov(x,y)}{\sqrt{var(x)} \times \sqrt{var(y)}} \quad \textit{Equation 4}$$

$$Cov(x,y) = \frac{1}{n-1} \sum_{i=1}^{n} (x - \bar{x})(y - \bar{y}) \quad \textit{Equation 5}$$

where: x is DBH and y is tree biomass.

2.3 Results

2.3.1 Plant vegetation

The results indicate there were: 88 different species in the evergreen forest, 54 of which were trees - including 2 Luxury species, 8 First Grade species, 7 Second Grade species, 14 Third Grade species, and 23 Ungraded species - and 34 of which were understory shrubs, vines, rattan, palms, and grass. The most common tree species in the evergreen forest were *Anishoptera costata*, *Eugenia sp.*, *Lithocarpus elegan,* and *Vatica astrotricha.*

There were 70 different species in the semi-evergreen forest, 46 of which were trees - including 3 Luxury species, 7 First Grade species, 4 Second Grade species, 13 Third Grade species, and 19 Ungraded species - and 24 of which were understory shrubs, vines, rattan, palms, and grass. The most common tree species in the semi-evergreen forest were *Hopea recopei*, *Dipterocarpus intricatus*, *Eugenia sp.*, *Cratoxylon prunifolium*, *Parinarium annamensis,* and *Ivingia malayan.*

There were 85 different species in the deciduous forest, of which 44 were trees - including 2 Luxury species, 7 First Grade species, 3 Second Grade species, 10 Third Grade species, and 22 Ungraded species - and 41 of which were understory shrubs, vines, rattan, palms, and grass. The most common tree species in the deciduous forest were *Dipterocarpus obtusifolius*, *Dipterocarpus turberculatus*, *Shorea obtuse*, *Lagertroemia macrocarpa, and Parinarium annamensis*.

Overall, there were 155 species of trees at least from 30 genera, including 69 medicinal plant species - encompassing 7 Luxury species, 9 First Grade species, 7 Second Grade species, 15 Third Grade species, and 117 ungraded species - that were identified in the evergreen, semi-evergreen, and deciduous forests.

The average density of understory trees < than 1.5 m in height was 61,875 ± 6,971 trees/ha in the evergreen forest, 54,167 ± 13,734 trees/ha in the semi-evergreen forest, and 54,167 ± 2,692 trees/ha in the deciduous forest.

The average density of understory trees > 1.5 m in height, but < 5 cm DBH, was 4,050 ± 652 trees/ ha in the evergreen forest; 3,000 ± 506 trees/ha in the semi-evergreen forest; and 2,653 ± 560 trees/ha in the deciduous forest.

The average density of trees with DBH>5 cm was 434 ± 355 trees/ha with an average volume of 275.18 ± 80.76 m^3/ha in the evergreen forest; 2,839 ± 643 trees/ha with an average volume of 217.97 ± 69.54 m^3/ha in the semi-evergreen forest; and .764 ± 249 trees/ha with an average volume of 169.92 ± 47.34 m^3/ha in the deciduous forest.

2.3.2 Biomass and carbon stocks of tree classes

Table 2.3. Carbon stocks of tree classes by DBH in 89 sample plots in the Preah Vihear Protected Forest.

Tree Class	Trees/DBH class in all sample plots (DBH in cm.)				AGB/DBH class in all sample plots (metric tons)				Carbon Biomass in all sample plots (metric tons)			
	0-30	31-60	61-90	≥90	0-30 cm DBH	31-60 cm DBH	61-90 cm DBH	≥ 90 cm DBH	0-30 cm DBH	31-60 cm DBH	61-90 cm DBH	≥ 90 cm DBH
Luxury	375	4			19.63	9.41			9.82	4.70		
First Grade	505	78	11	5	69.96	116.78	69.49	69.02	34.98	58.39	34.74	34.51
Second Grade	1476	114	5	6	155.08	154.76	26.39	84.28	77.54	77.38	13.20	42.14
Third Grade	1294	92	3		135.77	132.30	20.79		67.89	66.15	10.40	
Ungraded	1602	129	18	6	135.94	162.41	91.66	70.68	67.97	81.21	45.83	35.34
TOTAL	5252	417	37	17	516.38	575.66	208.34	223.98	258.19	287.83	104.17	111.99

Table 2.3 summarizes the information that was compiled from the sample plots and presented in Appendix 2.1, which was used to calculate the carbon stocks of tree species in the 89 biomass sample plots that were established in the Preah Vihear Protected Forest. It indicates that there were 5,723 trees in the 89 sample plots with an estimated above ground biomass of 1,524.36 mt, which is equivalent to approximately 762.18 mt of carbon biomass. The maximum carbon biomass (287.83 mt) was present in the 31-60 cm DBH class and the second most biomass (258.19 mt) was present in the 0-30 cm DBH class. The least carbon biomass (104.17 mt) was present in the 61-90 cm DBH class.

2.3.3 Biomass

The biomass and carbon stock evaluation presented in this study will contribute to the assessment of the extent of forest in the Preah Vihear Protected Forest that would be available to contribute to the global carbon balance. This determination is underscored in the Copenhagen Accord of December 2009, with reference to which it was stated that "Promoting sustainable forest management as part of the reduced emissions from deforestation and degradation in developing countries (REDD+) plus mechanism in the Copenhagen Accord of December 2009 implies that tropical forests will no longer be ignored in the new climate change agreement. As new financial incentives are pledged, costs and revenues on a tract of tropical forestland being managed or cleared for other land use options need to be assessed so that appropriate compensation measures can be proposed. Cambodia's highly stocked evergreen forest, which has experienced rapid degradation and deforestation, will be the first priority forest to be managed if financial incentives through a carbon payment scheme are available" (*Sasaki and Yoshimoto 2010*).

Table 2.4. Wood biomass in the Preah Vihear Protected Forest.

Forest Type	AGB (mt/ha) ± S.E	BGB (mt/ha) ± S.E	Total Biomass (mt/ha)± S.E
Evergreen Forest	274.416±31.713	48.443±5.011	322.859±36.721
Semi-evergreen Forest	219.2467±31.411	39.839±5.203	259.086±36.611
Deciduous Forest	108.844±8.787	21.634±1.514	130.479±10.299

The assessment of biomass was accomplished by summing the estimates of above ground biomass and below ground biomass. The results, which are presented in Table 2.4, indicate that the sum of above ground and below ground biomass was 322.859 ± 36.721 mt/ha in the evergreen forest; 259.086 ± 36.611mt/ha in the semi-evergreen forest; and 130.479 ± 10.299 mt/ha in the deciduous forest.

2.3.4 Carbon stocks assessment

Table 2.5. Estimated carbon stocks in the Preah Vihear Protected Forest.

Forest Cover Type	Number of plots	Number of trees measured	Carbon pool (mt/ha)		Total carbon stocks (mt/ha)
			Below ground	Above ground	
Evergreen	33	2964	24.22	137.21	161.43 ± 18.36
Semi-evergreen	17	1166	19.92	109.62	129.54 ± 18.31
Deciduous	39	1593	10.82	54.42	65.24 ± 5.15

The estimates of carbon stocks associated with the measurements of 5,723 live trees in 89 sample plots in the PVPF are provided for evergreen, semi-evergreen, and deciduous forests in Table 2.5. It indicates that the sum of above ground and below ground carbon stocks in the evergreen forest was 161.43 ± 18.36 mt/ha; 129.54 ± 18.31mt/ha in the semi-evergreen forest; and 65.24 ± 5.15 mt/ha in the deciduous forest. The differences of biomass and carbon stocks between evergreen, semi-evergreen and deciduous forest are primarily related to differences in tree densities and volumes.

Table 2.6. Comparison of reported carbon stocks in evergreen, semi-evergreen, and deciduous forests in Cambodia with those estimated in the Preah Vihear Protected Forest.

Forest Cover Type	Total carbon stocks (mt/ha)	
	Cambodia	PVPF
Evergreen	211 ± 90[a]	161.43 ± 18.36
Semi-evergreen	178 ± 93[a]	129.54 ± 18.31
Deciduous	126 ± 27[a]	65.24 ± 5.15

Note: [a] Estimates of forest carbon stocks in Cambodia were provided by the Cambodia Forestry Administration.

The estimates with standard errors of carbon stocks in the evergreen and semi-evergreen forests in the PVPF were comparable with those in other locations in Cambodia reported by the Cambodia Forestry Administration (Table 2.6). The estimates in the deciduous forests, which

account for two-thirds of the forests in the PVPF, however, were considerably lower than equivalent estimates.

2.3.5 Correlation between DBH and tree biomass, carbon stocks, and CO_2.

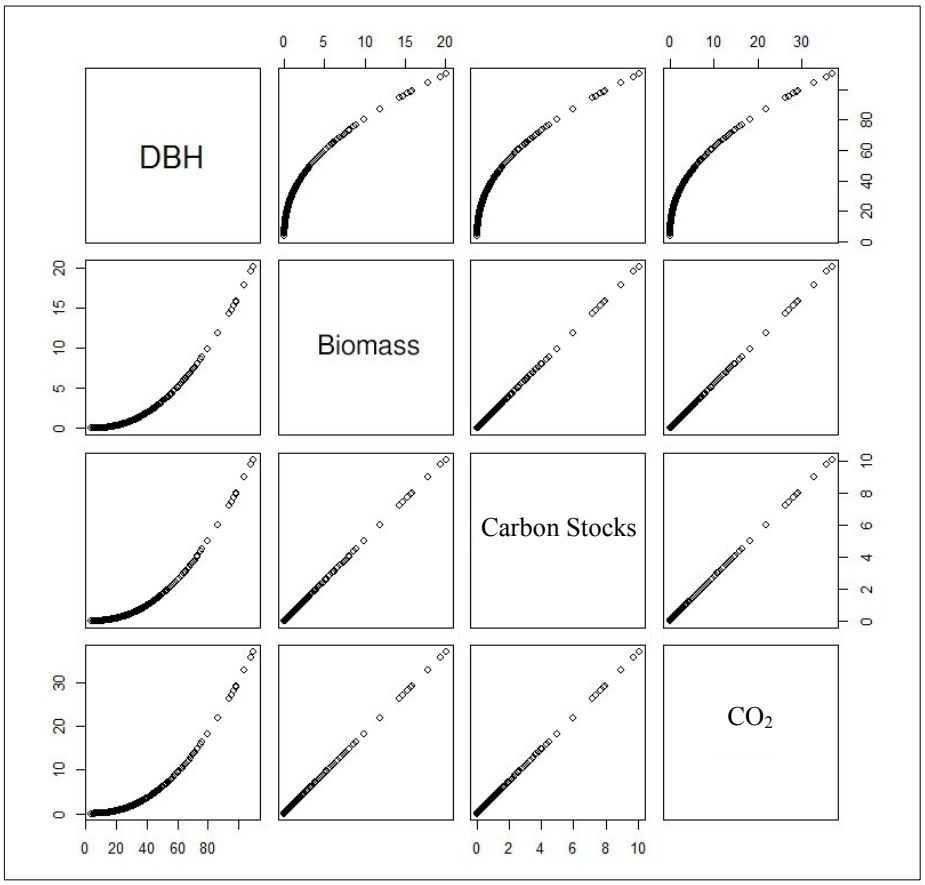


Figure. 2.1. Correlation between DBH, tree biomass, carbon stocks, and CO_2 sequestration.

The assessments of the correlation between DBH and tree biomass resulted in a correlation of 0.8526 in the evergreen forest, 0.8737 in the semi-evergreen forest, and 0.8781 in the deciduous forest. These results confirm the positive correlation and strong linear relationship between DBH and biomass in each of the forest cover types in the Preah Vihear Protected Forest (Figure 2.1).

2.4 Discussion

This study of carbon biomass suggests that the estimates in evergreen and semi-evergreen forests in the PVPF were similar to those in other forests and represent the carbon biomass in mature unlogged forests of these two forest cover types in Cambodia. The extent to which the relatively low estimates in the deciduous forest cover type were the result of the random selection of more cutover sampling sites in deciduous forests in the PVPF or the use of the more general, and perhaps less applicable, allometric equations for moist tropical forests and tropical forests in deciduous forests is uncertain. The random selection of more cutover sampling sites appears to provide the more plausible explanation. Preliminary results of student researchers supported under the ITTO-CBD project provide estimates of above ground carbon stocks in the deciduous forest cover type in the PVPF of between 80.24 and 99.30 tons/ha compared to 54.42 tons/ha in this study. The lower estimates of carbon stocks in deciduous forests in this study

suggest the efficacy of conducting further sampling to increase the accuracy of the estimates in deciduous forests and provide the means to facilitate a more inclusive and accurate evaluation of the feasibility of establishing REDD+ activities in the PVPF. The deciduous forest is the most abundant forest cover type in the PVPF and it is especially important to achieve reliable estimates of carbon stocks in those forests. This would entail a more extensive survey of biomass stratified for tree density and perhaps height, as well as the parallel development of allometric equations, incorporating tree heights, which are more specific to the deciduous forest cover type and tree species in the PVPF.

2.5 Conclusions and recommendations

2.5.1 Conclusions

The results of the preliminary assessment of carbon stocks in the PVPF revealed some substantial differences between evergreen, semi-evergreen and deciduous forests. The estimates of carbon stocks that were associated with the measurements of 5,723 live trees in 89 sample plots in the PVPF were 161.43 mt/ha in the evergreen forest, 129.54 mt/ha in the semi-evergreen forest, and 65.24 mt/ha in the deciduous forest. Since those measures excluded saplings and understorey vegetation with DBH<5cm, however, the average carbon stocks in each of those forest cover types would be somewhat higher than the estimated amounts.

The assessment of carbon stocks that was conducted will be especially useful in the context of planning REDD+ activities in the PVPF, in which researchers, as well as the government, will require this, as well as other related, information to monitor forest carbon stocks and forest carbon stock changes associated with alternations in prevailing patterns of land use. In order to obtain more accurate assessments of forest conditions, moreover, refined measures for calculating carbon stocks will be required to support forest monitoring of REDD+ initiatives. Those efforts will not only assist the Forestry Administration to obtain more accurate information describing the status of the country's forest resources and forest carbon stocks, but also will support implementation of national and international forestry policies.

2.5.2 Recommendations

- Organize assessments of carbon stocks, growth patterns of commercial tree species and fast-growing tree species, and the conservation of gene pools of commercial and non-commercial tree species in the PVPF.

- Conduct periodic studies of the current status and dynamics of the drivers of deforestation and forest degradation affecting carbon sequestration and carbon biomass capacity in the PVPF and promote agroforestry practices in degraded forest areas.

- Promote sustainable agriculture and agroforestry in agricultural use zones and community forests in and around the PVPF.

- Encourage the planting of trees and other plants that support local livelihoods, such as bamboo, and the cultivation of edible plants, such as mushrooms, to reduce local people’s use of wild forest plants.

- Increase law enforcement patrols in critical habitats and in areas in which illegal logging, wildlife poaching, and forest clearing and encroachment are more prevalent.

- Expand the use of the Spatial Monitoring and Reporting Tool (SMART) to strengthen the planning of law enforcement patrols in accordance with observed threats and the establishment of measurable responses to those threats.

- Strengthen cooperation with local authorities and local communities to deter illegal logging and the incidence of forest clearing and encroachment.

- Intensify campaigns against illegal logging and the incidence of forest clearing and encroachment and promote environmental education to strengthen understanding and increase awareness of those activities.

- Promote forest enrichment planting in natural forest areas of native forest trees provided from nurseries in the PVPF.

- Encourage household and community investments to support restoration efforts and the establishment of forest plantations to rehabilitate degraded and encroached reclaimed forests, especially in those instances in which natural succession is inadequate to ensure the ecological recovery of those areas.

- Increase the number of informal and formal meetings with government officials to strengthen bonds of political support to strengthen biodiversity conservation in the PVPF.

- Engage local communities regarding the importance of Biodiversity Hotspots in the PVPF.

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Annex 2.1. Tree DBH, wood biomass, and carbon biomass.

N°	Local name	Scientific name	Family	Tree Class	Tree Density (Trees/all plots)				AGB (mt/all plots)				Carbon Biomass (mt/all plots)			
					0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91
1	Kreul	*Melanorrihoea laccifera , Pierre.*	Anacardiaceae	lux	7				2.060				1.03			
2	Tra Trav	*Fagraea fragrans, Roxb.*	Loganiaceae	lux	3	2			0.074	2.775			0.04	1.39		
3	Thnong	*Pterocarpus Pedatus,*	Papilionaceae	lux	10				2.318				1.16			
4	Neang Nourn	*Dalbergia bariensis, Pierre*	Papilionoidae	lux		1				0.806				0.40		
5	Beng	*Afzelia xylocarpa(Kruz) Craib.or*	Caesalpiniaceae	lux	4				0.603				0.30			
6	Ang KortKmao	*Diospyros bejaudii Lecomte*	Ebenaceae	lux	365	2			18.869	7.014			9.43	3.51		
7	Ang Kanh	*Cassia Siamea*	Caesalpiniaceae	lux	6	2			0.160	2.394			0.08	1.20		
8	Kor Koh	*Sindora cochinnesis*	Caesalpiniaceae	1st	30	8			8.260	9.526			4.13	4.76		
9	Ko Kidek	*Hopea helferi, Brandis.*	Dipterocarpaceae	1st	24	12	10		3.351	15.410	61.685		1.68	7.71	30.84	
10	Ko kiKsach	*Hopea odorata*	Dipterocarpaceae	1st	3				0.383				0.19			
11	Chhlik	*Terminalia tomentosa*	Combretaceae	1st	10				1.349				0.67			
12	Phcheuk	*Shorea obtuse*	Dipterocarpacese	1st	5				0.901				0.45			
13	Popol	*Vitex sp*	Verbenaceae	1st	116	8		4	10.013	10.818		56.499	5.01	5.41		12.26
14	Popel	*Shorea roxburgshii, G.Don.*	Dipterocarpaceae	1st	143	29	1		22.155	45.461	7.800		11.08	22.73	3.90	
15	So Krom	*Xylia dolabriformis*	Mimosaceae	1st	44	5			5.779	8.540			2.89	4.27		
16	Sro Lao	*Lagerstroemia calyculata*	Lythraceae	1st	130	16		1	17.766	27.027		12.521	8.88	13.51		3.24
17	Chromas	*Vatica astotricha, Dyer.*	Dipterocarpaceae	2nd	531	13		2	42.558	14.492		23.496	21.28	7.25		5.64
18	Khlong	*Dipterocarpus tuberculatus, Roxb*	Dipterocarpaceae	2nd	314	16			41.445	21.081			20.72	10.54		
19	Chheul Teal	*Dipterocarpus altatus*	Dipterocarpaceae	2nd	9	3			1.117	4.171			0.56	2.09		
20	Tbeng	*Dipterocarpus obtusifoliius*	Dipterocarpaceae	2nd	335	28	1		34.332	37.277	4.085		17.17	18.64	2.04	
21	Phdeak	*Anishoptera costata*	Dipterocarpaceae	2nd	151	36	4	4	20.121	55.163	22.308	60.783	10.06	27.58	11.15	13.07
22	Khvav	*Adina cordifolia, Hook.f.*	Rubiaceae	2nd	2				0.066				0.03			
23	Srokum	*Payena elliptica*	Sapotaceae	2nd	134	18			15.436	22.579			7.72	11.29		
24	Kandol	*Careya sphoerica, Pierre*	Moraceae	3rd	1				0.049				0.02			
25	Kdol	*Sarcocephalus cordatus, Mig.*	Rubiaceae	3rd	4				0.200				0.10			
26	Trob Tum	*Crypteronia paniculata*	Lythraceae	3rd	36	20			3.138	28.039			1.57	14.02		
27	TroMeng	*Carallia lucida, Roxb.*	Rhizophoraceae	3rd	14	2			1.103	1.562			0.55	0.78		
28	TroMoung	*Garcinea oliveri, Pierre*	Guttiferae	3rd	106	2			4.030	1.729			2.01	0.86		
29	Thlork	*Parinarium annamensis, Hance*	Rosaceae	3rd	166	16			16.486	21.340			8.24	10.67		
30	Bram DamLeung	*Lagertroemia macrocarpa*	Combretaceae	3rd	86	8			14.185	10.017			7.09	5.01		
31	Pros	*Garcinia schefferi, Pierre*	Guttiferae	3rd	56	4			7.413	5.424			3.71	2.71		
32	PhaOng	*Calophyllum soulattrii*	Guttiferae	3rd	23	2			1.119	1.686			0.56	0.84		

N°	Local name	Scientific name	Family	Tree Class	Tree Density (Trees/all plots)				AGB (mt/all plots)				Carbon Biomass (mt/all plots)			
					0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91
33	Pring	*Eugenia*	Myrtaceaa	3rd	421	21	1		45.546	38.130	9.408		22.77	19.06	4.70	
34	Lngeang	*Cratoxylon prunifolium*	Hypericaceae	3rd	258	8			29.332	11.590			14.67	5.79		
35	Porn Talei	*Terminalia corticosa*	Combretaceae	3rd	20				3.271				1.64			
36	Sma Krobei	*Knema corticosa*	Myristicaceae	3rd	8	3			0.733	3.372			0.37	1.69		
37	Smach	*Melalcuca leucadendrom*	Mytaceae	3rd	93	2			8.559	2.292			4.28	1.15		
38	Svay Prey	*Mangifera duperreana, Pierre*	Anacardiaceae	3rd	2	4	2		0.611	7.118	11.387		0.31	3.56	5.69	
39	Kan teum	*N/A*	N/A	ungr	2				0.076				0.04			
40	Kantourt Prey	*Phyllanthus emblica*	Euphobiaceae	ungr	2				0.013				0.01			
41	Ka Nget	*N/A*	N/A	ungr	1				0.067				0.03			
42	Kachong	*N/A*	N/A	ungr	2				0.209				0.10			
43	Kapet	*N/A*	N/A	ungr	18				1.357				0.68			
44	Kchas	*Diospyros sylvatica*	Ebenaceae	ungr	7	1			1.501	3.659			0.75	1.83		
45	Ka del	*N/A*	N/A	ungr	1				0.083				0.04			
46	Kro Chak	*N/A*	N/A	ungr	2				0.074				0.04			
47	Kro Lev	*N/A*	N/A	ungr	2				0.042				0.02			
48	Krom	*Elaeocarpus thorelii*	Elaeocarpaceae	ungr	1				0.282				0.14			
49	Kray	*Polyalthia cerasoides,Benth & Hook*	Simaroubaceae	ungr	111				4.390				2.19			
50	Krang	*Lithocarpus elegans*	Fagaceae	ungr	2				0.411				0.21			
51	KroLoa	*N/A*	N/A	ungr	1				0.015				0.01			
52	Kres	*N/A*	N/A	ungr	5				0.138				0.07			
53	Kampet	*N/A*	N/A	ungr	20	3			0.627	3.962			0.31	1.98		
54	Khos	*Lithocarpus elegans*	Fagaceae	ungr	30				4.096				2.05			
55	Ktum	*Neonuclea sp*	Rubiaceae	ungr	2				0.556				0.28			
56	Khom	*N/A*	N/A	ungr	1				0.015				0.01			
57	KinhKourk	*N/A*	N/A	ungr	4				0.249				0.12			
58	KumKhneng	*N/A*	N/A	ungr	2				0.062				0.03			
59	Kolvek	*N/A*	N/A	ungr	2				0.087				0.04			
60	Krong	*Broussonetia papirifera Her*	Moraceae	ungr	27				0.769				0.38			
61	Changha	*N/A*	N/A	ungr	1				0.148				0.07			
62	Kreal Phnom	*N/A*	N/A	ungr	1				0.013				0.01			
63	Chang E sek	*N/A*	N/A	ungr	1				0.027				0.01			
64	Chong	*Raphistemma hoopenanum*	Asclepiadaceae	ungr	1				0.009				0.00			
65	Chrey	*Ficus rumphii*	Moraceae	ungr	1				0.029				0.01			
66	Chambak	*Irvingia malayana*	Simaroubaceae	ungr	92	10	8	6	9.462	22.155	40.271	70.682	4.73	11.08	20.14	14.94

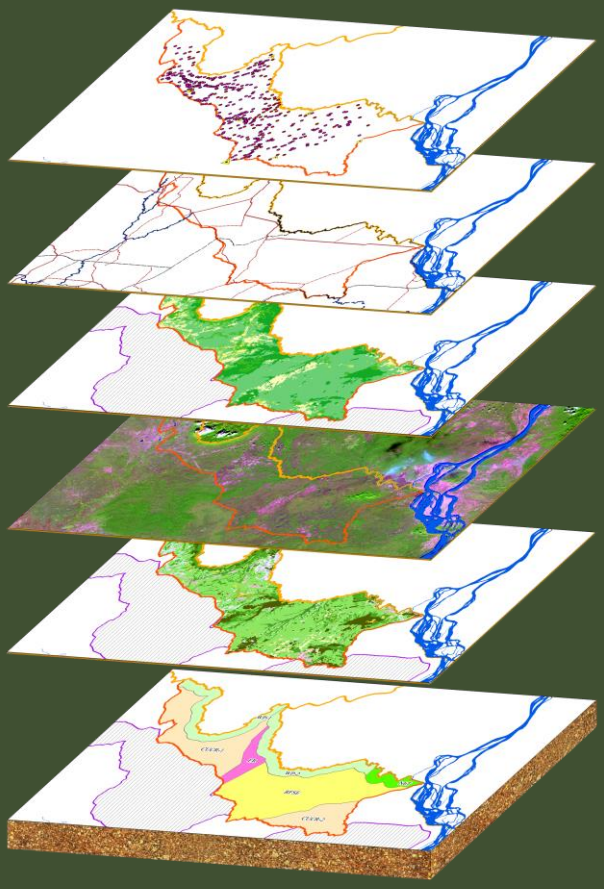
N°	Local name	Scientific name	Family	Tree Class	Tree Density (Trees/all plots)				AGB (mt/all plots)				Carbon Biomass (mt/all plots)			
					0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91
67	Chhlorng	*N/A*	N/A	ungr	4				0.127				0.06			
68	Chhlong	*N/A*	N/A	ungr	1				0.006				0.00			
69	Chunlos	*Lepisanthes rubiginosa*	Sapindaceae	ungr	3				0.046				0.02			
70	Cheung Ko	*Bauhinia variegata*	Leguminosae - Caesalpinioideae	ungr	2				0.235				0.12			
71	Cheung Popol	*N/A*	N/A	ungr	9				0.518				0.26			
72	Chheul Pleung	*Diopyros hermaphroditica*	Ebenaceae	ungr	44				0.873				0.44			
73	Nhor	*Morinda tomentosa*	Rubiaceae	ungr	2				0.278				0.14			
74	Dangkeab Kdam	*Antidesma ghaesembilla*	Euphorbiaceae	ungr	2				0.265				0.13			
75	Talinh	*N/A*	N/A	ungr	1				0.158				0.08			
76	Trobek Prey	*Lagertroemia floribunda*	Lythraceae	ungr	10				0.463				0.23			
77	Tro nge	*N/A*	N/A	ungr	3				0.090				0.04			
78	Tro Menh	*N/A*	N/A	ungr	2				0.374				0.19			
79	Tro Sek	*Peltophorum ferruginium*		ungr	27	2			5.951	1.562			2.98	0.78		
80	Tro Yeung	*Diospyros helferi*		ungr	58	8			3.804	9.955			1.90	4.98		
81	Trach	*Dipterocarpus intricatus*		ungr	223	39	10		32.406	70.619	51.394		16.20	35.31	25.70	
82	Trav	*N/A*	N/A	ungr	1				0.008				0.00			
83	Thleum Andeuk	*N/A*	N/A	ungr	2				0.116				0.06			
84	Teuk Bay	*N/A*	N/A	ungr	1				0.046				0.02			
85	Tepirou	*Cinnammomum cambodianum*		ungr	21				1.688				0.84			
86	Trous	*N/A*	N/A	ungr	1				0.008				0.00			
87	Trosong Damrei	*N/A*	N/A	ungr	1				0.407				0.20			
88	Thmeas	*Acacia intsia*	Leguminosae - Mimosoideae	ungr	1				0.029				0.01			
89	Bando Pech	*Tinospora crispa*	Menispermaceae	ungr	1				0.006				0.00			
90	Pet	*N/A*	N/A	ungr	1				0.137				0.07			
91	Bakdorng	*Gardenia philastrei*	Rubiaceae	ungr	5				0.696				0.35			
92	Phlou	*Cyclea peltata*	Menispermaceae	ungr	0				0.000							
93	Pnheav	*Baccaurea ramifiora*	Euphorbiaceae	ungr	2				0.101				0.05			
94	Phlov Sampoch	*N/A*	N/A	ungr	4				0.357				0.18			
95	Popeal Khe	*Alstonia scholaris*	Combretaceae	ungr	6	4			1.589	5.089			0.79	2.54		
96	Pong Ro	*Scheicheria trijuda*	Sapindaceae	ungr	6				0.522				0.26			
97	Pophlea	*Microcos tomentosa*	Tiliaceae	ungr	75				5.891				2.95			
98	Peal	*Cerbera manghas*	Apocynaceae	ungr	2				0.070				0.03			

N°	Local name	Scientific name	Family	Tree Class	Tree Density (Trees/all plots)				AGB (mt/all plots)				Carbon Biomass (mt/all plots)			
					0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91
99	Pol Vek	*N/A*	N/A	ungr	3				0.050				0.02			
100	Pouch Ourl	*Rhodomyrtus tomentosa*	Myrtaceae	ungr	6				0.124				0.06			
101	Prech Sankhom	*Melienthes suavis*	Opiliaceae	ungr	2	2			0.570	3.675			0.29	1.84		
102	Prech Changva	*Melienthes sp.*	Opiliaceae	ungr	2				0.093				0.05			
103	Preah Phnov	*Terminalia triptera*	Combretaceae	ungr	30	18			7.441	20.901			3.72	10.45		
104	Preal Phnom	*N/A*	N/A	ungr	3	1			0.515	1.122			0.26	0.56		
105	Phlorng	*Memecylon acuminatum*	Melastomaceae	ungr	68				3.675				1.84			
106	Phlou Thom	*Dillenia ovata*	Dilleniaceae	ungr	71				4.979				2.49			
107	Entanel	*Lagerstroemia loudonii*	Lythraceae	ungr	9				1.207				0.60			
108	Met	*N/A*	N/A	ungr	24				1.081				0.54			
109	MeKrolao	*N/A*	N/A	ungr		1				0.985				0.49		
110	Meisak	*Berrya cordifolia*	Tiliaceae	ungr	1				0.153				0.08			
111	Mean Prey	*Aporusa planchoniana*	Euphorbiaceae	ungr	99	8			7.880	11.614			3.94	5.81		
112	Meut	*N/A*	N/A	ungr	43				2.480				1.24			
113	Mkak	*Spondias pinnata*	Anacardiaceae	ungr	5				0.199				0.10			
114	Roka	*Bombax ceiba*	Bombacacea	ungr	20				2.066				1.03			
115	Romdoul	*Goniothalamus repevensis*	Annonaceae	ungr	91				3.041				1.52			
116	Roleay	*Lasianthus kamputensis*	Rubiaceae	ungr	2				0.536				0.27			
117	Romaing	*Diospyros ehretioides*	Ebenaceae	ungr	1				0.050				0.03			
118	Roveang	*N/A*	N/A	ungr	9				0.839				0.42			
119	Raing	*Barringtonia asiatica*	Lecythidaceae	ungr	44				0.444				0.22			
120	Rorl	*N/A*	N/A	ungr	1				0.144				0.07			
121	Lang Chey	*Buchanania reticulata*	Anacardiaceae	ungr	1				0.020				0.01			
122	Vor Kreal	*Uvaria rufa*	Annonaceae	ungr	10				0.187				0.09			
123	Vor Sleng	*Strychnos nux-vomica*	Loganiaceae	ungr	6				0.180				0.09			
124	Angkrorng	*N/A*	N/A	ungr	12				0.488				0.24			
125	Vor Antong	*Derris elliptica*	Leguminosae - Papilionoidae	ungr	1				0.060				0.03			
126	Vor Khchorng	*N/A*	N/A	ungr	1				0.038				0.02			
127	Vor Talinh	*N/A*	N/A	ungr	1				0.059				0.03			
128	Vor Phnheav	*N/A*	N/A	ungr	1				0.029				0.01			
129	Vor Chulous	*N/A*	N/A	ungr	1				0.042				0.02			
130	Vor Kravan	*Amomum krervanh*	Zingiberaceae	ungr	1				0.009				0.00			
131	Vor	*N/A*	N/A	ungr	2				0.035				0.02			

N°	Local name	Scientific name	Family	Tree Class	Tree Density (Trees/all plots)				AGB (mt/all plots)				Carbon Biomass (mt/all plots)			
					0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91	0-30	31-60	61-90	>=91
132	Vor Kuy	*Willughbeia edulis Roxb.*	Apocynaceae	ungr	7				0.156				0.08			
133	Vor Khlork	*N/A*	N/A	ungr	2				0.030				0.01			
134	Vor Khmous	*N/A*	N/A	ungr	1				0.011				0.01			
135	Vor Sangke	*N/A*	N/A	ungr	1				0.012				0.01			
136	Vor Angkrong	*N/A*	N/A	ungr	12				0.488				0.24			
137	Vor Ampel	*N/A*	N/A	ungr	11				0.431				0.22			
138	Vor Chundelsva	*Bauhinia harmandiana*	Caesal piniaceae	ungr	1				0.065				0.03			
139	Veay	*Diospyros filipendula*	Ebenaceae	ungr	7				0.239				0.12			
140	Sang Khor	*Zizyphus oenoplia*	Rhamnaceae	ungr	18	4			4.782	7.112			2.39	3.56		
141	Seman	*Nephehum hypolcucum*	Sapindaceae	ungr	3				0.639				0.32			
142	Sdok Sdol	*Walsura villosa*	Meliaceae	ungr	4				0.195				0.10			
143	Sdav	*Azadirachta indica*	Meliaceae	ungr	1				0.012				0.01			
144	Sro Ngam	*Tristaniopsis burmannica*	Myrtaceae	ungr	14				1.097				0.55			
145	Trolat	*Canarium album*	Burseraceae	ungr	3				0.512				0.26			
146	Srotum	*N/A*	N/A	ungr	1				0.642				0.32			
147	Sro Mor	*Terminalia chebula*	Combretaceae	ungr	2				0.067				0.03			
148	SaAtt	*N/A*	N/A	ungr	24				3.437				1.72			
149	Sambork Lavinh	*N/A*	N/A	ungr	1				0.007				0.00			
150	Sam Pouch	*N/A*	N/A	ungr	1				0.058				0.03			
151	Sam Rorng	*Sterculia plantanifolia*	Sterculiaceae	ungr	1				0.060				0.03			
152	Angkear	*N/A*	N/A	ungr	8				0.519				0.26			
153	AngKrong	*N/A*	N/A	ungr	5				0.345				0.17			
154	Ach Kandol	*Diospyros cambodiana*	Ebenaceae	ungr	35				1.299				0.65			
155	Ampong Vek	*N/A*	N/A	ungr	5				0.050				0.03			

Note: *lux = Luxury species; 1st = First Grade species; 2nd = Second Grade species; 3rd = Third Grade species; ungr = Ungraded species.*

INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST



CHAPTER III

LAND USE AND LAND COVER CHANGE SCENARIOS

KIM SOBON, SAY SINLY, NHAN BUNTHAN, PANG PHANIT, CHHEANG DANY, DENNIS CENGEL and YI NAROM

SUMMARY

There have been dramatic changes in land use in the Preah Vihear Protected Forest (PVPF) since 2000. In responding to those changes, date on land use were collected under the 'Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation Between Thailand, Cambodia and Laos (Phase III) project funded by the government and the people of Japan through the International Tropical Timber Organization (ITTO). The purpose of this study was to assess the manner in which land, forest cover, and tenure arrangements in the Preah Vihear Protected Forest have been shifting. This study of Land Use and Land Cover (LULC) used widely available data, including Landsat satellite images from the United States Geological Survey, Digital Elevation Model images from JICA, the existing geo-database of land cover from the Cambodia Forestry Administration, as well as field observations, interviews, and group discussions

The results of LULC analyses in the PVPF have indicated a decline in forestland from 97.62% in 2002 to 91.11% in 2014, equivalent to an average annual deforestation rate of 0.715% of the land area of the PVPF, which is lower, however, than the country's average annual deforestation rate of 1.055% during that same period. This means that to maintain the percentage of forest cover in the PVPF as it was in 2002 of 185,503 ha to compensate sufficiently to achieve the Cambodia Millennium Development Goals would require 12,369 ha of non-forest land to be converted to man-made forest tree plantations and agroforestry.

The changes in land cover that were observed during the most recent period from 2009 to 2014 were primarily associated with net 'losses' of 6158.38 ha to village settlements and 6705.73 ha to agricultural land. The representations of those changes in village settlements were primarily associated with net 'gains' of 333.55 ha from agricultural land, 5103.05 ha from forest land, 460.51 ha from grasslands and/or swamps, 205.05 ha from shrub lands, and 56.22 ha from water features (marshes). Other changes that occurred in agriculture land were primarily associated with net 'gains' of 5596.66 ha from forestland, 375.25 ha from grasslands and/or swamps, 729.32 ha from shrub lands, and 4.5 ha from water features. The largest percentage change in area was associated with village settlements and agricultural land, the area of which expanded by 81.54% and 71.74%, respectively, primarily as the result of the net 'gain' of 5103.05 ha of village settlements and 5596.66 ha of agricultural land from forestland.

Based on simulated LULC maps in 2030 for four scenarios using the Dyna-Clue Model combination with ArcGIS 10.0 conducted by the LULC modeling expert, the *unsustainable economic development and serious resource degradation* scenario predicted a considerable amount of land conversion to arable land and rubber plantations. The area of mixed deciduous and dry dipterocarp forests was predicted to decline from 22.9% of the entire Emerald Triangle Protected Forests Complex in 2013 to 15.1% in 2030. The simulations illustrated, as well, the results of the *low economic decline and localized resource degradation (business-as-usual)* scenario with restrictive policies in the Pha Taem Protected Forests Complex, which were deforestation and agricultural expansion in the remnant forests situated in the recreation forest and regulating water resources zones in the Preah Vihear Protected Forest and area close to the An-Ses international border between Cambodia and Thailand.

CHAPTER III

LAND USE AND LAND COVER CHANGE SCENARIOS

3.1 Introduction

This report is concerned with land use changes and human populations living in and around the Preah Vihear Protected Forest (PVPF) in the northern part of Preah Vihear province and the western part of Steung Treng province. There have been dramatic changes in land use in the PVPF since 2000 when the existing forest cover and topographic maps were made. Those maps are relatively large scale and are now out-of-date because of rapid changes in the landscape during the past several years. In responding to those limitations, more recent land use data were collected in 2013 as part of the 'Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation Between Thailand, Cambodia and Laos (Phase III) project funded by the government and the people of Japan through the International Tropical Timber Organization (ITTO). There have been various studies related to land use in the Preah Vihear Protected Forest, but most of those studies have focused on one zone and/or in very limited areas compared to the current study, which covers several geological areas.

The purpose of this study was to assess the manner in which land, forest cover, and tenure arrangements in the Preah Vihear Protected Forest have been changing. It is intended to contribute to efforts to increase the understanding of the changes that are taking place in land use, identify the drivers of changes affecting those land uses and tenure arrangements - especially forestland conversion and indigenous land alienation - and the effectiveness of participatory land-use planning (PLUP) processes in providing more rational direction to land cover changes and the stabilization of indigenous land rights. The results of this assessment include recommendations to government policy-makers and planners, as well as development partners, regarding strategic options to address the drivers of land use change in the Preah Vihear Protected Forest.

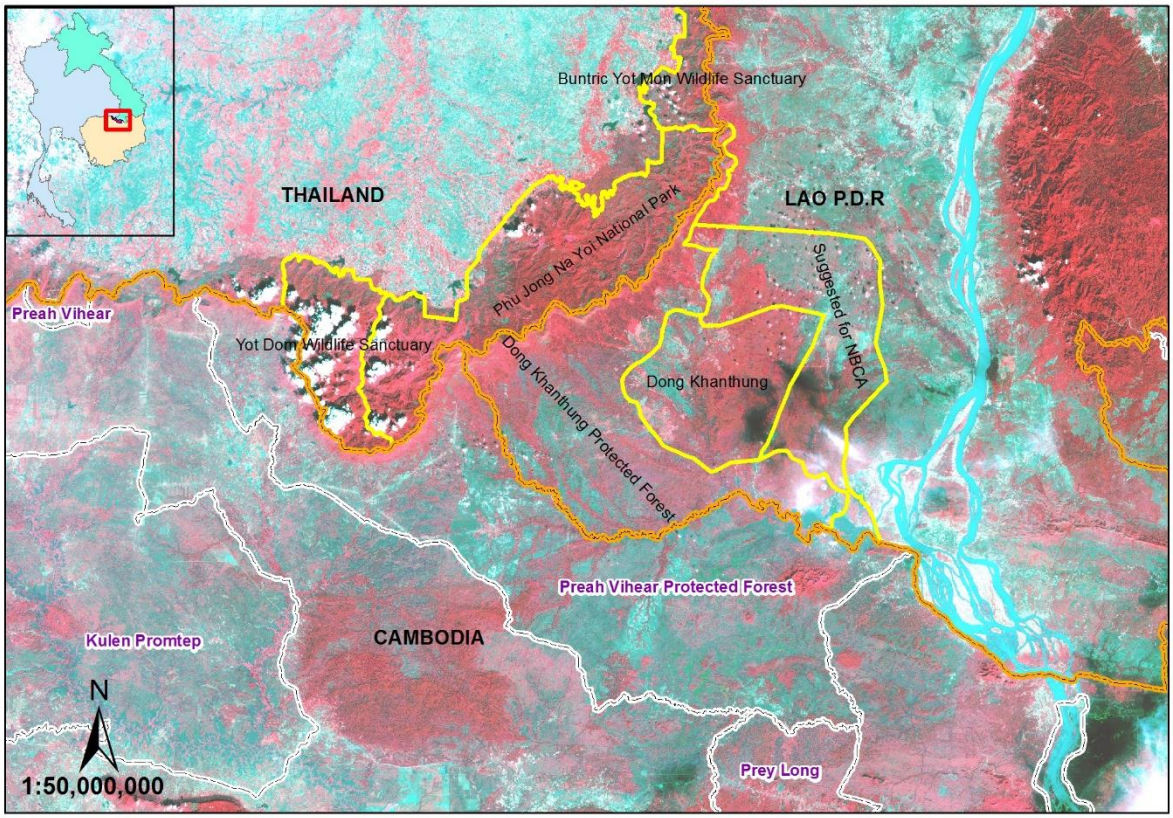
3.2 Methods

This assessment of land cover and land use changes was conducted in 2013 as a collaborative effort between the 'Trans-boundary Biodiversity Conservation' project and the local Cambodia Forestry Administration. The project in each of its several phases has been supporting local communities in the Preah Vihear Protected Forest since 2007 to improve the livelihoods of the people who are living in and around the PVPF through various interventions, including the establishment of Cow Banks and Rice Banks, the provision of microcredit facilities, and the enhancement of agricultural practices. The underlying objective of the study was to identify changes in land cover by means of satellite images and to compare land cover with previous land cover datasets developed by the Cambodia Forestry Administration in 2002, 2006 and 2010. The specific methods that were used included satellite interpretation, ground truth assessments, consultations with local communities and local authorities, and interviews with villagers to determine land-use activities.

Site assessments were conducted during the study to document land uses and the current situation associated with wildlife species and wildlife habitats and training was provided to four student researchers from the Prek Leap National School of Agriculture and the Royal University of Agriculture in the process of conducting their 'thesis' research with support under the project. The assessment of land use was conducted in 13 villages – 4 villages in Teuk Krahum commune, 7 villages in Morokot commune, and 2 villages in Chaom Ksan commune – in Chaom Ksan district. Participatory mapping approaches were used to incorporate local knowledge on the current status of land use in different aspects.

3.2.1 Study area

The study was located in the Preah Vihear Protected Forest in the northern part of Cambodia. The Preah Vihear Protected Forest shares its border with the Yot Dom Wildlife Sanctuary and Phu Jong Na Yoi National Park in Thailand and the Dong Khan Thong Proposed Conservation Area in Laos in the northern part of Cambodia, as well as with other protected forests - Prey Preah Roka and Prey Lang - in the southwest and southeast parts of the country, respectively (Map 3.1). In accordance with Sub-degree 76 ANKr.BK dated 30 July 2002, the Preah Vihear Protected Forest has 190,027 ha of land area located in Choam Ksan and Chhep districts in Preah Vihear province (Forestry Administration 2010).



Map 3.1. Geographical location of the study area.

3.2.2 Data collection

The study used widely available data, including Landsat satellite images from the United States Geological Survey (USGS), Digital Elevation Model (DEM) images from JICA, the existing geo-database of land cover from the Cambodia Forestry Administration, as well as

field observations, interviews, and group discussions (Kibret et al. 2016). For the 2013 Land Use and Land Cover (LULC) mapping, data were provided from Kasetsart University in Thailand, which conducted an assessment of land use changes throughout the 'Emerald Triangle' as part of Phase III project activities. The data were downloaded from USGS with the relatively cloud-free Landsat 8 OLI (Trisurat 2015).

3.2.3 Image data processing and classification

In order to assess the spatial patterns of land use and land cover changes in the Preah Vihear Protected Forest, there were 11 classes of land use patterns used that were compatible with the current version of Dyna-CLUE software (Trisurat 2015; Verburg and Overmars 2009). The imagery and raster datasets were rectified to the Universal Trans Mercator (UTM) coordinate system, World Geodetic System 1984 datum and measurements in meters. The process of remote sensing image analysis involved a combination of unsupervised and supervised classification approaches (Jefferson et al. 2008). Using previous understanding of the study area, clusters were assigned, including dry deciduous forest, evergreen forest, semi-evergreen forest, barren land, settlements and infrastructure, non-paddy agriculture, paddy fields, rubber plantations, cash crops, and water bodies.

3.2.4 Ground truthing and consultations

The study developed and administered semi-structured questionnaires that complemented field observations, remote sensing imageries, black and white aerial photographs, topographic maps, and secondary literature. There was also a reconnaissance survey conducted and the current LULC distribution in the study area was discussed with local agricultural and rural development 'experts' (Ariti et al. 2015). The ground truthing of 280 satellite imagery interpretation sample points was conducted in different forest types in the Preah Vihear Protected Forest.

Ground Truthed Points were collected through interpretation of aerial photographs in 2014 and field observations and group discussions organized in mid-2014 and 2015. Group discussions with 5 to 10 participants per group were organized in 13 villages in 3 communes, including 2 villages in Chaom Ksan commune, 4 villages in Teuk Krahum commune, and 7 villages in Morokot commune. Preliminary maps created from local knowledge and image interpretation were used during group discussions and transect walks. Some errors were purposely introduced into the maps to determine if those errors would be recognized by local communities.

3.2.5 Interviews

There were 104 individual and group interviews with local communities and military households who were active in land use activities, including hunting, trapping, fishing, and collecting non-timber forest products (NTFPs), and farmers were approached to participate in the study. Each interview was followed up by the administration of the questionnaire (Annex 3.1). The interviews were conducted by project staff and student researchers from the Royal University of Agriculture and Prek Leap National Agriculture School, whose research on land use was supported under the project. The data that were collected were transcribed, discussed

with local communities and other relevant stakeholders, and incorporated into the report and used in the production of maps depicting land use activities and occupancy (Laren 2006). The individuals and members of military households interviewed were predominately women, adults, and elders. Those individuals were able to provide historical perspective regarding the manner in which land use has changed over time and to identify the drivers of those changes.

3.2.6 Community meetings and participatory mapping

Commune meetings were organized in Chaom Ksan, Teuk Krahum and Morokot to introduce commune council and community members to the land use study, including its purposes, and the activities it would include, as well as to allow them to share their perspectives of land use considerations. The consultative meetings involved 114 participants and were conducted with commune councils, local communities, Cambodia Forestry Administration officials, and other relevant stakeholders on 2-4 February and 28 May 2015. The meetings were used to discuss land cover change scenarios, the impacts of land use changes on biodiversity, and community use areas in the Preah Vihear Protected Forest. The information provided by means of the interviews was depicted on a Preah Vihear Protected Forest map using 2014 Landsat Imagery to illustrate the scope and extent of traditional land use and Social Land Concessions to facilitate verifIcation of the information by village and commune chiefs and commune councils.

Subsequent to those discussions, participants were invited to draw commune land use maps to depict land use activities in their commune and its traditional territory (Figure 3.1). The procedures that were used were similar to other studies on Traditional Land Use and Occupancy that have recommend that such an approach should be gender-sensitive, address the issue of intellectual property rights, and ensure participation by local communities (Laren 2006).

Figure 3.1. Participatory mapping by local people and local authorities in Teuk Krahum commune.

3.2.7 Data analysis

The LULC assessment used ArcGIS 10.1 and Microsoft Excel to support the estimation of land use and land cover change analysis. The current land use situation was generated by using standardized overlay procedures with a combination of 2002 and 2010 forest cover datasets, 2009 land use, and data from ground truth assessments. The responses compiled

during the discussion groups with local communities, commune councils, and other relevant stakeholders regarding their perceptions of LULC drivers of change were expected to contribute to the comparison of observed and perceived LULC changes (Figure 3.2).

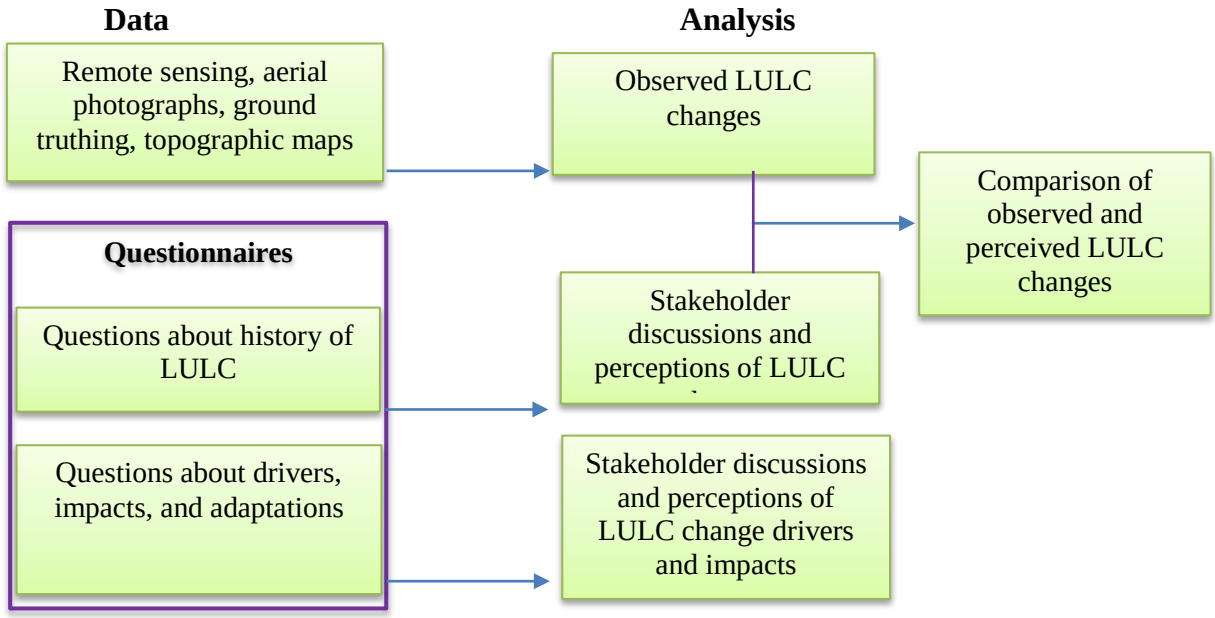


Figure 3.2. Flow diagram of land use study processes and procedures.

3.3 Results of land use and land use change

3.3.1 Overview of land use system

a) Land ownership

The Royal Government of Cambodia issued Sub-decree No. 76 to establish the Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation covering a land surface area of 190,027 hectares under the jurisdiction of the Forestry Administration in the Ministry of Agriculture, Forestry and Fisheries according to the provisions of the National Forest Sector Policy and the Forestry Law on July 30, 2002. The demarcation of the PVPF's boundaries was completed in 2010 with the support of the government, as well as that of DANIDA, but those boundaries have been disrupted to some extent because of the efforts of the military to expand their land for settlement and agriculture.

The Land Law (2001) has provisions for the registration of communal lands of indigenous communities to provide a mechanism to safeguard their land in the form of communal land titles (UN 2007). Indigenous people have been living in areas such as Malis, O Chunh, and Robunh villages for generations and the ethnic people living in those three villages - the "Kouy" - have their own language and manage their land collectively as "landholders." There have been successful efforts to revise the indigenous peoples' land policy, however, by placing limits on traditional land use. Individual farmers are prohibited from clearing a patch of forest or regrowth forest for farming, rice cultivation, or secondary crops, including cassava, sugar cane, corn, and vegetables. In 2013, the project attempted to encourage local communities to cultivate crops on lands that they have managed for a long time. There are still no land titles that have been registered, however, with the exception of the Social Land

Concessions that the government has provided to military families and for which systematic land registration procedures for preparing land titles is proceeding.

b) Traditional land use

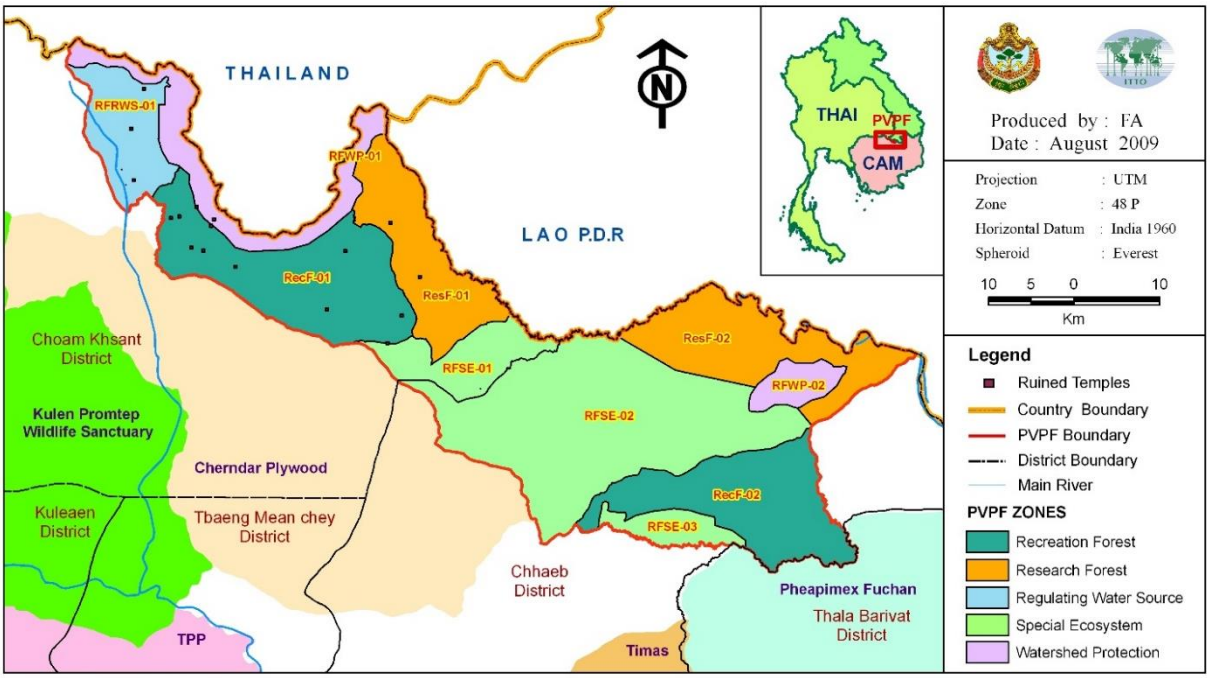
In past times, local people's ways of life were inextricably linked to the forests and lands that surround their homes and provide the resources that sustain their communities. Perhaps the most notable manifestation of these relationships to forestlands is embedded in their agricultural techniques and the practice of cultivating rice under shade trees, which is common in the Preah Vihear Protected Forest. Under this system, individual farmers clear a patch of degraded or regrowth forest for farming and cultivate rice and secondary crops, such as corn, vegetables, and some cassava (Figure 3.3).

Figure 3.3. Planting and cultivating rice integrated with other crops without tillage.

c) Forest conservation

The protection and preservation of forest areas are objectives of the 'Management Plan of the Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation 2010 - 2014.' In accordance with the Forestry Law, Article 10 states that "... protected forests shall be maintained primarily for protection of the forest ecosystems and natural resources therein." In compliance with the Forestry Law, there are five zones that have been identified and set aside for conservation purposes, including 67,459.60 ha of 'reserved forests for special ecosystems;' 39,310.41 ha of 'research forests;' 12,312.16 ha of 'forests for regulating water resources;' 18,659.7 ha of 'watershed protection;' and 52,285.74 ha of 'recreation forests.' Various areas of recreation forest (RecF-01) and forests for regulating water resources (RFRWS-01) (Map 3.2) were allocated for Social Land Concessions by the Royal Government of Cambodia in 2011 to construct settlements for military families, border police, and military bodyguards.

Customary law has traditionally prohibited harvesting trees in the immediate vicinity of village habitation areas to ensure the provision of protection, shade, and a proximal supply of non-timber forest products to local communities. In June 2012, however, in response to the land use policy reforms, various areas, including abundant forests, along the road from Chaom Ksan district to Anses and from Chaom Ksan district to Mum Bei, which form the Emerald Triangle boundary between Thailand, Cambodia, and Laos, were occupied by indigenous people for settlement and agriculture.



Map 3.2. Preah Vihear Protected Forest zonation 2011-2015.
Source: Cambodia Forestry Administration 2010.

3.3.2 Land use classification in the Preah Vihear Protected Forest

a) Land use and land cover change

Rapid changes in vegetative cover have occurred in the Preah Vihear Protected Forest over the past two decades. Until the mid-1970s, aside from fallow land and small paddy fields, most land was covered by a mosaic of secondary forest. Indigenous farming systems were subsequently disrupted during the Khmer Rouge period from 1970 to 1979, however, when families were removed from their homes and relocated. On returning to their homelands in Chaom Ksan district in Malis, O Chunh, and Robunh villages, some villagers began expanding paddy cultivation areas, although most others returned to the cultivation of their previous rice fields. Since 2010, though, forest conversion has accelerated because of natural population growth and migration, as well as expanding market access with the establishment of new settlement areas and the consequent expansion of rain-fed rice cultivation in Social Land Concessions, as well as increased encroachment

While this study primarily examines the impacts of land cover changes in the three communes in Chaom Ksan district, it should be recognized that illegal land encroachment and the occupation of land by the military are also occurring in other parts of the Preah Vihear Protected Forest, particularly in the recreation forest zone (RecF-01) depicted on Map 3.2. These are bound to have a profound effect on the lives of indigenous people. The O Chunh villagers, in particular, are concerned with their trees, especially resin trees (*Dipterocapus alatus*) that are cut down in their paddy fields and in the forest without consideration from either local authorities or the military.

In the assessment conducted in 2009, there were several categories of land uses in the PVPF, including agricultural land, forest cover, grassland, shrubland, and water bodies (Table 3.1; Map 3.3). Each of those categories was further subdivided such that, overall, there were 18 classes composed of 69 sub-classes provided in the Cambodia 2009 Land Use Classification Map.

While the 2009 land use data indicated a forest cover of 91.67%, the 2010 forest assessment conducted by the Forestry Administration revealed that forest cover had declined to 95.51%. The classifications in that assessment included evergreen forest, semi-evergreen forest, deciduous forest, wood and scrubland evergreen, wood and scrubland dry, other forestland, and non-forestland. The dry deciduous forest was the dominant forest type representing almost 59% of the land area of the PVPF. Subsequently, between 2002 and 2014, the non-forest classifications approximately doubled, resulting from a combination of decreases of other forest types.

Unrest along the Cambodia-Thailand trans-boundary area has also led to forest cover changes since the government provided 1,491 hectares to establish military bases and relocate military families through Social Land Concessions (Figure 3.4). This unrest increased pressures on forestlands and forest resources in the PVPF at the same time that local population growth and new immigrants have been increasing and agricultural land has been expanding at the expense of forestland (Figure 3.5).

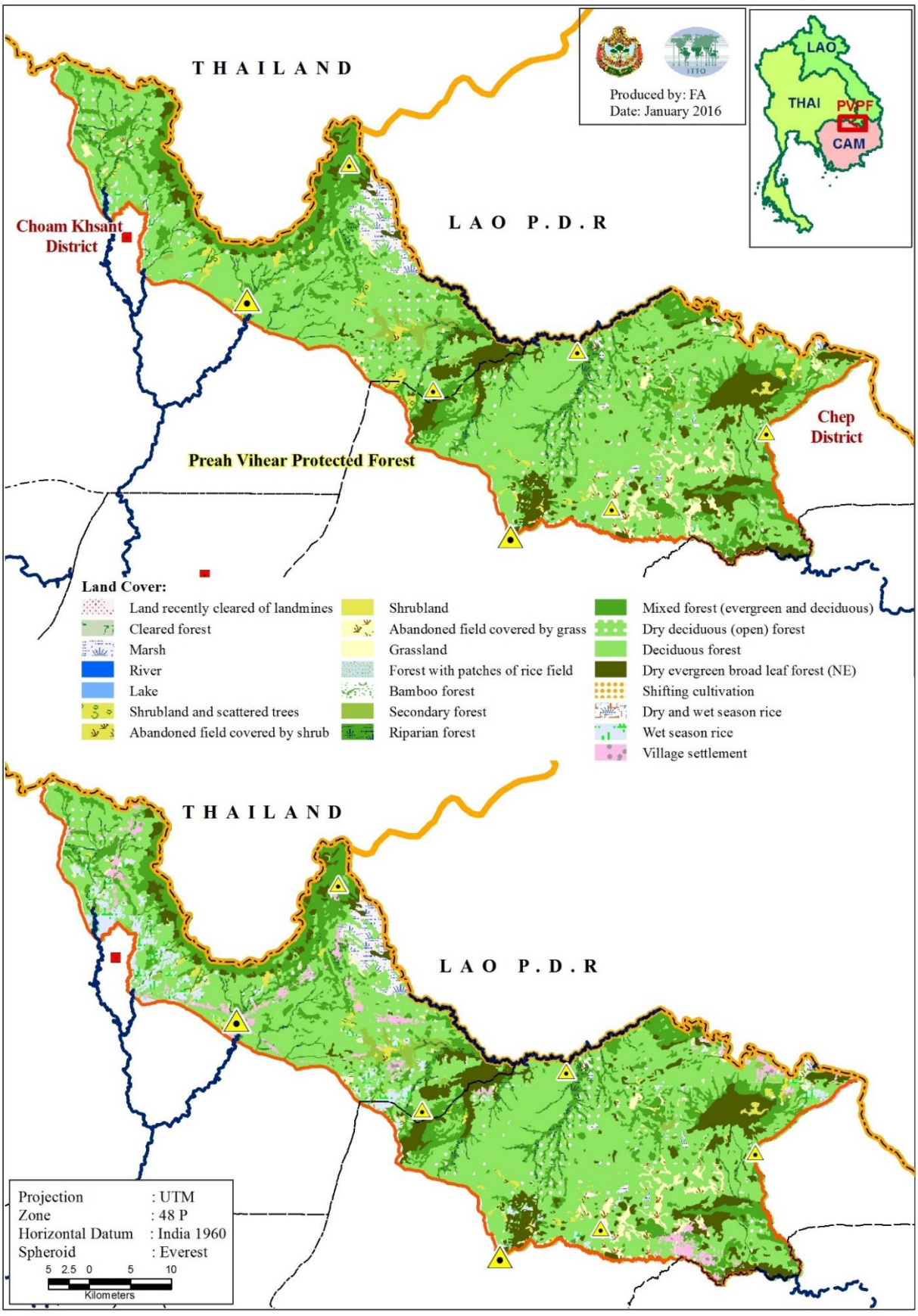
Figure 3.4. Land for agriculture and new settlements in Social Land Concessions.

Figure 3.5. Land for farming systems and forest protection.

Table 3.1. Land use classifications and land cover changes.

No	CATEGORY	NAME	Land use in 2009		Land use in 2014		Change	
			AREA (ha)	%	AREA (ha)	%	AREA (ha)	%
1	Village settlements	Village settlement	99.65	0.052	6258	3.293	6158.35	3.24
2	Agricultural lands	Shifting cultivation	300.53	0.158	259.71	0.137	-40.82	-0.02
		Wet season rice	1128.87	0.594	7541.88	3.969	6413.01	3.37
3	Forest cover	Mixed forest (evergreen and deciduous)	29386.09	15.464	28581.83	15.041	-804.26	-0.42
		Deciduous forest	93992.32	49.463	87438.76	46.014	-6553.56	-3.45
		Dry deciduous (open) forest	17759.47	9.346	15432.51	8.121	-2326.96	-1.22
		Dry evergreen broadleaf forest or Semi-evergreen	20428.96	10.751	20100.88	10.578	-328.08	-0.17
		Riparian forest	9439.43	4.967	8889.58	4.678	-549.85	-0.29
		Secondary forest	2597.69	1.367	2460.75	1.295	-136.94	-0.07
4	Swamps / Grasslands	Grassland	210.19	0.111	189.84	0.100	-20.35	-0.01
		Abandoned field covered by grass	5443.54	2.865	4632.1	2.438	-811.44	-0.43
5	Shrublands	Abandoned field covered by shrub	1036.88	0.546	937.19	0.493	-99.69	-0.05
		Shrubland	209.3	0.110	209.3	0.110	0	0.00
		Shrubland and scattered trees	2777.39	1.462	1938.71	1.020	-838.68	-0.44
6	Water Features	Marsh	5210.57	2.742	5152.93	2.712	-57.64	-0.03
		River	3.08	0.002		0.000	-3.08	0.00
		Lake	3.03	0.002	3.03	0.002	0	0.00
		Grand Total	**190,027**	**100**	**190,027**	**100**		

Note: *Land use 2009 map from JIC, and land use 2014 map from ITTO's project assessment, detected by using LANDSAT 8 OLI 2014.*



Map 3.3. (A) Land Use 2009 and (B) Land Use 2014 in the Preah Vihear Protected Forest.

The results of land cover change analyses in the PVPF have indicated a decline in forestland from 97.62% in 2002 to 91.11% in 2014, equivalent to an average annual deforestation rate of 0.715% of the land area of the PVPF, which is lower, however, than the country's average

annual deforestation rate of 1.055% during that same period. This means that to maintain the percentage of forest cover in the PVPF as it was in 2002 of 185,503 ha to compensate sufficiently to achieve the Cambodia Millennium Development Goals would require 12,369 ha of non-forest land to be converted to man-made forest tree plantations and agroforestry.

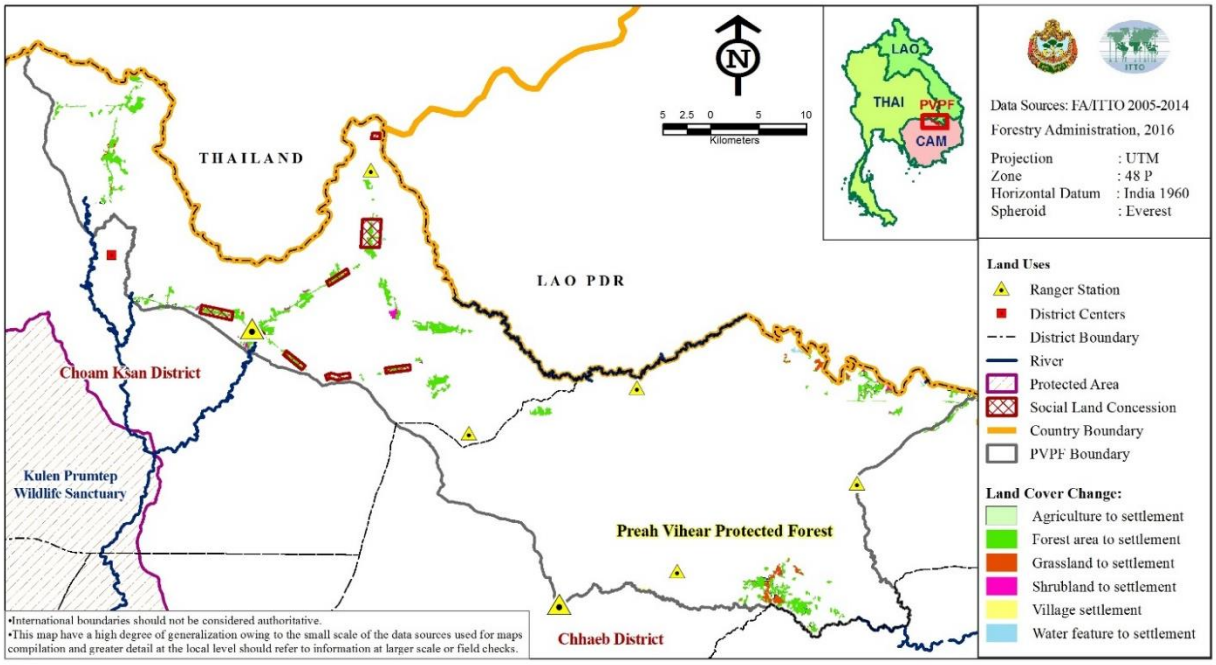
b) Land cover change patterns

The matrix presented in Table 3.2 is derived from GIS overlaid land use datasets for 2009 and 2014 to assess the patterns of land cover changes in the Preah Vihear Protected Forest. The results reveal that the greatest changes were associated with village settlements and agricultural land.

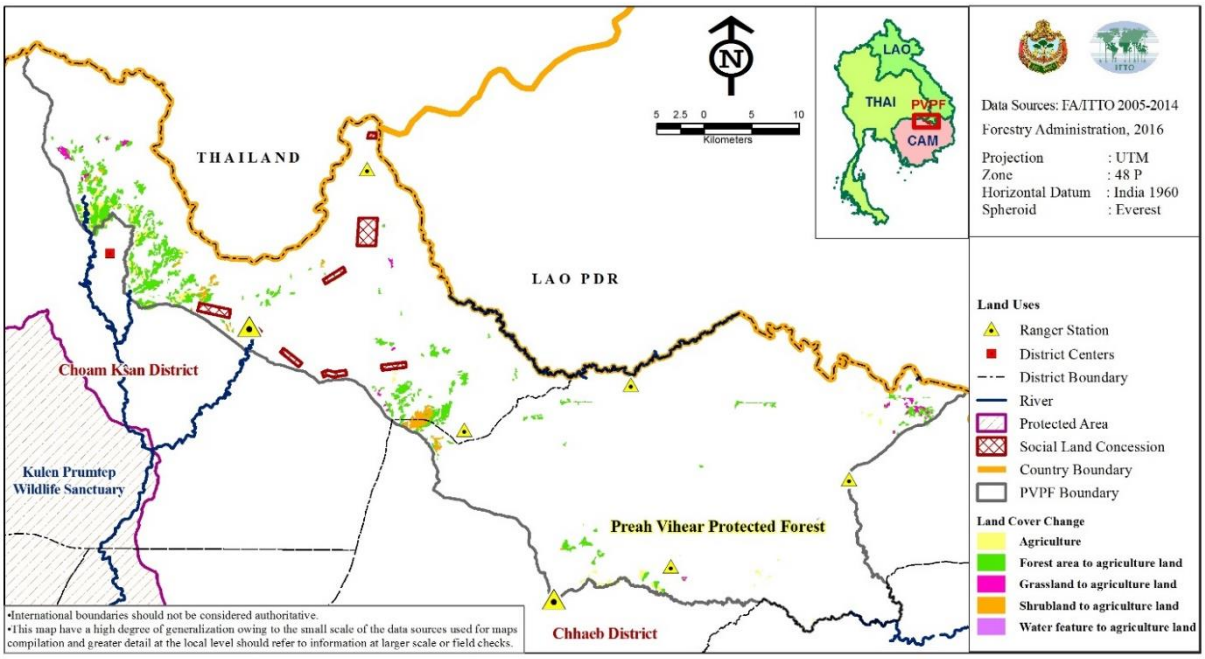
Table 3.2. Land cover change patterns.

Category	Village settlements	Agricultural Land	Forest Land	Swamps / Grasslands	Shrub lands	Water Features	**LC 2009**
Village settlements	99.65						**99.65**
Agricultural Land	333.55	1095.84					**1429.39**
Forest Land	5103.05	5596.66	162904.31				**173604**
Swamps / Grasslands	460.51	375.25		4821.94			**5657.7**
Shrub lands	205.05	729.32			3085.19		**4019.56**
Water Features	56.22	4.5				5155.96	**5216.68**
LC 2014	**6258.03**	**7801.57**	**162904.31**	**4821.94**	**3085.19**	**5155.96**	**190027**

The pictorial representations of those changes in land cover, which were primarily associated with net ‘losses’ of 6158.38 ha to village settlements and 6705.73 ha to agricultural land, are provided in Maps 3.4 and 3.5. The representations of those changes in village settlements were primarily associated with net ‘gains’ of 333.55 ha from agricultural land, 5103.05 ha from forest land, 460.51 ha from grasslands and/or swamps, 205.05 ha from shrub lands, and 56.22 ha from water features (marshes). Other changes that occurred in agriculture land were primarily associated with net ‘gains’ of 5596.66 ha from forest land, 375.25 ha from grasslands and/or swamps, 729.32 ha from shrub lands, and 4.5 ha from water features. The largest percentage change in area between 2009 and 2014 was associated with village settlements and agricultural land, the area of which expanded by 81.54% and 71.74%, respectively, primarily as the result of the net ‘gain’ of 5103.05 ha of village settlements and 5596.66 ha of agricultural land from forestland.



Map 3.4. Changes in land cover to village settlements between 2009 and 2014.



Map 3.5. Changes in land cover to agricultural land between 2009 and 2014.

3.3.3 Drivers of land use change

Land use practices are changing rapidly in the recreation forest and regulating water resource zones in the Preah Vihear Protected Forest. Part of those changes reflect a broader agricultural transition that has been occurring in the western part of the Preah Vihear Protected Forest. Since the An Sef international border between Cambodia and Thailand was opened, new road networks have begun construction that reaches further to the rural people in Chaom Ksan. Theories of agrarian transition have been advanced since Malthus (1798) first proposed that population growth drove land degradation and Boserup (1965) suggested that population pressure drives the changes from shifting cultivation to annual cultivation. Brookfield (1979;

1995) recognized that changes are not only driven by pressures, but by emerging opportunities that change the productivity or quality of labor. He suggested that the 'pressure of population' should be replaced by the recognition that the social and cultural contexts within which people produce and consume must be central to the understanding of agricultural systems and agrarian change.

- **Population growth**

In the Preah Vihear Protected Forest, the population has expanded rapidly from 14,189 people in 2007 (Seila program databases 2007) to 28,436 people in 2014 (Ministry of Planning 2014) (Table 3.3). There is an increasing proportion of the growing population comprised of migrants. Consequently, the percentage of indigenous people declined from 3 percent in 2007 to 2.5 percent in 2014. The combination of the growing number of migrants and outside speculators and investors is intensifying land competition in many parts of Chaom Ksan district, particularly in An Sef, O Chunh and Mum Bei villages, in the Preah Vihear Protected Forest, while land is increasingly viewed as a market commodity, even by local people.

Table 3.3. Population and forested area in the Preah Vihear Protected Forest.

Description	2006/2007	2010	2014
Forest area	183,392.6	181150.72	173,133.61
Non-forestland	6,192	8,876	13,794
Population	14189	17312	28,436

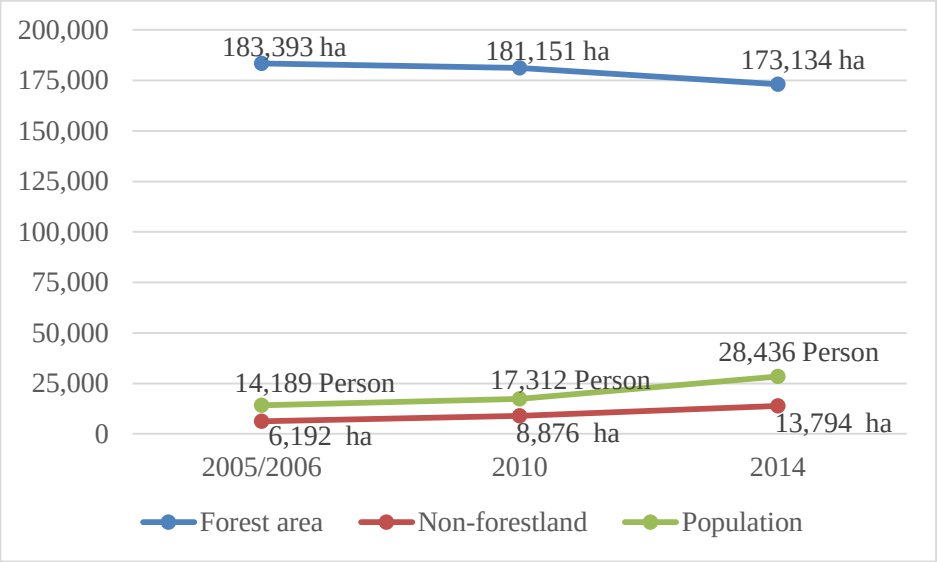


Figure 3.6. Population correlation with the loss of forestland.

Driving forces that affect land cover changes in the Preah Vihear Protected Forest are closely correlated with population growth (Figure 3.6). The annual population growth rate is approximately 1.55% in and surrounding the Preah Vihear Protected Forest (Forestry Administration 2010; NCDD; 2010; Ministry of Planning 2014). The population density (people per square kilometer) in and surrounding the Preah Vihear Protected Forest was approximately 7.5 people per square kilometer in 2007 and continued to increase to about 15

people per square kilometer in 2014. The negative correlation between forestland and population (0.99) is very high, which suggests that population pressure may be one of the principal forces driving land use intensification in the Preah Vihear Protected Forest.

- **Land policy changes**

In recent decades, the national government has begun to exert its claims to indigenous lands as part of the state's public land domain. Since border conflicts between Cambodia and Thailand were reignited in 2007, the Royal Government of Cambodia has extended road infrastructure into the Preah Vihear Protected Forest, constructed new settlements and educational facilities, and increased health services. In addition to these efforts to integrate the province through projects and investments, migrants from other provinces, including Prey Veng, Takao, Kampot and Kampong Cham, have been rapidly increasing in the Preah Vihear Protected Forest, particularly in Chaom Ksan district.

While government demarcation of most land has yet to occur, technical agencies and planners have allocated 1491 ha from the Preah Vihear Protected Forest through a grant to military families under the Social Land Concession program described in Sub-degree N° 15-16-17 ANKr.BK and issued on 19 January 2010. There are also 5058 ha of mixed deciduous forest in the western part of the Preah Vihear Protected Forest that have been requested as agricultural land for military households.

- **Land market**

Since 2013, sales of indigenous people's land in the Preah Vihear Protected Forest administered under communal management have occurred. These are "illegal land transactions" under the national Land Law (2001), which prohibits the sale of indigenous land. In relation to the land rights of indigenous communities, Article 25 of the Land Law states that "*the lands of indigenous communities are those lands where the said communities have established their residences and where they carry out traditional agriculture. The lands of indigenous communities include not only lands actually cultivated but also includes reserves necessary for the shifting of cultivation which is required by the agricultural methods they currently practice and which are recognized by the administrative authorities."* Some areas of mature forest may be included in the communal land titles of indigenous communities. The possibilities of communal ownership as described in Article 26 of the Land Law are that "*Ownership of the immovable properties ... is granted by the State to the indigenous communities as collective ownership. This collective ownership includes all of the rights and protections of ownership as are enjoyed by private owners. But the community does not have the right to dispose of any collective ownership that is State public property to any person or group.*" Even in the interim period prior to the recognition of communities as legal entities, indigenous peoples' have the land rights expressed in Article 23 of the Land Law, which asserts that "*Prior to their legal status being determined under a law on communities, the groups actually existing at present shall continue to manage their community and immovable property according to their traditional customs.*"

"Traditional customs," however, do not include land sales, particularly the collective land obtained as the result of forest land encroachment. While community lands cannot be legally

sold, the lack of surveys, registration, and documentation make indigenous land vulnerable to speculators who frequently enlist local officials to facilitate illegal sales. These conditions have resulted in a rapidly expanding illegal land market with indigenous communities increasingly aware that their communal resources have become a market commodity and a source of cash. The requirements for the cash to meet educational expenses and health costs, improve housing conditions, purchase consumer durables, and meet rising community and family expectations is common throughout virtually every indigenous community in the Preah Vihear Protected Forest and the motivation to raise cash through land sales is clearly present.

In most cases, even military houses granted under the Social Land Concession program that the government has provided to landless families are not allowed to be offered for sale. Some of those houses have, nevertheless, been sold, as many of the initial transactions have been made through a broker or land speculator who, in turn, has resold those houses to others. Once the initial transactions have been completed, moreover, community members are no longer included in the process and may only learn about the eventual owner when development occurs on the purchased land. The lack of transparency and clear communication in this process of multiple land transfers is creating tensions within villages. These offenses usually go uncontested, though, owing largely to the lack of process, documentation and viable enforcement and, as a result, feelings of discontent and animosity liner.

When asked the manner in which land sales are recorded and parcels delineated, villagers are unable to define the process or establish a clear distinction of the limits of the land sold. In many cases, a commune official stamps a document that denotes a sale. Money is exchanged with a general understanding of transfer of ownership without, however, the surveying or physical demarcation of the limits of the land. Villagers may use thumbprints to notify approval of sales, but rarely, if ever, receive a receipt or copy of the sales documents. Since there is some shame associated with the practice of selling land, moreover, these transactions generally do not involve witnesses. The result of this lack of transparency and documentation is the common scenario in which the new owners of the land clear and use much more land than was originally agreed. While the land areas of the villagers are not officially recognized by the commune council, buying and selling land in the commune is still made possible through customary trading that the villagers used to do among themselves. In recognition of these responses, community members express a sense of confusion and powerlessness, feeling that they have no recourse for contesting their claims. Once the land has been cleared and planted, people have claimed their land on the basis of their ongoing activities on the land and the implicit acceptance of those claims by their neighbors in the village through informal customary arrangements.

3.3.4 Commune-based land use in the Preah Vihear Protected Forest

The assessment of land use in three communes - Choam Ksant, Teuk Krahum, and Morokot - indicate that most of the cleared land in the Preah Vihear Protected Forest is used by villagers to grow cash crops and cultivate rice. In some cases, villagers do not have enough capital to use the land for cultivation, however, and it is left fallow for trees to regenerate.

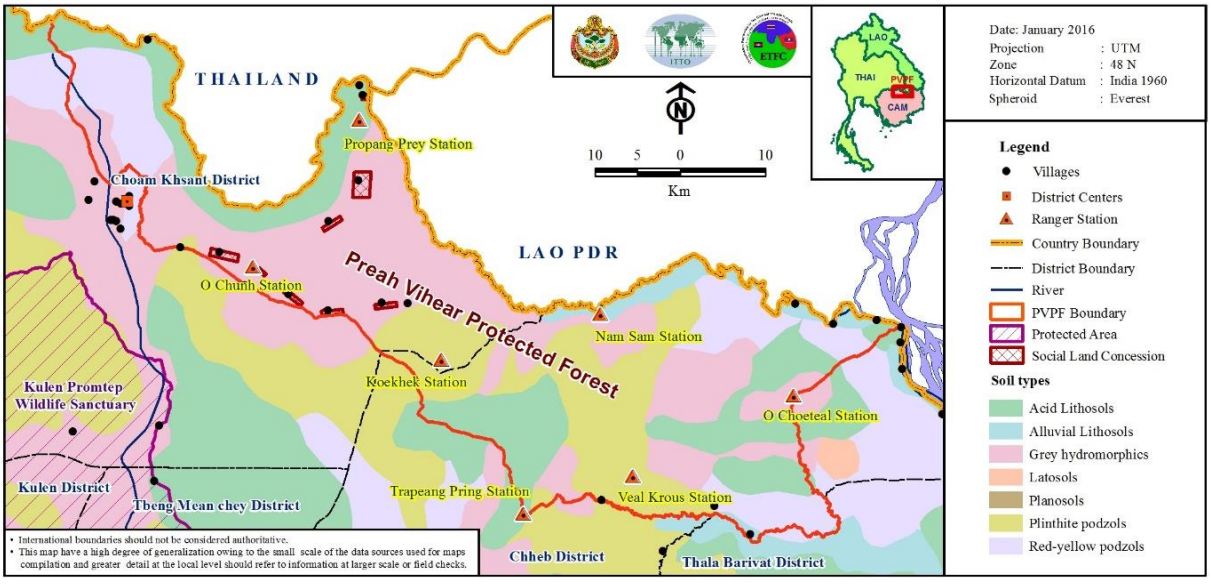
- **Soil productivities**

Soil is an important factor affecting the growth of plants. The soils of the PVPF were developed under a humid-to-sub-humid tropical climate with alternate wet and dry conditions from the decomposition of acid or basic rocks and alluvial outwash from either or both of those rock types. Soils in the PVPF include Acid Lithosols, Alluvial Lithosols, Grey Hydromorphics, Phinthite Podzols, and Red-yellow Podzols (Table 3.4 and Map 3.6). Soils in the planning area are fertile in Choam Ksan district for rain-fed rice production, but are less fertile in Chhep district.

Table 3.4. Soil types in the Preah Vihear Protected Forest.

N	Soil Type	Area (ha)	pH	Agriculture Potential
1	Acid Lithosols	44,494	5.2-5.5	**Generally good**: Soil needs protection from erosion and fire. Composition - phosphate and organic fertilizers (Rock Phosphate). *Cultivated on less than 1% of forest area.*
2	Alluvial Lithosols	7,029	4.3-5.5	**Good soil**: Potential Acidity: Recommend calmative canals. Cultivation concordance with the water regime. Green manure, phosphate, and potash (avoid the use of sulphate fertilizers). *60% cultivated. Flooded every year, rice planted with receding floodwaters.*
3	Grey hydromorphic	73,756	5.2-5.7	**Better soil than Clutural Hydromorphics:** Scattered in distant areas. Difficult access planting. 80% covered by forest in depressions and hollows. *20% cultivated. 80% dense forest, rice, seasonal crops.*
4	Phinthite podzols	38,488	4.5-5.0	**Soil poorer:** Low agriculture potential. Covered with open forest. Reserved for extensive livestock breeding. Cultivation not advisable. *Cultivated on 5%. Primary crop is rice.*
5	Red-yellow podzols	26,260	4.2-5.8	**Poor:** Structure easily destroyed. Soil rapidly leached, lacking fertilizer elements. *Cultivated on less than 25%. Main crops include rice, sugar palm, coconut, rubber, andseasonal crops.*
	Total	***190,027***		

Sources: Crocker (1962) and 2002 soil dataset from JICA.



Map 3.6. Soil types in the Preah Vihear Protected Forest.

Based on the mapping of the soil types and the cultivation suitability of the soils, most villagers in the study area rely on grey hydromorphic and red-yellow podzols, which account for 20-25% of the cultivated land area and a majority of the crops that are planted, including sugar palm, rice, mangos, cassava, and seasonal crops. Some 75-80% of the area is covered by mixed deciduous forest. The high productivity soils are situated in Choam Ksant and Morokot communes, where local communities benefit from planting a variety of crops, as well as fruit trees. General observations indicate that soils are found in varying proportions in the different villages and villagers plant a variety of crops that grow well and adapt to prevailing soil conditions. Crops that are suitable to be cultivated on the various soil types are presented in Figure 3.7, although it should also be recognized that various crops that are grown in the Preah Vihear Protected Forest by local communities are grown as the result of traditional practices.

- **Agricultural practices**

Most villagers in the Tek Krahum and Morokot communes plant rice around their homes in the rainy season and cultivate vegetables or cash crops in the dry season. Agricultural productivity is very low in the Choam Ksant commune, however, beacuse only a few farmers use chemical fertilizers and pesticides. The seeds to output ratio in the Preah Vihear Protected Forest is very high for rice cultivation, moreover, which suggests a relatively low rice yield in relation to inputs when compared to other areas in the province.

Since agricultural practices and the application of some improved technologies have been introduced and the availability of tractors has increased, cultivation practices have been considerably improved. There have been about 1690 local community members who have been provided with support to improve agriculture techniques through the project, including the introduction of rice intensification systems, home garden preparation, animal raising, agroforestry systems, and tree planting techniques. The primary agricultural challenge in the Preah Vihear Protected Forest is associated with water resources. Considering the prolonged period of drought during the dry season, water storage is limited, as is its use in agriculture.

There are opportunities for watershed development programs in the Preah Vihear Protected Forest because rainfall in the area is very high and with the construction of appropriate water storage reservoirs, especially in Choam Ksant commune, more paddy land would be able to be brought under cultivation. Recognizing the importance of water resources for agriculture and farming systems, the project sent representatives to a collaborative meeting with CARITAS NGO officers to study the feasibility of establishing solar water pumps in Robonh and O Chunh villages. The meeting was conducted on an ad-hoc basis to promote the development of community land use-based agriculture to reduce dependence on forest resources and encourage biodiversity conservation. The project also established ponds to reserve water to support local community farming in the dry season in Teuk Krahorm and Morokot communes. Those ponds contribute to efforts to improve community-based land uses in the Preah Vihear Protected Forest by increasing agricultural productivity, especially through the establishment of home gardens and animal raising, while reducing dependence on forest resources.

Vegetables and other crops that are usually grown in this commune include pineapples, water lily, sponge gourd, cucumber, leguminous crops, bananas, maize, eggplant, sugarcane, cassava, rice and other vegetables and fruit trees.

Figure 3.7. Vegetables and other crops grown in the Preah Vihear Protected Forest.

3.3.5 Land use and land cover change scenarios

There was a series of land cover change scenarios that was developed under the project to facilitate understanding the impacts of land use changes in which each scenario attempted to translate projected socioeconomic shifts into biodiversity response indicators using the correlation between population density and socioeconomic conditions. Those scenario structures are summarized in Table 3.5

Table 3.5. Land cover change scenario descriptions.

Scenario	Correlation	Focus	Scenario Structure
I	High Population and High Economic Growth	Environment, Poverty Reduction, Human Values	1. Conventional with gradual convergence in income and culture toward dominant market model (market driven with policy reforms). 2. Social and environmental problems overwhelm market and policy responses. 3. Fundamental changes in values, lifestyles, and institutions.
II	High Population and Low Economic Growth		1. Rapid market driven growth with convergence in incomes and culture. 2. Self-reliance and preservation of local identities, fragmented development. 3. Emphasis on local solutions to economic, social, and environmental sustainability.
III	Low Population and High Economic Growth	Business and Sustainability	Market driven growth, economic sufficiency, top-down approach to sustainability, bottom-up approach to sustainability, ad hoc alliances, innovation.
IV	Low Population and Low Economic Growth	Environment	Corresponds,to market driven and policy reforms. Social and Environmental problems overwhelm market and policy responses. The need to break down unbridled conflict, institutional disintegration, and economic collapse, poverty and repression..

Source: Carpenter et al. (2005).

The results of the land use change scenarios studies delivered the clear message that the business-as-usual trend would lead to a significant shift in land use from natural or semi-natural forested areas and savannahs toward settlements and agricultural systems. The land use changes, moreover, would be distributed unevenly between industrialized and developing geographical regions. In the economic and population growth scenario, a transformation of forestland toward agricultural land, including paddy fields, cassava plantations, and other plantation land, would occur, although with significant differences depending on locations in the Preah Vihear Protected Forest.

The LULC scenario analyses suggest that the principal "drivers" of future land use in the Preah Vihear Protected Forest will be agricultural production systems, especially agroforestry systems in the recreation forest and regulating water resources zones. The results of the LULC analysis in the Preah Vihear Protected Forest are summarized in Figure 3.8, which provides a regional breakdown and an indication of the overall uncertainty of model results.

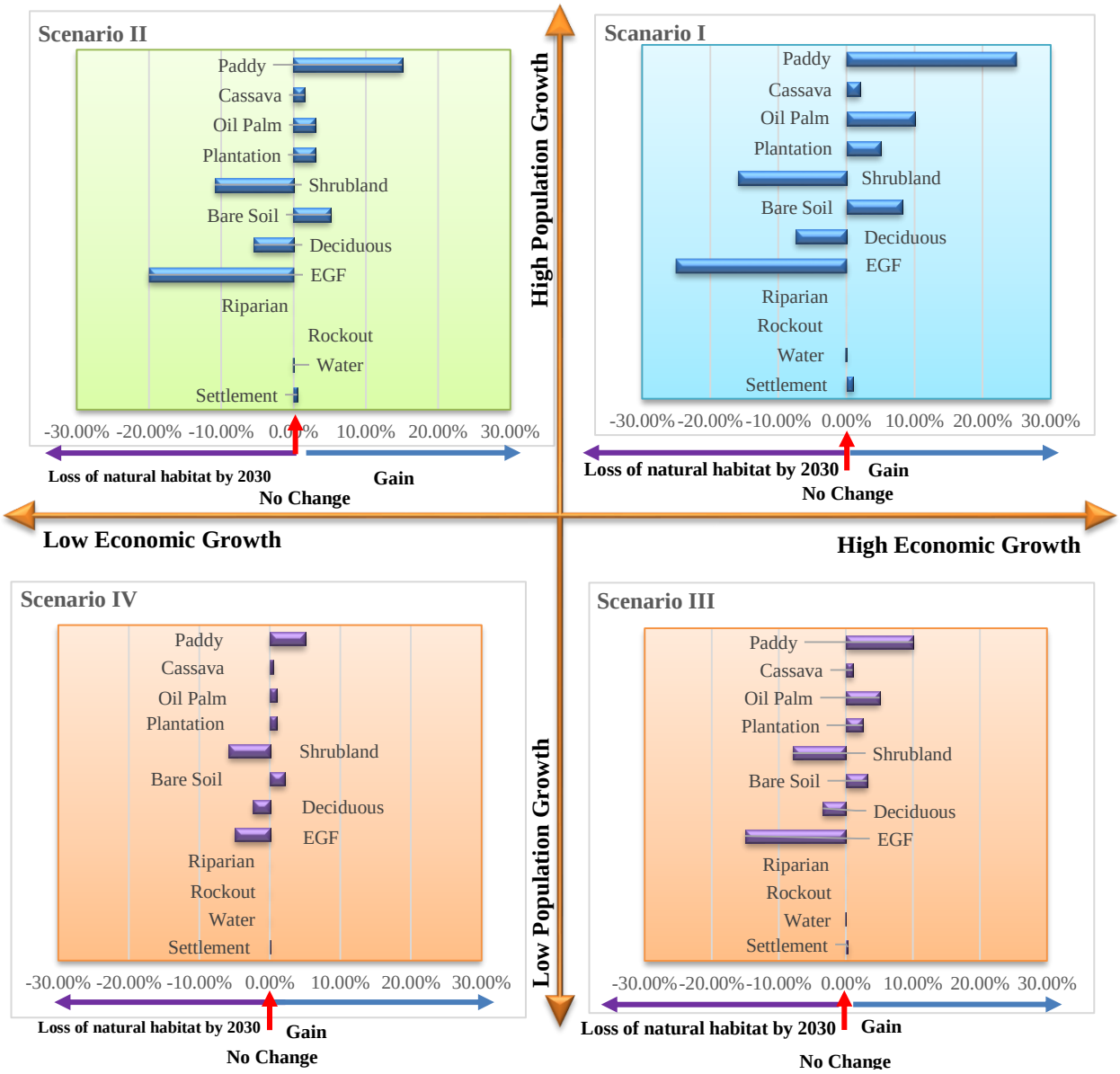


Figure 3.8. Land cover change scenarios.

Land use scenarios in the Preah Vihear Protected Forest were initially discussed during the joint training workshop on “Land use and land cover change modeling” that was organized by the Preah Vihear Forestry Administration Cantonment on 14-16 March 2014. Those scenarios continued to be discussed with commune councils, local communities, and other stakeholders in the meeting on land uses and the identification of community use areas in the Preah Vihear Protected Forest organized on 2–4 February 2015.

The significant factors and coefficients of the logistic regression models used in the assessment determined the locational suitability of the 8 LULC classes highlighted in Table 3.6. In 'running' the LULC model, several parameters, including altitude, slope, annual rainfall, and distances from urban areas and stream, as well as ease of access to roads, are required and were correlated to remaining evergreen forest (Trisurat 2015).

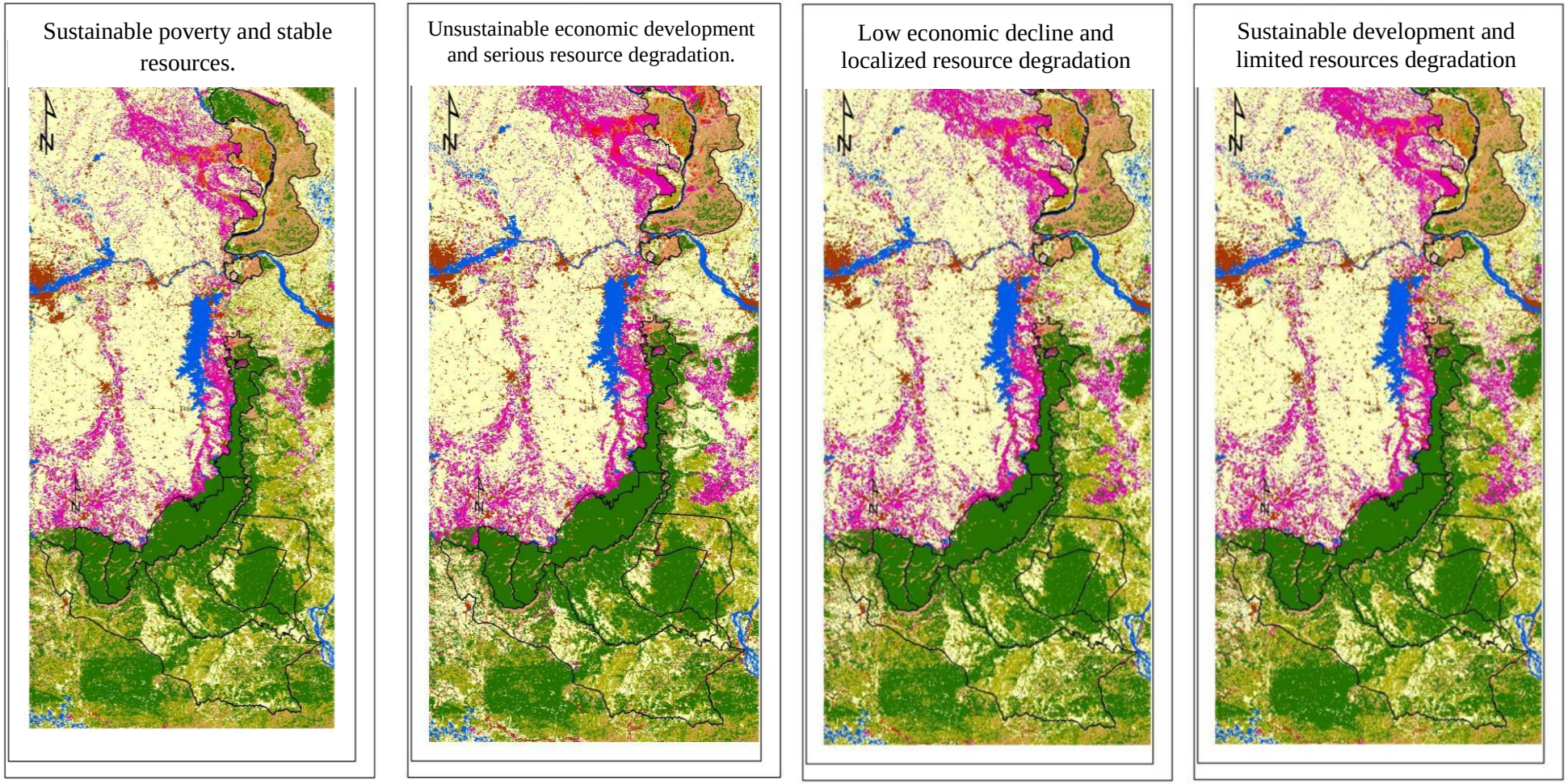
Table 3.6. Beta values of significant location factors for regression models related to each land use type.

	Evergreen	Mixed deciduous	Dry dipterocarp	Plantations	Rubber	Agriculture	Settlements	Bare soil
Variables	forest	forest	forest					
DEM (m) 0	0.0020	ns	-0.0130	0.0152	0.0111	-0.0033	0.0028	0.0075
Slope (%) 1	ns	0.1033	ns	-0.0962	-0.1185	-0.1200	ns	-0.0347
Aspect 2	ns	ns	ns	ns	0.0007	ns	ns	ns
Population density (person/km2) 3	-0.0388	-0.0011	-0.0004	-0.0007	-0.0006	-0.0002	0.0017	ns
Annual rainfall (mm) 4	0.0087	-0.0064	-0.0027	0.0191	-0.0064	-0.0067	0.0076	-0.0148
Rainfall in the wettest quarter (mm) 5	-0.0074	0.0081	0.0066	-0.0233	0.0083	0.0059	-0.0111	0.0160
Rainfall in the driest quarter (mm) 6	-0.0448	0.1519	0.2902	-0.3836	-0.1795	-0.1019	-0.1217	ns
Distance to road (m) 7	0.0002	8.9E-05	5.7E-05	-0.0014	-0.0005	-0.0003	-0.0029	-0.0001
Distance to stream (m) 8	8E-05	0.6E-05	5.1E05	-0.0004	-0.0006	-0.0001	-0.0001	ns
Distance to city 9	3.8E 05	-0.3.2E-05	1.1E-05	ns	ns	1.6E-05	-3.0E-05	-3.4E-05
Acrisol soil 10	3.2217	0.4374	2.3320	0.7626	0.6666	1.5903	-0.3665	0.7441
Arenosol soil 11	1.5034	ns	1.3106	0.7348	ns	2.1740	-0.5131	ns
Cambisol/Plinthosol soil	3.5029	0.5725	2.4457	ns	-1.5936	1.3835	-0.6280	ns
Ferralsol soil 13	3.5540	ns	Ns	-1.8358	0.8336	1.1610	ns	ns
Gleysol/Fluvisol soil	2.1677	0.9295	1.9162	ns	Ns	1.8357	-1.1610	ns
Leptosol soil 15	4.7861	ns	2.0991	ns	Ns	1.9332	ns	ns
Lixixol soil 16	2.8929	ns	Ns	ns	1.6638	1.6729	ns	ns
Luvisol/Solonetz soil	2.4951	ns	3.0006	ns	-2.4466	1.7767	ns	ns
Slope complex 18	2.4752	ns	4.2447	ns	1.7360	ns	-0.7401	2.2224
Rock 19	3.6601	ns	3.5119	-3.3545	-1.3257	ns	-1.7182	0.9972
constant	-11.2522	-0.2324	-8.3067	-5.1757	4.1205	7.5319	1.4886	8.0077
AUC	0.902	0.758	0.767	0.837	0.802	0.815	0.903	0.797

AUC = area under curve; ns = not statistically significant.

Data sources: ITTO PD 577/10 Rev.1 (F) project; Trisurat 2015.

In the technical reports of the ITTO PD 577/10 Rev.1 (F) project (Trisurat 2015; Hosmer and Lemeshow 2000), the predicted models were outstanding for forests and settlements (AUC>0.9) and forest plantations and agriculture (0.8≤AUC<0.9), and were acceptable for deciduous forest and bare soil (0.7≤AUC<0.8). Based on the simulated LULC maps in 2030 for the four scenarios using the Dyna-Clue Model combination with ArcGIS 10.0 conducted by the LULC modeling expert, the *unsustainable economic development and serious resource degradation* scenario predicted a considerable amount of land conversion to arable land and rubber plantations. The area of mixed deciduous and dry dipterocarp forests was predicted to decline from 22.9% of the entire Emerald Triangle Protected Forests Complex in 2013 to 15.1% in 2030. The simulated maps depicted in Map 3.7 illustrate, as well, the results of the *low economic decline and localized resource degradation (business-as-usual)* scenario with restrictive policies in the Pha Taem Protected Forests Complex, which were deforestation and agricultural expansion in the remnant forests situated in the recreation forest and regulating water resources zones in the Preah Vihear Protected Forest and area close to the Anses international border between Cambodia and Thailand.



Map 3.5. a) Predicted land uses and land cover changes for *Sustainable poverty and stable resources* scenario.
b) Predicted land uses and land cover changes for *Unsustainable economic development and serious resource degradation* scenario.
c) Predicted land uses and land cover changes for *Low economic decline and localized resource degradation* scenario.
d) Predicted land uses and land cover changes for *Sustainable development and limited resources degradation* scenario.

Data sources: ITTO Project PD 577/10 Rev.1 (F) project; Trisurat (2015).

The principal uncertainties in the future land use dynamics are the development of demands for agricultural products and trends in yields of different cultivation systems. The combination of both provides the response to net area expansion and the internal transformation between settlements and agricultural land in the Preah Vihear Protected Forest. The International Institute for Sustainability Analysis and Strategy (IINAS) prediction is that the conversion of forested areas into agricultural land will continue at least until 2050 (Uwe and Ulrike 2013). In the Preah Vihear Protected Forest, the results from the simulated LULC model indicate that not only forests would be affected by future land use demands from agriculture, but also savannahs and grasslands, with resultant changes in habitats and biodiversity.

The underlying purpose of the LULC assessments was to avoid the negative impacts of the trend scenarios through the implementation of mitigation policies and measures. The assumption of high economic growth – additional yields increased beyond those already assumed in the trend scenario – would contribute to reductions in land use for agriculture. The significant reduction in agricultural land use or restrictive land use policies would result in reductions in deforestation and other land conversion in the Preah Vihear Protected Forest. Other options of the mitigation policies, considering other implications of positive tradeoffs between biodiversity, employment, and human health, would occur. These would affect sustainable food policies, which would require additional safeguards (Tellus Institute 2010).

3.3.6 Proposed land use planning in the Preah Vihear Protected Forest

The unrest along the Cambodia-Thailand border has led to forest cover changes, especially since the provision by the government pf approximately 19,496 hectares to establish military bases, as well as land for military families, through social land concessions. There have been 2,144 hectares of those concessions established in the Preah Vihear Protected Forest, which has affected forestlands and the use of forest resources at the same time that local population growth and increased in-migration have expanded the area of forestland converted to agricultural land.

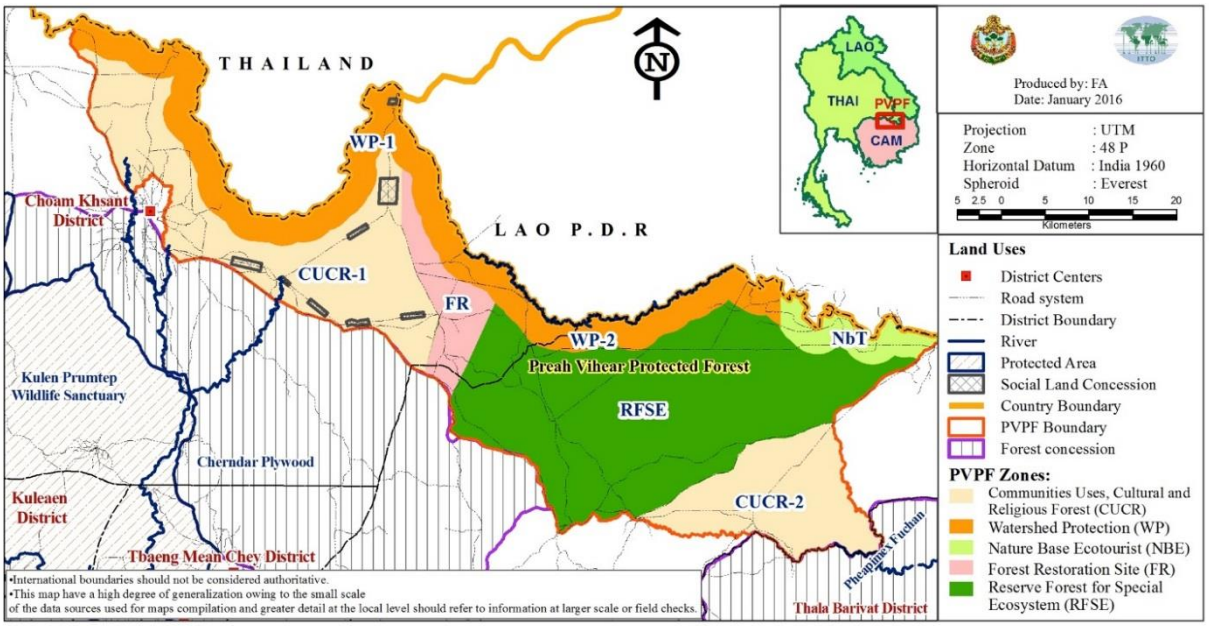
Interviews that were conducted indicated that local people occupied, on average, residential land of 0.286 ha (standard deviation = 0.164 ha), with minimum and maximum occupied areas of 0.075 ha and 0.450 ha, respectively. There were 71.4% of those villagers whose land tenure was officially recognized by local authorities, which who had issued letters of land occupation that were co-recognized by the commune and infantry brigade No. 9 and issued by either the commune or the village chief. There is another form of land tenure, as well, consisting of a letter of land occupation inherited from relatives that is officially recognized by the commune. That form of land tenure accounted for 23.8% of the interviewed villagers, while those who purchased their land accounted for 4.8% of the villagers. The villagers generally build houses on their land and use the rest of the land to plant garden crops, vegetables, fruit plants, and paddy rice, but there were at least 7.1% of interviewed villagers who have left their land covered with natural forest and have yet to grow a crop because of the lack of inputs and resources, which is especially the case among military families.

The farmland occupied by each village family was, on average, 2.07 ha (standard deviation = 0.359 ha), while military families were each provided with 0.45 ha of residential land and 2 ha of paddy rice field, or 2.45 ha of land. The projected relationship between the increase in non-

forestland and population growth revealed a strong correlation with land area occupied by local people.

Map 1.3 (Chapter 1) illustrates the occurrences of forestland conversion in which forestland has been cleared to the greatest extent between 2010 and 2014. It is apparent from that depiction that the conversion of forestland to non-forestland generally occurs in village and commune areas, as well as to some extent along the boundary of the southern and eastern part of the PVPF. Some extensive areas of forestland conversion have occurred in Morokot commune near the core zone of the PVPF forest, as well as in the central area of the PVPF near Dang Phlet commune in Chhep district.

Since 2010, the majority of deforestation and forest degradation in the Preah Vihear Protected Forest has been associated with land use policy changes in which the government has allocated land for developing infrastructure and constructing settlements for military households along the border to support community development (Map 1.2 and Map 1.3 in Chapter 1). There have also been other causes, especially illegal logging, because of the rapid increase in market demand for commercial timber, timber for housing construction, and fuelwood. It is as the result of the lack of land for agriculture that people have strived to acquire more land to cultivate their crops by clearing more forests for slash and burn cultivation, as well as the establishment of plantations. That cultivation has occurred, especially, along the road from Choam Ksan district to Anses and from Choam Ksan to Mumbei and Obunh, where new villages have been established.



Map 3.8. Proposed forest land use zoning in the Preah Vihear Protected Forest 2016-2020.

Table 3.7. Proposed forestland use zoning in the Preah Vihear Protected Forest.

No.	Description	Compartment	Area of Compartment (ha)	Administrative Location
1	Community Use, Cultural Heritage, and Religious Forests (CUCR)	CUCR-1	40,800	Teuk Krahum, Morokot, and Choam Khsant communes, Choam Khsant district.
		CUCR-2	22,222	Chhaeb Pi and Kampong Sralau Mouy communes, Chhaeb district
2	Nature-based Tourism (NbT)	NbT	6,809	Kampong Sralau Mouy commune, Chhaeb district
3	Reserve Forests for Special Ecosystems (RFSE)	RFSE-1	3,965	Morokot commune, Choam Khsant district
		RFSE-2	67,473	Kampong Sralau Mouy and Chhaeb Pi communes, Chhaeb district
4	Watershed Protection (WP)	WP-1	30,594	Choam Khsant, Teuk Krahum and Morokot communes, Choam Khsant district
		WP-2	8,937	Kampong Sralau Mouy commune, Chhaeb district
5	Forest Restoration Site (FR)	FR	9,227	Morokot commune, Choam Khsant district
	Total		***190,027***	

There are five land use zones that have been proposed in the Preah Vihear Protected Forest (Map 3.8; Table 3.7), including:

- **Community Use, Cultural Heritage and Religious Forests:** The Community Use, Cultural Heritage, and Religious Forests zone is sub-divided into two compartments. There are several small village settlements, as well as agricultural land, which includes rice fields and farmland for local community use, and swidden (chomkar velchum) areas, located in these two compartments. The CUCR zone would have 63,022 ha and contain many temple sites, as well as areas in which local people regularly collect non-timber forest products for subsistence use, and areas allocated for settlement under social land concessions. Local communities would have customary user rights to collect forest and non-forest products for household use in a transparent, sustainable manner in these areas in accordance with the Forestry Law. The cultural heritage and religious and spirit forests in which local communities have retained their beliefs in accordance with their traditions and culture, would be retained as religious and cultural forests in this zone. The PVPF contains many sites with cultural significance, including ancient temples, as well as sacred forests. The project team, with the assistance of local communities, identified 17 sites of ancient temples in the PVPF. Some local people have reported that there are several other sites in the PVPF that have small temples, as well, but it is difficult to access those sites because of

land mines and unexploded ordnance that remain under ground in the area around those sites.

- **Nature-based Tourism Sites:** The Nature-based Tourism Sites zone has Special Natural Landscapes for recreation and nature-based tourism that include wetlands and scenic settings such as the Lapov River that marks the international border between Cambodia and Lao PDR. This zone would comprise areas with high potential value for nature-based tourism activities and it would have the scenic and cultural resources required to generate considerable long-term revenues through nature-based tourism. There would be a wide range of nature-based tourism features to attract visitors who would want to experience nature. Those would include wildlife viewing, bird-watching, trekking, mountain biking, boating, and rafting, and there would be opportunities to establish high-end eco-lodges, helicopter over-flights, and other services, as well. Cultural and traditional recreational activities would also be encouraged to provide tourists with the opportunity to visit local villages in the PVPF to experience the traditions and customs of ethnic minority communities and the ways and manners of life of local people. The PVPF is included in national plans to expand nature-based tourism in Cambodia and provides optimal locations such as that of the Preah Vihear Temple to link nature-based tourism in Preah Vihear province with tourism along the mountain range of northern Cambodia.

- **Reserved Forests for Special Ecosystems:** The Reserved Forests for Special Ecosystems zone has characteristics that are compatible with ecological management core zones. The two compartments in this zone would be primarily used for research and would contain large numbers of plant and animal species important for biodiversity conservation. Some of the species in this zone might be especially valuable for medicinal, captive breeding, nature-based tourism, or other purposes and the ecosystems in this zone would act as gene banks that might eventually provide substantial financial returns to the country. This zone, moreover, would become increasingly valuable as other forested areas throughout Asia are lost and fewer countries maintain genetic resources. The zone would have several species of commercial tree species, medical plants, herbs, and non-timber forest species, as well, and exceptionally high biodiversity conservation values. Each of the species in the PVPF that is listed as Endangered or Rare in the Wildlife List Declaration (Prakas) of MAFF and the International Union for the Conservation of Nature (IUCN) Red List would be present in this zone. The Reserved Forests for Special Ecosystems zone would be managed primarily for biodiversity conservation and activities in this zone would be closely monitored to ensure that they would not violate the Forestry Law and that they would have minimal impacts on biodiversity conservation.

- **Watershed Protection:** There are two compartments in the zone reserved for Watershed Protection and regulating water resources. The priority use in this zone would be to protect forest areas and steep slopes, or watershed catchments that are the most susceptible to erosion. Most of the zone would consist of mountainous areas of watershed classes II and III along the Cambodia-Thailand border that provide watershed services to lowland areas around the northern Great Lake (Tonle Sap) and neighboring

provinces. The zone would cover much of the border area of the PVPF, underscoring the importance of its role in watershed management in Northern Cambodia. The management of this zone would ensure that activities have minimal impacts on watershed values and the role of the PVPF in the regulation of water resources. This is especially critical considering the significant investments that have been made in the PVPF with regard to irrigation, agriculture, forestry, and freshwater fisheries. The zone would be an important indicator of the forest ecosystem services that are provided in the PVPF.

- **Forest Restoration Sites:** The Forest Restoration zone would have an area of 8,000 ha that is heavily degraded and require interventions associated with various forest landscape restoration techniques, including Assisted Natural Regeneration, Enrichment Planting, and the establishment of tree plantations. One of the principal reasons for the loss in forest cover in the PVPF is the increased demand for agricultural and agro-industrial land, especially with regard to the conversion of forestland to social land concessions. If this trend continues, the current rate of substitution planting of trees would not be able to compensate sufficiently to maintain the current percentage of forest cover in the PVPF.

The most significant forest ecosystem services provided in the PVPF include carbon sequestration, the maintenance of unpolluted air, the prevention of land degradation and the erosion and siltation of rivers, the regulation of water resources, and the provision of high quality drinking water. These watersheds contribute vital livelihood support through the delivery of high quality drinking water to thousands of local people, as well as water for agriculture and fisheries activities in downstream areas for communities throughout Preah Vihear province, as well as in the country's northern flood plain. The PVPF's watersheds are also the source of water for the Tonle Sap Great Lake and the Mekong River. The maintenance of forest cover in the PVPF would not only provide numerous opportunities for promoting national economic growth through the provision of its various ecosystem services, but it would also ensure a regulated supply of high quality drinking water across three provinces and reduce the risk of flooding, especially in Preah Vihear Province, by regulating river flow regimes.

3.4 Discussion of interventions

3.4.1 Drivers of land tenure change

Poverty appears to be the most common force driving indigenous communities to sell their land and villagers have frequently reported accumulating debt because of costs incurred from illnesses or food shortages as the principal reasons for selling their land. The cost of medicine and the services of doctors are frequently unable to be paid out of cash-on-hand and family heads often reluctantly agree to land sales. It is as the result of over-charging and not having sufficient opportunities to borrow money at reasonable interest rates that many indigenous families have had no recourse but to sell their farmland, exacerbating conditions of food insecurity and limited cash incomes.

Villagers also respond to emerging opportunities to educate their children, which creates another cash requirement. While there are no "official" fees associated with attending district schools, teachers regularly expect students to seek them out for individual tutoring sessions for which the students must pay. Students accept that these tutoring sessions are a necessary prerequisite for passing exams and advancing to higher grades. In Sen Rung Reung 1-2-3-4 and 5 villages, educational opportunities are limited and relatively costly for poor rural families. In contrast, with support provided from the ITTO project, O Chunh and Robunh have been more successful at establishing better educational opportunities for its children.

One of the principal factors in the establishment of new market linkages has been the development of road networks and the growth of district and provincial towns. It seems more than likely that a significant proportion of indigenous lands will be sold to outsiders over the next decade unless actions are initiated to slow this process. Joint action is required that links indigenous communities, NGOs, and local government in efforts to increase transparency and establish the rule of law. If this is accomplished, the efforts to map and support communal land titling efforts, endorsed by relevant central government agencies, will proceed. Support is also required to assist indigenous communities in developing sustainable income generation practices.

3.4.2 Impacts of PLUP and CLUP

It is important to assess the impacts of participatory land-use planning and commune land use planning (CLUP) in the Preah Vihear Protected Forest and their effectiveness in directing land use planning and stabilizing land tenure for local communities. Natural resource planning processes involve a multi-stakeholder dialogue and produce maps and planning documents that are recognized by the government. The production of those documents contributes to efforts to regulate land use and stabilize tenure in accordance with national law and policy.

Small-scale land use mapping efforts have been occurring in the Preah Vihear Protected Forest since 2013 as part of the project during a period of increasing incidences of illegal land grabbing and forest land encroachment occurring in various locations by migrants and members of the military. Consultation meetings and participatory mapping were conducted by project staff to identify the current land use status of indigenous communities and land rights. The Chiefs of the communes of Choam Ksan, Teuk Krahum, and Morokot indicated that most of the land was allocated by the military without the participation of other institutions, local authorities, or other relevant stakeholders. The military households, as a result, do not clearly recognize the demarcated areas that have been allocated for agricultural use or the forests reserved for protection. The project has assisted these communities in and around the Preah Vihear Protected Forest to increase their understanding of land use regulations and the boundaries of the PVPF by showing them the concrete demarcation poles near the forest and explaining customary user rights according to the Forestry Law through consultations and extension meetings.

Most of the villagers have indicated their concerns about land alienation occurring in neighboring communities and appreciated the usefulness of mapping these areas. Commune councils stated that "if we have no maps or cooperation from the military and other relevant stakeholders, land disputes will increase." In one assessment, 80% of the villagers interviewed

said they wanted maps to display in their village. They understand that land tenure assists them in their efforts to stop illegal forestland encroachment, land grabbing, and other related activities. They use land tenure as documents to establish their territorial claims with outsiders, including government authorities and private company representatives. Previously, villagers did not have clearly demarcated boundaries and would frequently cross each other's territories to make new swidden fields and gather non-timber forest products. There were also disputes during those times, but those were resolved using accepted traditional procedures.

Commune sketch maps, as well as GIS maps, created by project staff have assisted commune chiefs to understand community boundaries and discuss land use zoning to assist in the preparation of the management plan in the Preah Vihear Protected Forest. Since management has involved the participation of multiple stakeholders and land use decisions have been led, especially, by the military, however, PLUP and CLUP have been largely ignored. Without the participation of local authorities and other relevant stakeholders in the mapping process, the exercise is ineffective in stabilizing land use and tenure and also appears to generate more conflicts associated with land use management in the Preah Vihear Protected Forest that were not widely accepted or acknowledged. In those cases, PLUP and CLUP must be considered to be a component of a larger process of institutional capacity building at the community level as land use plans so that planning and management capacity building is implemented in an effective manner to lead to more sustainable land use transitions in the Preah Vihear Protected Forest.

3.4.3 Direct impacts of land use changes

Since forest cover has changed more rapidly in the PVPF, especially in the past 5-10 years, forest resources have been increasingly affected by human activities. The impacts of those activities are expressed in various forms, including forestland conversion, unsustainable agricultural practices, hunting and poaching, and illegal logging and fishing. The consequences of those impacts include the loss of habitats for biodiversity, as well as the loss of species, natural resource degradation, and land degradation.

A. Habitat loss

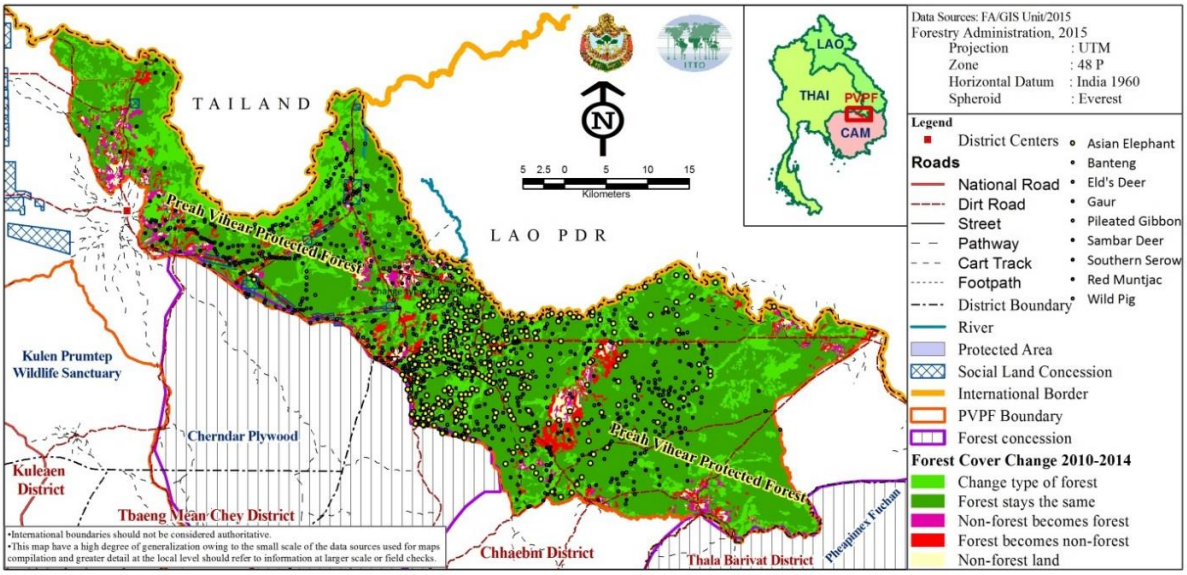
Forest fragmentation occurs when large areas of continuous forest are divided into smaller blocks by roads, agriculture, urbanization, and other developments. That process reduces a forest's function as a habitat for plant and animal species and impairs its effectiveness in performing other functions, including water and air purification (Thomson 2015).

Habitat fragmentation affects biodiversity in the PVPF by reducing the amount of available habitat (i.e., deciduous forests, evergreen and semi-evergreen forests, riparian forests, and marshlands) for the organisms occupying an ecological niche and, as a consequence, mobile animals, especially birds and mammals, retreat into remnant patches of habitat.

Non-forest cover land increased by 5.82% to 13,794 ha in the twelve year period from 2002 to 2014. Increases in agricultural and residential land have been the principal factors underlying forest destruction and the loss of habitat. Villages are widely distributed along the road that connects Chaom Ksant district to the Emerald Triangle trans-boundary region. That road cuts

through the middle of the PVPF, where evergreen forests provide ecological niches, and connects to the eastern part of the PVPF to Chhep district. Its presence will inevitably affect not only wildlife and plant habitats, but also the areas through which the trans-boundary areas in the north and in the dense forests in the central part of the PVPF are the principal corridors through which many species move.

Land encroachment and expanding cultivation areas into forest areas, or cutting trees for charcoal manufacturing, potentially affect the integrity of forests, ecosystems, and wildlife habitats in the PVPF and surrounding areas. The clearing of forests for agriculture has been a traditional activity of local communities who live in and around the PVPF. They have cleared and burned land to produce crops over a 2-4 year cycle. The predominant form of shifting cultivation involves clearing communal land for agricultural purposes. Those activities destroy forests that lie on communal land within the borders of the PVPF, as well as habitats for wildlife, and succeeding human activities in adjacent areas have caused large mammals to move out of the area. The loss of habitat has influenced wildlife in the planning area, especially large mammals such as the Asian elephant. The fragmentation of habitat has caused the Asian elephant to live in much smaller herds that are isolated from other groups, thus reducing opportunities for breeding and compromising genetic viability. Such forest destruction apparently no longer occurs to a considerable extent in the PVPF, however, except in its eastern part where indigenous communities still continue the traditional practice of shifting cultivation.



Map 3.9. Wildlife distribution of large herbivorous mammals and forest cover changes.

Map 3.9 illustrates the distribution of some large, herbivorous wildlife species in the PVPF, which includes some of the forest areas that have been converted into non-forestland. Those large mammals, according to local people, which previously were commonly seen eating grass and coming into the forests near the villages, especially Elephants, Gaur, and Banteng, have rarely been seen since military families arrived in 2011,

Once home to the largest known collection of large mammals and water birds outside Africa, Cambodia's Northern Plains is renowned for its ecological productivity and thriving wildlife populations. The proposed Preah Roka Protected Forest, which is adjacent to the Preah Vihear

Protected Forest, contains a diverse mosaic of habitats that support at least 28 threatened species. Based on confirmed records in the adjacent protected areas and habitats in the proposed reserve, there are an additional 19 threatened species that are considered to be present, as well. Principal among those confirmed species is the Asian elephant, populations of which have declined by 50% over the past three generations as the result of a series of threats that now endanger their long-term survival. The losses, degradation, and fragmentation of critical habitats have increased the challenges confronted by remaining populations. Other species found in the proposed reserve include 2 Critically Endangered tree species and 7 Endangered mammal species, including the Pileated Gibbon, Eld's Deer, and the Dhole. Preah Roka also contains no less than 5 Critically Endangered bird species, which is one of the highest concentrations of birds on the edge of extinction, including the White-shouldered Ibis, the Giant Ibis, and three species of vultures. Other Endangered bird species that have been recorded in the proposed reserve include the Green Peafowl and the White-winged Duck.

According to interviews of local people, there used to be many species of wild cattle, especially Gaur and Banteng, and some predators in many of the middle parts of the western area of the PVPF in the O Chunh and Robonh areas that have not been seen since the arrival of the immigrants.

In a case study conducted in Chaom Ksant district by students of Prek Leap Agricultural University supported under the project, it was found that 5,882 ha (3.1%) of forestland had been converted into residential and agricultural land between 2002 and 2010 and, of that area, 399 hectares had been allocated to social land concessions in Chaom Ksant district where the PVPF partially covers those areas. Those conversions have led to reduced forest cover that used to provide the principal habitat and food-stock territory of wild pigs, cattle, reptiles, mammals, and some birds since the grassland with open deciduous and riparian forests has been converted to residential and agricultural land. The local people reported that those species were no longer seen in the numbers that they used to be seen. Land degradation and climate change, resulting in low rice productivity, are also considered causative factors affecting the loss of habitat. The expansion of farmland has been occurring for the past five years in the area of Chaon Ksant district and forest cover has declined from 88.7% in 2010 to 82% in 2014.

B. Degradation of species

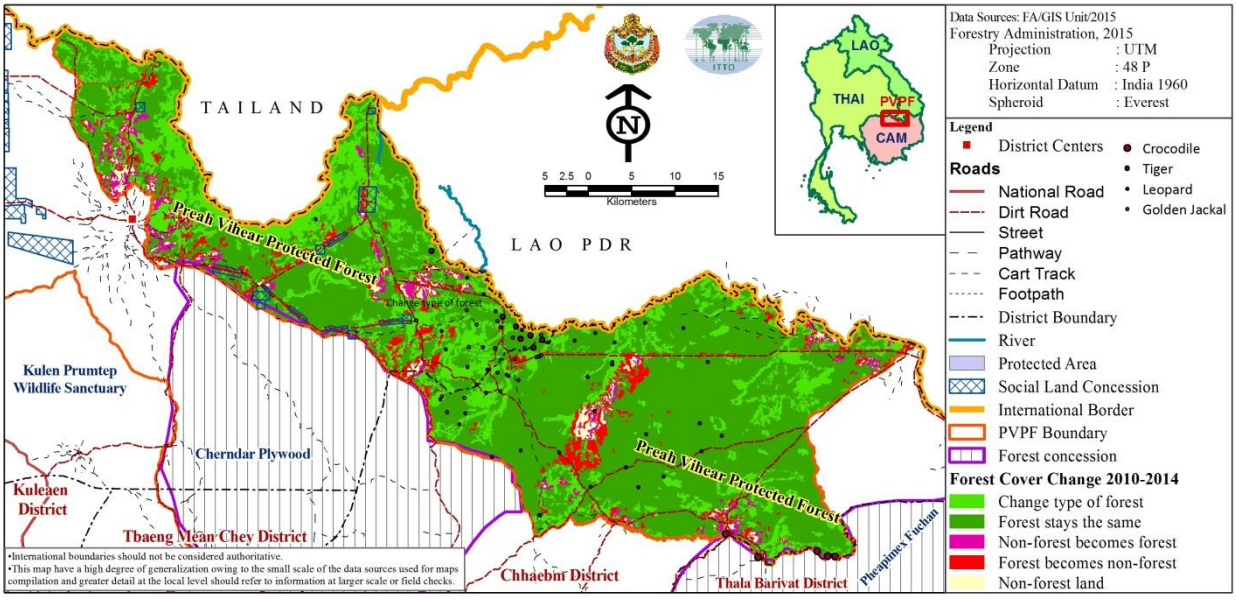
Forestland use changes have also had serious effects on various kinds of vegetation and fauna, particularly terrestrial species in different forest types, as the result of forestland clearance and species disturbances associated with collecting timber and other forest resources near farmlands. There are more than 40 species of flora that have been affected, including various timber species and NTFPs, medical plants, edible wild vegetables, and other species that are either cut or cleared to be collected for use or burned when clearing forestland (Annex 3.2). The timber species include *Dalbergia barriensis Pierre, Pterocarpus macrocarpus, Afzelia xylocarpa, Albizia lebbeck, Dalbergia cochinchinensis, Cassia siameca, Diospyros bejaudii, Fagraea fragrans, Shorea cochinchinensis, Hopea ahelferi Brandis. Hopea odorata Roxb., Melanorrihoea laccifera, Xylia dolabriformis, Terminalia alata, Shorea siamensis, Diospyros helferi, Lagerstroemia calyculata, Anishoptera costata, Dipterocarpus obtusifolius, Dipterocarpus tuberculatus, Dipterocarpus intricatus, Vatica astotricha, Dipterocarpus altatus,*

Shorea vulgaris, Lagertroemia macrocarpa, Irvingia malayana Oliv, Lagertroemia floribunda, and Parinarium annamensis.

The affected medicinal plants include *Aporusa planchoniana, Spirolobium cambodianum, Stephania rotunba, Cananga latifolia, Tinospora crispa, Strychnos nux-vomica, Phyllanthus emblica, Ploiarium altemifolium, Terminalia triptera, Pouzulzia zeylanica, Holarrhena pubescens, Lasiantus kamputansis, Heliotropium indicum, and Cenolophon oxymitrum.*

Some of the other affected NTFPs include *Collamus spp., Plectocomia pierreana, Ochna integerrima, Korthalsis bejaudii, Shoren Vulgaris Picrre, Dioscorea hispida, Bambusa bambos, Arundinaria pusillag, Dendrocalamus gigentus, Coscinium usitatum, Areca triandra, Oncosperma tigillarium, Dioscorea brevipetiolata, Dioscorea oryzetorum, Dioscorea esculenta,* and honey.

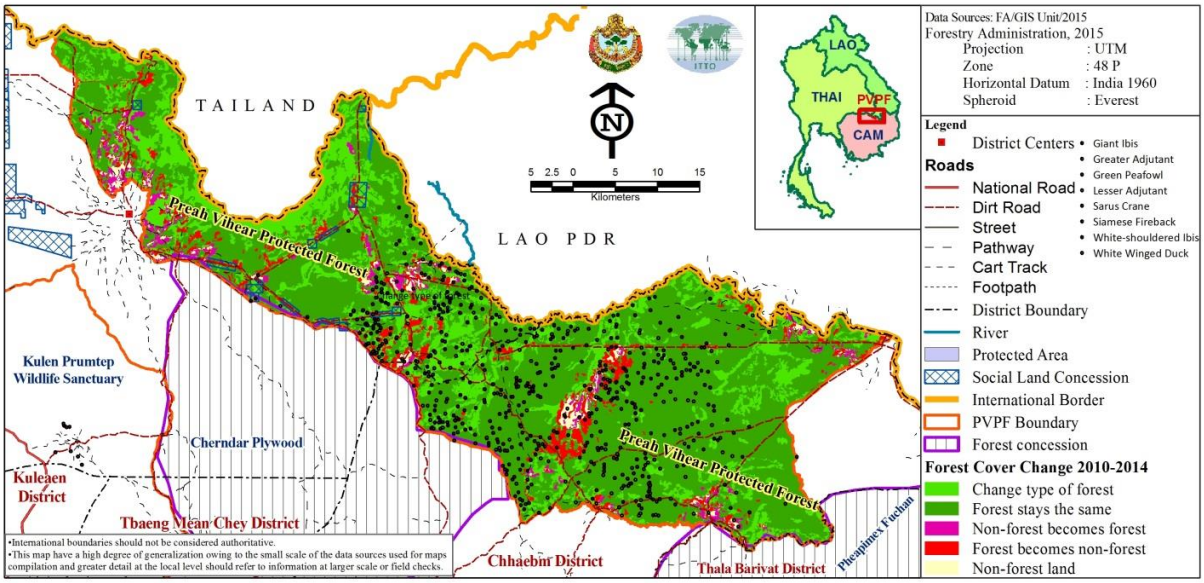
Habitat fragmentation is often a cause of species becoming threatened or endangered. Forestland conversion has resulted not just in the loss of species, but also food-stocks and wildlife habitats. The lack of food and loss of territory have put much more pressure on wildlife to move to the north along the border since many species of wildlife have been hunted for food and captured for the wildlife trade (Map 3.10). The northern part of the PVPF has consequently become the principal habitat and corridor for several species of wildlife, especially endangered species, since many parts of the PVPF have been threatened by human activities.



Map 3.10. Distribution of carnivore and predator species in the Preah Vihear Protected Forest and forest cover changes.

In interviews that were conducted with local people, it was reported that more than 32 species of wildlife have been affected by forestland clearance and encroachment, including primarily mammals such as the Gaur, Banteng, Wild Pig, Red Muntjac, Long-tailed Macaque, Pileated Gibbon, Sunda Pangolin, Pygmy Loris, Burmese Hare, Common Palm Civet, and East Asian Porcupine. Some species of reptiles that have also been affected include snakes, frogs, and some fish (Annex 3.3).

Forest birds, including the Lesser Whistling-duck, Green Peafowl, Red Junglefowl, Great Hornbill, and Greater Adjutant have also been affected by forest clearance (Map 3.11).



Map 3.11. Distribution of wild bird species in the Preah Vihear Protected Forest and forest cover changes.

The participatory assessment of degraded species associated with forestland use changes indicates that plants and wildlife may have decreased in the area by as much as 35% compared to the levels that people used to collect and hunt five years ago. Those species are now rarely, if ever, seen in the nearby forest areas around their farmlands.

C. Natural resources degradation

Forestland assumes a critical role in supporting not just a wide-ranging niche of biodiversity species, but provides a means of living for villagers as a source of various forest products, including fuelwood, wild vegetables and fruits, medicinal plants, and resin. Forest resources and livelihoods often reflect a negative relationship, however, since resources to support livelihoods are often used unsustainably. The participatory appraisal of natural degradation was conducted to evaluate the extent of decreases in the past 3-5 years. The respondents reported that NTFPs previously contributed at least 40% to their daily food and fuelwood consumption, but the resources have since become considerably degraded and household members are spending much more time collecting fuelwood for cooking. While villagers used to collect dead wood within a short distance of their homes, they now have to travel at least 1-3 km to collect enough fuelwood for a week's use.

D. Land degradation

Land degradation results from deforestation and unsustainable resource use, as well as improper agricultural practices. It is a development through which the value of the biophysical environment is affected by a combination of human-induced processes acting on the land. Land degradation impacts agronomic productivity, the environment, and food security (Conacher et al. 1995).

There are two primary causes of land degradation in the PVPF resulting from forestland use changes. The first of those causes is associated with forest canopy destruction in which villagers clear forestland up to 6-12, or even 18, months prior to planting a crop, cutting down trees and burning wood. Those practices are often accompanied by runoff and bush fires that result in environmental degradation in which understory forest species, including grasses and shrubs, die off or are burned, leaving little remaining food for wildlife prey species.

There are more than 40 species, including seedlings and tall trees, of approximately 12,000 plants per hectare in the deciduous forest. When bush fires occur, those plants are destroyed and the disturbances may obstruct forest canopy development in which the succession of a deciduous forest ecosystem may not proceed through its natural stages of development into dense forest. There are microorganisms that are also destroyed in the topsoil, which may not be able to continue to produce humic materials and other effects occur that may reduce the porosity of underground water tables.

There are at least 36% of local farmers who have used strong poisonous chemical pesticides as part of their pest management 'strategies' and soil productivity conditions may be gradually declining since local communities often exceed recommended applications of chemical fertilizers and pesticides, which may affect downstream fish populations. There were reported to be more than 10 species of fish that have been affected since farmers now rarely see those fish on their farms. The amounts of fish caught have declined from 30% to 50% in the past five years as reported by local people.

Land degradation has lowered the productivities of many crops, especially rice, the yields of which have gradually declined in the area from 2.5-3.0 mt/ha, on average, to 1.0-1.5 mt/ha. There are about 60% of families who have been affected by lowering soil productivities. In the initial year of rice planting on cleared forestland, villagers commonly harvest 2.0-3.0 mt/ha, but over the succeeding 3 year period, yields decline to 1.0 mt/ha. Villagers reported that if farmlands have some trees dropping decaying leaves on the ground, yields increase considerably, which suggests that agroforestry provides a potential means of mitigating some of the impacts of land degradation.

3.4.4 Indirect impacts of land use changes

Land use changes may also have various indirect effects, including environmental degradation, species migration, and other related threats.

A. Environmental degradation

Forestland conversion is often the initial cause of the environmental degradation that impairs forest ecosystem functions, including the capability of capturing and storing carbon and maintaining and enhancing soil productivities. Estimates of carbon stocks in the PVPF range from 0-211 mt/ha. Non-forestlands, other forests, and deciduous forests capture carbon at the lowest rates, which range from 0-114 mt/ha, while riparian forests capture it at moderately low to medium rates ranging from 115-178 mt/ha, semi-evergreen forests at moderately high rates ranging from 179-197 mt/ha, and evergreen forests at the highest rates, which range from 198-211 mt/ha (UNEP-WCMC 2010). Land use changes and forest degradation affect carbon

capture in the PVPF, especially in deciduous forests, and release carbon dioxide into the atmosphere when forests are burned in the process of clearing land for agriculture.

The sandy soil that covers more than half of the area of the PVPF makes it particularly susceptible to soil erosion if the cover vegetation has been removed and damaging activities reduce soil productivity by altering soil texture and structure, soil pH, porosity, water storage capacity, and nutrients, increasing soil erosion and compaction and reducing underground water penetration. Subsequent to the clearing of forestland, soil productivity becomes degraded as mixed vegetation is removed in some areas of deciduous forest in the PVPF and, as a result, crops can no longer be grown productively because those soils become shallow with only gravel and stones remaining. These forms of land degradation occur primarily on the farmlands of some of the more recent immigrants in Teuk Kraham and Morokot communes.

B. Species migration

The loss of habitats through forestland conversion reduces the grasses and understory vegetation available to prey species, which, in turn, has an effect on predator species. That is the principal reason that some large mammals and wild birds, particularly wetland birds, have not been seen as much over the past several years in some areas of the PVPF. It is because of the loss of their habitats, especially ponds and riparian forests that are used in the dry season. There are some local people who have indicated that they still continue to see those animals gathering at ponds in close proximity to the dense forest in the south-central part, as well as in the northern part, of the PVPF, especially at the triangle that forms the primary corridor along the trans-boundary region between Cambodia, Thailand, and Lao PDR. Some parts of the dense forest near the Lapov River have become important habitats for those species. Villagers have also indicated that some migratory species of mammals might retreat into other areas outside the PVPF as the result of habitat fragmentations and disturbances, or into neighboring territories in Laos and Thailand. Those species include the Long-tailed Macaque, Golden Jackal, Dhole, Smooth-coated Otter, Tiger, Leopard, Fishing Cat, Sambar, Banteng, Gaur, and Southern Serow. igrating wetlanMd birds include the Lesser Whistling-duck, Green Peafowl, White-winged Duck, Great Hornbill, Sarus Crane, White-breasted Waterhen, White-rumped Vulture, White-shouldered Ibis, Giant Ibis, and Greater Adjutant. Those species of wetland birds have only rarely been seen flying across the ponds or other parts of the PVPF in comparison to five years ago.

C. Other related threats

There are several other threatening factors that affect wildlife species, Those are induced by human activities and include collecting forest products, poaching, illegal cutting of trees, using chemical substances, electric shocking of fish, and people moving through the forest.

Local people regularly enter the forest around their farmlands to collect timber and NTFPs, sometimes collecting extensive amounts of those products for more than domestic use. Those activities may threaten not only those species living near their farmlands, but also other wildlife species that inhabit the forest.

Intensive infrastructure development, which is also a form of forestland conversion, has resulted in some pathways or paved roadways on which vehicles are driven across forestland to access farmland or connect to other farmlands and villages, which leads to more people moving through the forest. The illegal cutting of trees and poaching occurs, as well, and causes some habitat fragmentation. The accessed road connecting Teuk Kraham commune to the last village - Techo Morokot - in Morokot commune separates the corridor between the Dangrek Mountain Range and the triangle area because illegal forest offenses occur more often in the forest along the road. The habitats along streams are also sometimes affected by road construction.

Agricultural development, which increases the use of chemical substances, also affects wildlife species in agricultural, aquatic, and forest ecosystems. Fishing using either electric shock techniques or poisonous substances is a form of illegal poaching that also affects not only aquatic species in streams and ponds, but also wetland birds by reducing some of their food sources.

The dependence of the poor on natural resources, including timber, as well as wildlife for the wildlife trade, also results in some competition associated with collecting forest products that seems to affect wildlife species living around their farmland.

3.4.5 Causes and effects of land use changes

Figure 3.9 depicts the principal causes and effects of land use changes. The primary causes of land use changes in the PVPF are: (1) population growth; (2) wildlife and timber trading; (3) economic development; and (4) low agricultural productivities. Population growth and wildlife and timber trading are the proximate causes and the resulting effects include habitat fragmentation, species and land degradation, and environmental degradation.

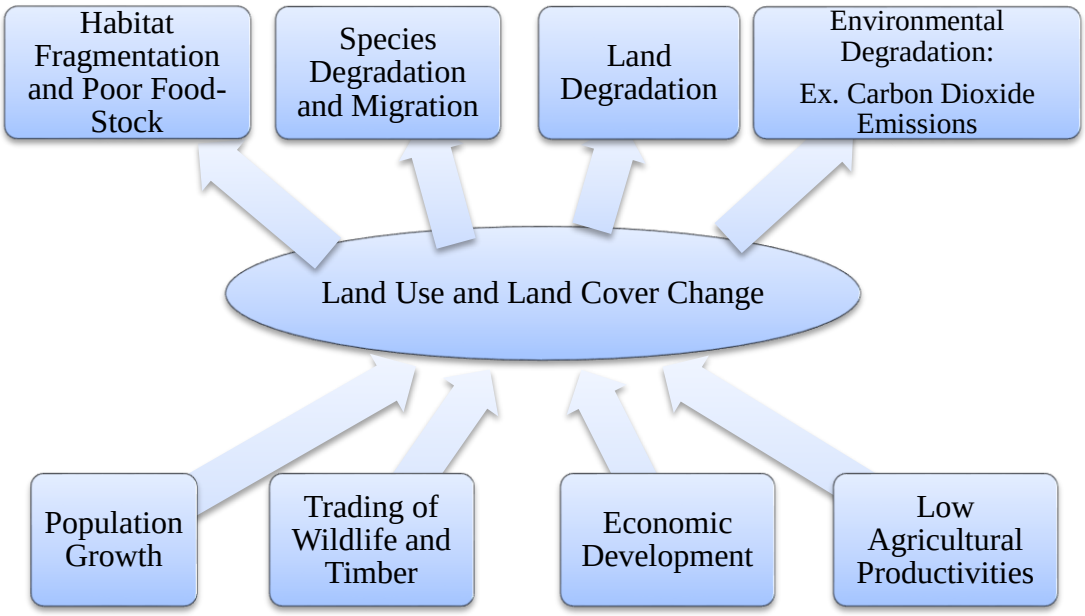


Figure 3.9. Causes and effects of land use changes.

3.4.6 Challenges of land use management in the Preah Vihear Protected Forest

The principal challenges of land use management in the Preah Vihear Protected Forest are the consequences of land reform policies and planning for development. Those effects have impacted the efficiency of economic and social activities, as well as infrastructure development, in the Preah Vihear Protected Forest and increased inequities in the distribution of agriculture, settlement, recreational, and institutional land use resources (Table 3.8).

Table 3.8. Challenges of land use management in the Preah Vihear Protected Forest.

Challenge	Concerns	Suggestions
1- No land tenure	- land certificate signed by chief of commune. - when the land is sold, the agreement is made between the seller and buyer. - local community is concerned about claiming land tittles. Some people leave heir hometowns and buy land from the military in the PVPF without documentation.	- Clear land use planning. - Providing land certificates for land owners.
2- Allocation of land for development along the border	- collaboration among institutional organizations is still limited. - commune councils indicate that if there are no maps or cooperation from the military and other relevant stakeholders, land disputes will increase. - overlapping land allocation locations between communes and the military.	- Strengthening cooperation among military organizations, local authorities and the local Forestry Administration. - Supporting clear land use planning.
3- Forest land encroachment and land occupied by local people and the military	- the expansion of agricultural land and increases in migrants threaten land cover in the PVPF. - internal conflicts among government institutions in land use management.	- Strengthening law enforcement and cooperation among line agencies.
4- Unclear Land Use Planning	- useful consideration of land availability in the PVPF for community development, investment, and surveying. - land distribution does not include public consultations.	- Conducting PLUP/CLUP for land use planning.
5- Lack of collaboration among local authorities, the military, and relevant institutions	- trust and coordination between relevant line departments at the sub-national level is not yet improved.	- Strengthening cooperation among military organizations, local authorities, and the local Forestry Administration.
6- Lack of management of migrants	- rural migrants contribute to deforestation along the border because they occupy land or clear forests for new settlements. - the expansion of agricultural land contributes to further deforestation.	- Chiefs of villagees shall record and report the number of migrants and collaborate with local police and village bodyguards.

Challenge	Concerns	Suggestions
7- Knowledge of local communities is limited and poverty is extreme.	- most people, particularly military families, rely on forest resources and land for agriculture. - local people generate income through clearing forests and sometimes selling encroached land to new landowners and then occupying or clearing forests at other locations.	- Supporting clear land use planning. - Increasing awareness of landlessness and the Social Land Concession program.
8- Limited market for selling agricultural products.		- Encouring modern agriculture by providing training progrsam on agricultural techniques and marketing.

3.4.7 Holistic analysis and proposed interventions

The results of several workshops and discussion groups conducted with local communities revealed that most (60-80%) land use challenges were able to be addressed by communities by strengthening collaboration amount institutions, restricting migration, and improving the capacities of local people. These efforts would require additional assistance from outsiders at the provincial level and/or the policy level, however, ranging from 10-25%, as depicted in Figure 3.10. There were only 5-45% of 5 of the 8 challenges that were identified by discussion groups, which were considered at the commune level to be able to be addressed by communities that reflected the higher levels of assistance that would be required at those levels. The priority challenges that will have to be addressed to ensure sustainable land use management include land tenure, the preservation of land from further allocation to social land concessions, land use planning, and combating forest land encroachment.

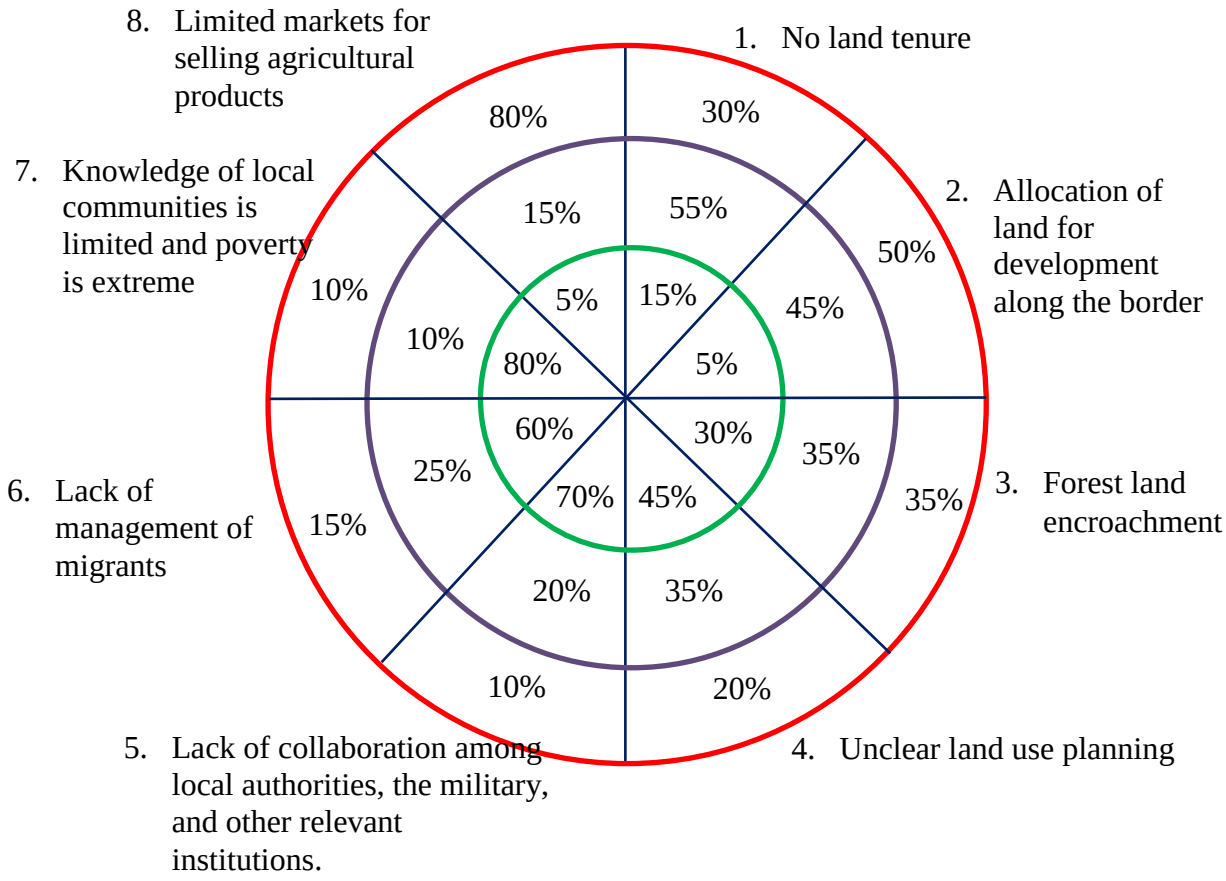


Figure 3.10. Holistic analysis of land use challenges in the Preah Vihear Protected Forest.

In recognition of community requirements and current conditions in communes, proposed intervention options developed by the project are presented in Table 3.9.

Table 3.9. Proposed interventions to improve land use management in the Preah Vihear Protected Forest.

Intervention Option	Justification	Requesting organization to provide support	Potential Constraints	Performance indicators
1- Land Use Planning (PLUP/CLUP)	- Provides clear indications of the boundaries of community development areas, areas reserved for Social Land Concessions, and conservation zones for biodiversity and wildlife habitat in the PVPF. - Reduces drivers of land cover changes in the PVPF.	Department of Land Use, Urban Management and Planning shall collaborate with the Preah Vihear Forestry Administration Cantonment, commune councils, and the military to discuss future land use management in the PVPF.	- Organizing PLUP/CLUP is a long-term process and participatory approach. - PLUP/CLUP requires budget support. - The issuing of land titles will have to await the conclusion of the PLUP process and has not yet been tested at a larger scale.	
2- Strengthen collaboration among government institutions	- Improves common understanding of land use management in the PVPF. - Strengthens efforts to combat illegal forestland encroachment and land occupancy in the PVPF.	The Preah Vihear Forestry Administration Cantonment shall strengthen collaboration with the military, commune councils, and relevant stakeholders to resolve land use problems in the PVPF.		
3- Improve water provisions by constructing a reservoir or small irrigation system in the lowlands.	- Provides water for crop production, as well as for peoples' domestic consumption. - Contributes to drought relief during	Department of Water Resources.	- The short time available for storing water. - The importance of	One of the indicators that should be measured includes the number of households that have

Intervention Option	Justification	Requesting organization to provide support	Potential Constraints	Performance indicators
	the dry season and increases the level of villagers' access to sanitation. - There is no better option for providing water for villagers than the construction of reservoirs.		selecting vegetation that is compatible with the period of water availability in the reservoir.	sufficient water to use.
4- Improve farming systems by introducing fast-growing crops that can be planted after seasonal flooding in June or July and are able to grow in villagers' homestead gardens.	- The objective of proposing this intervention is to improve the livelihoods of villagers by diversifying their food security.	- The Choam Ksant Agricultural Officer shall collaborate with local villagers.		
5- Soil quality improvements by developing and introducing techniques and practices in those areas where soil quality is poor, especially in the mixed sandy and sandy soil used by villagers to grow sugarcane.	- Improves soil quality and crop production. - Reduces the causes of poverty and contributes to more effective land use. - This is one of the best means to reduce the reliance of local people on forests while improving their livelihoods.	- The Choam Ksant Agricultural Officer shall collaborate with local villagers. - The commune development council shall coordinate this intervention. - Villagers, with the assistance of soil experts, shall implement the intervention.	- The limited participation of villagers in the program because of the time required for its implementation.	- Laboratory tests of soil quality. - Indicators such as the percent of land allocated to different crops and the increases in yields.

3.5 Conclusions and recommendations

3.5.1 Conclusions

Rapid changes in vegetative cover have occurred in the Preah Vihear Protected Forest over the past two decades as the result of land use policies, increasing population and movement of migrants, and the expansion of land for settlement and agriculture. There have been successful efforts to revise indigenous peoples' land policy, moreover, by placing limits on traditional land use in which individual villagers would be prohibited from clearing a patch of forest or regrowth forest for farming, rice cultivation, or secondary crops. There are still no land titles that have been registered with the exception of the Social Land Concessions that the Government has provided to military families and for which land registration procedures for preparing land titles has been proceeding.

The series of LULC assessments conducted under the project indicate that the principal "drivers" of future land use in the Preah Vihear Protected Forest will be agricultural production systems, especially agroforestry systems in the recreation forest and regulating water resources zones. The driving forces that affect land cover changes in the Preah Vihear Protected Forest are closely correlated with population growth. The annual population growth rate is approximately 1.55% in and around the Preah Vihear Protected Forest and the population density, which was approximately 7.5 people per square kilometer in 2007, continued to increase to about 15 people per square kilometer in 2014. The negative correlation between forestland and population (-0.99) is very high, which suggests that population pressure has been one of the forces driving land use intensification in the Preah Vihear Protected Forest.

The underlying purpose of the LULC assessments was to develop the means to avoid the negative impacts of the trend scenarios through the implementation of mitigation policies and measures. The assumption of high economic growth – additional yields increased beyond those already assumed in the trend scenario – would contribute to reductions in land use for agriculture and deforestation and other land conversions in the Preah Vihear Protected Forest.

The principal challenges of land use management in the Preah Vihear Protected Forest are the consequences of land reform policy and planning for development. Those consequences have impacts on the efficiency of economic and social activities, as well as the development of infrastructure in the Preah Vihear Protected Forest. The results of several workshops and discussion groups conducted with local communities suggested that most land use challenges would be able to be addressed by communities by strengthening collaboration among institutions, restricting migration, and improving the capacities of local people. Those efforts would require some assistance at the provincial level and/or at the policy level, however. The issues that will have to be addressed to ensure sustainable land use management include land tenure, the preservation of land from further allocation of Social Land Concessions, clear land use planning, and combating forest land encroachment.

3.5.2 Recommendations

- Conduct periodic studies of the current status and dynamics of the drivers of deforestation and forest degradation affecting land use and land cover changes in the Preah Vihear Protected Forest.
- Organize assessments of growth patterns of commercial tree species and fast growing tree species and the conservation of gene pools of commercial and non-commercial tree species in the Preah Vihear Protected Forest.
- Encourage the planting of trees and other plants that support local livelihoods, such as bamboo, and the cultivation of edible plants, such as mushrooms, to reduce local people's use of wild forest plants.
- Promote forest enrichment planting in natural forest areas of native forest trees provided from nurseries in the Preah Vihear Protected Forest.
- Promote sustainable agriculture and agroforestry in agricultural use zones and community forests in and around the Preah Vihear Protected Forest.
- Conduct economic valuations of selected ecosystem goods and services and carbon credits in the Preah Vihear Protected Forest.
- Increase law enforcement patrols in critical habitats and in areas in which illegal logging, wildlife poaching, and forest clearing and encroachment are more prevalent.
- Encourage household and community investments to support restoration efforts and the establishment of forest plantations to rehabilitate degraded and encroached reclaimed forests, especially in those instances in which natural succession is inadequate to ensure the ecological recovery of those areas.
- Expand the use of the Spatial Monitoring and Reporting Tool (SMART) to strengthen the planning of law enforcement patrols in accordance with observed threats and the establishment of measurable responses to those threats.
- Strengthen cooperation with local authorities and local communities to deter illegal logging and the incidence of forest clearing and encroachment.
- Intensify campaigns against illegal logging and the incidence of forest clearing and encroachment and promote environmental education to strengthen understanding and increase awareness of those activities.
- Increase the number of informal and formal meetings with government officials to strengthen bonds of political support to strengthen biodiversity conservation in the Preah Vihear Protected Forest.
- Provide specialized training in agroforestry practice and wildlife distribution management, land use planning, biodiversity conservation and sustainable forest resources management to local Forestry Administration officers and protected forest officials at the operational level to strengthen resource management capacities.
- Organize a program of research to investigate ecological relationships in plant communities, as well as individual plant species, including native species of wild orchids, insectivorous plants, medicinal plants, and other rare, endangered and endemic plant species, to strengthen management applications.
- Develop environmental education programs that explain the purposes of the PVPF and incorporate information on the environmental effects associated with the unsustainable use of natural resources and the rights and responsibilities of local people with regard to the management of forest, wildlife and biodiversity resources.

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Annex 3.1: Questionnaire on Land Use and Land Use Impact.

Code No. :……

Location : Village :……Commune :……District :……Province: Preach Vihear
Date of interview: / / 2014
Education : 1. Illiterate, 2. Primary school, 3. Secondary, 4. High school, 5. University, 6. Other (specify):……

I. Information about Interviewee and Relationship Status

1) Name of interviewee :…….., Sex : □ Male, □ Female,
Ages :……yrs, Relationship with family head[1]:……., Marital status[2]:…,
Place of birth: □ In village/commune, □ Other:…....

2) Main occupations[3]: First job :……., Second job :…….

3) Attitude towards interviewing:
□ Friendly, □ Not friendly, □ Very busy, □ Hesitate to reply

4) Situation while interviewing:
□ Good, □ Disturbance by others, □ Raining or noisy

5) Family members/Household composition:

No.	Age ranges	No. of people
1.	0-15 years	
2.	15-30 years	
3.	30-50 years	
4.	50-60 years	
5.	> 60 years	
1 Relationship Codes: 1. Family head, 2. Spouse, 3. Child, 4.Parent, 5. Grandchild, 6. Sibling, 7. Other (specify) :…..		
2 Marital Codes : 1. Married, 2.Single, 3. Divorced, 4.Widow/Widower, 5. Other (Specify) :…..		
3 Job Codes: 1.Vendor, 2. Manufacturing shop, 3. Agri-product manufacturer, 4. On-farm job, 5.Construction labour, 6. Fisherman, 7. Forest product collector, 8. Animal raising, 9. Own business (ex. carpenter, brick production, alcoholic fermentation ...) 10. Farmer, 11. Full-time job, 12 Other (Specify) :…..		

6) How long have you lived here?
□ < 1 year, □ 1-3 years, □ 3-5 years, □ > 5 years

7) What kind of house?
□ Roofing tile, □ Metal-roofed house, □ Thatch, □ Brick-wall house, □ Fribo-roofed house, □ Other (Specify):……..

II. Forest Clearing and Status

8) Did the household clear any forest during the past 12 months?

1. If 'no', go to 9.		(1-0)		
If YES:	2. How much forest was cleared?	ha		
	3. What was the cleared forest (land) used for? Codes: 1=cropping; 2=tree plantation; 3=pasture; 4=non-agric uses (Rank max 3), 5=NA	1.Rank1	2.Rank2	3.Rank3
	4. If used for crops, which principal crop was grown? Rank max 3	1.Rank1	2.Rank2	3.Rank3

	5. What type of forest did you clear? □ 5.1. Evergreen, □ 5.2. Semi-evergreen, □ 5.3 Deciduous, □ 5.4. Riparian forest, □ 5.5. Degraded forest, □ 5.6 Other forest (Ex. bamboo…), 7. NA	
	6. If secondary forest, what was the age of the forest?	years
	7. What was the ownership status of the forest cleared? (code tenure)	
	8. How far from the house was the forest cleared located?	km
9. Has the household over the last 5 years cleared forest? If 'no', go to 11.		1-0
10. If 'yes': how much forest (approx.) has been cleared over the last 5 years?		ha
11. How much land used by the household has over the last 5 years been abandoned (left to convert to natural re-vegetation)?		ha

9) What is the current status of forest around your farmland?

1. How far is it from the house/homestead to the edge of the nearest natural or managed forest that you have access to and can use?	A. … measured in terms of distance (straight line)?	**km**
	B. … measured in terms of time (in minutes of walking)?	**min**
2. Does your household collect firewood? **If 'no', go to 7.**		**(1-0)**
3. **If 'yes'**: how many hours per week do the members of your household spend on collecting firewood for family use? (adult time should be reported; child time=50 % of adult time)		**(hours)**
4. Does your household now spend more or less time on getting firewood than you did **5 years ago**? **Codes: 1=more; 2=about the same; 3=less**		
5. How has availability of firewood changed **over the past 5 years**? **Codes: 1=declined; 2=about the same; 3=increased** **If code '2' or' 3', go to 7.**		

6. **If declined** (code '1' on the question above), how has the household responded to the decline in the availability of firewood? Please rank the most important responses, max 3.	**Response**	**Rank 1-3**
	1. Increased collection time (e.g., from further away from house)	
	2. Planting of trees on private land	
	3. Increased use of agricultural residues as fuel	
	4. Buying (more) fuelwood and/or charcoal	
	5. Buying (more) commercial fuels (kerosene, gas or electricity)	
	6. Reduced the need for use of fuels, such as using improved stove	
	7. More conservative use of fuelwood for cooking and heating	

	8. Reduced number of cooked meals	
	9. Use of improved technology	
	10. Increased use of non-wood wild products (ex. reeds)	
	11. Restricting access/use to own forest	
	12. Conserving standing trees for future	
	13. Making charcoal	
	14. Other, specify:	
7. **If Yes:** What are the reasons behind that? Please all suitable responses.	**Multiple Response**	**Tick**
	1. Many trees have been cut down as the result from clearing forest in the village/commune areas	
	2. I have plated tree for firewood	
	3. Villagers planted tree for firewood	
	4. Agroforestry has been promoted among people in the village/commune	
	5. There have been supplies from other sources	
	6. Other (Specify):	

III. <u>Collecting Forest Products</u>

10) What are the quantities and values of forest products the members of your household mainly collected for both own use and sale over the past 12 months? max 3 things.

1. Forest product	2.Collected by whom?[1)]	3. Collected	4. Quantity collected (6+7)	5.Unit	6.Own use (incl. gifts)	7. Sold (incl. barter)	8. Price per unit	9. Type of market[3)]	10. Gross value	11. Tran-sport/ marketing	12. Purch. inputs &	13. Net income (10-11-12)

***1) Codes**: 1=only/mainly by wife and adult female household members; 2=both adult males and adult females participate about equally; 3=only/mainly by the husband and adult male household members; 4=only/mainly by girls (<15 years); 5=only/mainly by boys (<15 years); 6=only/mainly by children (<15 years), and boys and girls participate about equally; 7=all members of household participate equally; 8=none of the above alternatives.*

***2) Codes**: 1. Evergreen, 2. Semi-evergreen, 3. Deciduous, 4. Riparian forest, 5. Degraded forest, 6. Other forest (Ex. bamboo…), 7. Other area (ex. crop plantation, planted forest,…..)*

***3) Codes**: 1. Own used, 2. Users in the village, 3.Trader in the village, 4. Processing house, 5. Government officers, 6. NGO staff, 7. Users outside the village, 8. Traders outside the village, 9. Other (Specify):……..*

11) Have you ever used chemical fertilizer or pesticide on crops or rice field for the last three years?

□ No, I have never used kinds of those, just natural materials.

□ Yes,

If Yes, A. what you used?.....,

B. What amount?: □ Don't know, just used, □ It fits dose recommended

What the effect of using?
A. kill all kinds of microorganism, B. Increase of yield, C. Decrease of yield,
D. Decrease of fish, E. Other effects (specify):……

12) What species of wildlife, plant, bird, and fish have you observed to be presenting in or around forestland before villagers clear those areas to set up residential or farmland? describe those name:

12.1 Plant:……
12.2 Mammal:……
12.3 Reptile:……
12.4 Bird:……
12.5. Fish:……

13) What happened to those species after you clearing the forestland?
□ More, □ About the same, □ Less
Please tick, if it either increases or decreases

Species	1. <10%,	2. 10-30%,	3. 30-50%	4. >50%
A. Plant species				
B. Mammal				
C. Reptile				
D. Bird				
E. Fish				

14) What are the most threatening activities destroying those species in the village, induced by human activities?

Cause of Impact	Rank in order.
Cutting timber	
Firing	
Poaching	
Other (specify):……	

15) Do you think those would (1) increase, (2) decrease, or (3) still be the same as now in the future?why?.....……
……

16) Do you think you like to conserve these kinds of vulnerable species? □ 1=yes, □ 0=No

17) How can you participate in conserving those species? (Multiple responses):
□ Stop poaching & illegal cutting trees,
□ Planting tree as agro-forestry,
□ Educate young generation to conserve biodiversity,
□ Contribute budget,
□ Participate by patrolling,
□ Report forest offense case to authority,
□ Persuade my villagers to stop destroying forest resources,
□ Other (specify):…….

Annex 3.2: Species of trees primarily affected.

No.	Khmer Name	Scientific Name	Family	Grade	IUCN	Status		
						ST	SRR1	PVPF
Tree								
1.	Kreul	*Melanorrhera laccifera*	Anacarliaceae	L	NA	√	X	√
2.	Neang Nourn	*Dalbergia barriensis, Pierre*	Papilionaceae	L	EN	√	√	√
3.	Angkanh	*Cassia Siamea*	Caesalpinioideae	L	NA	X	√	√
4.	Troyeung	*Diospyros helferi, C.B.Clarke*	Ebenaceae	L	NA	√	X	√
5.	Angkort Khmao	*Diospyros bejaudii Lecomte*	Ebenaceae	L	NA	√	√	√
6.	Beng	*Afzelia xylocarpa (Kruz.) Craib*	Caesalpinioideae	L	EN	X	X	√
7.	Chres	*Albizia lebbeck (L.) Benth*	Fabaceae	L	NA	√	X	√
8.	Kro Nhoung	*Dalbergia cochinchinensis*	Leguminosae	L	VU	X	√	√
9.	Tatrav	*Fagraea fragrans*	Loganiaceae	L	NA	√	X	√
10.	Thnong	*Pterocarpus macrocarpus, Kurz.*	Papilionaceae	L	NA	X	√	√
11.	Krokoh	*Sindora cochinchinensis, Baill*	Caesalpiniaceae	1	NA	√	X	√
12.	Trosek	*Peltophorum dasyrrhachis Kurz, var*	Caesalpinioideae	1	NA	√	√	√
13.	Popel	*Hopea recopei*	Caesalpinioideae	1	EN	√	√	√
14.	Chhlik	*Terminalia alata*	Combretaceae	1	NA	X	√	√
15.	Phcheuk	*Shorea obtuse*	Diperocarpaceae	1	LC	X	√	√
16.	Koki Dek	*Hopea helferi, Brandis.*	Dipterocarpaceae	1	CE	√	X	√
17.	Koki Msao	*Hopea odorata*	Dipterocarpaceae	1	VU	√	X	√
18.	Raing Phnom	*Shorea siamensis*	Dipterocarpaceae	1	LC	√	X	√
19.	Srolao	*Lagerstroemia calyculata*	Lythraceae	1	NA	√	X	√
20.	Sokrom	*Xylia dolabriformis*	Minosoideae	1	NA	√	X	√
21.	Dauchem	*Heritiera javanica*	Sterculiaceae	1	NA	√	X	√
22.	Pdeak	*Anisoptera costata*	Diperocarpaceae	2	EN	√	X	√
23.	Tbeng	*Dipterocarpus obtusifolius, Teysm.*	Diperocarpaceae	2	NA	X	X	√
24.	Khlong	*Dipterocarpus tuberculatus, Roxb*	Diperocarpaceae	2	LC	X	√	√
25.	Chromash	*Vatica astrotricha*	Diperocarpaceae	2	NA	√	√	√
26.	Chheul Tealteuk	*Dipterocarpus alatus, Roxb*	Diperocarpaceae	2	EN	√	X	√
27.	Chheul tealthngor	*Dipterocarpus dyeri*	Diperocarpaceae	2	CE	√	X	√
28.	Chorchong	*Shorea vulgaris*	Diperocarpaceae	2	NA	√	X	√
29.	Chheuteal	*Dipterocarpus*	Diperocarpaceae	2	EN	√	X	√

No.	Khmer Name	Scientific Name	Family	Grade	IUCN	Status		
						ST	SRR1	PVPF
	Bangkouy	*costatus*						
30.	Trach	*Dipterocarpus intricatus*	Dipterocarpaceae	2	LC	√	√	√
31.	Bramdam Leung	*Lagerstroemia macrocarpa*	Lythraceae	3	NA	√	√	√
32.	Thlork	*Parinarium annamensis, Hance*	Rosacees	3	NA	√	X	√
33.	Trabek Prey	*Lagerstroemia floribunda*	Lythraceae	NG	NA	X	√	√
34.	Chambak	*Irvingia malayana*	Simaroubaceae	NG	LC	√	√	√
35.	Sdao	*Azadirachta indica*	Meliaceae	NG	NA	√	√	√
36.	Lvay	*Dillenia pentagyna*	Dilleniaceae	NG	NA	√	X	√
37.	Sromor	*Terminalia chebula*	Combretaceae	NG	NA	X	√	√
Medicinal Plants								
38.	Mean Prey	*Aporusa planchoniana*	Euphorbiaceae	NG	NA	√	√	√
39.	Vor Bandol Pech	*Tinospora crispa*	Menispermaceae	Climber	NA	√	√	√
40.	Sleng	*Strychnos nux-vomica*	Loganiaceae	NG	NA	√	X	√
41.	Kantourt Prey	*Phyllanthus emblica*	Euphobiaceae	NG	NA	√	X	√
42.	Prah Phnov	*Terminalia triptera*	Combretaceae	NG	NA	√	X	√
43.	Kandab Chang he	*Pouzoizia zeylanica*	Urticaceae	Shrub	NA	√	X	√
44.	Teukdoh khla	*Holarrhena pubescens*	Apocynaceae	NG	LC	√	X	√
45.	Ramleay	*Lasiantus kamputansis*	Rubinaceae	Shrub	NA	√	X	√
46.	Krokei	*Cenolophon oxymitrum*	Zingiberaceae	Shrub	NA	√	X	√
47.	Chhke Sreng	*Cananga latifolia*	Annonaceae	NG	NA	√	√	√
48.	Kamreuk Kum	Spirolobium cambodianum *Baill.*	Apocynaceae	Shrub	NA	X	√	√
49.	Koma Pech	*Stephania rotunda*	Menispermaceae	Climber	NA	X	√	√
50.	Damrey Pram dok	*Ploiarium alternifolium*	Theaceae	Shrub	NA	√	X	√
Other Types of Non-Timber Forest Product								
51.	Pdao Tres	*Plectocomia pierreana*	Palmae	Climber	NA	√	X	√
52.	Kongkea	Ochna integerrima *(Lour.) Merr.*	Ochnaceae	NG	NA	X	√	√
53.	Pdao Som	*Korthalsis lacinosa*	Palmae	Climber	NA	√	X	√
54.	Kdouch (Vor)	*Dioscorea hispida*	Dioscorea	Climber	NA	√	√	√
55.	RuseuyKley	*Bambusa bambos*	Gramineae	Bamboo	NA	√	√	√
56.	Ruseuy	*Arundinaria*	Gramineae	Bamboo	N	X	√	√

No.	Khmer Name	Scientific Name	Family	Grade	IUCN	Status		
						ST	SRR1	PVPF
	Prech	*pusillaq*						
57.	Ruseuy Prey	*Dendrocalamus giganteus*	Gramineae	Bamboo	LC	√	√	√
58.	Vor Lameat	*Coscinium usitatum*	Menispermaceae	Climber	NA	√	X	√
59.	Damlong Tearn	*Dioscorea brevipetiolata*	Dioscoreaceae	Climber	NA	√	X	√
60.	DamlongChrouk	*Dioscorea oryzetorum*	Dioscoreaceae	Climber	NA	X	√	√
61.	Damlong Sya	*Dioscorea esculenta*	Dioscoreaceae	Climber	NA	√	√	√
	Total					46	29	61

Note: Tree Quality: L= Luxury grade, 1= 1st Grade, 2= 2nd Grade, 3= 3rd Grade, and NG= Non-grade timber

Location of Rapid Assessment: ST= Sen Teches village, SRR1= Sen RungReung 1 village, PVPF= Preah Vihear Protected Forest

IUCN Red List: CE= Critically Endangered, EN= Endangered

1) VU= Vulnerable
2) LC= Low Risk/Low Concern

Status:

1) √= directly threatened in its habitat during forestland conversion
2) X= was not claimed

Annex 3.3: Species of wildlife primarily affected.

No.	Khmer Name	English Name	Scientific Name	IUCN	CITES	Cambodia status	ST	SRR1	PVPF
Mammal									
1.	Pongroul	Sunda Pangolin	*Manis javanica*	EN	II	R	√	√	√
2.	Svakdam	Long-tailed Macaque	*Macaca fascicularis*	N-t	II	C	√	√	√
3.	Sampouch korleung	Yellow-throated Marten	*Martes flavigula*		III	C	√	√	√
4.	Sampouch thom	Large-spotted Civet	*Viverra megaspila*		III	C	√	X	√
5.	Sampouch KroHoub	Common Palm Civet	*Paradoxurus hermaphroditus*	LC	III	C	√	√	√
6.	Sampouc Phnom	Binturong	*Arctictis binturong*	VU	III	C	√	X	√
7.	Ska Touch	Small Asian Mongoose	*Herpestes javanicus*	LC		C	√	√	√
8.	Ska Thom	Crab-eating Mongoose	*Herpestes urva*		III	C	√	X	√
9.	Chrouk Prey	Eurasian Wild Pig	*Sus scrofa*	LC		C	√	√	√
10.	Kdannheng touch	Lesser Mousedeer	*Tragulus kanchil*	LC		C	√	√	√
11.	Preus	Sambar	*Rusa unicolor*	VU		C	√	X	√
12.	Romaing	Eld's Deer	*Rucervus eldii*	EN		En	√	√	√
13.	Chhlous	Red Muntjac	*Muntiacus muntjak*	LC		C	√	√	√
14.	Tonsong	Banteng	*Bos javanicus*	EN		R	√	X	√
15.	Kamprok thom	Black Giant Squirrel	*Ratufa bicolor*	NT	II	R	√	√	√
16.	Kanghech Kampou chea	Cambodian Striped Squirrel	*Tamiops rodolphi*			C	√	√	√
17.	Kanghen	Indochinese Striped Squirrel	*Menetes berdmorei*			C	√	√	√
18.	Chhmaba Kantuy Khmao	Indian Giant Flying Squirrel	*Petaurista philippensis*			R	X	√	√
19.	Kamprok	Small Flying Squirrel sp	*Hylopetes sp*				√	√	√
20.	Broma	East Asian Porcupine	*Hystrix brachyura*	VU		C	√	√	√
21.	TongsayKul	Burmese Hare	*Lepus peguensis*	LC		C	√	√	√
Sub total							***20***	***16***	***21***
Bird									
22.	TorTear	Chinese Francolin	*Francolinus pintadeanus*			C	X	√	√
23.	mannprey	Red Junglefowl	*Gallus gallus*			C	√	X	√

No.	Khmer Name	English Name	Scientific Name	IUCN	CITES	Cambodia status	ST	SRR1	PVPF
24.	kngork	Green Peafowl	*Pavo muticus*	VU	II	R	√	X	√
25.	Broveuk	Lesser Whistling-duck	*Dendrocygna javanica*			C	X	√	√
26.	Trosek Touch kballeung	Yellow-crowned Woodpecker	*Dendrocopus mahrattensis*			C	X	√	√
27.	TrosesPoustnort	Rufous-bellied Woodpecker	*Dendrocopos hyperythrus*			C	√	√	√
28.	TrosestnortchampousKhmao	Rufous Woodpecker	*Celeus brachyurus*			C	X	√	√
29.	Kengkorngtouch	Oriental Pied Hornbill	*Anthracoceros albirostris*		II	C	√	X	√
30.	Laotthom	Greater Coucal	*Centropus sinensis*			C	X	√	√
31.	Laot sbov	Lesser Coucal	*Centropus bengalensis*			C	√	√	√
32.	Seksork	Red-breasted Parakeet	*Psittacula alexandri*		II	C	X	√	√
33.	Khlengsrak	Barn Owl	*Tyto alba*		II	C	√	X	√
34.	Lolorkbay	Spotted Dove	*Streptopelia chinensis*			C	X	√	√
35.	Lorlork trang	Red Collared Dove	*Streptopelia tranquebarica*			C	√	√	√
36.	Popol klal beitorng	Orange-breasted Green Pigeon	*Treron bicincta*			C	√	X	√
37.	Kokkor	Cattle Egret	*Bubulcus ibis*		III	C	X	√	√
38.	Trodork touch	Lesser Adjutant	*Leptoptilos javanicus*	**VU**		R	√	√	√
39.	Trodok thom	Greater Adjutant	*Leptoptilos dubius*	**EN**		En	√	X	√
Sub total							***10***	***12***	***18***
Reptile									
40.	Andeuk prech	Elongated Tortoise	*Indotestudo elongata*	EN	II		√	√	√
41.	Andeuk sakol	Malayan Snail-eating Turtle	*Malayemys subtrijuga*	VU			√	X	√
42.	Kantheay Asia	Asian Softshell Turtle	*Amyda cartilaginea*	VU			X	√	√
43.	Ansorng	Water Monitor	*Varanus salvator*		II		X	√	√
44.	Trokourk	Bengal Monitor	*Varanus bengalensis*		I		√	√	√
45.	Poursvek roneam	King Cobra	*Ophiophagus hannah*		II		√	√	√
46.	Pousvek Krobei	Monocled Cobra	*Naja kaouthia*		II		√	√	√

No.	Khmer Name	English Name	Scientific Name	IUCN	CITES	Cambodia status	ST	SRR1	PVPF
47.	Pousvek Dambok	Indochinese Spitting Cobra	*Naja siamensis*		II		√	√	√
48.	PoursPrey	Indochinese Ratsnake	*Pytas korros*				√	X	√
49.	Pous Samlab kangkeb	Chequered Keelback	*Xenochrophis piscator*				X	√	√
50.	Kantrorng	Water Dragon	*Physignathus cocincinus*				√	X	√
Sub total							***8***	***8***	***11***
Total							**38**	**36**	**50**

Note:

Critically Endangered	CR
Endangered	EN
Vulnerable	VU
Near-threatened	NT
Data Deficient	DD
Least Concern	LC

Status:

1) √= was claimed to be affected in habitat of specific area during forestland conversion
2) X= was claimed not to be affected in habitat of specific area

Location of Rapid Assessment: ST= Sen Teches village, SRR1= Sen RungReung 1 village, PVPF= Preah Vihear Protected Forest

INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST

CHAPTER IV

FLORAL DIVERSITY

PANG PHANIT, PENG SOPHEAKT, YOU KIMLENG, KIM SOBON, SAY SINLY, CHHEANG DANY, DENNIS CENGEL and *LIM SOPHEAP*

Summary

The landscape of the PVPF is composed of hill evergreen forest, lowland evergreen forest, open forest, dried deciduous forest, grassland, and wetlands. A primarily seasonal network of rivers and streams flows through the PVPF, contributing ultimately to the flow of the Mekong River. It is the result of its diversity of plant environments that the PVPF is home to a mosaic of ecosystems and supports a great number of wildlife species. There is a variety of flora in the PVPF that is useful to humans, including commercial species, medicinal plants and herbs, and non-timber forest products. The objectives of this floral survey were to document the current extent of plant species and compile lists of species' distributions of the floral species in the Preah Vihear Protected Forest. Its specific objective was to confirm the presence or absence of threatened species of plant communities in the Preah Vihear Protected Forest, particularly with respect to the domesticated use of plants by local communities. Floral surveys follow the "random meander," in which the recorder walks in a random manner through different forest types in the Preah Vihear Protected Forest, recording every species observed on the boundaries between various plant communities, as well as the conditions of each of those communities. The collected unknown plant species were labeled and photographed on the same day that they were collected. The floral survey was conducted in several locations in Ro Bunh, Kbal Damrey, Nam Sam, and other sites in the different plant ecological zones of the PVPF, especially in evergreen, semi-evergreen, and deciduous forests.

There were 432 species of flora recorded in the field survey in the Preah Vihear Protected Forest. Of those species, there were 160 timber and non-timber species, 43 shrub species, 63 climber species, 49 spermatophytes, 46 pteridophytes - including 30 orchid species - 42 mushroom species, 11 bamboo species, and 17 palm species. The timber species included 12 species of Luxury grade, 18 species of 1st Grade, 16 species of 2nd Grade, 22 species of 3rd Grade and 92 species of non-grade.

There are at least 42 species of mushrooms growing in the PVPF, as well as 107 edible species of vegetables, 22 of which are collected by local people to meet daily consumption requirements, as well as to sell in markets to generate incomes. The edible mushrooms and other edible vegetables are natural foods with high nutritious, especially protein, value that are available from May to July for consumption by local communities. Of the 432 species of plants present in the Preah Vihear Protected Forest, 243 have some part that may be used as traditional medicine and, of those, 46 are collected by traditional doctors and local communities. There are more than 30 orchid species present in the Preah Vihear Protected Forest, as well, and of those more than 15 have been observed by the project team, which has brought them from the forest for ex-situ conservation in the Morokut nursery. The fruits of forest trees may also be used as sources of food, which may be collected throughout the year. Those fruits may also be processed and preserved to sell in markets to generate additional income.

CHAPTER IV

FLORAL DIVERSITY

4.1 Introduction

According to Dy Phon (1981; 1982), Cambodia possessed 2,308 of the 8,000 species described in the Flora Generale de l'Indochine of Cambodia, Laos, and Vietnam. The 2,308 species belong to 852 genera in 164 families. It was later estimated that there were 12,000-15,000 species of plants in the three countries (IUCN 1995). The World Conservation Monitoring Centre (WCMC) (2000) estimated there were 8,260 plant species in Cambodia alone, however, 10% of which were endemic (In Global Biodiversity UNEP and WCMC 2000). The richness of plant species in the Preah Vihear Protected Forest (PVPF) is closely related to its consistently moderately high humidity (74%), abundant rainfall (124 days a year, with an average annual rainfall of 1,556.3 - 2,035.5 mm), warm temperatures (33ºC), geological formations, and soil composition. The PVPF is situated primarily in lowland, with some high altitude areas on the escarpment of the Dangrek Mountain range. The composition of floral species shares affinity with those of the Indochinese floristic province, Indo-Malayan region (Cambodia Forestry Administration 2010).

The landscape of the PVPF is composed of hill evergreen forest, lowland evergreen forest, open forest, dried deciduous forest, grassland, and wetlands. A primarily seasonal network of rivers and streams flows through the PVPF, contributing ultimately to the flow of the Mekong River. It is the result of its diversity of plant environments that the PVPF is home to a mosaic of ecosystems and supports a great number of wildlife species. There is a variety of flora in the PVPF that is useful to humans, including commercial species, medicinal plants and herbs, and non-timber forest products. The objectives of this floral survey were to document the current extent of plant species and compile lists of species' distributions of the floral species in the Preah Vihear Protected Forest. Its specific objective was to confirm the presence or absence of threatened species of plant communities in the Preah Vihear Protected Forest, particularly with respect to the domesticated use of plants by local communities.

4.2 Survey methods

Floral surveys follow the “random meander” described in Cropper (1993), in which the recorder walks in a random manner through different forest types in the Preah Vihear Protected Forest, recording every species observed on the boundaries between various plant communities, as well as the conditions of each of those communities.

In collaboration with the Royal University of Agriculture and the Prek Leap National School of Agriculture, forest types and accessibility were evaluated in the PVPF and plants were identified as part of the botanical survey. Plant taxonomy guide books were used to faciitate plant identification. Plant specimens were collected from the trunks and main branches of trees in those instances of unknown species and assistance was requested from botanical experts to confirm the identities of those plants and provide their scientific names. The collected unknown plant species were labeled and photographed on the same day that they were collected. The floral survey was conducted in several locations in Ro Bunh, Kbal

Damrey, Nam Sam, and other sites in the different plant ecological zones of the PVPF, especially in evergreen, semi-evergreen, and deciduous forests.

4.3 Results of the floral survey

4.3.1 Flora and plant types

- **Plant types**

The forests in the Preah Vihear Protected Forest grow in one of the driest regions of the northern provinces of Cambodia. It receives, on average, 1,511 mm of rainfall per year, but has a dry season that lasts for more than five months. Based on the 2014 classification, there are three types of forest cover in the Preah Vihear Protected Forest - deciduous, semi-evergreen, and evergreen forests. The deciduous forests contain almost exclusively (>90%) dipterocarp tree species; the semi-evergreen mixed forests contain both deciduous and evergreen tree species, in which dipterocarp species represent more than 50% of forest stands; and the evergreen forests are dominated by evergreen tree species and often merge into semi-evergreen forests (Nophea et al. 2002).

In conducting the field survey, it was often difficult to distinguish between semi-evergreen and evergreen tree species because both of those forest types contain 60-80% the same tree species. In some cases, semi-evergreen forests become evergreen forests as the result of the logging of the forests and in those areas it is rather open and heavily disturbed (Cambodia Department of Forests 1994). The semi-evergreen forests are relatively open and have low crown covers, exhibiting only a closed canopy structure during the rainy season, while deciduous forests usually have an open canopy structure throughout the year. The current status of tree growth in semi-evergreen forests is characterized by diameters of less than 40 cm of the dominant trees with the trees with diameters greater than 40cm of relatively poor growth. Most tree species are dominated by dipterocarp tree species and a few gregarious tree species, including *Lagerstroemia spp.* and *Xylia dolabriformis,* as well as numerous scattered associated species, such as *Melanorrhera laccifera; Sindora cochinchinensis* Baill*; Hopea recopei; Hopea odorata; Dialium cochinchinensis; Albizia lebbeck; Anisoptera costata;* and *Vatica astrotricha*. Important indigenous tree species include *Afzelia xylocarpa; Pterocarpus pedatus; Dalbergia cochinchinensis;* and *Dalbergia bariensis,* a high-value broadleaved tree. These species are threatened in their natural habitats in the PVPF as the result of illegal logging. A number of bamboo species are also present in semi-evergreen forests.

In the dry season, deciduous forests are subject to frequent fires and although fire is a natural phenomenon in these systems, human intervention has exacerbated the incidence of fire as the result of the extremely dry conditions during the dry season. It is because of the fires that the understory is nearly always sparse and dominated by grasses. During the wet season and at the start of the dry season, before burning has occurred, these grasses are typically 0.5-2 m tall. Human impacts, such as degradation from fire, typically occur with more frequency in deciduous forest compared to the other forest types. In contrast to the denser crown closure found in evergreen forests, deciduous forests naturally have a very open canopy leaving them more susceptible to drying out and, hence, more prone to fire. Even in undisturbed deciduous forests, crown cover may only have 40% closure. The canopy covers of deciduous, semi-evergreen, and evergreen forests are depicted in Figures 4.1 to 4.3, respectively.

Figure 4.1. Deciduous forest and open dry deciduous forest canopy cover.

Figure 4.2. Mixed deciduous and semi-evergreen forest, and semi-evergreen forest canopy cover.

Figure 4.3. Evergreen forest and mixed semi-evergreen forest canopy cover.

- **Floral vegetation**

Table 4.1. Plant species in the Preah Vihear Protected Forest.

Species	Luxury	1st jGrade	2nd Grade	3rd Grade	No-grade	TOTAL
Timber	*12*	*18*	*16*	*22*	*92*	*160*
Shrub					*43*	*43*
Climber					*63*	*63*
Spermatophytes					50	50
Pteridophytes					46	46
Mushroom					42	42
Bamboo					11	11
Palms					17	17
TOTALS	*12*	*18*	*16*	*22*	364	432

There were 432 species of flora recorded in the field survey in the Preah Vihear Protected Forest (Table 4.1). Of those, species, there were 160 timber and non-timber species, 43 shrub species, 63 climber species, 49 spermatophytes, 46 pteridophytes - including 30 orchid species - 42 mushroom species, 11 bamboo species, and 17 palm species. The timber species included 12 species of Luxury grade, 18 species of 1st Grade, 16 species of 2nd Grade, 22 species of 3rd Grade and 92 species of non-grade, as described in Annex 4.1. The classification of timber species with DBH ≥ 5 cm was based on Prakas No. 89.

4.3.2 Identification of main timber tree species

The process to distinguish between floral species in the Preah Vihear Protected Forest was facilitated by the relative weighting of several factors, including the relative richness of individual floral species in and around the PVPF; the social and/or economic importance of each species to local communities and relative to their regional, national and international distributions; and the extent to which each species represents, or is an indicator of, the biodiversity of the area.

Those criteria resulted in the selection of 12 representative timber tree species, including *Dalbergia cochinchinensis; Dalbergia barensis; Afzerlia xylocarpa; Pterocarpus macrocarpus; Hopea odorata; Xylia xylocarpa; Sindora siamensis; Shorea vulgaris, or Shorea guiso; Anisoptera costata; Diospyros cruenata; Diospyros bejaudii;* and *Fagraea fragrans* (Table 4.2).

Table 4.2. Important timber tree species in the Preah Vihear Protected Forest.

No.	Local name	Scientific name	Tree class	IUCN status
1	Kronhoung	*Dalbergia cochinchinensis*	Luxury	Vulnerable
2	Neang Nourn	*Dalbergia barensis*	Luxury	-
3	Beng	*Afzerlia xylocarpa*	Luxury	Endangered
4	Thnong	*Pterocarpus macrocarpus*	Luxury	Vulnerable
5	Chheu Kmao	*Diospyros cruenata*	Luxury	-
6	Angkort Kmao	*Diospyros bejaudii*	Luxury	-
7	Tatrav	*Fagraea fragrans*	Luxury	-
8	Koki	*Hopea odorata*	1st	Vulnerable
9	Sokrom	*Xylia xylocarpa*	1st	Vulnerable
10	Krokoh	*Sindora siamensis*	1st	Least Concern
11	Chor Chong	*Shorea vulgaris or Shorea guiso*	2nd	Critically Endangered
12	Phdeak	*Anisoptera costata*	2nd	Endangered

The taxonomies, grades, distributions, habitats, and other related information, including current assessments of the status of each species as reported in the IUCN Red List List (i.e., Critically Endangered, Endangered, Threatened, Vulnerable, Near-Threatened, Least Concern) are presented for the representative timber tree species in the PVPF in the following discussion.

❖ ***Dalbergia cochinchinensis* Pierre** (Vulnerable)

Taxonomy and Commercial Grade

Cambodian name : Kra-nhourng
Scientific name : *Dalbergia cochinchinensis* Pierre
Synonym : *Dalbergia cambodiana* Pierre
Family : *Fabaceae*
Sub-family : *Faboideae*
Commercial Grade-Cambodia: Luxury


Distribution and Habitat: Native to Indochina and adjacent countries, this tree species is shade-tolerant when young. It usually occurs sparsely in open and semi-deciduous forests from 400 to 500 m above sea level (a.s.l.) and prefers deep sand, clays, or calcareous soils (Khorn 2002). This rosewood prefers uniform rainfall that ranges from 1200-1650 mm per year. The species requires high amounts of light to thrive and is drought tolerant and able to grow on most soils (DFSC 2000). In Cambodia, the species is found in Kampong Thom, Preah Vihear, Ratanakiri, Pursat, Siem Reap, Kratie, Koh Kong, Stung Treng, and Modulkiri provinces.

Uses: The wood is expensive and is illegally exported for high prices. It is used for making high-quality furniture, art handicrafts, and musical instruments. The root base and root can also be used for high-quality art handicrafts (CTSP 2004).

Current Status: *Dalbergia cochinchinensis* has been found during field surveys in former forest concessions, protected areas, and various regions in the Northern Highlands of Cambodia. Illegal cutting in many areas has resulted in few and sparse populations of this species. This presents difficulties in securing germplasm sources within and outside of protected forests and national parks. In 2002, the second Cambodia Tree Seed Project (CTSP) meeting on Forest Gene Conservation Strategy defined *Dalbergia cochinchinensis* Pierre as a priority species requiring immediate conservation intervention and appropriate protection. This species is protected by the Cambodian Forestry Law.

❖ ***Afzelia xylocarpa* (Kruz.) Craib** (Endangered)

Taxonomy and Commercial Grade

Cambodian name : Beng
Scientific name : *Afzelia xylocarpa* (Kruz.) Craib.
Synonym : Pahudia cochinchinensis Pierre
Family : *Fabaceae*
Sub-family : *Caesalpinioideae*
Commercial Grade-Cambodia : Luxury

Distribution and Habitat: This species is found in Laos, Thailand, Cambodia and Vietnam. It is a light-demanding species occurring on well-drained flatlands or transitional zones between evergreen and dry open dipterocarp forest, usually from 500 to 700 m a.s.l. The species also occurs above 900 m in mixed forest (Dy Phon, 2000). (Dy Phon, 2000) The tree is often associated with *Dalbergia oliveri*, *Pterocarpus macrocarpus*, *Lagerstroemia calyculata*, *Dipterocarpus tubinatus*, and *Tetrameles nudilora*. Trees occur in a scattered manner in mixed forests and do not usually form pure stands. In Cambodia, this species is found in Kampong Thom, Kratie, Stung Treng, Preah Vihear, Siem Reap, Battambang, Ratanakiri, Mondulkiri, Kampot, and Pursat provinces (Khorn 2002).

Uses: The wood is valuable because of its rich dark or light-red color, prominent veins, hardness, and durability. The wood is used in various ways, including for house construction, cabinet and furniture-making, and high quality handicrafts (CTSP 2004). The bark is used for tanning animal skins and also for local human and veterinary medicines (Dy Phon 2000). The fatty cotyledons of young seeds are edible (DFSC 2000).

Current Status: Since the wood of *'beng'* is very valuable, this species is over-exploited and in danger of extinction if adequate protection measures are not implemented. In most of its area of distribution, mature trees have been reduced dramatically and sometimes it is very difficult to locate them to collect seeds. The number of mature trees has been reduced significantly and it is now difficult to find significant sources of germplasm.

In 2002, the second meeting on the Forest Gene Conservation Strategy defined *Afzelia xylocarpa* (Kruz.) Craib as a priority species requiring immediate protection and conservation. This species is protected by the Cambodian Forestry Law.

- ***Pterocarpus macrocarpus* Kurz** (Vulnerable)

Taxonomy and Commercial Grade

Cambodian name	: Thnong
Scientific name	: *Pterocarpus macrocarpus* Kurz
Family	: Fabaceae
Commercial Grade-Cambodia	: Luxury


Distribution and Habitat: This species is a common constituent of tropical deciduous forests in Cambodia, Laos and Vietnam (FIPI 1996). In Cambodia the species usually occurs in dense deciduous or cleared forests up to 700 m a.s.l. (Dy Phon 2000). The species is rarely found in primary forests. The tree is often mixed with many other species, but often occurs as a dominant plant. It is a light-demanding, drought tolerant tree that is suitable for well drained, light textured soils with shallow depths and little humus (Khorn 2002). It is found in Kampong Thom, Stung Treng, Preah Vihear, Rattanakiri, Kratie, Siem Reap, Kampot, Pursat, Mondulkiri, Kampong Speu and Koh Kong provinces.

Uses: This species produces a strong wood and valuable timber that is used for luxury furniture, cabinetwork, art handicrafts, musical instruments and flooring (CTSP 2004). In Cambodia, it is a luxury wood that is in demand for making house pillars. The sap is used against childhood 'thrush' and in distempering and the roots are used as a component of a remedy regulating menstruations (Dy Phon 2000). In Thailand, it has been one of the primary export timbers harvested from natural forests (Joker 2000a). The bark provides a red dye and tannin. The species is nitrogen fixing and suitable for agroforestry systems and soil improvement (LTSP 2009).

Current Status: In Cambodia, *Pterocarpus macrocarpus* occurs primarily in the North. Most timber is harvested from natural forests and the species is suffering from over-exploitation and agricultural expansions (CTSP 2004). Its natural habitats are being destroyed and degraded and the species is encountering the possibility of extinction if protection measures are not taken. In 2002, the second CTSP meeting on the Forest Gene Conservation Strategy defined *Pterocarpus macrocarpus* as a priority species requiring immediate conservation intervention and appropriate protection. This species is protected by the Cambodian Forestry Law.

- ***Diospyros cruenata* Thwaites**

Taxonomy and Commercial Grade

Cambodian name	: Cheou kmao
Scientific name	: *Diospyros cruenata Thwaites*
Family	: Ebanaceae
Commercial Grade-Cambodia	: Luxury

Distribution and Habitat: *Diospyros cruenata* is found in dense and mixed forests of East Asia.

Uses: The wood of *Diospyros cruenata* is valued for the manufacture of ornamental

trinkets and is excellent for fuelwood (Dy Phon 2000).

Current Status: Since the wood is very valuable and there is a very high demand for it in the market, this species is over-exploited and in danger of extinction if adequate protection measures are not implemented. Its distribution is scattered and its habitats have been destroyed by forestland conversion and clear cutting. The number of mature trees has been reduced significantly and it is now difficult to find significant sources of germplasm.

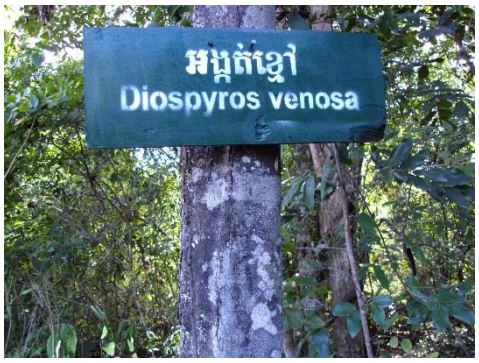
In 2002, the second CTSP meeting on the Forest Gene Conservation Strategy defined *Diospyros cruenata* Thwaites Pierre as a priority species requiring immediate protection and conservation. This species is protected by the Cambodian Forestry Law.

- ***Diospyros bejaudii* Lecomte**

Taxonomy and Commercial Grade

Cambodian name : Angkat khmao
Scientific name : *Diospyros bejaudii* Lecomte
Family : Ebenaceae
Commercial grade-Cambodia : Luxury

Distribution and Habitat: *Diospyros bejaudii* Lecomte is found in dense and semi-dense forests of Cambodia, where it is a narrow endemic (Dy Phon 2000).



Uses: This species is much in demand for the manufacture of knife handles and musical instruments (Dy Phon 2000).

Current Status: Since its wood has a high value, this species is over-exploited and in danger of extinction if adequate protection measures are not implemented. Its distribution is scattered and its habitat is being destroyed and degraded through forestland conversion and selective illegal logging. The number of mature trees has been reduced significantly and it is now difficult to find significant sources of germplasm. In 2002, the second CTSP meeting on the Forest Gene Conservation Strategy defined *Diospyros bejaudii* Lecomte as a priority species requiring immediate conservation intervention and appropriate protection. This species is protected by the Cambodian Forestry Law.

- ***Fagraea fragrans* Pit**

Taxonomy and Commercial Grade

Cambodian name : Ta trao
Scientific name : *Fagraea fragrans* Pit
Family : Loganiaceae
Commercial grade-Cambodia : Luxury

Distribution and Habitat: This species is widely distributed in Vietnam, Cambodia, Laos, Thailand, Java, Sumatra, Peninsular Malaysia, and India. In Cambodia, it is usually found in semi-deciduous forests and rarely in dense or open forests (Cambodia Forestry Administration 1997). The tree prefers sandy soils that are periodically inundated along streams or rivers, usually below 800 m a.s.l. This is a pioneer species in burned forestlands (FIPI 1996). It is found in Koh Kong, Pursat, Stung Treng, Kratie, Kampong Thom, Mondulkiri and Preah Vihear provinces (Khorn 2002).

Uses: The wood is used for house pillars in construction, but also in the manufacture of furniture coffins (FIPI 1996). In the Khmer culture, *Fagraea fragrans* Pit is used for making doors and door frames, particularly in some historic temples (Cambodia Forestry Administration 1997). The bark is used in traditional medicine. The tree can be planted to provide shade (FIPI 1996).

Current Status: Since this wood is very valuable and in high demand, the species is over-exploited and in danger of extinction if adequate protection measures are not implemented. Its distribution is scattered and its habitats are being destroyed and degraded by forestland conversion and selective illegal logging. The number of mature trees has been reduced significantly and it is now difficult to find significant sources of germplasm.

In 2002, the second CTSP meeting on the Forest Gene Conservation Strategy defined *Fagraea fragrans* Pit as a priority species requiring immediate protection and conservation intervention. This species is protected by the Cambodian Forestry Law.

- ***Hopea odorata* Roxb.** (Vulnerable)

Local Name : Koki Msao
Scientific name : *Hopea odorata* Roxb.
Family : Dipterocarpaceae
Class : 1st

Distribution and habitat: *Hopea odorata* is found in dense forests in the Indochinese, Malay Peninsula and Andaman Islands, as well as in Cambodia, Laos, Vietnam, Thailand, Myanmar, and India (Dy Phon 2000; Toyama 2013). The tree grows in lowland evergreen and mixed deciduous forests along streams on deep rich soils (Ashton 1998). The records of the World Agroforestry Center indicate that *Hopea odorata* commonly

grows along streams to 600 m altitude under conditions with mean annual rainfall of 2,200 to 5,000 mm and temperatures of 36-40 degrees Celsius. In Cambodia, the tree grows in small groups or alone in dense evergreen forests in wet and deep soils in Kratie, Koh Kong, Kampong Thom, Steung Treng, Preah Vihear, Ratanakiri, and Siam Reap provinces. Normally, during the first five years of growth, it is shade tolerant, but subsequently requires sunlight (Sareth,2002). Asessments have indicated that *Hopea odorata* is widely distributed in the Preah Vihear Protected Forest, Prey Preah Roka, and Prey Korki in the northern part of Preah Vihear province.

Uses and products: The wood is a strong light hardwood used for construction, furniture, veneer, railway sleepers, train carriages, and river or sea boats (Joker 2000b). It is a high-value wood that is resistant to termites (CTSP 2004). The bark contains tannin that is suitable for tanning leather and also produces inferior liquid resin. It is also used to treat diarrhea and as a part of the remedy for the treatment of inflammations of the gums and incontinence. It may also replace areca nut in betel quid (Dy Phon 2000). The fruits are sometimes chewed and have medicinal use (LTSP 2009). The wood is very hard and heavy weighing 755 kg per cubic meter. The tree is sometimes used to provide shade and for reforestation in Southeast Asia (Orwa et al. 2009).

Current Status: *Hopea odorata* grows well in semi-evergreen forests, in particular, but has been seriously depleted as the result of heavy exploitation and degradation of habitats by individuals and former forest concessionaires. Large populations of this species are now rarely found inside the Preah Vihear Protected Forest. Currently, there are only scattered trees that occur and finding mother trees for seed collection is a difficult task. *Hopea odorata* often grows in moist forests along streams, but when its habitat is destroyed, it cannot regenerate naturally. In 2002, the second CTSP meeting on the Forest Gene Conservation Strategy defined *Hopea odorata* as a priority species requiring immediate conservation interventions and appropriate protection.

- ***Xylia xylocarpa* (Roxb.) Taub.** (Vulnerable)

Local Name : Sokrom
Scientific name : *Xylia xylocarpa* (Roxb.) Taub.
Family : Leguminosae
Class : 1st



Distribution and Habitat: *Xylia xylocarpa* is naturally distributed in the Indochinese region, including Cambodia, Vietnam, Laos, and Thailand (Dy Phon 2000), as well as in Myanmar spreading west to India (Schmidt 2004). It is seen growing in dense Dipterocarp and fire-exposed forests (Dy Phon 2000), dry evergreen forests and mixed deciduous forests (Larsen et al., 1985). This species can grow in altitudes up to 850 m with average annual rainfall of 1200 to 1700 mm.

In Cambodia, it grows sparely in open deciduous or deciduous dipterocarp forests, especially in dry and hot areas in different ecological zones, excluding the coastal area. Assessments indicate that it is widely distributed in the Preah Vihear Protected Forest and in the northern part of Preah Vihear province.

Uses and products: *Xylia xylocarpa* is a 1st Grade timber in the Leguminosae family. In the humid tropics of West Africa, it is used in agroforestry systems for fodder (Larbi et al., 2005). Its wood is heavy, hard, and durable and it is resistant to insects. It is used primarily for construction (Larsen et al. 1985), houses pillars, cabinetwork, boats and carts (Dy Phon 2000). The basic density of this species is 0.72 g/cm^3 at a moisture content of 49.8% (Josue 2004). The bark and fruit provide medicines in traditional use (Schmidt 2004). The Cambodian people use the bark to cure haemoptysies.

Current Status: *Xylia xylocarpa* occurs primarily in open deciduous forests in the Preah Vihear Protected Forest Currently, most timber is illegally logged from natural forests and the species is suffering from over-exploitation and agricultural expansion. Its natural habitats are being deforested and degraded and the species may become rare in the PVPF if protection measures are not taken.

❖ ***Sindora siamensis* Teysm .ex Miq. var. cochinchinensis** (Least Concern)

Local Name : Kokoh
Scientific name : *Sindora siamensis* Teysm .ex Miq.var. cochinchinensis
Family : Leguminosae
Class : 1st

Distribution and Habitat: *Sindora siamensis* is a native species of Cambodia, Laos, Malaysia, Thailand, and Viet Nam (WCMC 1998). It is defined as a dominant species in dry deciduous dipterocarp forests with highly characteristic tree taxa (Stott 1990). It is normally seen in open Dipterocarpus and secondary forests (Dy Phon 2000). Normally, this species grows in areas with annual rainfall of 1,000-2,000 mm or more at elevations up to 500 m (Larsen et al. 1985). There are two types of *Sindora siamensis* in Cambodia - *Sindora siamensis* Teysm.ex Miq.var. Siamensis with the common name of Korkoh spine fruit and *Sindora siamensis* Teysm .ex Miq.var. cochinchinensis with the common name of Korkoh shiny fruit. On the basis of general observations, the *Sindora siamensis* Teysm .ex Miq. var. Siamensis is smaller and rarely seen in dense forest.

In Cambodia, it is a dominant species and common throughout the country in lowland areas. Its occurs sparely in open deciduous or semi-evergreen forests in the Preah Vihear Protected Forest and in the northern part of Preah Vihear province.

Uses and products: *Sindora siamensis* has a strong wood that is generally used for heavy constructions (Larsen et al., 1985), ship building, furniture making, and carvings (WCMC 1998). The timber is used for planking, poles, joinery, and fuelwood (Soerianegara and Lemmens,1994). It provides excellent flooring, beams, and columns, as well (Dy Phon 2000). Its wood is also good for charcoal production, but it is not widely used for that purpose because of its cost. The wood density of this species is about 880 kg/m^3 at a moisture content of 12% and at a moisture content of 3.17%, the wood produces 73.92% of fixed carbon with an ash content of 3.47% (Sayakoummane and Ussawarujikulchai 2009). The bark is used for partition walls and the wood oil for caulking boats and dyeing fishing nets. The fruit may be used as a medicine (Cruz-Garcia and Price 2011). Young seeds are edible, as well, and the aril of the seed is sometimes used as a substitute for betel.

Current Status: In Cambodia, *Sindora siamensis* occurs primarily in open deciduous forests in the Preah Vihear Protected Forest. Currently, the species is suffering from over-exploitation, agricultural expansion, and the illegal logging of natural forests. Its natural habitats are being deforested and degraded and the species may become rare in the PVPF if protection measures are not taken.

- ***Shorea vulgaris,* or *Shorea guiso* (Blanco) Blume** (Critically Endangered)

Local Name : Choe Chong
Scientific name : *Shorea guiso* (Blanco) Blume
Family : Dipterocarpaceae
Class : 2nd

Distribution and Habitat: *Shorea guiso* is a common species that is distributed in Cambodia, Laos, Vietnam, Thailand, Peninsular Malaysia, Sumatra, Borneo and the Philippines (Meijer 1974). In Cambodia, it is found in the mixed Dipterocarp or dense hill forests at altitudes of 600 m (Dy Phon 2000) and, in Borneo, it is common in slightly seasonal climatic areas on well-drained red soils in lowland forests and in other parts of the island around limestone hills (Soerianegara and Lemmens 1994). It is found in the northern and eastern parts of Cambodia, including in the semi-evergreen forests in the central part of the PVPF, and it grows sparely in open semi-evergreen and evergreen forests in Preah Vihear, Kratie, Rattanakiri, and Mundulkiri provinces.

Uses and products: The principal product of the tree is the resin that the Cambodian people collect for household use and for sale. That resin is primarily mainly used for boat varnishes, furniture, and the production of torches (Dy Phon 2000). In thePhilippines, the timber is used as red balau and rarely seen to be used in heavy construction because of its low wood density (Soerianegara and Lemmens 1994).

Current Status: In Cambodia, *Shorea guiso* occurs primarily in semi-evergreen forests in the Preah Vihear Protected Forest. Currently, the species is suffering from illegal logging in natural forests. Its natural habitats are being degraded and the species may become rare in the PVPF.

- ***Anisoptera costata* Korth.** (Endangered)

Local Name : Phdeak
Scientific name : *Anisoptera costata* Korth.
Family : Dipterocarpaceae

Distribution and Habitat (Soil/site requirement): *Anisoptera costata* is native to the Indochinca peninsula, Thailand, and Malaysia. It sometimes grows gregariously in pure stands, but it normally occurs with Dipterocarps and Shorea (Sam et al. 2004). It occurs at altitudes of up to 700 m in humid areas with mean annual rainfall of 1,500-2,200 mm and an average annual humidity of 75-85%. The mean annual temperature in areas it grows is 25-27°C. and the dry season in those areas can last for 4-6 months (JICA 2003). In Cambodia, it is found in the northern and eastern parts of the country, including in the semi-evergreen forests in the central part of the PVPF and it grows sparsely in open semi-evergreen and evergreen forests in Preah Vihear, Kratie, Rattanakiri and Mundulkiri provinces. Usually, this species grows with a variety of other dipterocarp species, including *Dipterocarpus alatus, Dipterocarpus costaus, Shorea guiso, and Hopea odorata.*

Uses and products: The wood of this species is used for veneer, plywood, furniture, flooring, interior finishing, ship planking and general construction (Sam et al. 2004). Its wood is easy to saw and its resin has a good odor and is used for caulking ships. It is sometimes planted along streets as a shade tree, as well (Joker 2004).

Current Status: *Anisoptera costata* occurs in semi-evergreen and evergreen forests in the PVPF. Currently, the species is suffering from illegal logging for household consumption. Its natural habitats are being degraded and it may become rare in the PVPF.

4.3.3 Mushrooms

There are at least 42 species of mushrooms growing in the PVPF, including both edible mushroom and non-edible, or toxic, mushrooms, as described in Annex 4.5. Edible mushrooms are natural foods with high nutritious, especially protein, value that are available from May to July for consumption by local communities. In this survey, the edible mushrooms that are collected by local communities which were identified included Termitomuces staiatus, Pholiota nameco, Phset Chheu (*Auricularia polytricha)*, Phset Kngok (*Amanita hemibapha*), Phset Kanchor ,and Phset Phock (*Geastrum triplex*) (Figure 4.4).

Figure 4.4. Phset Chheu (*Auricularia polytricha);* Phset Kngok (*Amanita hemibapha*); and Phset Phock (*Geastrum triplex*).

4.3.4 Edible plants

Some of the plants growing in the natural forests along water coursess in the PVPF can be classified as local vegetables, which are now increasing in value with the increasing awareness of the nutritional advantages associated with eating those plants. Natural vegetables are not only relatively free of toxic substances, but they also have relatively high nutritional values, and can be used as medicinal herbs. There are 107 of those edible species of vegetables growing in the PVPF that are described in Annexes 4.1 through 4.5, 22 of which are collected by local people to meet daily consumption requirements, as well as to sell in markets to generate incomes. Those species include *Cratoxylum formosum; Barringtonia acutangula; Smilax glabra; Curcuma alismatifolia; Arundinaria pusilla; rattan shoots; Albizia lebbeck, Melienthes suavis; Azadiraehta indica; Indigogera galegoides; Dioscoreabrevipetiolata; Alpinia galangal; Dioscoreahispida den; Dioscorea oryzetorum; Dioscorea pentaphylla; Sauropusan drovnus; Kaempteria hamandinna; Sphenoclea zeylanica; Moringa oleifera;* and *Garcinea schomburghiana* (Figure 4.5). *The* fruits of forest trees may also be used as sources of food, which may be collected throughout the year. Those fruits may also be processed and preserved to sell in markets to generate additional income. There are 14 species of fruits that are regularly collected by local communities, including *Willughbeia edulis; Phyllandthus emblica; Baccaurea ramiflora; Schleicheria trijuga; Zizyphus oenopliamill; Artocarpus asperula; Syzygium lineatum; Dialium cochinchinansis; Nephelium hypoleucum; Mitrella mesnyi; Ziziphus jujiba; Euphoria cambodiana; Passiflora foetida;* and *Sandoricum koetjape* (Figure 4.6).

Figure 4.5. M*elalcuca leucadendrom; Azadirachta indica;* and *Careya sphaerica.*

Figure 4.6. *Eugenia sp.; Nephelium hypoleucum;* and *Baccaurea ramifiora.*

4.3.5 Medicinal plants

Medicinal plants are the sources of important medical resources for local communities. Recent research in the Preah Vihear Protected Forest has indicated that 51% of local communities regularly use medicinal plants and 23% of biomedicines and traditional medicines are used in a complementary manner according to interviews that were conducted by a student researcher from the Royal University of Agriculture whose research was supported under the project. Medicinal plants complement the non-timber forest products that once were common throughout a large part of the Preah Vihear Protected Forest. Checklist interviews, the National Research Center for Traditional Medicine (2006), and Dy Phon (2000) have indicated that about 243 of the 432 species of plants present in the Preah Vihear Protected Forest have some part that may be used as traditonal mediicine, as described in Annexes 4.1 through 4.5. Of those species of plants, 46 are collected by traditional doctors and local communities based on their local knowledge. Those species include *Holarrhena curtisii*; *Passiflora foetida*; *Loranthus sp*; *Artocarpus asperula; Afzelia xylocarpa*;,*Bridelia cambodiana; Tetraceara sarnebtosa; Lagerstroemia floribunda*; *Pterocarpus macrocarpus*; *Cananga latifolia; Fagraea fragrans*; *Sauropus androgynous; Diospyros helferi*; *Azadirachla indica; Careya arborea; Pouzolzia zeylenica; Pouzolzia zeylanica*; *Acacia intsia; Dalbergia cochinchinensis*; *Cayratia trifolia*; *Melanorrihoea laccifera*; *Hopea odorata*; *Zizyphus oenoplia; Diospyros nitida; Albizia lebbeck*; *Evonymus cochinchinensis; Spirolabium cambodianum; Bauhiniia malabarica*; *Dalbergia barriensis*; *Banhinia bassacensis*; *Stephania sp; Peltophorum dasyrachis; Dipterocarpus intricatus*; *Shorea obtusa*; *Cinnamomum cambodianum; Alstonia scholaris*; *Albizia corniculata; Dipterocarpus obtusifolius; Lagerstroemia sp; Parinarium annamensis; Irvingia malayana; Artocarpus semperyirens; Xylia dolabriformis*; *Sindora cochinchinensis*; *Dialium cochinchinensis;* and *Aquiaria crassna* (Figure 4.7 and Figure 4.8)

Figure 4.7. *Phyllanthus emblica; Acacia intsia; and Tinospora crispa.*

Figure 4.8 *Leea indica; Tetracera indica;* and *Passiflora foetida.*

4.3.6 Decorative plants

The current number of orchid species known in Cambodia is about 188 (Govaerts et al. 2006). Of those 188 species, 6 are reported in the IUCN Red List of "Threatened Species of Orchids." Those species include *Aerides odorata* (Least Concern), *Cymbidium lancifolium* (Least Concern), *Dendrobium pulchellium* (Vulnerable), *Doritis pulcherrima* (Vulnerable), *Paphiopedilum callosum* (Nearly-Threatened), and *Paphiopedilum villosum* (Nearly-Threatened). The Preah Vihear Protected Forest offers some of the most varied habitats, especially evergreen, semi-evergreen and deciduous forests, for orchids in the northern part of Cambodia, but there is very little information available about orchids in this area because of the limitations of orchid researchers. There are more than 30 orchid species present in the Preah Vihear Protected Forest and of those more than 15 have been observed by the project team, which has brought them from the forest for ex-situ conservation in the Morokut nursery to breed and to request assistance from orchid experts to confirm the identification of each of those species.

This study found that local communities frequently collect orchids from natural forests in the Preah Vihear Protected Forest. The local communities in the Chaom Ksan district use orchids for decoration with collected plants from the wild grown in pots or on trees around homesteads. Some orchids species seen in the market at the Ansef international check point that aresold by local people include *Microsorum punctatum, Drynaria quercifolia, Platycerium cororium, Curcuma sparganiifolia, Helminthostachys zeylanica, Humata angustata, Marsilea quadrifolia,* and *Ochna integerrima* (Figure 4.9).

Figure 4.9. Orchid species collected by local people from the Preah Vihear Protected Forest and sold in the market along the border with Thailand.

4.4 Conclusions and recommendations

4.4.1 Conclusions

The heterogeneity in terms of species composition and distribution of life forms and taxonomic groups in the Preah Vihear Protected Forest that has consistently increased the number of species which are found suggests that the diversity of the canopy flora greatly exceeeds the estimated 432 species. While the surveyed forest areas have been generally disturbed as the result of selective logging activities, those areas are not beyond recovery. The canopies of surveyed areas remain somewhat closed and the conditions for regrowth are favorable, although a complete recovery would take some time. A recovery period of up to 30-100 years seems likely before the forests in the Preah Vihear Protected Forest could be logged again in a sustainable manner. That assesment is based on experience from other parts of Southeast Asia, such as that of the Yayasan Sabah forest concession in which the logging cycle is 30 years if the forest is managed using Reduced Impact Logging practices that leave the forest relatively intact (Glen Reynolds, Royal Society, personal communication). There is a post-logging study in Berau, Indonesia, that has also suggested a recovery period of 96 years after moderate logging of 8.3 trees/ha to achieve 90% of the steady-state density of harvestable dipterocarps (Sist, 2001).

Based on the results of this study, it seems reasonable to conclude that the species diversity of vascular plant species living in the forest canopy of the proposed conservation area of the core zone in the Preah Vihear Protected Forest is high, although further assessment is required to obtain a greater understanding of the number of species. The realization that a large number of canopy plant species still persists in the Preah Vihear Protected Forest in spite of past logging activities indicates that the canopy flora is not under immediate threat of further decline, provided that the forest is not degraded from its present state. It should be recognized, however, that there is no record of the pre-logging species diversity in the Preah Vihear Protected Forest, rendering it difficult to quantify the effects of logging on the canopy flora. Sustainable logging does not necessarily pose a threat to the present overall diversity of the canopy flora, but some ecological changes may only have an effect after a long period of time (Corlett and Turner 1997). It would, therefore, be advisable to continue to monitor the long-term effects of logging on species diversity as a part of management practices.

It would also be advisable to designate forest areas with high conservation value in the Preah Vihear Protected Forest as non-intervention forests to not only provide a reference point for future evaluations of the effects of management practices, but also refuges for species not able to persist in logged forests. There is a representative example of such a high conservation value forest is the Nam Sam forest area in the eastern part of the Kbal Damrey area that contains remnants of such forest with a wildlife corridor and tracts of good wildlife habitat.

4.4.2 Recommendations

- Conduct periodic studies of the current status and dynamics of floral species affected by land use and land cover changes in the PVPF.

- Encourage the planting of trees and other plants that support local livelihoods, such as bamboo, and the cultivation of edible plants, such as mushrooms, to reduce local people's use of wild forest plants.
- Promote forest enrichment planting in natural forest areas of native forest trees provided from nurseries in the PVPF.
- Promote sustainable agriculture and agroforestry in agricultural use zones and community forests in and around the PVPF.
- Increase law enforcement patrols in critical habitats and in areas in which illegal logging, wildlife poaching, and forest clearing and encroachment are more prevalent.
- Strengthen cooperation with local authorities and local communities to deter illegal logging and the incidence of forest clearing and encroachment.
- Intensify campaigns against the illegal trade of endangered floral species and the incidence of forest clearing and encroachment and promote environmental education to strengthen understanding and increase awareness of those activities.
- Increase the number of informal and formal meetings with government officials to strengthen bonds of political support to strengthen biodiversity conservation in the PVPF.
- Encourage household and community investments to support restoration efforts and the establishment of forest plantations to rehabilitate degraded and encroached reclaimed forests, especially in those instances in which natural succession is inadequate to ensure the ecological recovery of those areas.
- Strengthen the capacities of botanists, biologists, and taxonomists by establishing herbariums and supporting the higher education of Cambodia's plant specialists.

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Annex 4.1: List of timber and non-timber species in the Preah Vihear Protected Forest.

No	Khmer Name	Scientific Name	Family	Timber Classification	Habitat			Cambodia Status	CITES	IUCN Red List	Other uses	
					EF	SF	DF				Medicinal Plant	Edible Plant
Forest Tree Species												
1	Kreul	*Melanorrhera laccifera*	Anacarliaceae	L	+	-	-	C			√	
2	Cheung chab	*Dasymaschalon lomentaceum*	Annoceae	L	+	-	-	C				√
3	Neang Nourn	*Disoxylon oliveri*	Caesalpinioideae	L	+	+	-	En		EN	√	
4	Angkanh	*Cassia Siamea*	Caesalpinioideae	L	-	-	+	C			√	√
5	Tra Yeung	*Diospyros pilosanthera*	Ebenaceae	L	+	+	-	C		NE	√	
6	AngkotKmao	*Diospyros bejaudii* Lecomte	Ebenaceae	L	+	+	+	R				
7	Chheu Kmao	*Diospyros spp*	Ebenaceae	L	+	-	-	R	II			
8	Beng	*Afzelia xylocarpa* (Kruz.) Craib	Caesalpinioideae	L	-	+	+	En		EN	√	
9	Chres	*Albizia lebbeck* (L.) Benth	Fabaceae	L	+	+	-	C			√	
10	Kranhoung	*Dalbergia cochinchinensis*	Leguminosae	L	-	-	+	En	II	VU		
11	Tatrav	*Fagraea fragrans*	Loganiaceae	L	+	-	-	R			√	
12	Thnong	*Pterocarpus macrocarpus*, Kurz.	Papilionaceae	L	-	-	+	En		VU	√	
13	Krokoh	*Sindora cochinchinensis*, Baill	Caesalpiniaceae	1	+	++	+	C				√
14	Trasek	*Peltophorum ferruginium*	Caesalpinioideae	1	+	+	+	C			√	
15	Popel	*Hopea recopei*	Caesalpinioideae	1	+	+	+	C			√	
16	Chhlik	*Terminalia tomentosa*	Combretaceae	1	-	-	+++	C			√	
17	Phcheuk	*Shorea obtuse*	Diperocarpaceae	1	-	-	+++	C			√	
18	Koki Dek	*Hopea ahelferi*	Dipterocarpaceae	1	+	+	-	R		CR		
19	Koki Msaov	*Hopea odorata*	Dipterocarpaceae	1	+	-	-	nt		VU	√	
20	Koki Thmor	*Hopea ferrea*	Dipterocarpaceae	1	+	-	-	R		EN		
21	Raing Phnom	*Shorea siamensis*	Dipterocarpaceae	1	+	-	-	C				
22	KraLanh	*Dialium cochinchinensis*	Fabaceae	1	+	-	-	C				√
23	Sroloav	*Lagerstroemia sp.*	Lythraceae	1	+	+	-	C				
24	Yeang	*Chukrasia tabularis*	Meliaceae	1	+	-	-	C				
25	Sokrum	*Xylia dolabriformis*	Minosoideae	1	+	+	-	nt			√	
26	Dounchem	*Heritiera javanica*	Sterculiaceae	1	+	-	-	R				
27	Popol	*Vitex sp*	Verbenaceae	1	+	+	-	C			√	√
28	Popolo Thmor	*Vitex pinnata*	Verbenaceae	1	+	-	-	C			√	
29	Sakaut Tmart	*Stereospermum chelonoides*	Bignoniaceae	1	-	-	+	C				
30	Sampor	*Artocarpus nitidus*	Moraceae	1	-	-	+	C				

No	Khmer Name	Scientific Name	Family	Timber	Habitat						Other uses	
31	Phdeak	*Anisoptera costata*	Diperocarpaceae	2	++	++	-	En		EN	√	
32	Tbeng	*Dipterocarpus obtusifoliius*	Diperocarpaceae	2	-	-	+++	C				
33	Khlong	*Dipterocarpus turberculatus*	Diperocarpaceae	2	-	+	+++	C				
34	Chromas	*Vatica astrotricha*	Diperocarpaceae	2	++	++	+	C				
35	Chheul Teal	*Dipterocarpus altatus*	Diperocarpaceae	2	+++	++	-	C		EN	√	
36	Chheul Teal Thngor	*Dipterocarpus dyeri*	Diperocarpaceae	2	+	-	-	C				
37	Chor Chong	*Shorea vulgaris*	Diperocarpaceae	2	+	+	-	R				
38	Chheul Teal Bangkouy	*Dipterocarpus costatus*	Diperocarpaceae	2	+	-	-	C				
39	Trolatt	*Vatica philastreana,* Pierre	Dipterocarpaceae	2	+	-	-	C				
40	Trach	*Dipterocarpus intricatus*	Dipterocarpaceae	2	-	-	+++	C			√	
41	Koki Ksach	*Hopea pierrei,* Pierre	Dipterocarpaceae	2	+++	-	-	C		CR	√	
42	Lum Bor	*Shorea sp.*	Dipterocarpaceae	2	+++	-	-	C				
43	Chham Chha	*Toona febrifuga.*M.Roem	Meliaceae	2	++	-	-	C				
44	Khvav	*Haldinia cordifolia*	Rubiaceae	2	+++	-	-	C			√	
45	Srokum	*Madhuca major*	Sapotaceae	2	+++	+	+++	C			√	
46	Phcheuk Otdom	*Shorca thorelli,* Pirre	Dipterocarpaceae	2	+	-	-	C			√	
47	Svay Chamreang	*Swintonia pierrei,* Hance	Anacardiaceae	3	+	-	+	C			√	√
48	Svay Prey	*Mangifera indica*	Anacardiacees	3	+	-	+	C			√	√
49	Kray	*Polyalthia cerasoides,*Benth & Hook	Annonaceae	3	+	+	+	C				
50	Bram Damleung	*Terminalia mucronata, Graib ct Huth*	Combretaceae	3	-	-	+++	C				
51	Krobaov	*Hydnocarpus annamensis*	Flacourtiaceae	3	-	+	-	C				
52	Phaong	*Callophyllum sp*	Guttiferae	3	+	+	-	C			√	
53	Tromoung	*Garcinia oliveri,* Pierre	Guttiferae	3	+	+	+	C			√	√
54	Langeang	*Cratoxylon prunifolium,* Dyer	Hypericaceae	3	+++	+++	+++	C			√	√
55	Kandol	*Careya sphaerica,* Pierre	Moraceae	3	-	-	+++	C			√	√
56	Khnol Prey	*Artocarpus chaphash* Roxb	Moraceae	3	+	-	-	C				
57	Sma Krabei	*Knema corticosa,*Lour.	Myristicaceae	3	+	-	++	C			√	
58	Pring	*Eugenia sp.*	Myrtaceaa	3	+	-	-	C			√	
59	Smach	*Melalcuca leucadendrom*	Mytaceae	3	+	+	+	C			√	
60	Tromeng	*Carallia lucida,* Roxb.	Rhizophoraceae	3	+	+++	-	C			√	
61	Thlork	*Parinarium annamensis*	Rosacees	3	+	+	-	C			√	√

No	Khmer Name	Scientific Name	Family	Timber	Habitat						Other uses	
62	Chang ourt thmat	*Vitex pinnata*,L.	Verbenaceae	3	+++	-	-	C			√	
63	Check Tum	*Cinnamomum litsacfolium*, Thw	Lauraceae	3	+	-	-	C			√	
64	Bankoav	*Aglaia cambodiana*, Pierre	Meliaceae	3	+	-	-	C				
65	Bay Pouvaing	*Aglaia spectabilis*,S.K.Jain & Benn	Meliaceae	3	+	-	-	C				
66	Prous	*Garcinia schefferi, Pierre*	Guttiferae	3	+	-	-	C				
67	SamPong	*Tetrameles nudiflora*	Datiscaceae	3	+++	-	+	C			√	
68	Pring Doskrobei	*Syzygium cumini*	Myrtaceae	3	+	+	-	C			√	√
69	Pring Phnom	*Syzygium lineatum*	Myrtaceae	NG	+	-	+++	C				√
70	Ramdoul	*Miliusa mesnyi*	Annonaceae	NG	-	+	+	C			√	√
71	Dork Por	*Markhamia stipulacea pierrei*	Bignoniaceae	NG	+	+	-	C			√	
72	Roka	*Bombax ceiba or Bombax malabaricum*	Bombacacea	NG	+++	+++	-	C			√	
73	Trab Tum	*Crypteronia paniculata*	Crypteroniaceae	NG	+	-	-	C				√
74	Plou Thom	*Dillenia ovata*	Dilleniaceae	NG	+	-	-	C			√	√
75	Phlov Neang	*Cleistanthus tomentosus*	Euphorbiaceae	NG	+	+	-	C				
76	Khos	*Lithocarpus elegans*	Fagaceae	NG	+	-	-	C				√
77	Prous	*Garcinia schefferi*	Guttiferae	NG	+	-	+++	C				
78	Tepirour	*Cinnamomum cambodianum*	Lauraceae	NG	-	-	+	C			√	
79	Snoul	*Dalbergia nigrescens*	Leguminosae	NG	+	-	-	C				√
80	Char	*Butea monosperrna*	Leguminosae - Papilionoidae	NG	-	+	+	C			√	√
81	Chamreark	*Albizia corniculata*	Leguminosae-Mimosoideae	NG	+	-	-	C			√	
82	Trabek Prey	*Lagertroemia floribunda*	Lythraceae	NG	+	-	-	C			√	
83	Sdok Sdol	*Walsura villosa*	Meliaceae	NG	+	+	-	C			√	
84	Lvea Prey	*Ficus hispida*	Moraceae	NG	-	-	+	C			√	√
85	Smach Dom	*Syzygium zeylanicum*	Myrtaceae	NG	+	-	-	C			√	
86	Pong Ro	*Scheicheria trijuga*	Sapindaceae	NG	+	-	-	C			√	√
87	Semorn	*Nephelium hypoleucum*	Sapindaceae	NG	+++	+	-	C				√
88	Savmav Prey	*Nephelium lappaceum*	Sapindaceae	NG	+++	+	-	C			√	√
89	Chambak	*Irvingia malayana*	Simaroubaceae	NG	+	+	+	C				
90	Samrong	*Sterculia lychnophora* Hance.	Sterculiaceae	NG	-	-	+	C				
91	Samrorng	*Scaphium macropodium*	Sterculiaceae	NG	+	-	-	C				√
92	Kropul Buy	*Litsca glutinosa*	Lauraceae	NG	+	+	-	C				

No	Khmer Name	Scientific Name	Family	Timber	Habitat						Other uses	
93	Chhke Sreng	*Cananga latifolia*	Annonaceae	NG	+++	-	-	C			√	√
94	Chor Chhork	*Antiaris toxicaria*	Moraceae	NG	+++	-	-	C			√	√
95	Chhrey Kreum	*Ficus benjamina*	Moraceae	NG	+	-	-	C			√	√
96	Chheu Phleung	*Diopyros hermaphroditica*	Ebenaceae	NG	+++	-	-	C			√	
97	Chheu Romors	*Schima wallichii*	Theaceae	NG	+++	-	-	C			√	
98	Thkov	*Anthocephalus chinensis*	Rubiaceae	NG	+	-	-	C			√	
99	Popel Khe	*Terminalia bialata*	Combretaceae	NG	+	-	-	C			√	
100	Porn	*Spondias pinnata*	Anacardiaceae	NG	-	-	+	C			√	
101	Preah Phnov	*Terminalia triptera*	Combretaceae	NG	+++	-	-	C			√	
102	Sdao	*Azadirachta indica*	Meliaceae	NG	+	-	+	C			√	√
103	Sleng	*Strychnos nux-vomica*	Loganiaceae	NG	+	-	-	C			√	
104	Svay Reanov	*Azadirachta indica*	Rutaceae	NG	+	-	-	C			√	√
105	KanSeng	*Strychnos nux-vomica*	Xanthophyllaceae	NG	+	-	-	C			√	
106	Dangkov Khmoch	*Azadirachta indica*	Ebennaceae	NG	-	-	+	C			√	√
107	Pnheav	*Strychnos nux-vomica*	Euphorbiaceae	NG	+	-	-	C			√	√
108	Khmea	*Maclura cochinchinensis*	Moraceae	NG	+	-	+	C			√	√
109	Chheu Daikhmao	*Wrightia annamensis*	Apocynaceae	NG	+	-	-	C			√	√
110	Talatt	*Canarium album*	Burseraceae	NG	+	-	+	C			√	√
111	Thmear	*Acacia intsia*	Leguminosae-Mimosoideae	NG	+	-	+	C			√	
112	Phnov	*Aegle marmelos*	Rutaceae	NG	+	-	+	C			√	
113	Preah Thlork	*Ellipanthus tomentosus*	Connaraceae	NG	+	-	+	C			√	
114	Lvearng	*Dillenia indica*	Dilleniaceae	NG	+	+	+	C				
115	Raing Teuk	*Barringtonia acutangula*	Lecythidaceae	NG	+	+	+	C			√	√
116	Lve	*Dillenia pentagyna*	Dilleniaceae	NG	+	-	-	C			√	√
117	Sro Mor	*Terminalia chebula*	Combretaceae	NG	-	-	+	C				
118	Ach Kandol	*Diospyros cambodiana*	Ebenaceae	NG	-	+	-	C			√	
119	Daiy Khla	*Wrightia annamensis*	Apocynaceae	NG	-	-	+	C				√
120	Trobek Chou	*Terminalia pierrei*	Combretaceae	NG	+++	-	-	C				
121	Popel Khe	*Alstonia scholaris*	Apocynaceae	NG	++	-	+	C			√	
122	Cheung kor	*Tetracera scadens*	Dilleniaceae	NG	+	-	-	C			√	√
123	Mean Prey	*Aporusa planchoniana*	Euphorbiaceae	NG	+++	-	-	C			√	√
124	Kantourt Prey	*Phyllanthus emblica*	Euphorbiaceae	NG	+++	-	-	C			√	√
125	Krong	*Aporusa filicifolia*, Baill.	Euphorbiaceae	NG	-	-	+++	C			√	

No	Khmer Name	Scientific Name	Family	Timber	Habitat						Other uses	
126	Phlorng	*Memecylon acuminatum*	Melastomaceae	NG	+	-	-	C				
127	Phlorng Chou	*Memecylon edule*	Melastomaceae	NG	+	-	+	C			√	√
128	Sro Ngam	*Tristaniopsis burmannica*	Myrtaceae	NG	+	-	-	C				
129	Lveang	*Cathunaregam tomentosa*	Rubiaceae	NG	+	-	+++	C			√	√
130	Krovann	*Amomum krevanh*	Medical Plant	NG	+	-	+	C			√	
131	Kor Mouy	*Euonymus cochinchinensis*	Celastraceae	NG	+	-	+	C			√	
132	Kram Puk	*Randia uliginosa*	Rubiaceae	NG	+	-	++	C			√	
133	Khmea	*Memecylon edule*	Melastomaceae	NG	+	-	-	C			√	
134	Reiy	*Anogeissus rivularis*	Combretaceae	NG	-	-	+	C				
135	Steav	*Homalium brevidens*	Flacourtiaceae	NG	+++	-	-	C				
136	Angkea sel	*Ochna integerrima*	Ochnaceae	NG	++	-	+	C			√	
137	Krokhub Prey	*Scolopia spinosa*	Flacourtiaceae	NG	++	-	-	C			√	√
138	Kanthom Thet Prey	*Cassia timoriensis*	Leguminosae-Caesalpinioideae	NG	+	-	+	C			√	√
139	Sleng Kong	*Hoarrhena pubescens,Wrightia pubescens*	Apocynaceae	NG	+++	-	+	C			√	
140	ChunLous	*Erioglossum edul, Lepisanthes rubiginosa*	Sapindaceae	NG	+	-	+	C			√	√
141	Chrey Teuk	*Ficus subpyriformis*	Moraceae	NG	+	-	+	C				√
142	Chrey Leap	*Ficus racemosa*	Moraceae	NG	+	+	+	C			√	√
143	ChheuKao	*Murraya paniculata*	Rutaceae	NG	+	+	+	C				
144	Bak Dang	*Gardenia philastrei*	Rubiaceae	NG	+	-	-	C				
145	Brodakk	*Mitrephora maingayi*	Annonaceae	NG	-	-	+	C				√
146	Prich	*Melienthes suavis*	Opiliaceae	NG	-	+	-	C				√
147	Pring Oul	*Syzygium bracteatum*	Myrtaceae	NG	-	-	+	C				√
148	Roleay Chheam	*Lasianthus Kamputensis*	Rubiaceae	NG	+++	-	-	C			√	
149	Roleay Thom	*Neonauclea scssilitlora*	Rubiaceae	NG	+	-	+	C			√	
150	Sang Khor	*Zizyphus oenoplia*	Rhamnaceae	NG	+	-	-	C			√	√
151	Phlaing	*Glycosmis pentaphylla*	Rutaceae	NG	+	-	+	C			√	√
152	Deum Yuthaka	*Randia fasciculata Dc*	Rubiaceae	NG	+	-	-	C			√	
153	Nhor Prey	*Morinda tomentosa*	Rubiaceae	NG	+++	-	+	C			√	
154	Daiy Khla	*Gardenia angkoriensis*	Rubiaceae	NG	+++	-	-	C			√	
155	Tromoung Sek	*Suregada multiflorum*	Euphorbiaceae	NG	+	-	+	C			√	
156	Tromouch	*Antidesma acidum*	Euphorbiaceae	NG	+	-	-	C			√	√
157	Tumpong Phleung	*Croton oblongifoius*	Euphorbiaceae	NG	+	-	+	C			√	

No	Khmer Name	Scientific Name	Family	Timber	Habitat						Other uses	
158	Porphlea	*Grewia asiatica.L*	Tiliaceae	NG	+	-	-	C			√	√
159	Pika or Sromdav	*Oroxylum indicum*	Bignoniaceae	NG	+	-	+	C			√	√
160	Sromor Pipheth	*Terminaha bellirica*	Combretaceae	NG	+	-	-	C			√	

Timber Classification: L= Luxury, 1 = First Grade, 2 = Second Grade, 3 = Third Grade, NG = Non-Grade.

Notes:

1) Habitats: EF = Evergreen Forest; SF = Semi-evergreen Forest; DF = Deciduous Forest.
2) Plant Occurrence: Ù = Present; X = Absent.
3) Cambodia Classification: RS = Rare Species.

Annex 4.2: Shrub plant species.

No	Khmer Name	Scientific Name	Family	Other uses	
Shrub Plant Species				**Medicinal plant**	**Edible Plant**
1	Phnom Phneng	*Hymnocardia wallichii*	Euphorbiaceae		√
2	Snay	*Streblus asper*	Moraceae	√	√
3	KorkTong	*Crotalaria juncea*	Leguminosae	√	√
4	KanhcheuBaydach	*Cappris micracantha*	Capparidaceae	√	√
5	Kantrork Damrey	*Clausena excavata var.*	Rutaceae	√	
6	KanTaing Buysor	*Sida acuta subsp. Acuta*	Malvaceae	√	
7	Kamreuk Kum	*Spirolobium cambodianum*	Apocynaceae	√	
8	Krabei Trork	*Ficus paumila Lim*	Moraceae	√	
9	KroPort Chrouk	*Sida cordifolia*	Malvaceae	√	
10	Ngop	*Sauropus androgynus*	Euphorbiaceae	√	√
11	ChumPouChrolouk	*Bixa orellana*	Bixaceae	√	√
12	Cheu Em	*Albizia myriophylla*	Leguminosae	√	
13	Nhenh	*Petunga roxburghi De*	Rubiaceae	√	
14	Dang Heth	*Cassia alata*	Leguminosae	√	
15	Dash Reach	*Brucea javanica*	Simaroubaceae	√	
16	Dong Preah	*Arenga pinnata*	Palmae	√	
17	Deum Pramath Mnus	*Brucea javanica*	Simaroubaceae	√	
18	TumPaing Bachouprey	*Ampelocissus arachnoidea*	Vitaceae	√	√
19	Damrey Bramdork	*Ploiarium alternifolium*	Theaceae	√	
20	BuyKdaing	*Leea indica*	Leeaceae	√	
21	Pourch	*Rhodomyrtus tomentosa*	Myrtaceae	√	√
22	Preah Khlorb	*Mimosa pudica*	Leguminosae	√	
23	Mrech Tunsay	*Baeckea frutescens*	Myrtaceae	√	
24	Smaov Cheung Toke	*Coldenia procumbens*	Borginacee	√	
25	Ang Krorng	*Zizyphus cambodiana*	Rhamnaceae	√	
26	Anchanh	*Gmelina asiatica*	Vebenaceae	√	√
27	AnTungSor	*Eurycoma longifolia*	Simaroubaceae	√	
28	DangKeabKdam	*Antidesma ghaesembilla*	Euphorbiaceae	√	√
29	KantuyTrokourt	*Phyllodium elegans*	Leguminosae-Papilinoidae	√	
30	Kantrok Samlor	*Murraya koenigii*	Rutaceae	√	√
31	Kantrok Khmoch	*Clausena excavata var. villosa*	Rutaceae	√	
32	Kam Rotesh	*Ixora chinensis*	Rutaceae	√	√
33	Kam RoteshDorng	*Ixora flavescens*	Rutaceae	√	
34	KhtumKork	*Cephalanthus angustifolius*	Rubiaceae	√	
35	Leach Phtous	*Lasianthus hoensis*	Rubiaceae	√	
36	Mchou Preuk	*Embelia ribes*	Myrsinaceae	√	√
37	Tronum kamphen	*Dendrolobium lanceoarium*	Leguminosae-Papilionoidae	√	√
38	Tronum Bangkouy	*Dendrolobium baccatum*	Leguminosae-Papilionoidae		√
39	Preal	*Colona auriculata*	Tiliaceae		
40	PhlouBath	*Dillenia hookeri*	Dilleniaceae	√	√
41	Yi houp	*Mangliatia candollii*	Magnoliaceae		
42	Sangke Prey	*Callicarpa brevipes*	Verbenaceae	√	
43	Snov	*Sesbania javanica*	Leguminosae-Papilionoidae		√

Annex 4.3: Climber and vine species.

No	Khmer Name	Scientific Name	Family	Other uses	
Climber and Vine Species				**Medicinal plant**	**Edible Plant**
1	Vor Kuy	*Willughbeia edulis*, Roxb	Apocynaceae	√	
2	Vor Chuy	*Steptocaulon juventas*	Asclepiadaceae	√	
3	Vor Doh Kun	*Tetracera indica*	Dalleniaceae	√	
4	Vor Meas	*Cassytha filiformis*	Lauraceae	√	
5	Vor Em	*Albizia myriophylla*	Leguminosae-Mimosoideae	√	
6	Vor Yeav	*Stryehnos axillaris*	Logariaceae	√	
7	Vor Bandolpich	*Tinospora crispa*	Menispermaceae	√	
8	Vor Phlou	*Cyclea peltata*	Menispermaceae	√	
9	Vor Sangkhor	*Zizyphus oenoplia*	Rhamnaceae	√	
10	Vor Tumpaing Buychou	*Ampelocissus arachnoidea*	Vitaceae	√	√
11	Vor Khanma	*Ancistrocladus harmandii*	Ancistrocladaceae		
12	Vor Andatt Trokourt	*Aniseia martinicensis*	Convolvulaceae		√
13	Vor AngKreng Angkrorng	*Abrus precatorius*	Papilionoideae	√	
14	Vor Banla Saett	*Acacia concinna*	Mimosoideae	√	
15	Vor Buy damneub	*Acacia thailandica*	Mimosoideae	√	
16	Vor ThmorTeab	*Acacia pennata*	Mimosoideae		
17	Koma Pich	*Stephania rotunda*	Menispemaceae	√	√
18	Kdouch	*Dioscorea hispida*	Dioscoreaeae	√	√
19	Khleng Por	*Bauhinia bassacensis*	Leguminosae	√	
20	Thmenh Trey	*Bridelia cambodiana*	Euphorbiaceae	√	
21	Vor Kor Mouy	*Parameria loevigata*	Apocynaceae	√	
22	Vor Kleb	*Pothos sp*	Araceae	√	
23	Vor Chhaeung Pours	*Jasnitnum scandens*	Oleaceae	√	
24	Vor Chundeusva	*Bauhinia harmandiana*	Caesal piniaceae	√	
25	Vor Tri	*Ichnocarpus frutescens*	Apocynaceae	√	
26	Vor Thmenh Tri	*Ichnocarpus oxypetalus*	Apocynaceae	√	
27	Vor Totong	*Loeseneriella dinhensis*	Hippocrateaceae	√	
28	Vor Treal Sva	*Uvaria rufa*	Annonaceae	√	√
29	Vor RumPours	*Connarus semidecandrus*	Connaraceae	√	
30	Vor Sav mav	*Passiflora foetida*	Passifloraceae	√	√
31	Vor Khnanh	*Lygodium flexuosum*	Schiceaceae	√	
32	Vor AnTong	*Derris elliptica*	Leguminosae	√	
33	Sleng DangDeung	*Gloriosa superba*	Liliaceae	√	
34	Vor Angkhournh	*Entada pursaetha subsp.prusaetha*	Leguminosae-Papilinoidae	√	√
35	Angkhournh Sva	*Bauhinia bassacensis*	Leguminosae-Papilinoidae	√	
36	Brunh Sva	*Archidendron quocense*	Leguminosae-Papilinoidae	√	
37	KroLam Per	*Aganosma marginata*	Apocynaceae	√	√
38	Dam LongChvaprey	*Dioscorea esculenta*	Dioscoreaceae		√
39	Damlong Chrouk	*Dioscorea oryzetorum*	Dioscoreaceae		√
40	Damlong Chheam Meann	*Dioscorea alata*	Dioscoreaceae	√	√
41	Damlong Teuk	*Dioscorea pentaphylla*	Dioscoreaceae		√
42	Damlong Tearn	*Dioscorea brevipetiolata*	Dioscoreaceae		√
43	Vor Cha	*Butea superba*	Leguminosae-Papilinoidae	√	
44	Vor Koury	*Myxopyrum smilacifolium*	Rosaceae	√	
45	Kambor Phnom	*Vallaris solanacea*	Apocynaceae	√	
46	Khnhe	*Mucuna pruriens*	Leguminosae-Papilinoidae	√	
47	Trocheak Tunsay	*Argyreia obtecta*	Convolvulaceae		
48	Trocheak Krash	*Hoya kerrei*	Asclepiadaceae	√	
49	Vor Trodett	*Cayratia trifolia*	Vitaceae	√	
50	Vor Tros	*Combretum trifoliatum*	Combretaceae	√	
51	Treal DohKrobei	*Anomianthus dulcis*	Annonaceae		√
52	Treal Thom	*Rauwenhoffia siamensis*	Annonaceae	√	√
53	Vor Tolprey	*Gymnema sylvestris*	Asclepiadaceae	√	
54	Sleuk Bas	*Coccinia grandis*	Cucubbitaceae	√	√
55	Vor Phorm	*Paederia scandens*	Rubiaceae	√	√

No	Khmer Name	Scientific Name	Family	Other uses	
Climber and Vine Species				**Medicinal plant**	**Edible Plant**
56	PhkaKrodas	*Bougainvillea hybride*	Nyctaginaceae		
57	Pol Ek	*Trichosanthes tricuspidata*	Cucubbitaceae	√	√
58	Mlou	*Piper betle*	Piperaceae	√	√
59	Vor Khnay Morn	*Dalbcrgia horrida var. glaberseceus*	Leguminosae-Papilinoidae	√	
60	Vor Ta Euk	*Merremia hederacca*	Convolvulaceae	√	
61	Vor Ampel Sleuk			√	
62	Vor Taling			√	
63	Vor Chout			√	

Annex 4.4: Palm and bamboo species.

No	Khmer Name	Scientific Name	Family	Other uses	
Palmae Species				**Medicinal plant**	**Edible Plant**
1	Traing	*Carypha umbraculifera*	Palmae	√	
2	Tun Se	*Caryota urens*	Palmae		√
3	Pha Av	*Licuala spinosa*	Palmae	√	√
4	Sla	*Areca catechu*	Palmae	√	√
5	Chak	*Nypa fruticans*	Palmae		√
6	Pdao Teuk	*Calamus godefroyi*	Palmae		
7	Pdao Krek	*Calamus viminalis*	Palmae		
8	Pdao Tresh	*Plectocomia pierreana*	Palmae		
9	Sla Prey	*Areca triandra*	Palmae	√	
10	Pdao Chhaing	*Calamus palustris var. cochinchinensis*	Palmae		√
11	Pdao Soam	*Korthalsia lacinosa*	Palmae		
12	Preah Pdao	*Korthalsia bejaudii*	Palmae		
13	Pdao Snoh or Tresh Anhmorn	*Myrialepis paradoxa*	Palmae		
14	Pdao Dambang	*Calamus rudentum*	Palmae		√
15	Sla Taornn	*Oncosperma tigillarium*	Palmae		√
16	Treak	*Livistonia saribus*	Palmae		
17	Pdao Rampeak	*Calamus salicifolius*	Palmae	√	√
Bamboo Species					
1	Rusey Khley	*Bambusa bambos*	Gramineae		√
2	Rusey Khley Srok	*Gigantochloa albociliata*	Gramineae	√	√
3	Rusey Teu Srokchin	*Bambusa multiplex*	Gramineae		√
4	Rusey Prich	*Arundinaria pusilla*	Gramineae		√
5	Rusey Prey	*Dendrocalamus giganteus*	Gramineae		√
6	Rusey Srok	*Dendrocalamus membranaceus*	Gramineae	√	√
7	Rusey Pinh Pong	*Arundinaria falcata*	Gramineae		√
8	Rusey Keo	*Bambusa vulgaris*	Gramineae	√	√
9	Rusey Thngor	*Bambusa procera*	Gramineae		√
10	Rusey Sach	*Glochidion lanceolarium*	Euphorbiaceae		√
11	Rusey Roleak	*Bambusa blumeana*	Gramineae		√

Annex 4.5: Mushroom species.

No	Khmer Name	Scientific Name	Family	Other uses	
Mushroom				Medicinal plant	Edible Plant
1	Phsett	*Cyathus striatus*	Agaricaceae		
2	Phsett Kngork	*Amanita hemibapha*	Amanitaceae		√
3	Phsett Trocheak Kandol	*Auricularia polytricha*	Auriculariaceae	√	√
4	Phsett	*Auriscalpium vulgare*	Auriscalpiaceae		
5	Phsett	*Leccinellum griseum*	Boletaceae		
6	Phsett	*Phylloporus bellus*	Boletaceae		
7	Phsett Kraing Meas	*Tylopilus balloui*	Boletaceae		
8	Phsett	*Cantharellus cibarius*	Cantharellaceae		
9	Phsett	*Clavaria miyabeana*	Clavariaceae		
10	Phsett Korny	*Calocera cornea*	Dacrymycetaceae		
11	Phsett	*Dacryopinax spathularia*	Dacrymycetaceae		
12	Phsett	*Mollisia cinerea*	Dermateaceae		
13	Phsett	*Hydnotrya tulasnei*	Discinaceae		
14	Phsett	*Porodisculus pendudus*	Fistulinaceae		
15	Phsett	*Ganoderma chalceum*	Ganodermataceae		
16	Phsett Linh Cheuy	*Ganoderma ludidum*	Ganodermataceae		
17	Phsett Phork	*Geastrum triplex*	Geastraceas		
18	Phsett	*Gomplus floccosus*	Gomphaceae		
19	Phsett	*Hydnum repandum*	Hydnaceae		
20	Phsett	*Hygrocybe cantharellus*	Hygrophoraceae		
21	Phsett	*Crustodontia chrysocreas*	Incertae sedis		
22	Phsett	*Rigidoporus microporus*	Meripilaceae		
23	Phsett	*Abortiporus biennis*	Meruliaceae		
24	Phsett	*Stereopsis burtiana*	Meruliaceae		
25	Phsett	*Xeromphalina tenuipes*	Mycenaceae		
26	Phsett Ambosh	*Lentinus sajor-caju*	Polyporaceae		√
27	Phsett Chromash	*Lentinus squarrosulus*	Polyporaceae		√
28	Phsett	*Microporus affinis*	Polyporaceae		
29	Phsett	*Microporus xanthopus*	Polyporaceae		
30	Phsett	*Pycnoporus coccineus*	Polyporaceae		
31	Phsett	*Trametes suaveolens*	Polyporaceae		
32	Phsett	*Trametes trogii*	Polyporaceae		
33	Phsett	*Psathyrella candolleana*	Psathyrellaceae		
34	Phsett	*Lactarius volemus*	Russulaceae		
35	Phsett	*Russula japonica*	Russulaceae		
36	Phsett	*Scleroderma columnare*	Scleromataceae		
37	Phsett	*Stereum ostrea*	Stereaceae		
38	Phsett	*Gymnopilus liquiritiae*	Strophariaceae		
39	Phsett	*Daldinia concentrica*	Xylariaceae		
40	Phsett	*Xylaria filiformis*	Xylariaceae		
41	Phsett	*Xylaria longipes*	Xylariaceae		
42	Phsett	*Xylaria mellissii*	Xylariaceae		

Annex 4.6: Spermatophytes and pteridophytes.

No	Khmer Name	Scientific Name	Family	Other uses	
Spermatophytes				**Medicinal plant**	**Edible Plant**
1	Kor Pramneum	*Goniothalamus laoticus*	Annonaceae	√	
2	BroLao Amper	*Aganosma marginata*	Apocynaceae	√	√
3	Smao Kantuy Kamprok	*Uraria lagopodioides*	Leguminosae - Papilionoidae	√	
4	Smao Chunchean	*Paspalum commcrsonii*	Gramineae	√	
5	Smao Chumpou	*Carthamus tinctorius*	Compositae	√	
6	Smao Cheung Krass	*Eleusine indica*	Poaceae	√	
7	Smao Cheung Kok	*Lindernia crustacean*	Scrophulariaceae	√	
8	Smao Thnok Teuk	*Xyris indica*	Xyridaceae	√	
9	Trokoun Beung	*Ipomoea aquatic*	Convolvulaceae	√	√
10	Vor Sdom Prey	*Dioscorea bulbifera*	Dioscoreaceae	√	√
11	Smao Ruy	*Vemonia cincrea*	Compositae	√	
12	San Seum Doch	*Drosera indica*	Droseraceae	√	
13	An Takk RuyPhka Sor	*Drosera peltata*	Droseraceae		
14	Sang Keuch	*Impatiens relaxata*	Fabaceae	√	
15	Chang Krorng SvaSleuk Bram	*Crotalaria quinquefolia*	Leguminosae - Papilionoidae	√	
16	Tronum Ban Kouy	*Dendrolobium lanceolatum*	Fabaceae		
17	Chang Kesh Angkrorng	*Tadehagi triquetrum*	Fabaceae	√	
18	Trum Khmoch	*Tephrosia purpurea*	Fabaceae	√	√
19	Cho Hook	*Uraria crinite*	Fabaceae	√	
20	Smao	*Canscora andrographioides*	Gentianaceae		
21	Smao	*Cracosna xyridiformis*	Gentianaceae		
22	Pulvea or Brovek	*Strychnos nux-blanda*	Loganiaceae		
23	Kamping Pouykork	*Catharanthus roseus*	Lythraceae	√	
24	Smao	*Rotala wallichii*	Lythraceae		
25	Kobas prey	*Hibiscus tiliaceus*	Malvaceae	√	
26	Nhenh Bath	*Melastoma saigonense*	Melastomaceae	√	
27	Tabun	*Xylocarpus granatum*	Meliaceae		
28	Chhnok Batt	*Ardisia helferiana*	Myrsinaceae	√	
29	Prolett	*Nymphaea nouchali*	Nympheaeceae		√
30	Chheam Antong	*Gomphia serrata*	Ochnaceae	√	
31	Kamping Puyteuk	*Ludwigia adscendens*	Onagraceae	√	√
32	Smao	*Anthogonium gracile*	Orchidaceae		
33	Smao	*Dendrobium ellipsophyllum*	Orchidaceae		
34	Smao	*Dendrobium pseudotenellum*	Orchidaceae		
35	Smao	*Eria Panea*	Orchidaceae		
36	Champos Tea	*Cyanotis cristata*	Commelinaceae	√	
37	KanTraing Hekrohum	*Polygonum chinense*	Polygonaceae		
38	KanTraing He	*Polygonum tomentosum*	Polygonaceae	√	√
39	Smao Angkam (Smao Dek)	*Darsilanthus disjunctus*	Restionaceae		
40	Smao	*Mimulus orbicularis*	Scrophulariaceae		
41	Sambok Cheas	*Helicteres angustifolia*	Sterculiaceae		
42	Kantuy Kamprok	*Helicteres hirsute*	Sterculiaceae		
43	Smao Krochao (Krocheb)	*Melochia corchorifolia*	Sterculiaceae		
44	Popork Rosatt	*Waltheria indica*	Sterculiaceae		
45	So Phii	*Anneslea fragrans*	Theaceae		
46	Preal Chulous or Preal Vinh Kse	*Colona auriculata*	Tiliaceae		
47	Krochork Andeuk	*Curcuma sparganiifolia*	Zingiberaceae		√
48	Krokor Sbatt	*Elettaria cardamornum*	Zingiberaceae	√	√
49	Smao Krochork	*Impatiens balsamina*	Balsaminaceae	√	
50	KroKor Prey	*Hedychium coccineum*	Zingiberaceae	√	√

No	Khmer Name	Scientific Name	Family	Other uses	
Pteridophytes				**Medicinal plant**	**Edible Plant**
1	Bandett	*Humata angustata*	Davalliaceae		
2	Sroka Chrass	*Humata repens*	Davalliaceae		
3	Sourng Sang	*Dicranopteris linearis*	Gleicheniaceae		
4	Kantury Kngork	*Helminthostachys zeylanica*	Ophioglossaceae		
5	PorProk SleukTouch	*Drynaria rigidula*	Polypodiaceae		
6	PorProk	*Drynaria quercifolia*	Polypodiaceae	√	
7	Srom Dav	*Microsorum punctatum*	Polypodiaceae	√	
8	Samnum Preahream	*Platycerium cororium*	Polypodiaceae		
9	Sambok Sromoch	*Lecanopteris sinuosa*	Polypodiaceae		
10	Bangorng Cheat	*Loxogramme avenia*	Polypodiaceae		
11	Brang Teuk	*Acrostichum aureum L*	Adiantaceae	√	
12	Chork Toch	*Salvinea cucullata*	Salviniaceae	√	
13	Chantul Phnom	*Marsilea quadrifolia*	Marsileaceae	√	
14	BroMoy Damrey	*Bolbitis copelandii*	Asplen Iaceae	√	
15	Banheu Kaek	*Viscum articulatum*	Loranthaceae	√	
16	Banheu Kaek Thom	*Scurrula ferruginae*	Loranthaceae	√	
17	Oh Kide	**(More than 30 Species)**			

INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST

CHAPTER V

THE DISTRIBUTION OF LANDSCAPE WILDLIFE SPECIES

CHHEANG DANY, DENNIS CENGEL, PANG PHANIT, KIM SOBON, SAY SINLY, LIM SOPHEAP and YOU KIMLENG

SUMMARY

The Cambodia Forestry Administration, in cooperation with the Cat Action Treasury from 1998 to 2005 and the Wildlife Conservation Society from 1999, and in Phase II (2008-2010) and Phase III (2012-2016) of the ITTO Emerald Triangle Trans-boundary Biodiversity Conservation project, has conducted several biodiversity surveys in the Preah Vihear Protected Forest (PVPF). The cumulative results of those surveys have documented the presence of a fauna that is probably unique in Southeast Asia with regard to its representation of species of dry dipterocarp forests and other habitats, many of which are in rapid decline elsewhere in the region. There are at least 57 mammal species, more than 255 bird species, and 58 reptile species that have been documented. Indeed, the PVPF is either a last refuge for, or maintains important populations of 23 Critically Endangered and Endangered species from the International Union for the Conservation of Nature (IUCN) Red List. This diversity does not mask the disappearance of several animal species that formerly occurred in the Preah Vihear Protected Forest, including the Asian Two-horned Rhinoceros (*Dicerorhinus sumatrensis*), the Lesser One-horned Rhinoceros (R*hinoceros sondaicus*), which was last observed in the 1930s, and Kouprey (*Bos sauveli*) and Wild Water Buffalo (*Bubalus bubalis*), both of which were apparently extirpated by 1964.

The initial step of the process used to distinguish landscape wildlife species in the Preah Vihear Protected Forest was determined by the relative weighting of several factors, including the relative frequency of occurrence of individual wide-ranging landscape wildlife species in and around the PVPF; the social and/or economic importance of each species to local communities and relative to their regional, national and international distributions; and the extent to which each species represents, or is an indicator of, the biodiversity of the area. Those criteria resulted in the initial selection of 11 mammal, 10 avian and 1 reptile landscape wildlife species, which are presented with their International Union for the Conservation of Nature (IUCN) Red List classifications. Of the 22 landscape wildlife species selected, 10 of the 11 mammals - including the Asian Elephant (*Elephas maximus*), Banteng (*Bos javanicus*), Tiger (*Panthera tigris*), Gaur (*Bos gaurus*), Pileated Gibbon (*Hylobates pileatus*), Sambar (*Rusa unicolor*), Sumatran (Southern) Serow (*Capricornus sumatraensis*), Leopard (*Panthera pardis*), Golden Jackal (*Canis aureus*), and Wild Boar (*Sus scrofa*), as well as 3 of the 10 birds – including the Green Peafowl (*Pavo muticus*), White-winged Duck (*Asarcornis scutulata*), and Siamese Firebird (*Lophura diardi*) - and the 1 reptile – the Siamese Crocodile (*Crocodylus siamensis*) - were classified as landscape wildlife species that are present in each of the three countries of the Emerald Triangle Protected Forests Complex. It was to facilitate species-specific comparisons across the three countries that the distributions of those 14 landscape wildlife species are presented in this report.

There are considerable amounts of information that have been collected on landscape wildlife species in the PVPF and the most important recommendation resulting from this study is that efforts should continue to apply the results presented on these distributions to achieve trans-boundary biodiversity conservation throughout the Emerald Triangle Protected Forests Complex.

CHAPTER V

THE DISTRIBUTION OF LANDSCAPE WILDLIFE SPECIES

5.1 Introduction

This chapter provides descriptions of the current distributions of landscape wildlife species in the Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation (PVPF) in Cambodia. The PVPF, which is located in northern Cambodia and borders Thailand and Lao PDR, is an area that supports high biodiversity associated with seasonally dry dipterocarp forests. The area has been surveyed for important wildlife species starting in 1998 (in collaboration with the Wildlife Conservation Society) and this report summarizes that material and the results of the studies conducted under the ITTO Emerald Triangle Trans-boundary Biodiversity Conservation project, as well as other projects in which related wildlife data have been compiled.

5.1.1 The path to effective trans-boundary biodiversity conservation

The production of the maps that depict the current distributions of landscape wildlife species in the PVPF presented in this report represents the completion of several of the steps of the process that contributes to the achievement of the project's objective of trans-boundary biodiversity conservation (Figure 1). The conceptual structure describing the prospective path to conservation provides for the three countries – Cambodia, Thailand, and Lao PDR - to continue to manage their parts of the Emerald Triangle Protected Forests Complex autonomously, but to endeavor to share information and data and collaborate to develop a unified trans-boundary management framework to conserve regional biodiversity.

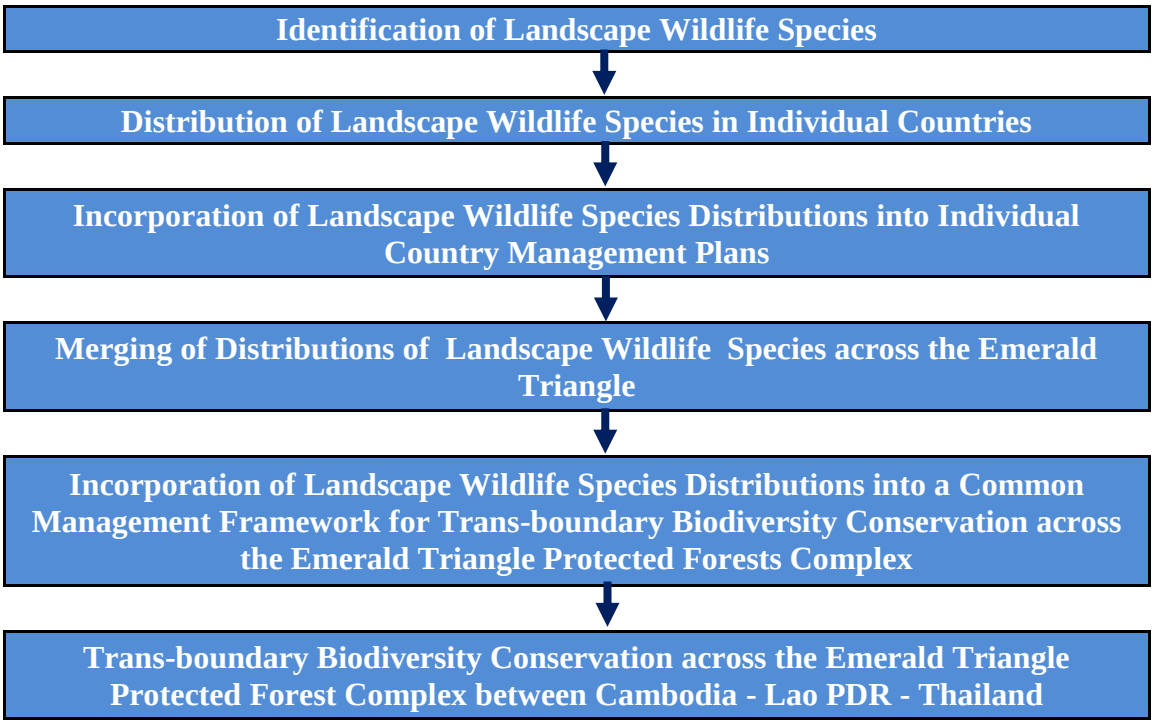


Figure 5.1. The path to effective trans-boundary biodiversity conservation.

- ***Identification of Landscape Wildlife Species***

The initial step of the process to distinguish landscape wildlife species in the PVPF was determined by the relative weighting of several factors, including the relative frequency of occurrence of individual wide-ranging landscape wildlife species in and around the PVPF; the social and/or economic importance of each species to local communities and relative to their regional, national and international distributions; and the extent to which each species represents, or is an indicator of, the biodiversity of the area.

Those criteria resulted in the initial selection of 11 mammal, 10 avian and 1 reptile landscape wildlife species, which are presented with their International Union for the Conservation of Nature (IUCN) Red List classifications, in Table 5.1. Comparable criteria resulted in the selection of 17 and 18 landscape wildlife species in the Pha Taem Protected Forest Complex in Thailand and the Dong Kangthung Protected Forest in Lao PDR, respectively (Bhumpakphan 2015). Of the 22 landscape wildlife species selected in the PVPF, 10 of the 11 mammals - including the Asian Elephant (*Elephas maximus*), Banteng (*Bos javanicus*), Tiger (*Panthera tigris*), Gaur (*Bos gaurus*), Pileated Gibbon (*Hylobates pileatus*), Sambar (*Rusa unicolor*), Sumatran (Southern) Serow (*Capricornus sumatraensis*), Leopard (*Panthera pardis*), Golden Jackal (*Canis aureus*), and Wild Boar (*Sus scrofa*), as well as 3 of the 10 birds – including the Green Peafowl (*Pavo muticus*), White-winged Duck (*Asarcornis scutulata*), and Siamese Firebird (*Lophura diardi*) - and the 1 reptile – the Siamese Crocodile (*Crocodylus siamensis*) - were classified as landscape wildlife species that are present in each of the three countries of the Emerald Triangle Protected Forests Complex. It was to facilitate species-specific distributional comparisons across the three countries that the distributions of those 14 landscape wildlife species are presented in this report.

- ***Distribution of Landscape Wildlife Species in Individual Countries***

The succeeding step in the process was to determine the distributions of the selected landscape wildlife species in the Emerald Triangle Protected Forests Complex. There was a series of maps that was produced with known species distributions for each country, which was based on various sources of data.

- ***Incorporation of Landscape Wildlife Species Distributions in Individual Country Management Plans***

The initial information on the distributions of landscape wildlife species in and around the PVPF was incorporated into the 'Management Plan 2010-2014' (Cambodia Forestry Administration 2010) to inform the decision-making process. The updated distributions presented in this report were used to revise and update the 2016-2020 management plan of the PVPF. Comparable information was incorporated into the management plan for the Pha Taem Protected Forest Complex in Thailand, although similar data have not yet been used to inform decision-making processes in the Dong Kangthung Protected Forest in Lao PDR.

- ***Merging of Distributions of Landscape Wildlife Species across the Emerald Triangle and Incorporation into a Common Management Framework for Trans-boundary Biodiversity Conservation***

The concluding steps of the process are the most challenging since their ultimate achievement will require strengthened cooperation and coordination, not only among resource managers involved with the resolution of technical matters, but also among regional and national governments. The success of these collaborative efforts will result in the adoption of a common management framework with shared actions to be applied across the Emerald Triangle Protected Forests Complex to conserve biodiversity. The representative merging of wildlife distributional data across the region is exemplified in actions that were undertaken in the third phase of the project, in which data from the three countries were modeled and used to predict the distributions of 12 wildlife species, including 9 mammal and 3 avian species, under projected socioeconomic conditions in the Emerald Triangle Protected Forests Complex.

Table 5.1. Landscape wildlife species selected in the Preah Vihear Protected Forest.

English name	**Scientific name**	**IUCN status**
Mammals		
Asian Elephant*	*Elephas maximus*	Endangered
Banteng*	*Bos javanicus*	Endangered
Eld's Deer	*Rucervus eldii*	Endangered
Tiger*	*Panthera tigris*	Endangered
Gaur*	*Bos gaurus*	Vulnerable
Pileated Gibbon*	*Hylobates pileatus*	Vulnerable
Sambar*	*Rusa unicolor*	Vulnerable
Sumatran (Southern) Serow*	*Capricornis sumatraensis*	Vulnerable
Leopard*	*Panthera pardus*	Near-Threatened
Golden Jackal*	*Canis aureus*	Least Concern
Wild boar*	*Sus scrofa*	Least Concern
Birds		
Giant Ibis	*Thaumatibis gigantea*	Critically Endangered
White-rumped Vulture	*Gyps bengalensis*	Critically Endangered
Greater Adjutant	*Leptoptilos dubius*	Endangered
Green Peafowl*	*Pavo muticus*	Endangered
White-winged Duck*	*Asarcornis scutulata*	Endangered
Sarus Crane	*Antigone antigone*	Vulnerable
Lesser Adjutant	*Leptoptilos javanicus*	Vulnerable
Black-necked stork	*Ephippiorhynchus asiaticus*	Near-Threatened
King Vulture	*Sarcoramphus papa*	Least Concern
Siamese Fireback*	*Lophura diardi*	Least Concern
Reptiles:		
Siamese Crocodile*	*Crocodylus siamensis*	Critically Endangered

*Note: The species that are present in each of the three countries are designated with an *.*

5.1.2 The Preah Vihear Protected Forest

The PVPF is located between 13°51'19" and 14°25'01" north latitude and 104°51'42" and 105°47'04" east longitude (Map 2.1 in chapter 2). It has a land surface of 190,027 ha dominated by forests, particularly dry dipterocarp deciduous forests, which in the most recent assessment of forest cover in 2014 accounted for more than 59 % of land cover. There are three principal forest cover types (evergreen, semi-evergreen, and deciduous) and between 2002 and 2014, the forest area of the PVPF declined by more than 6%, although evergreen forest increased, and forest continues to account for more than 91% of land cover as described in chapter I (Table 1.9, Figure 1.3).

The PVPF is situated in a lowland area crossed by the steep Dangrek Mountain Range along the border with Thailand in the northwest that results in a gradually decreasing slope toward the southeast. The highest altitude is 766 m and the lowest is 66 m. The climate is dry tropical monsoon with most precipitation occurring during the rainy season from April to October. The average annual rainfall is more than 1,500 mm; the average temperature is 33^0 C.

The PVPF, which was established on 30 July 2002, forms part of the Indo-Burma Biodiversity Hotspot, which is 1 of 35 designated Global Biodiversity Hotspots (Critical Ecosystem Partnership Fund 2015). It contains the most extensive remaining continuous natural forest of a unique landscape with exceptional global importance for biodiversity in Southeast Asia and is 1 of 9 Biodiversity Corridors in the Greater Mekong Sub-region. The diversity of plant communities forms a mosaic of ecosystems that provides habitats for several threatened and endangered wildlife species. The PVPF is probably the most important site worldwide for the critically endangered Giant Ibis (*Thaumatibis gigantea*), as well as the most important site in Southeast Asia for three critically endangered vultures: the White-rumped Vulture (*Gyps bengalensis*); Slender-billed (or Long-billed) Vulture (*Gyps tenuirostris*); and Red-headed Vulture (*Sarcogyps calvus*). The area also has important populations of Asian Elephant, Banteng, Eld's Deer (*Rucervus eldii*), Fishing Cat (*Prionailurus viverrinus*), Dhole (*Cuon alpinus*) and White-winged Duck, each of which is endangered or vulnerable. Other endangered or vulnerable species include Gaur, Northern Pig-tailed Macaque (*Macaca leonine),* Green Peafowl, and Sarus Crane (*Antigone antigone*).

The Cambodia Forestry Administration (formerly the Cambodia Department of Forestry and Wildlife), in cooperation with the Cat Action Treasury from 1998 to 2005 and the Wildlife Conservation Society from 1999, and in Phase II (2008-2010) and Phase III (2012-2016) of the ITTO Emerald Triangle Trans-boundary Biodiversity Conservation project, has conducted several biodiversity surveys in the PVPF. The cumulative results of those surveys have documented the presence of a fauna that is probably unique in Southeast Asia with regard to its representation of species of dry dipterocarp forests and other habitats, many of which are in rapid decline elsewhere in the region (Table 5.2). There are at least 57 mammal species, more than 255 bird species, and 58 reptile species that have been documented in the PVPF. Indeed, the PVPF is either a last refuge for, or maintains important populations of 23 Critically Endangered and Endangered species from the International Union for the Conservation of Nature (IUCN) Red List. This diversity does not mask the disappearance of several animal species that formerly occurred in the Preah Vihear Protected Forest, however, including the Asian Two-horned Rhinoceros (*Dicerorhinus sumatrensis*), the Lesser One-

horned Rhinoceros (R*hinoceros sondaicus*), which was last observed in the 1930s, and Kouprey (*Bos sauveli*) and Wild Water Buffalo (*Bubalus bubalis*), both of which were apparently extirpated by 1964.

Table 5.2. Numbers of wildlife species reported country-wide and in the Preah Vihear Protected Forest in 2010 and 2014.

Class	**No. of species (Cambodia) 2010-2014**	**No. of species (relative % in the Preah Vihear Protected Forest) 2014**
Mammals	125-135	> 57 (42%)
Birds	540-635	>255 (40%)
Reptiles	73-95	58 (61%)
Amphibians	62-65	No formal study conducted
Insects	> 400	No formal study conducted

5.2 Methods

5.2.1 Baseline information

Baseline information on the distribution of mammal and avian landscape wildlife species in the PVPF was accumulated through various sources, including:

- Ground surveys conducted through the Cambodia Wildlife Protection Office (now the Cambodia Department of Wildlife and Biodiversity) in the Forestry Administration in collaboration with the Cat Action Treasury from 1998-2005, the Wildlife Conservation Society from 2004-2008, and under the second phase of the ITTO 'Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos' project from 2008 to 2010. Individual observations of species were incorporated into spatial GIS representations and output on maps prepared by the Cambodia Wildlife Protection Office;
- The 'Management Plan 2010-2014' for the PVPF, which incorporates species distribution maps and provides checklists of mammals, birds and reptiles present in the PVPF; and
- Literature reviews and specialized wildlife guidebooks that were produced, particularly 'A Guide to the Mammals of Cambodia' (Men et al. 2008), that provide overviews of distributions of wildlife species in Cambodia.

5.2.2 Data collection

The updating of the baseline information on the distribution of the landscape wildlife species was accomplished during the third phase of the project by establishing 40 2-3 km transect lines that passed through various wildlife habitats in the PVPF and its buffer areas in Chhaep

and Choam Khsant districts. Ten of those transect lines were established between the villages of Kakheuk and Prey Prah Rokar; ten between Kakheuk and Kbal Damrey; and 20 others within the core zone of the PVPF in the Nam Sam area. The lines were traversed monthly 2-4 times by 2-5 project staff assisted by undergraduate students from the Royal University of Agriculture and Prek Leap National College of Agriculture under the supervision and support of the project. The information provided from camera traps used to survey and detect wildlife species in the PVPF under a complementary project initiated in 2013 and supported by JICA and implemented by the Wildlife Conservation Society was used to supplement the baseline information. The camera trapping component, which used 70 cameras that were periodically moved to different locations, covered about 35,000 hectares of the PVPF.

The sources of acceptable evidence of the presence of wildlife species included signs and direct observations collected by means of:

- Spotlighting, tracks, droppings, hair snags and photographs from remote cameras for mammals (excluding bats);
- Irregular morning and evening observations conducted by project field staff and opportunistic visual sightings of birds; and
- Searches by rock rolling, tree bark removal and displacement of fallen timber, as well as opportunistic sightings, for reptiles.

The collected data were verified by the following means:

- Specialized wildlife guidebooks and checklists were used to reference animal ranges and corroborate identification of those wildlife species that were observed.
- Specialized wildlife guidebooks and checklists were used to confirm the identification of the species that were captured in the photographs from camera traps.
- In planned consultations with local villagers during community livelihood project activities, the specialized wildlife guides and checklists were used to confirm and update the presence of wildlife species in areas near the villages. The consultations were designed to provide a sample of 90 household interviews conducted in 9 villages in the PVPF, particularly in O Chunh, Robunh, Trapeang Prey, Sen Dekchas, Kbal Dam Rey and Sen Rung Reung 3-4 villages, as well as in the Nam Sam area.

5.3 Results

5.3.1 Individual species accounts

The distributions and other pertinent information that is provided on the 14 selected landscape wildlife species in the PVPF are subdivided by mammal, avian, and reptile species and within each of those subdivisions presented in the order of the status of each species' current assessment as reported in the IUCN Red List (i.e., Critically Endangered, Endangered, Threatened, Vulnerable, and Near-Threatened to Least Concern). Those descriptions are interspersed with accounts of other important wildlife species in the PVPF, as well.

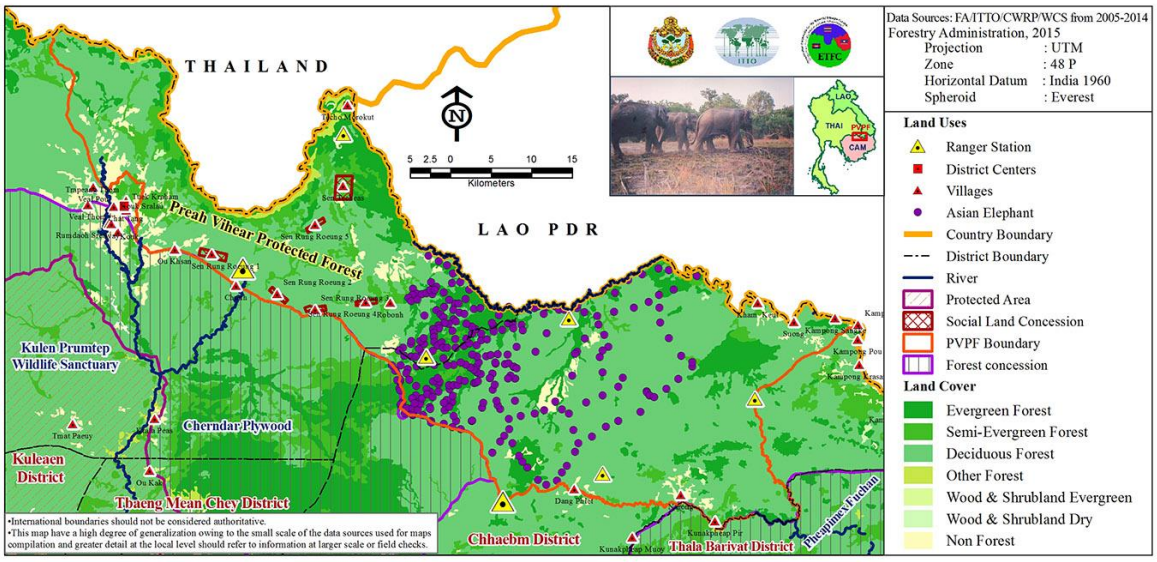
5.3.1.1 Mammals

Asian Elephant (*Elephas maximus*)

There are numerous records of Asian Elephant in every season indicating that it is resident year-round in the PVPF, although the number of individuals (5) is considerably smaller than

in the Thailand-Lao PDR border region (45-50). Considering that the habitats in the areas adjoining the PVPF are similar to those within its boundaries, it is probable that Asian Elephants from the PVPF cross the international border into Lao PDR.

The Asian Elephant population in the PVPF may have been connected previously to that in the Kulen Promtep Wildlife Sanctuary through the previously suspended Cherndar forest concession, but there is no evidence to suggest that it still moves into that area. Its range may have changed to some extent in recent years, perhaps as the result of hunting and other disturbances, but surveys and patrolling efforts vary across years and available meteorological information is insufficient to assess the effects of rainfall on movements of Asian Elephant.

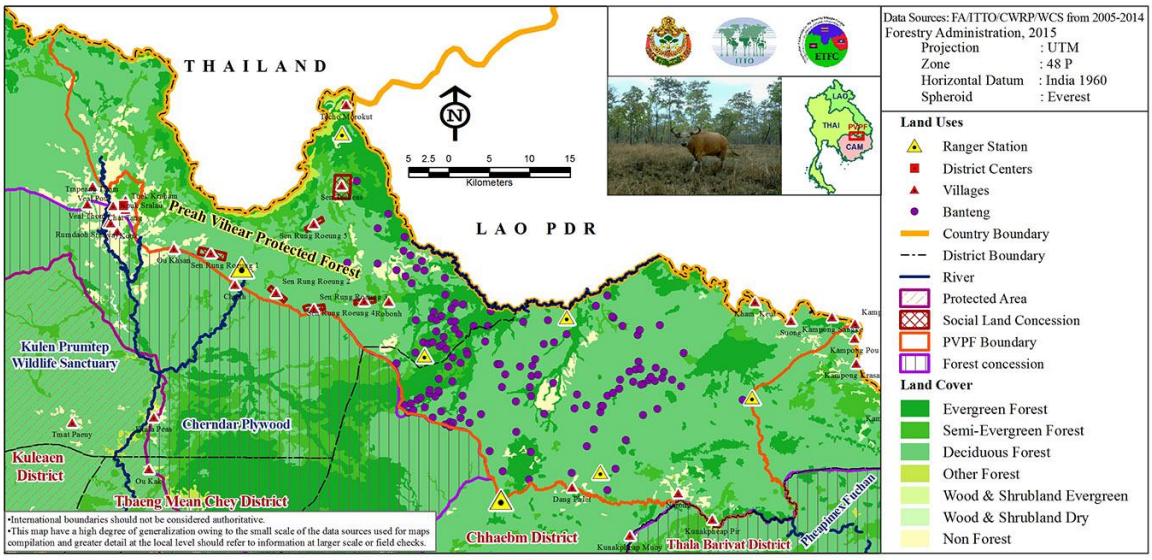


Map 5.1. Distribution of Asian Elephant in and around the Preah Vihear Protected Forest.

Banteng (*Bos javanicus*)

Banteng are widespread across the PVPF and the area of the previously suspended Cherndar Plywood forest concession. They are observed relatively frequently by means of camera traps, tracks, and through direct observation. Banteng prefer more open forest than gaur and this might also be the case in the Preah Vihear Protected Forest. Sufficient information on abundance is not yet available, but the PVPF is almost certainly of international importance in supporting efforts to conserve this species. Banteng have disappeared from most of the rest of

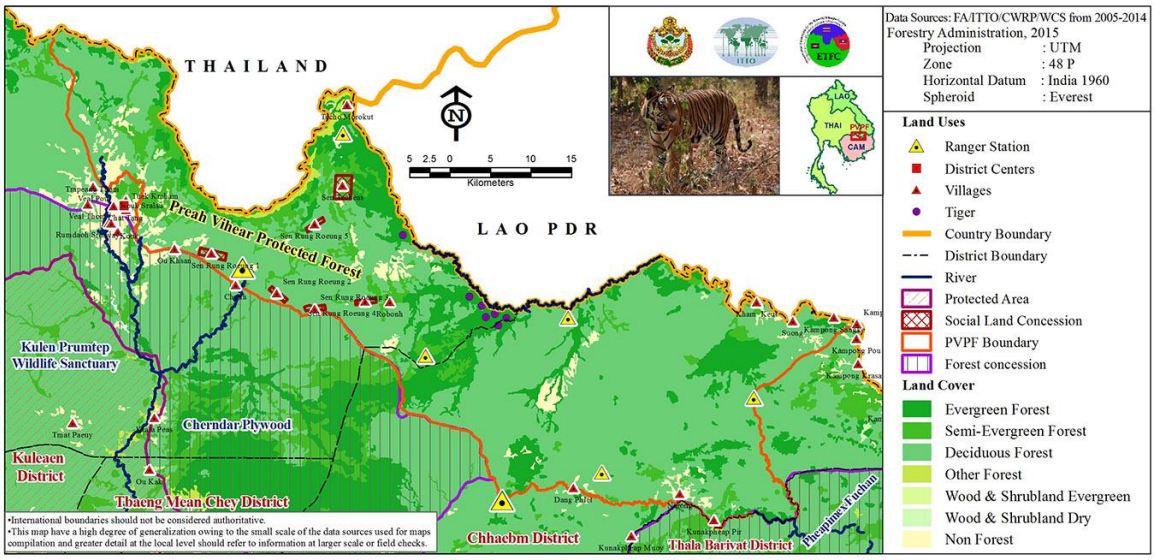
its range in Southeast Asia and it is only in the northern and eastern plains of Cambodia that the species continues to be relatively widespread. Fragmented populations elsewhere occur in only limited areas of its former distribution. Enforcement activities to control hunting and deforestation are the most important safeguards for protecting remaining Banteng in the PVPF.



Map 5.2. Distribution of Banteng in and around the Preah Vihear Protected Forest.

Tiger (*Panthera tigris)*

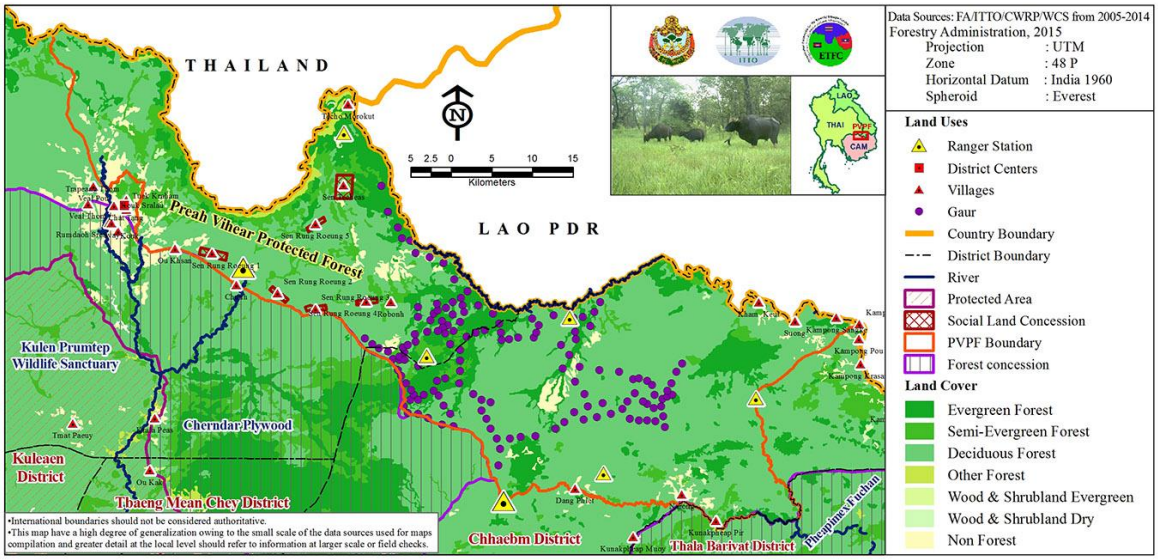
The Indochinese Tiger, *Panthera tigris corbetti*, occurs in Myanmar, Thailand, Lao PDR, Vietnam, Cambodia and southwestern China. It was considered as recently as the 1980s-1990s to be widespread throughout the region, but "vast areas of Southeast Asia [were] recently found to be void of tigers and depleted of prey by hunters (IUCN 2015a)." In the PVPF, there have been no confirmed observations of tigers since 2005 (Cambodia Wildlife Research Program 2002; Wildlife Conservation Society 2008; Cambodia Forestry Administration 2014). Tiger Range States Government estimates of national populations currently surpass 350 (Thailand - 200; Myanmar - 85; Cambodia - 20; Vietnam - 20 and Lao PDR - 17), but those estimates are mostly speculative and the number of tigers in confirmed, protected populations in these countries is considered to be substantially lower (202) with most of the animals in Thailand (185). There is no current evidence of breeding tigers in either Cambodia or Vietnam. Moreover, Myanmar has only one potentially viable population and Lao PDR has but a single confirmed population that consists of less than 20 mature individuals.



Map 5.3. Distribution of Tigers in and around the Preah Vihear Protected Forest.

Gaur (*Bos gaurus*)

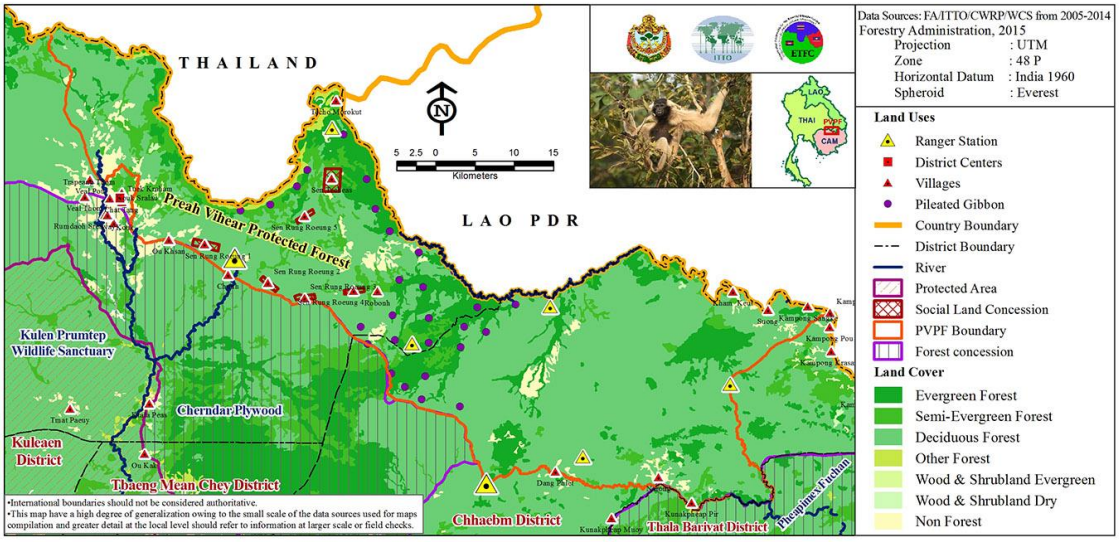
Gaur are most common in the central part of the PVPF and in the area of the previously suspended Cherndar forest concession. This may be the result of selection by Gaur of evergreen, semi-evergreen and riverine forests, which are most abundant in those areas. Gaur have been recorded relatively frequently during annual large mammal surveys in the PVPF, although data that have been collected have not yet facilitated population estimates. Gaur have a wider global distribution, but may be even more threatened in Southeast Asia than Banteng and have disappeared from much of their former range. The population of Gaur in the PVPF is interconnected to other sites in the northern and eastern plains of Cambodia and, as a result, the PVPF is considered to be of international importance for the conservation of this species.



Map 5.4. Distribution of Gaur in and around the Preah Vihear Protected Forest.

Pileated Gibbon (*Hylobates pileatus*)

The distribution of the Pileated Gibbon is restricted to forests in southeast Thailand and Cambodia that extend to the Mekong River (Brockelman 1975; Brockelman and Gittins 1984; Marshall and Sugardjito 1986) and, as a result, its range is relatively limited and its distribution within that range is decreasing as the area of forest declines. If deforestation trends persist, it is probable that Pileated Gibbons in Cambodia, as in Thailand, will be confined to protected forests. The Pileated Gibbon is distributed widely across the PVPF, nevertheless, inhabiting areas of evergreen and mixed deciduous-evergreen forest (Wildlife Conservation Society 2008) and the relatively intact nature of those forests underscores the extent of the importance of the PVPF to the conservation of this species. The habitat provided by the Emerald Triangle Protected Forests Complex, moreover, is enhanced by the connectivity of the PVPF to the adjacent Yot Dom Wildlife Sanctuary and Phu Jong Na Yoi National Park in Thailand, where small populations of Pileated Gibbons have also been reported.

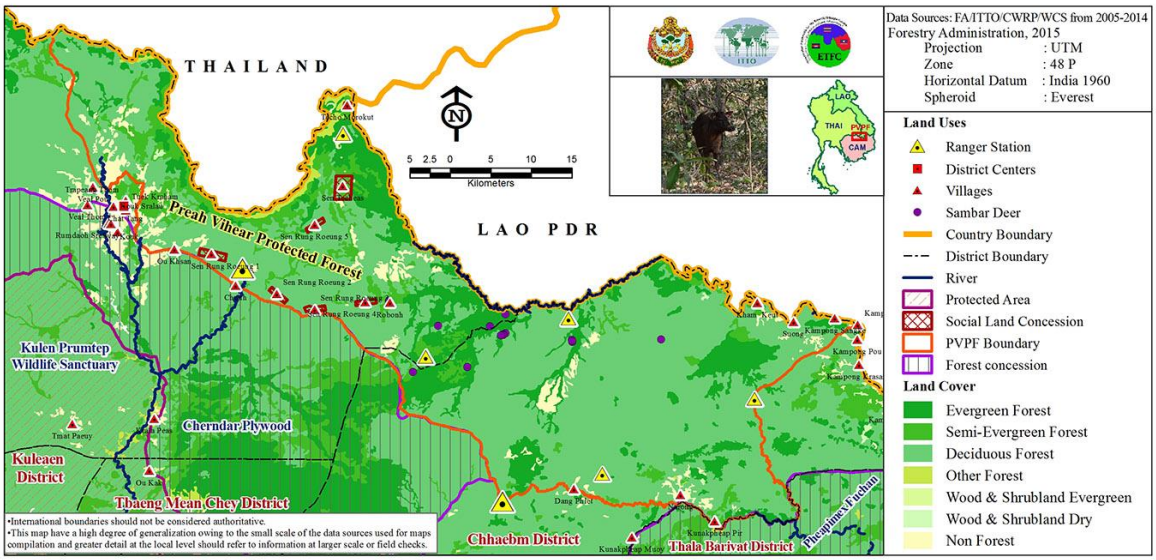


Map 5.5. Distribution of Pileated Gibbon in and around the Preah Vihear Protected Forest.

Sambar (*Rusa unicolor*)

The distribution of the Sambar, which extends from India and Sri Lanka east along the southern Himalayas to Taiwan and further south into Bangladesh and throughout mainland Southeast Asia into Borneo and Sumatra, is highly fragmented throughout much of its range. In Cambodia, Sambar are relatively common in some areas, but the species is entirely absent from others even though there is suitable habitat. This differentiation appears to be primarily correlated with hunting

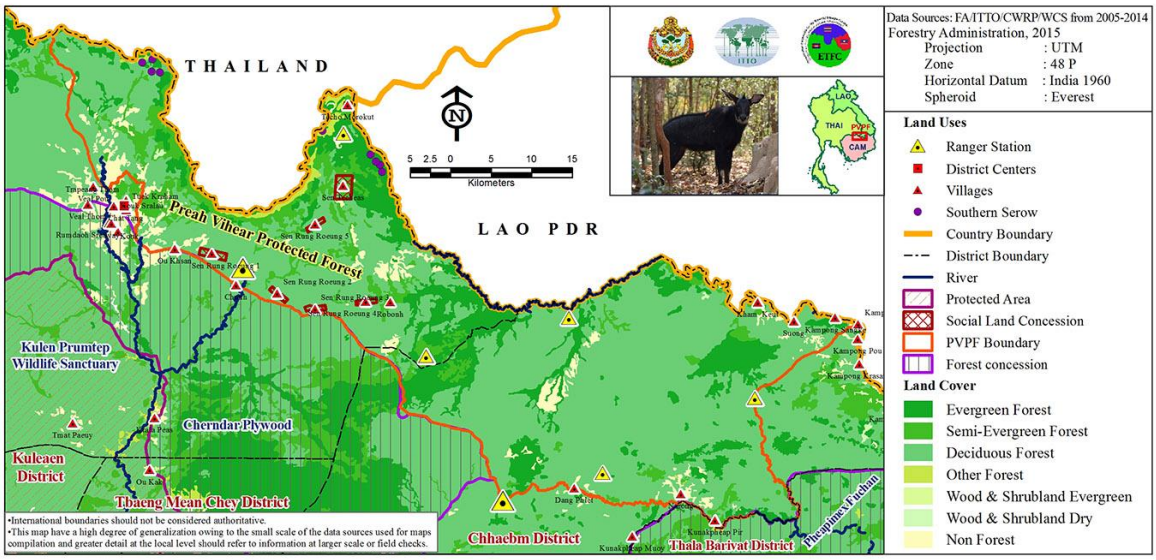
pressure. In the PVPF, Sambar are common and are recorded in most habitats. Some recent studies have affirmed, however, that while the species was still considered to be widespread at the time of the wildlife assessment conducted in 2008, Sambar populations, especially in the Eastern Plains, have declined since that assessment with no significant signs of recovery (IUCN 2015b).



Map 5.6. Distribution of Sambar in and around the Preah Vihear Protected Forest.

Sumatran (Southern) Serow (*Capricornis sumatraensis)*

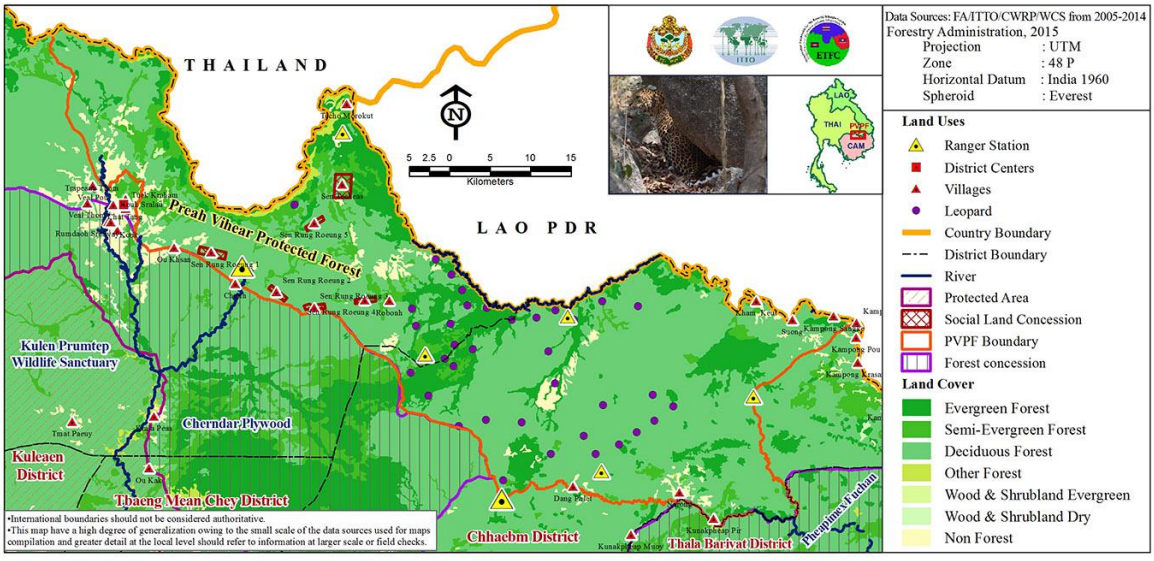
The Sumatran (Southern) Serow is a species of goat-antelope native to mountain forests of Indonesia, Malaysia, Thailand, and Cambodia. There is very little information available about this solitary, nocturnal species, including the status of its reproduction. It occupies seasonal ranges and uses well-marked trails that often run along ridges of steep hills covered by both primary and secondary forests, where it browses on a wide variety of leaves and shoots. The principal threats to the Sumatran (Southern) Serow are hunting, and to a lesser extent habitat loss, although the species is considered to tolerate environments that are only moderately degraded. The Sumatran (Southern) Serow is regarded to be relatively well-protected in Cambodia compared to other range states in southeast Asia, where populations have been declining.



Map 5.7. Distribution of Sumatran (Southern) Serow in and around the Preah Vihear Protected Forest.

Leopard (*Panthera pardus*)

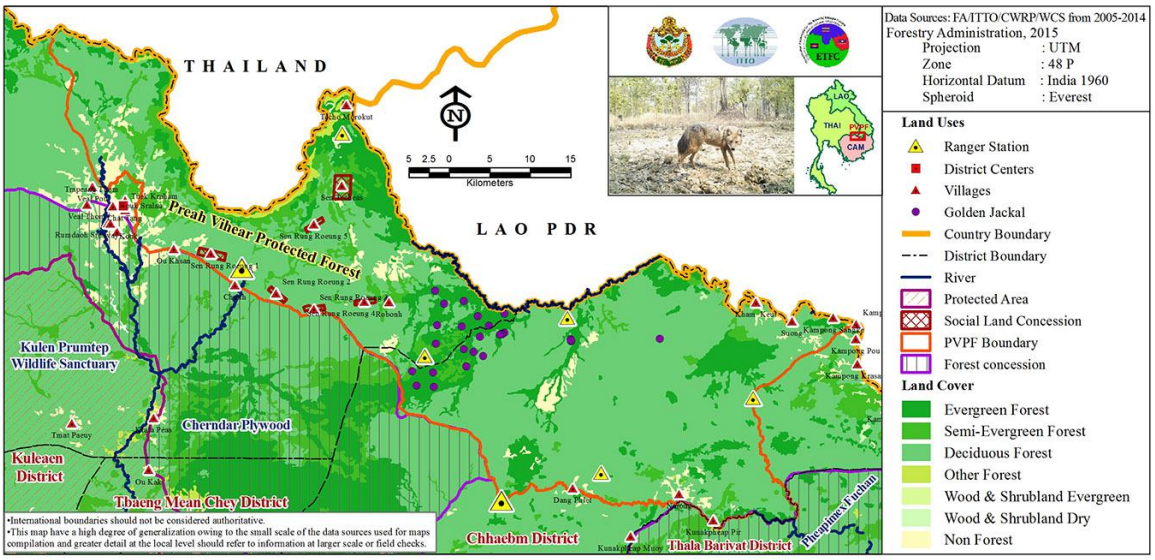
Leopards are widely distributed across the PVPF with many records from the southeast dry dipterocarp forest (Wildlife Conservation Society 2008), as well as the evergreen forest of the mid-central section of the PVPF. The species, which is prevalent from Africa to East Asia, is disappearing in some areas with the loss of habitat, increased hunting and declining numbers of prey species. In Cambodia, the number of leopards captured by camera traps has been increasing in the dry forests of the Eastern Plains (World Wide Fund for Nature 2015). Those areas, as well as the large comparable areas of habitat with adequate prey species in the PVPF, are of considerable significance to the long-term survival of the Leopard in Southeast Asia.



Map 5.8. Distribution of Leopard in and around the Preah Vihear Protected Forest.

Golden Jackal (*Canis aureus*)

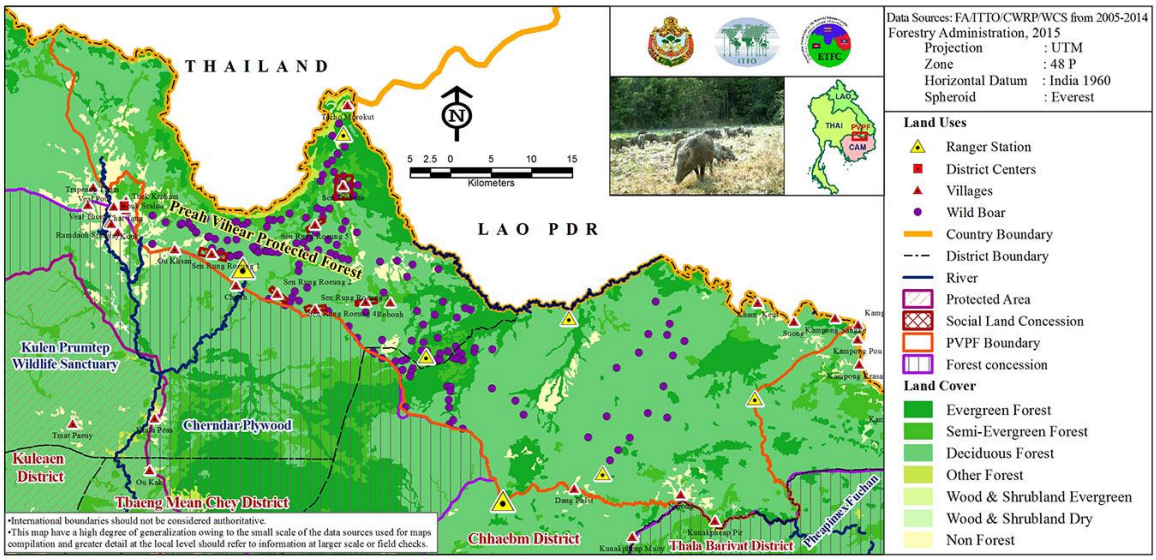
The Golden Jackal is widespread and common throughout its range in Asia and Africa, as well as in some European countries. High population densities have been observed in areas with abundant food and cover. In the PVPF, the Golden Jackal is the most frequently recorded of all the large carnivore species (Cambodia Wildlife Research Program 2002; Wildlife Conservation Society 2008). Its tolerance of dry habitats and its omnivorous diet allow it to survive across a range of habitats, although tropical dry and moist deciduous forest with deer as the primary prey species are considered to be its optimal habitats. The quality of its habitats and increasing numbers of prey species accentuate the importance of the PVPF to the Golden Jackal.



Map 5.9. Distribution of Golden Jackal in and around the Preah Vihear Protected Forest.

Wild Boar (*Sus scrofa*)

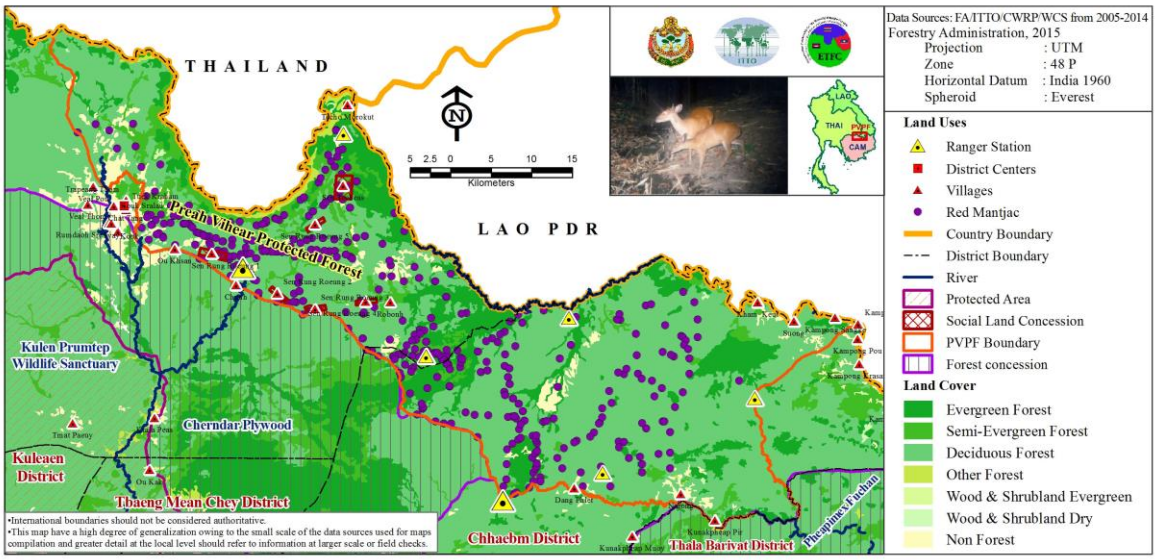
The Wild Boar is widespread throughout most habitats in Cambodia and the most frequently recorded mammal species in the PVPF. It has one of the widest geographic distributions of terrestrial mammals and its range has been greatly expanded as the result of human intervention. The species now occurs in a wild or scarcely modified wild state on every continent with the exception of Antarctica, as well as on several oceanic islands. The PVPF is particularly important to the Wild Boar because of its large area of quality habitat and increasing numbers of prey species, which provide it with local sources of protein. It is commonly hunted by villagers in and around the PVPF, as well as across its range in Cambodia, primarily for food subsistence.



Map 5.10. Distribution of Wild Boar in and around the Preah Vihear Protected Forest.

Red Muntjac (*Muntiacus muntjak)* (Least Concern)

This species is widespread and abundant throughout much of the PVPF as an important prey for large carnivores.



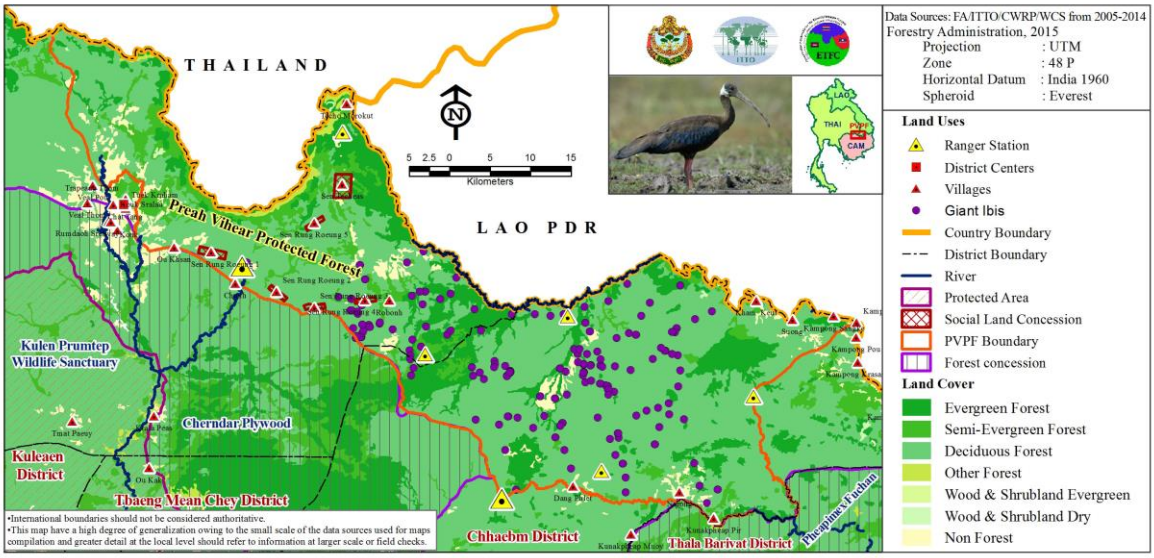
Map 5.11. Distribution of Red Muntjac in and around the Preah Vihear Protected Forest.

5.3.1.2 Birds

Giant Ibis (*Thaumatibis gigantea*) (Critically Endangered)

The PVPF is the most important global site of the Gia nt Ibis. Up to 36 nests have been found in the PVPF in recent years and it is probable that the population there exceeds 100 birds if there are as many non-breeding individuals as there are adults. The global population was most recently estimated to be approximately 200 individuals.

Since ibises are not vulnerable to nest predation by humans, the bird nest protection program is not used for protecting this species, although it could be effectively used for monitoring its population. Its relative, the Critically Endangered White-shouldered Ibis (*Pseudibis davisoni*) has not been observed frequently in the PVPF, although it is possible that it might be seen regularly in some areas.



Map 5.12. Distribution of Giant Ibis in and around the Preah Vihear Protected Forest

White-rumped Vulture (*Gyps bengalensis*) (Critically Endangered)

The White-rumped Vulture breeds in small numbers in the PVPF. In the 2007-2008 breeding season, four nests were found, of which two were successful, and over 40 were counted at the annual Cambodian vulture census conducted in June 2008. It is also regularly recorded at monthly 'vulture restaurants' when over 60 individuals may be recorded. Vultures in the PVPF and elsewhere breed in loose colonies in trees, often selecting sites close to reliable food sources. This species is threatened globally by the use of the veterinary drug 'diclofenac,' which is extremely toxic to vultures, as well as by limited food availability, habitat loss, nest predation and loss, and locally, incidental poisoning that targets other species. The PVPF is probably the most important site for this species in Southeast Asia. Since the White-rumped Vulture is rapidly declining in the principal parts of its range in South Asia due to the effects of 'diclofenac,' the Southeast Asian sub-population of this species will be the only remaining population that is not affected by this drug. The PVPF is, therefore, of critical importance for its survival as a species.

Slender-billed Vulture (*Gyps tenuirostris*) (Critically Endangered)

The Slender-billed Vulture is recorded regularly in the PVPF at 'vulture restaurants' and there were 11 individuals recorded at the 2008 census, a large proportion of the minimum known population size in Cambodia. The threats to this species are similar to those of other vultures, but the population size of this species is even smaller and, thus, it might be even more threatened. Since it is a component of the network of sites that support vultures, the PVPF assumes a vital role in the conservation of the Slender-billed Vulture.

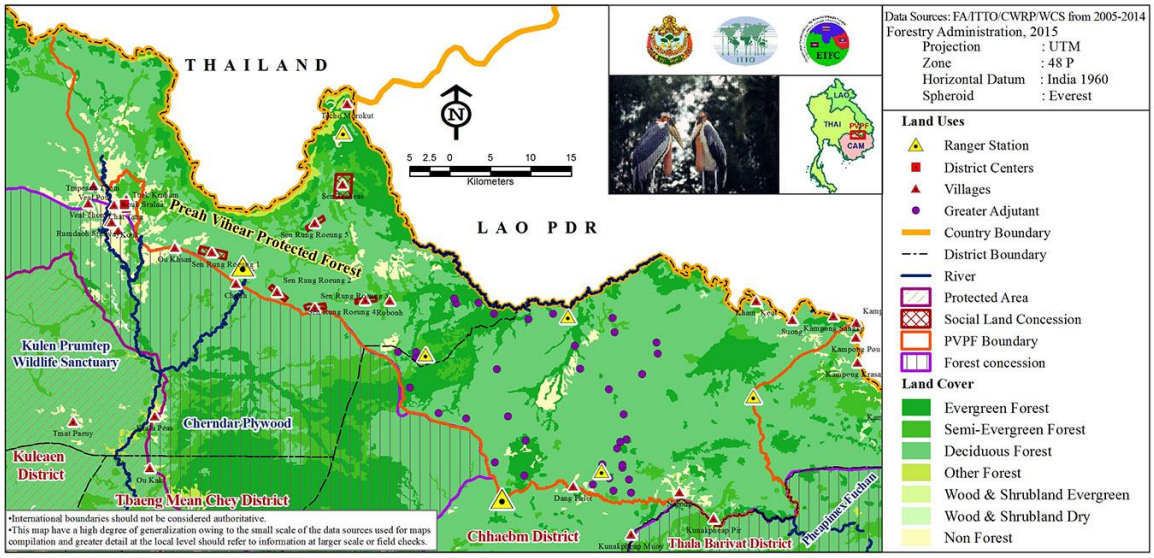
Red-headed Vulture (*Sarcogyps calvus*) (Critically Endangered)

Red-headed Vultures are found in the highest numbers in the PVPF, including 19 individuals that were counted in the 2008 census. This species breeds in the PVPF, as well. It is not as social as other vultures and may feed more often away from larger carcasses such as those

used at 'vulture restaurants.' It might, therefore, be under-recorded in censuses. It suffers the same threats, however, as do the *Gyps* species and the PVPF is of critical importance to its global survival.

Greater Adjutant (*Lepoptilos dubius*) (Endangered)

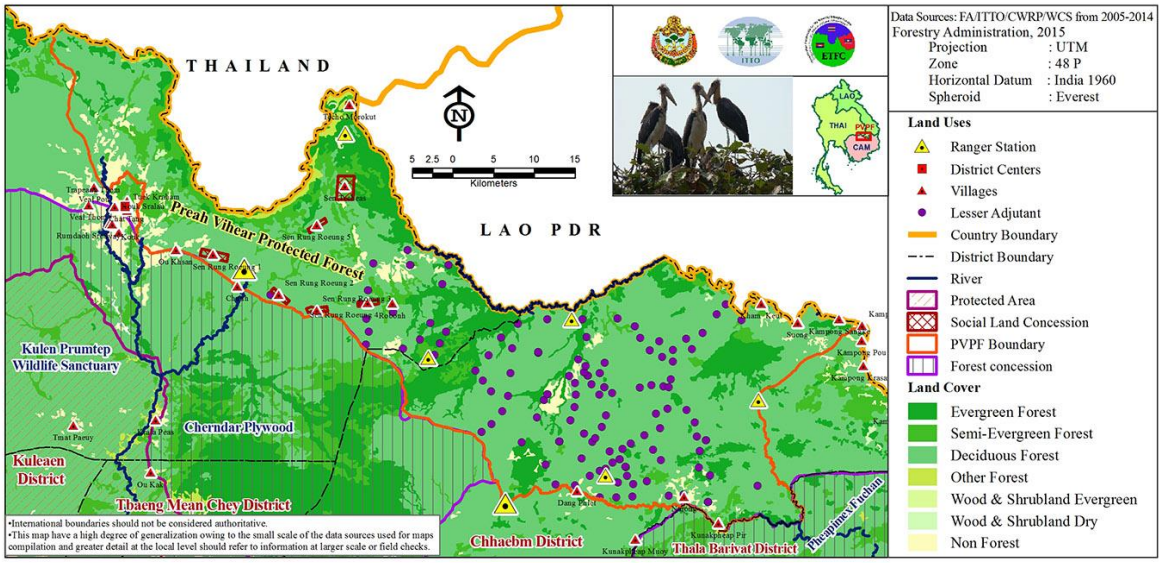
The Greater Adjutant is rarely found in the PVPF, principally in the southeast in both the Core Zone and Buffer Zone 1. It does not breed in the PVPF and it is not thought to be resident.



Map 5.13. Distribution of Greater Adjutant in and around the Preah Vihear Protected Forest.

Lesser Adjutant (*Leptoptilos javanicus*) (Vulnerable)

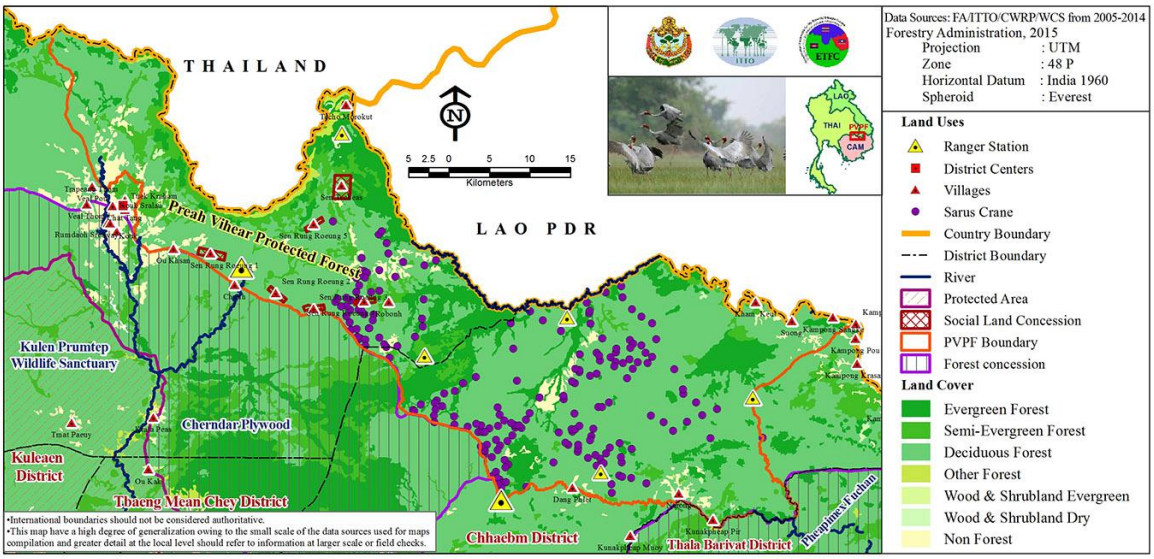
The Lesser Adjutant breeds in large numbers in colonies across the PVPF. The largest count was in 2007 when there were 115 nests. It is common at trapeangs and other wetlands and it is found in wetlands in both open forest and evergreen forest and is part of a very large Northern Plains population that may surpass the population of the Tonle Sap Biosphere Reserve. The population in the PVPF seems to be increasing, moreover, which reflects the effectiveness of the bird nest protection program. The PVPF population may be considered to be of international importantance since the global population is believed to be declining.



Map 5.14. Distribution of Lesser Adjutant in and around the Preah Vihear Protected Forest.

Sarus Crane (*Grus antigone*) (Vulnerable)

The numbers of the Sarus Crane have increased dramatically in the PVPF since the nest protection program started in 2004 - there were 16 nests found in 2004 and 33 nests in 2008. Prior to the initiation of that program, eggs and chicks were often taken by local community members and military personnel and sold in Thailand, but that threat has now been largely eliminated. Other threats include disturbances and losses of habitat, which have now been reduced, although those remain concerns outside the PVPF. The Sarus Cranes breeding in the PVPF are part of the largest population in Southeast Asia and are thought to travel to An Trapeang Thmor in Banteay Mencheay in the non-breeding dry season.



Map 5.15. Distribution of Sarus Crane in and around the Preah Vihear Protected Forest.

Black-necked Stork (*Ephippiorhynchus asiaticus*) (Near-Threatened)

The Black-necked Stork breeds in small numbers in the PVPF and it is not very abundant. It prefers larger grasslands, or veals, with some flooding.

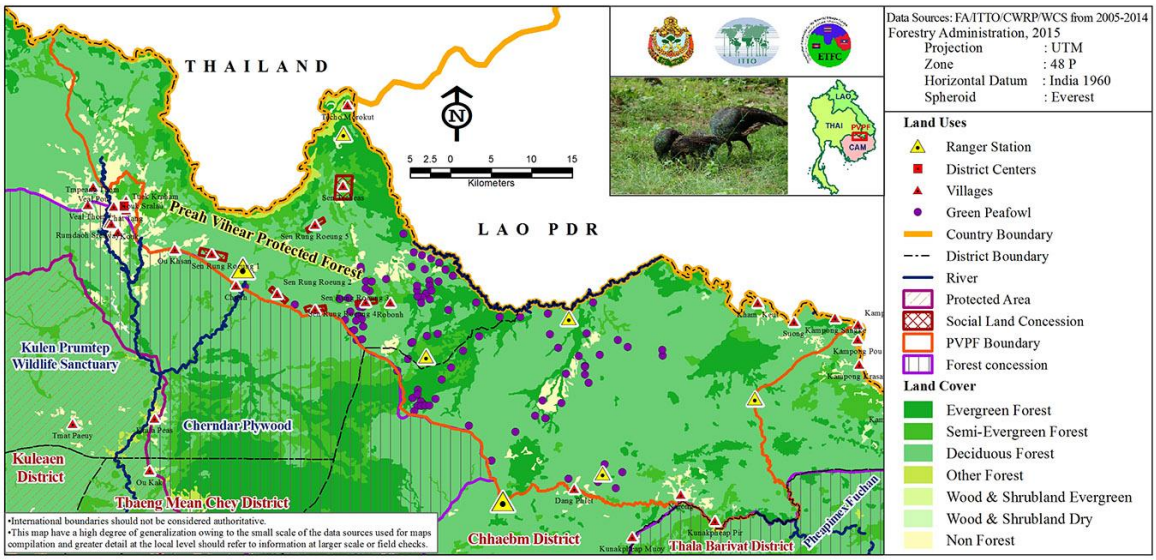
Red Jungle Fowl (*Gallus gallus*) (Least Concern)

The Red Jungle Fowl is still reasonably common in the PVPF even though the size of this bird makes it quite attractive for hunting by local people.

Green Peafowl (*Pavo muticus*)

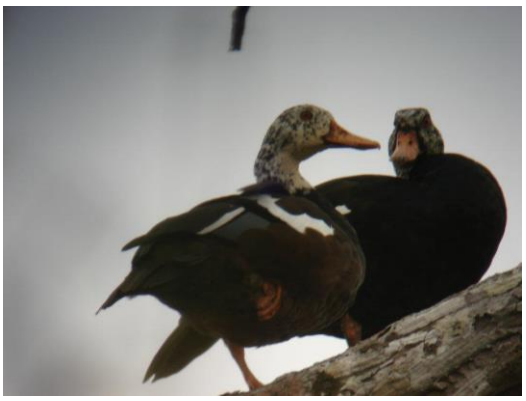
Green Peafowl are observed south and west of Kahkeuk station and along the catchment of the O'Kapok 'trapeang,' or wet season stream, in the mid-central section of the PVPF. Since the species is thought to prefer undisturbed dry dipterocarp forest near streams and wetlands, those areas may provide it with its most

suitable habitat. Elsewhere within its range, its numbers are declining rapidly and the only large populations remaining are believed to be in northern and eastern Cambodia and west-central Vietnam. The forests of the PVPF are considered to be of international significance to the long-term survival of this species. Habitat degradation and hunting are its most serious threats and fragmentation of habitat may increase its susceptibility to each of those threats.

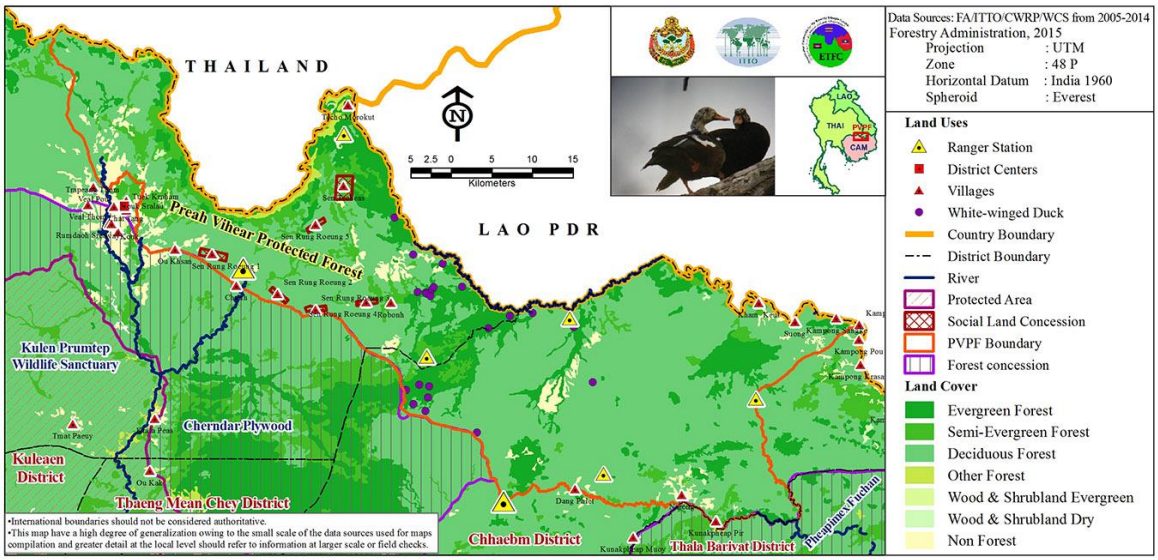


Map 5.16. Distribution of Green Peafowl in and around the Preah Vihear Protected Forest.

White-winged Duck (*Asarcornis scutulata*)



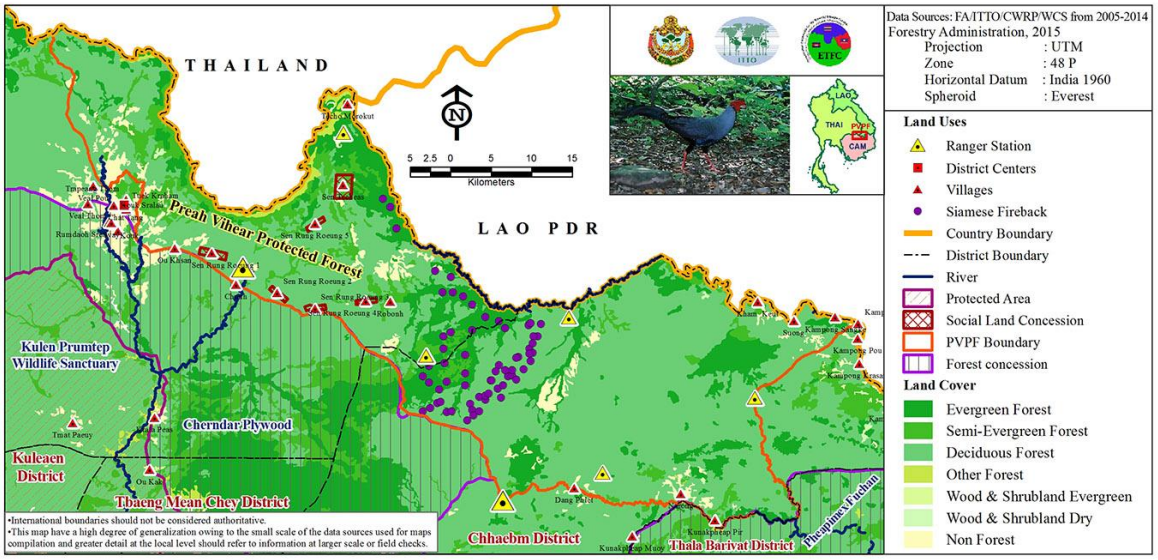
The large White-winged Duck has been observ ed in a small number of sites in riverine forest near Roboinh village, Kahkeuk station (at the O Koki and O Kapok 'trapeangs') and in areas of the previously suspended Cherndar Plywood forest concession. This species has experienced a precipitous decline of at least 95% of its original population in Asia and has been extirpated from some countries as a result of egg collecting, destruction of riverine habitats, deforestation and hunting (Green 1993) and has not recovered (Birdlife International 2015a). It prefers dense forest with permanent water pools or rivers and low levels of disturbance for nesting. The global population of the White-winged Duck, which is a popular species for bird watching, is highly fragmented and it is only in Cambodia and Myanmar that important populations remain, which further emphasizes the international significance of the PVPF to the conservation of this species.



Map 5.17. Distribution of White-winged Duck in and around the Preah Vihear Protected Forest.

Siamese Fireback (*Lophura diardi*)

The Siamese Fireback is observed in Cambodia, Thailand, Lao PDR, and Vietnam. It is thought to prefer undisturbed dry dipterocarp forest near streams and wetlands and those areas may be the most suitable for this species in the PVPF, where it is locally common. Its population across the region is suspected to number 20,000 – 50,000 individuals on the basis of a population in Cambodia that is conservatively estimated to be about 2000 individuals (Birdlife International 2015b). It is considered to be undergoing a slow-to-moderate decline, however, as the result of habitat loss and hunting pressure, but it is now considered to be more resilient to those threats than previously recognized. The relatively intact dry dipterocarp forests of the PVPF reflect the importance of those habitats to the Siamese Fireback.

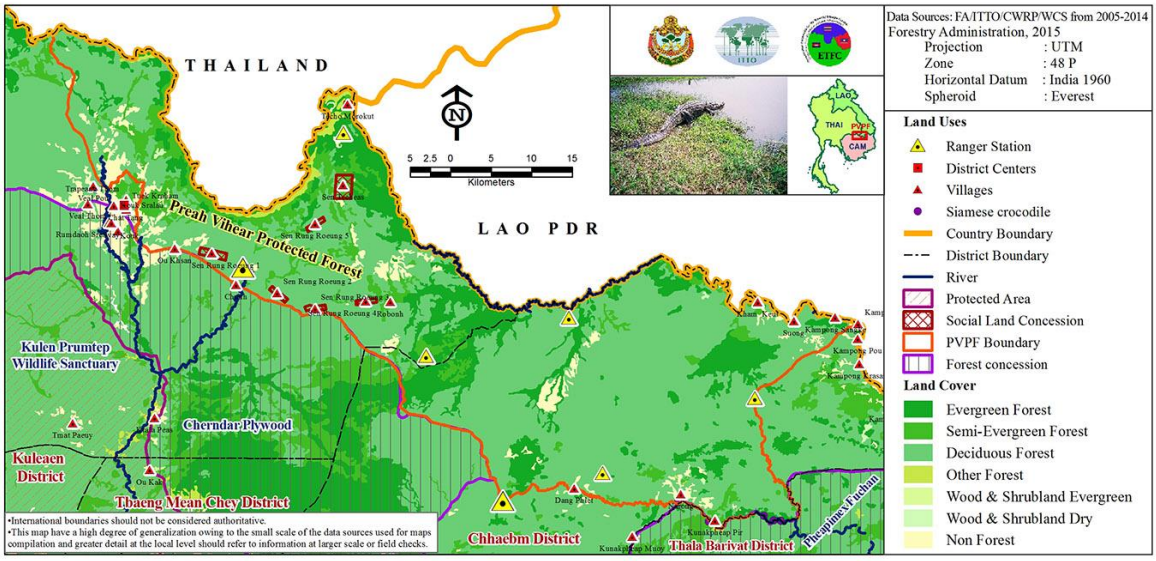


Map 5.18. Distribution of Siamese Fireback in and around the Preah Vihear Protected Forest.

5.3.1.3 Reptiles

Siamese crocodile (*Crocodylus siamensis*)

Habitat destruction and hunting have eradicated the relatively small Siamese Crocodile from 99 per cent of its historical range in freshwater rivers and marshes throughout Southeast Asia over the past 100 years. There are now only about 250 adult Siamese Crocodiles remaining in the wild, predominantly in the most remote highlands of the Southwest Cardamom Mountains of Cambodia. The principal threats to the continued survival of this species include hunting for crocodile skins and large-scale hydroelectric dam development with its accompanying loss of habitat, which threaten remaining breeding populations in the Cardamom Mountains, as well as the unintentional bycatch of Siamese Crocodile in fishing nets in the PVPF. There are indications that in the PVPF some Siamese Crocodiles are in the Lapov River, which forms the international border between Cambodia and Lao PDR, as well as in the southeast. The partnership established between the Cambodian Government and Fauna and Flora International has initiated an ex-situ breeding program and mitigation planning that is considering the translocation of the Siamese Crocodile to safer sites.



Map 5.19. Distribution of Siamese Crocodile in and around the Preah Vihear Protected Forest.

Elongated tortoise (*Indotestudo elongata*) (IUCN - Vulnerable; CITES - Appendix II)

The Elongated Tortoise is widespread throughout dry deciduous and open forests in mainland tropical areas of Cambodia, Vietnam, Laos, Thailand, Northern Peninsular Malaysia, and from China to India. This species is featured in the international pet trade and in the Far East trade for medicine, ornaments and food (Daltry and Momberg 2000). There were a few carapaces and shells of this species uncovered in a hunting camp, as well as in an abandoned NTFP collectors' campsite in the forest,,and there were some spotted in a village settlement near the PVPF in Chunh.

Bengal monitor (*Varanus bengalensis*) (CITES - Appendix I)

The Bengal Monitor, or clouded monitor lizard, is widespread, but heavily hunted throughout Asia. The international trade in Bengal Monitor skins is estimated to be about 1 million skins per year. These spotted lizards are probably present in the area in different habitats at lower and medium elevations ranging through dense evergreen logged forest, open forest, bamboo forest and farmlands (Chheang at al. 2002). The species has been commonly harvested by local villagers from forested areas, especially in the PVPF, for subsistence and for sale.

Water monitor (*Varanus salvator*) (CITES - Appendix II)

The Water Monitor is is the world's second largest lizard, reaching a maximum length in excess of 2.5 m (Daltry and Momberg 2000). This species is highly adaptable and still widespread across tropical Asia, although millions are hunted annually for their meat and skin and populations have plummeted in many areas (Bennett 1998). The Water Monitor is the most heavily exploited monitor and international trade in Water Monitor skins in Southeast Asia is estimated to be 1.0-1.5 million skins (Linda 2009). Water Monitors are frequently encountered near rivers in the PVPF and several have been seen trapped in fishing nets and snared for bushmeat. This species has been commonly harvested by local villagers from forest areas, especially in the PVPF, for subsistence and for sale.

Reticulated python (*Python reticulatus*) (IUCN - Near-Threatened); CITES - Appendix II) and Burmese python *Python molurus bivittatus* (IUCN - Near-Threatened; CITES - Appendix II)

The Reticulated Python, with a weight of more than 100 kg and a girth of about 60 centimeters, is considered to be the world's longest snake, reportedly reaching lengths of about 10 m (Cox 1991). This species of python is distributed throughout most of Southeast Asia and is well-known to local people who hunt it for its meat and skin. The Reticulated Python is a target of both the international pet trade and the skin trade, and populations have been depleted locally in many countries (Daltry and Momberg 2000). Groombridge and Luxmoore (1991) have reported that many of the python skins that were exported from Thailand had originated in Cambodia and were sold for US$ 13-17/m. Local villagers and field guides have indicated that the area is home to both the Reticulated Python and the Burmese Python, but the project field team has not encountered significant evidence confirming their presence, except for parts of the skins of both species observed in houses of local villagers in Choam Khsan and Chhep districts. These species have been harvested by local villagers from forest areas, especially in the PVPF, for subsistence and for sale.

5.4 Conclusions and recommendations

5.4.1 Conclusions

The Trans-boundary Biodiversity Conservation project has enabled the collection of considerable amounts of supplementary information on the habitats and distributions of landscape wildlife species in the PVPF. The enhanced information available on the distributions of those landscape wildlife species provided in this study is especially important for several reasons:

- It extends the current state of knowledge regarding the distributions of individual landscape wildlife species of the PVPF, several of which are on the IUCN Red List;
- It provides valuable information on the current use of habitats by individual wildlife species to inform management planning processes, especially those associated with the development and application of habitat suitability models, in the PVPF, as well as across the Emerald Triangle Protected Forests Complex; and
- It reaffirms the importance of the forests of the PVPF in ensuring the conservation of the biodiversity of one of the region's most significant globally-recognized hotspots.

5.4.2 Recommendations

The single most important recommendation stemming from this study of the distribution of landscape wildlife species in the PVPF is that the Cambodia and Thailand Project Components, in cooperation with natural resource managers from Champasack University in Lao PDR, should continue to endeavor to use the results presented on these distributions to achieve trans-boundary biodiversity conservation throughout the Emerald Triangle Protected Forests Complex. This will require the ultimate development of a common management framework with shared and coordinated actions, which will lead, over time, to the following achievements:

- Strengthened cooperation with local authorities and local communities to deter illegal logging, the illegal trade in wildlife, and the incidence of forest clearing and encroachment.
- Expanded use of the Spatial Monitoring and Reporting Tool (SMART) to strengthen the planning of law enforcement patrols in accordance with observed threats and the establishment of measurable responses to those threats.
- Strengthened capacities of rangers and increased law enforcement patrols in critical habitats and in areas in which illegal logging, wildlife poaching, hunting and forest clearing and encroachment are more prevalent.
- Enforced restrictions on the use of firearms in the PVPF.
- Intensified campaigns against poaching, hunting and the illegal trade in wildlife, including the consumption of bushmeat and the promotion of environmental education to strengthen understanding and increase awareness of those activities.
- Expanded cooperation with protected area resource managers and local and regional government officials in Cambodia, Thailand, and Lao PDR to enforce control of cross-border illegal logging and the illegal wildlife trade using international convention, such as CITES, as one of the means for organizing action programs.
- Increased number of informal and formal meetings with government officials to strengthen bonds of political support to strengthen wildlife management and conservation in the PVPF.
- Encouragement of household and community investments to support restoration efforts and the establishment of forest plantations to rehabilitate degraded and encroached reclaimed forests, especially in those instances in which natural succession is inadequate in important wildlife habitats to ensure the ecological recovery of those areas.
- Encouragement of wildlife viewing activities at those sites in the PVPF considered to have the most potential for low-impact, nature-based tourism development that are managed to ensure that those activities are sustainable.
- Establishment of more effective operational management programs on the basis of the application of the results of cross-border research conducted in Cambodia, Thailand, and Lao PDR to sustain and enhance populations of landmark wildlife species.
- Maintainence of ecological corridors linking cross-border landscapes and ensuring the uninterrupted migration of landmark wildlife species across the Emerald Triangle Protected Forests Complex.
- Maintainence and/or enhancement of seasonal watering holes (trapeangs) to preserve ecological integrity and mitigate the impacts of climate change on water resources supporting local livelihoods and providing seasonal habitats for waterfowl.
- Efforts to ensure the rescue and propagation of rare and endangered wildlife species and the reintroduction of rescued and propagated species into the wild.

- Promotion of management exchange programs with cross-border natural resource managers in adjoining protected areas of Thailand and Lao PDR.
- Provision of specialized training in forest and wildlife management, biodiversity conservation and sustainable forest resources management to local Forestry Administration officers and protected forest officials at the operational level to strengthen resource management capacities.
- Organization of research on selected landmark wildlife species, including rare, endangered and endemic species, to support the development of species-specific management plans.
- Organization of workshops, meetings, and training programs involving local communities to enhance the understanding of the contributions to local livelihoods associated with sustainable forest and wildlife management, biodiversity conservation, and community forestry programs in accordance with national forest development policies and plans.
- Development of environmental education programs that explain the purposes of the PVPF and incorporate information on the environmental effects associated with the unsustainable use of natural resources and the rights and responsibilities of local people with regard to the management of forest, wildlife and biodiversity resources.

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INTERGRATING FOREST BIODIVERSITY RESOURCE MANAGEMENT AND SUSTAINBLE COMMUNITY LIVELIHOOD DEVELOPMENT IN THE PREAH VIHEAR PROTECTED FOREST

- *Chapter I: Forest cover trends in the Preah Vihear Protected Forest (PVPF)*
- *Chapter II: Preliminary Assessment of Carbon Stocks*
- *Chapter III: Land Use and Land Cover Change Scenarios*
- *Chapter IV: Floral Diversity*
- *Chapter V: The Distribution of Landscape Wildlife Species*
- ***Chapter VI: Sustainable Livelihoods Assessment***

CHAPTER VI

SUSTAINABLE LIVELIHOODS ASSESSMENT

SAY SINLY, PHENG SOPHEART, DENNIS CENGEL, LIM SOPHEAP, CHHEANG DANY, PANG PHANIT, KIM SOBON and YI NAROM

Summary

Livelihoods comprise the capabilities, assets - including stores, resources, claims and access- as well as activities required for a means of living. Those livelihoods are sustainable that are able to cope with and recover from stresses and shocks, maintain or enhance their capabilities and assets, and provide sustainable livelihood opportunities for the next generation. The primary purpose of this study was to assess livelihood resources, including natural, economic, human, and social capital, in the Preah Vihear Protected Forest and, on the basis of that assessment, propose sustainable livelihood approaches. There were 85 interviewees from 8 villages of Teuk Krahum and Morokot communes in the Preah Vihear Protected Forest selected to participate in the assessment.

Assets and Vulnerabilities: The population increased at an average annual rate of 1.17% between 2011 and 2014 and about 87% of those villagers had limited education. There are usually two laborers, or 'breadwinners,' who receive some form of salary, in each household, which, on average, has four people. Since there have been no close reciprocal relationships between institutions, the provisions of stakeholders do not often match with the requirements of the people. The poor depend to a considerable extent (12%-30%) on natural resources for their incomes since those assets gradually deteriorate and require replacement. The incomes available from agricultural sources account for from 16% to 46% of incomes because farming may only be conducted during the rainy season. There is not enough irrigation during the dry season and lower productivity soils cover 58% of the project area. Most villagers, especially more recent inhabitants, cannot access many assets, including farmland and land tenure, intensive and diversified agricultural techniques, markets for agricultural products, toilet and sanitation facilities, materials for preventing malaria infection, or lower rates of loans.

Livelihood Strategies: There are four principal livelihood strategies that local communities have been using to meet their requirements and attain their goals. These include: (1) salary-paid employment; (2) farming; (3) collecting forest resources; and (4) businesses. The results indicated that the annual incomes of traditional communities were US $1,550, while those of more recent inhabitants were US $2,007. The income earned from forest resources represented 12% of the income of new residents and 30% of the income of local indigenous people. Forest resources, nevertheless, provide a significant source to meet subsistence requirements, as well as act as a "safety net" in the event of emergencies or a "gap filler" in the event of seasonal shortages and, occasionally, as a means to permanently escape poverty.

Income strategies and outcome indicators: The principal livelihood strategies associated with salary-paid employment, farming, collecting forest resources, and businesses match with the principal indicators of livelihood strategies, which include (1) more income; (2) improved well-being; (3) reduced vulnerability; (4) enhanced food security; and (5) more sustainable use of natural resources.

Sustainable livelihood approaches must be addressed through the expansion of agricultural diversification, intensification and extensification, agroforestry and home gardens, and small enterprise development. Increasing the use of these approaches will require that vocational training and other support continues to be provided. Land use planning must also be accomplished according to prevailing policies and legislation, as well as with regard to soil productivities, and the rights to secure access to capital assets, including farmland, must be ensured.

CHAPTER VI

SUSTAINABLE LIVELIHOODS ASSESSMENT

6.1. Introduction

6.1.1 Background

The Development Objective of the third phase of the "Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos" project was 'To contribute to the conservation of trans-boundary biodiversity in the Emerald Triangle Protected Forests Complex between Thailand, Cambodia and Laos.' The project's Specific Objective was 'To strengthen the protection of trans-boundary habitats of protected wide-ranging wildlife species in the Emerald Triangle.' The project has endeavored to achieve these objectives through the provision of outputs that (1) establish and implement management plans that incorporate research results on wide-ranging species and ecological processes which are compatible between the three countries participating in the project; (2) strengthen the capacity of multi-stakeholders in biodiversity conservation and monitoring; and (3) empower local communities to implement activities linking livelihoods improvement to reduced dependence on resources of protected areas in the Emerald Triangle Protected Forests Complex. The last output is reflected in the understanding that its achievement will contribute not only to enhanced protection and conservation, but also to the maintenance of sustainable uses of the area's natural resources.

In order to achieve the goal of reducing dependence on forest resources in protected areas, the sustainable livelihood approach provides a useful means for understanding forest-based livelihood development. In this context, livelihood resources - i.e., the assets that local communities have - including natural, economic, human, and social capital - have to be examined to recommend prospective livelihood approaches.

Since 2010, the population has dramatically increased in the Preah Vihear Protected Forest (PVPF) as a result of the establishment of Social Land Concessions, social-economic development, and the increased presence of the military. Consequently, the forest resources in the PVPF have become more degraded, especially over the past 5 years. In many places in and around the PVPF, relatively large areas of forestland have been converted into agricultural land and the lack of suitable strategies for livelihood improvement is one of the principal reasons for the resulting unsustainable development occurring.

Life in a new place is very difficult for those people, especially military families. In order to maintain their lives, they must make a living to feed their families and forestland and biodiversity resources have been traditionally used to produce incomes and provide them with daily food and resources. It is their livelihood requirements that must initially be met. Nevertheless, there are some people who use this opportunity to attempt to increase their wealth by overexploiting the area's natural resources and competing with those attempting to use their livelihood strategies in such a manner that sustainable biodiversity conservation and

development are not able to be achieved. This exemplifies the close linkages that exist between sustainable development and natural resource conservation.

This report assesses the sustainability of livelihood strategies and shares of income and describes the responsibilities of project staff, local authorities, and other relevant stakeholders that have been providing some form of support to local communities. The livelihood strategies assessment reveals the livelihood strategies that people living in the PVPF have been using by combining accessible assets to increase incomes and wellbeing, reduce vulnerability, improve food security, and contribute to sustainable national resources management.

6.1.2 Objective

The primary objective of the study was to assess the livelihood resources in the Preah Vihear Protected Forest and, on the basis of that assessment, propose sustainable livelihood approaches. Secondary objectives were to (1) describe the range of available livelihood resources (natural, economic, human, and social capital) that are combined in the selection of different livelihood strategies; 2) account for vulnerability; and (3) match livelihood strategies with outcomes.

6.2. Methodology

6.2.1 Sources of data

The study used a rapid appraisal survey to assess the progress of the project's community development component. The survey was designed to ensure that it was responding to the objectives of the study. In order to obtain data for the assessment, two sources of data were used: a review of the literature and a field survey, which included interviews, rapid appraisals, and observations.

6.2.2 Primary data collection

The study survey focused on the assessment of some recently established inhabitants—recently established communities who have primarily effected changes in the state of natural resources and are sensitive about responsibilities for those changes. There were 85 people living in 8 different villages and 10 commune council and villages chiefs who were selected to be interviewed in the survey (Table 6.1). Ten interviewees were selected in each of the 8 villages in the two communes—Teuk Krahum and Morokot - with the exception of the selection of 15 people from the largest population village: Sen RungReung 5. Of the 10 samples in each village, 5 were women. Each respondent was chosen as an accurate source of information regarding their family. Their ages ranged from 18 to 60 years.

Table 6.1. Numbers of stratified samples.

No	Name of Village	No. of families	Population	No. of Samples
1	Sen RungReung 1	427	1406	10
2	Sen RungReung 5	257	1898	15
3	Sen Teches	327	1237	10
4	Sen RungReung 2	287	1078	10
5	Sen RungReung 3	129	527	10
6	Sen RungReung 4	310	1123	10
7	Malis	72	328	10
8	Robonh	67	276	10
Total		**1876**	**7873**	**85**

6.2.3 Procedures

6.2.3.1 Research instruments

A six-page structured questionnaire was developed to gather relevant information about the families of the sample villagers. The questions were designed to ensure that they would be understandable.

6.2.3.2 Data gathering

Every sample was interviewed individually on a case-by-case basis. The administration of the questionnaire to an interviewee required about 30 minutes. Open-ended questions were useful in conducting a qualitative assessment. There were at least three students from the Preak Leap School of Agriculture whose thesis research, which was supported under the project, was either wholly or partly relevant to different aspects of local communities' livelihoods. These student participated in the assessment and linked their thesis research questionnaires with the targeted samples interviewed in this study.

The principal part of data gathering, the collecting of secondary data, included reviewing data available from the project provided in 'The Management Plan of the Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation,' and scanning the internet for articles related to the use of sustainable livelihood approaches.

6.2.4 Coverage of study

The scope of the study was to assess local community livelihoods information from two communes—Teuk Krahum commune (Malis, Sen RongReung1 & 5 villages) and Morokot commune (Sen RongReung2, 3, 4, Robonh, and Sen Teches villages). The principal points of the assessment were directed to: (1) livelihood resources (natural, economic, human, and social capital); (2) other relevant development and investment projects and organizations; (3) the progress of the project's ICDP program and related community development activities; (4) the Vulnerability Context; (5) economic opportunities; and (6) assessments of challenges and possible resolutions.

6.2.5 Participatory appraisal

The assessment was conducted in late 2014 and early 2015 to evaluate the forest-based livelihoods and other potential economic opportunities available to local communities. The targeted groups were defined prior to Focus Group Discussions and Rapid Rural Appraisals that were conducted simultaneously. There were a number of local communities involved with the project's beneficiaries in the eight villages of military families. The meetings were organized on several occasions to collect information and separate individual interviews were administered in several cases. The primary groups targeted included Cham Ksant and Morokot commune councils; relevant local authorities; village chiefs; local Forestry Administration Division and Triage officials; and villagers - the current project beneficiaries - and other groups considered to be conducting livelihood strategies.

The assessment included the analysis of incomes from principal sources, which were categorized as forest resources, farm employment, and other sources. There was an economic opportunity analysis for increasing incomes that was developed using an Income Source Matrix.

6.2.6 Data analysis

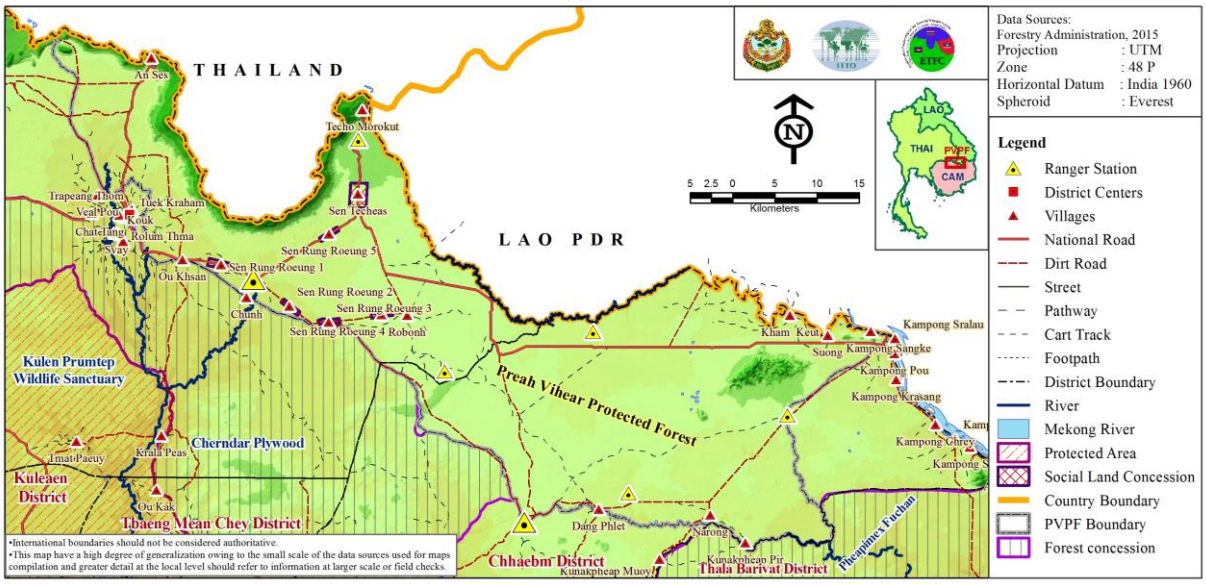
The analytical tools used in the survey included Venn diagrams, livelihood matrixes, SWOT analysis, graphical and tabular comparisons, and scaling of satisfaction. Statistical analysis was facilitated using SPSS 20.0 to provide assessments on the basis of Descriptive Analyses, Frequency Comparisons, and Crosstabs and pie charts and bar charts were used in interpreting and analyzing quantitative information. The descriptive analyses were particularly useful in interpreting qualitative questions related to the responses provided by interviewees.

6.3. Geographic and demographic features

6.3.1 Location and background

The PVPF covers two districts, including Chheb and Choam Ksan, in Preah Vihear province and shares its boundary with (Map 6.1):

- Thailand and Lao PDR to the North;
- Kampong Sralou Muoy and Chheb Pir communes of Chheb district to the East;
- The previously suspended Chendar Plywood Forest Concession to the South;
- Choam Ksan and Toeuk Kraham commune, Choam Ksan district to the West.



Map 6.1. Administrative location and briefing map of the Preah Vihear Protected Forest.

Subsequent to the integration of the Khmer Rouge into the RGC in 1998, the RGC directed the forest areas toward sustainable forest management and natural resources conservation. On 30 July 2002, the RGC issued Sub-decree No. 76 to establish the Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation (or the Preah Vihear Protected Forest), which is under the administrative jurisdiction of the Forestry Administration in the Ministry of Agriculture, Forestry and Fisheries in accordance with the National Forest Sector Policy and the Forestry Law.

The PVPF has a land surface area of 190,027 hectares. Its highest altitude is 766 m in the triangle area of the Dangrek Mountain Range bordering Thailand and its lowest altitude is 66 m in Choam Ksan District.

6.3.2 Population

The Preah Vihear Protected Forest encompasses portions of two districts (Choam Ksan and Chheb) with 5 communes and 21 villages. Choam Ksan District is located in the northwest of the PVPF and Chheb District in the northeast. The communes and villages of the two districts are widely distributed in and around the PVPF (Forestry Administration 2016).

In and around the PVPF, there are 6,478 families, including 4,830 families in Choam Ksant district and 1,648 families in Chheb district that comprise an overall population of 28,436. Some 97% of the population is Cambodian, while nearly 3% is ethnic. Life expectancy is increasing and according to a relatively recent report is 58 years for women and 54 years for men.

The population density almost doubled with an increase from 8 to 15 persons/km^2 in the project area between 2006 and 2014, primarily as the result of the establishment of several Social Land Concessions and immigration driven by economic development and increases in land prices.

6.4 Sustainable livelihoods

6.4.1 Definitions of livelihood

The word “livelihood” may be used in many different manners, but the following definition captures the broad notion of livelihood understood throughout this study. “A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to their livelihoods at the local and global levels and in the short and long term" (Chambers and Conway, 1992).

An individual's livelihood refers to their "means of securing the basic necessities - food, water, shelter and clothing - of life." It is defined in the Oxford Dictionary of English as a set of activities, involving securing water, food, fodder, medicine, shelter, clothing and the capacity to acquire those necessities working either individually or as a group by using endowments (both human and material) for meeting the requirements of the self and his/her household on a sustainable basis with dignity. The activities are usually carried out repeatedly, such as in the case of a hunter's livelihood that depends on the availability and accessibility of wildlife.

The concept of livelihood provides the framework in this study for collecting data and information on sustainable livelihoods of local communities in the Preah Vihear Protected Forest. Their basic needs and other necessities are reflected in livelihood resources on which their sustainable livelihood approaches are based.

6.4.2 Sustainable livelihoods framework

There are five principal framework indicators for analyzing sustainable livelihoods, which, in different contexts, are achieved through access to a range of livelihood resources, including natural, economic, human and social capital that are combined in the pursuit of different livelihood strategies (e.g., agricultural intensification or extensification; livelihood diversification; or migration). The analysis of the range of formal and informal organizational and institutional factors that influence sustainable livelihood outcomes is central to the framework (IDS 1998).

The development of a sustainable livelihoods approach to sustainable development is one that involves public participation and integrates environmental, social, and economic issues into a holistic structure for analysis and management. It is a way of thinking about the objectives, scope and priorities for development. In essence, it is a way of putting people at the center of development, increasing the effectiveness of development assistance. The framework does not attempt to provide an exact representation of reality. It does, however, endeavor to provide a way of thinking about the livelihoods of poor people that will stimulate debate and reflection, and will improve performance in poverty reduction programs. A livelihoods framework is a tool to use to improve our understanding of livelihoods, particularly the livelihoods of the poor (DFID 1999).

This depiction emphasizes that a sustainable livelihood approach to sustainable development is one in which social wellbeing, economic opportunities, good governance, and biodiversity conservation, as well as other measures of welfare, are included to pursue poverty alleviation.

While the sustainable livelihoods approach is broad and encompassing, it may be distilled to six core objectives, each of which aims to increase the sustainability of poor people's livelihoods through the promotion of:

- improved access to high-quality education, information, technologies and training;
- enhanced nutrition and health;
- a more supportive and cohesive social environment;
- more secure access to, and better management of, natural resources;
- better access to basic, facilitating infrastructure;
- increased secure access to financial resources; and
- a policy and institutional environment that supports multiple livelihood strategies and promotes equitable access to competitive markets for all.

6.4.3 Livelihood resources

Livelihood resources refers to the capital of a local community (Figure 6.1). There are many resources in the Preah Vihear Protected Forest, but it is not enough to simplify those assets so as to be understood in the context of sustainable livelihoods and poverty elimination.

Livelihood resources provide the means to increase opportunities through the ownership, or the right to use, resources. The ability to obtain positive livelihood outcomes is founded on the assertion that people require a range of those assets. Moreover, no single category of assets on its own is sufficient to yield the many and varied livelihood outcomes that are sought. That is particularly the case with poor people whose access to assets tends to be very limited and, as a result, poor people have to seek ways of protecting and combining those assets that they have in innovative manners to ensure survival (DFID 1999).

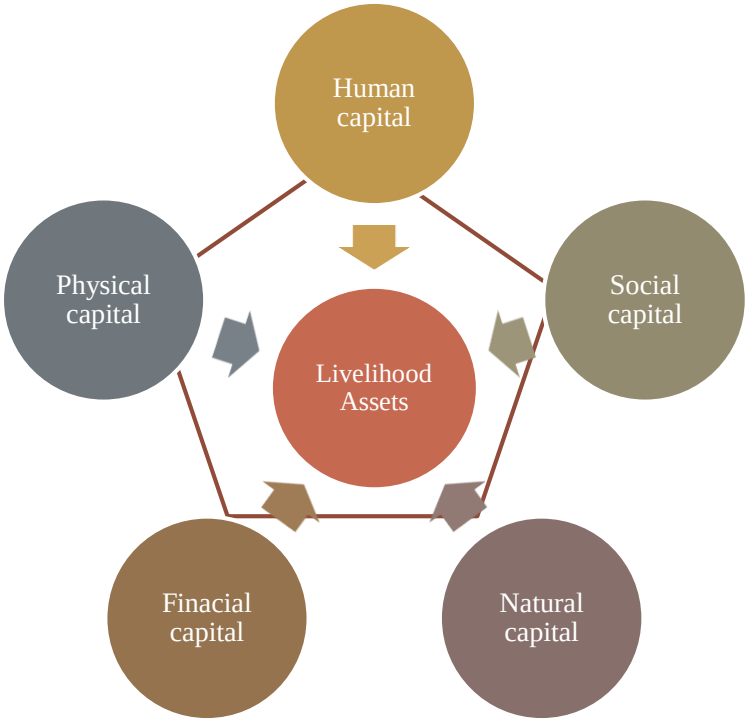


Figure 6.1. Livelihood resources.

6.4.3.1 Human capital

Human capital refers to the skills, knowledge, ability to labor, and good health that together enable people to pursue different livelihood strategies. At the household level, human capital is a measure of the amount and quality of labor available, which varies according to household size, skill levels, leadership potential, and health status.

A. Education

International evidence demonstrates that improved literacy and education among farmers is a critical element associated with improved agriculture productivity, rural employment diversification and income growth. It also encourages and promotes the sustainable use of natural resources and leads to a greater understanding of environmental conditions (FA 2010).

The results of the livelihoods survey that was conducted in the Preah Vihear Protected Forest revealed that 81% of the respondents had completed primary (43%) or secondary (38%) school; 13% had completed high school; and 6% were illiterate (Table 6.2). Wives were more predominant in terms of those who were either illiterate or whose formal education was terminated with the completion of primary school, while husbands were more predominant with regard to the top two levels of education that reflect completion of either secondary school or high school.

Table 6.2. Relative levels of education of local communities disaggregated by husbands and wives.

Relative Level of Education							
No.	Education Level	Husbands (number)	Husbands (percent)	Wives (number)	Wives (percent)	**Total (number)**	**Combined (percent)**
1	Illiterate	3	4%	7	8%	**10**	**6%**
2	Primary	22	25.9%	51	60%	**73**	**43%**
3	Secondary	42	49.4%	23	27%	**65**	**38%**
4	High School	18	21.2%	4	5%	**22**	**13%**
	Totals	**85**	**100%**	**85**	**100%**	**170**	**100%**

Local people — generally the traditional communities in Teuk Krahum commune — are primarily illiterate, especially the girls. As the result of the influx of immigrants - mostly military families - that started in 2010, however, the overall rate of illiteracy has decreased dramatically as the result of infrastructure development and the establishment of several new schools and health centers associated with the recognition of the importance of education. The management plan of the Preah Vihear Protected Forest states that the percentage of the population between 6-17 years of age attending school in the project area in Preah Vihear is 64%. Illiteracy is still considered high, especially for women, and illiterate women between 15-35 years old accounted for 6,670 of 36,813 women (18%) between those ages. The combined illiteracy figure for both males and females was 9,483 of 74,048 individuals (12%). Those outcomes reflect a combinaiton of various social, cultural and economic factors. While girls enroll in school at about the same age as boys, earlier dropout rates occur with the onset of puberty as family responsibilities start to predominate. Parents are often less willing to invest in educating females because of the larger share of their spending allocated to education. There are not enough secondary shcools and no modes of travelling long distances, moreover, and making provisions for staying far away from home is culturally unexceptable for girls (Forestry Administration 2010).

Many young students are able to continue to high school, especially those whose seconadry schools are close to Teuk Krahum commune where there is a high school. This is still considered to be an important constraint for prospective generations, however. Levels of higher education are often reflected in the levels of incomes of those whose salay-based employment is as government officers. While education cannot be considered to represent a complete measurement of a familiy's income, it is crucial for families to use their understanding of social issues and development to assess their vulnerabilities in efforts to develop suitable strategies related to health, sanitation, income generation, and sustanable natural resources management. Local communities, as an example, are able to understand how to reduce the risks of malaria through activities they have learned from health care officers, as well as from each other.

In efforts to encourage education, the project has supported primary students in local communities in the project area by constructing two primary school buildings and providing study materials and biodiversity conservation mainstreaming materials, as well as commercial.

B. Population growth

Population growth and the viability of the household labor force are important components of human capital that reflect competition for natural resources extraction, employment opportunities, family income generators, and local economic growth. The information that project staff obtained from the interviews with relevant village chiefs revealed that the population growth increased rapidly initially and almost doubled, but then increased more gradually at an average annual rate of 1.17% between 2010 and 2014.

In 2010, there were at least 8 new villages established in Teuk Krahum and Morkot communes during the period that commune administrative boundaries were revised. Some villages were restructured to be managed through the new Morokot commune and there have been many new people residing in those villages since that time, primarily newcomers obligated to serving in the military, as well as their relatives. This has resulted in the expansion of farm and residential land and increased pressure on natural resources, including timber, non-timber forest products, fish, and wildlife, which have declined dramatically in the area. Despite the somewhat unregulated growth, some of the new immigrants are educated and have various technical skills and are able to promote socioeconomic development more effectively since new forms of production, businesses, and markets are considered to be important factors that influence local economic growth. This approach represents a sustainable livelihood strategy that is exemplified by the establishment of a few local markets in which several families in a village gather together to sell products from their houses in 'home-markets' to enable villagers to buy and sell a variety of products. This has resulted in a reduction in the number of people entering the forest to hunt or fell trees for domestic use.

There are many businesses and employment opportunities that require various vocational skills and specialized knowledge. The primary skills that local villagers have, however, are restricted to traditional agricultural practices, furniture manufacturing, employment as mechanics, or collecting non-timber forest products. These skills are not useful enough and they have to be provided with more opportunities to strengthen their capacities, especially with respect to employing intensive agricultural techniques, diversifying agriculture, raising animals, agroforestry, handicraft making, and small enterprise management.

C. Household labor

Household labor is one of the most important indicators used to measure potential income generation of families and it is important to assess the active ages and occupations of household members. Survey respondents indicated that each family, on average, has 5 members, but only 2 of those are in active ages that facilitate the earning of money. The other 3 household members may be either children or older people over 55 years old of age who are retired and do not produce income; instead, they may actually increase the burden on other family members (Table 6.3).

Table 6.3. Family differentiation according to categories of household labor.

Patterns of Family Size				Number of families categorized according to categories of household labor 15-55 years old (person)								
No.	Number of Members	Number of Families	Percent of Families	1	%	2	%	3-4	%	5-9.	%	Total
1	1-3	25	29	15	60	8	32	2	8	-	-	25
2	4-6	40	47	4	10	24	60	12	30	-	-	40
3	7-10	16	19	0	0	0	0	13	81	3	19	16
4	>10	4	5	0	0	0	0	1	25	3	75	4
	Total	**85**	**100**	**19**		**32**		**28**		**6**		**85**

Note: 1, 2, 3-4 and 5-9 represent the labor force size per family.

There were 47% of the surveyed families whose members ranged between 4 to 6 people; those with more than 7 members accounted for 24% of the families; and those with 1 to 3 members represented 29% of the families. In comparing the numbers of 'breadwinners,' families that had one 'breadwinner' accounted for 22% of the families; those that had two 'breadwinners' accounted for 38% of the families; and those that had three-to--four 'breadwinners' accounted for 33% of the families. Families with 5-9 'breadwinners represented only 7% of the families.

6.4.3.2 Social capital

Social capital refers to those groups of people who are associated with networks or have connectedness—these include political or civic bodies that work together and share interests among themselves. More formalized groups might include memberships in community forestry or fisheries groups, while relationships of trust or reciprocity might include associations or non-profit organizations that provide safety nets for the poor (DFID 1999).

Within the administrative structures of sub-national government, there are four levels of management organization. Those consist, in descending order, of provincial, district, commune, and village levels. The flow of work within that structure is hierarchical and based on a 'bottom up' democratic form through which the National Committee for Sub-National Democratic Development leads the efforts, starting with the expression of prioritized requirements of villages to communes and advancing through progressively higher levels from communes to districts and districts to province. This means that people's requirements, or issues of concern, must be transferred from the grass roots level to policymakers to resolve these matters. Commune investment plan projects are generally prepared every year to address concerns raised by local people and those plans must be integrated into district development plans at the time that District Integration Workshops are organized. This planning process is not meant to respond to every requirement immediately, especially with regard to securing sufficient financial support to address such an extensive number of basic needs. Time, budgets, and technical support from other provincial authorities are required to ensure appropriate results. That is the reason that support is required from other stakeholders and networks to collaborate together to achieve development (Figure 6.2). The private sector, development partners, and government organizations are important elements of the sustainable development process, which provides financial and/or technical support to the process.

While there are no community forestry or community fisheries organizations in the Preah Vihear Protected Forest, some traditional communities have assumed important roles assisting each other in their communities. There are some 14 institutions and projects that include the private sector, development partners, government organizations, and other entities that have been operating in Teuk Krahum and Morokot communes. They support local community programs to improve livelihoods, education, health care, social welfare, economic development, religion, and culture. Their activities are designed to alleviate poverty, develop physical infrastructure, conserve natural resources, provide social welfare services, provide credit investment projects, and support small and medium enterprises throughout the communes and districts.

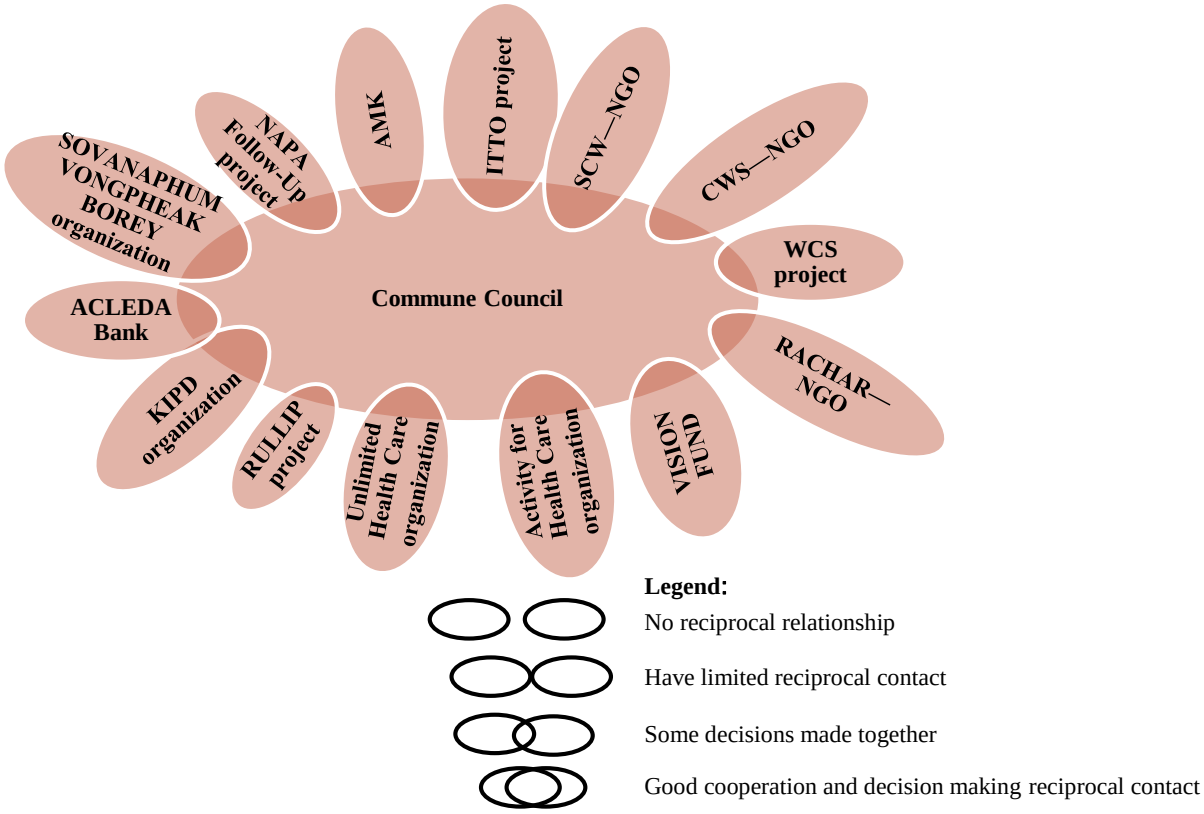


Figure 6.2. Venn diagram of reciprocal relationships and exchanges.

6.4.3.3 Natural capital and income

Natural capital refers to the natural resource stocks from which resource flows and services (e.g., land, water, erosion protection, NTFPs) useful for livelihoods are derived. There is a wide variation in the resources that make up natural capital ranging from intangible public goods such as the atmosphere and biodiversity to divisible assets used for production (e.g., trees and land) (DFID 1999).

A. Forest resources

The Preah Vihear Projected Forest extends over 190,027 hectares. Its evergreen and semi-evergreen forests covered 26.43% of its area in 2014. These forests contain predominantly high-value resources, including timber and non-timber forest products, as well as ecosystem services, and have been assuming critical roles improving the livelihoods of local

communities by providing goods and services to meet subsistence requirements and serving as a "safety net" in the event of emergencies, as well as a "gap filler" in the event of seasonal shortages, and, occasionally, as a means to permanently escape poverty.

Collecting timber and non-timber forest products is not a short-term, but rather an annual process. There are two primary types of forest products—timber and non-timber forest products - that community members commonly access. Timber is collected throughout the year for income rather than for domestic use, although these activities often may become illegal. Non-timber forest products, in contrast, are collected for domestic use rather than income, depending on the times of flowering and fruiting seasons of particular plants. The most common non-timber forest products that are collected include wild vegetables and fruits, honey, fuelwood, medical plants, and poles. These can be categorized according to the grouping of wild products in the forest and the seasons, which may occur at the same time or at different times, as pictured in the seasonal calendar provided in Table 6.4.

Table 6.4. Seasonal calendar associated with the collection of timber and NTFPs.

Name of NTFP	Monthly collection period											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fruits of *Willughbeia edulis*				√								
Fruits of *Popowa aberrans*			√									
Fruits of *Nephelium hypoleucum*				√	√							
Fruits of rattan *(Lpeak)*						√	√					
Edible Wild Mushrooms						√	√					
Korthalsia lacinosa	√	√	√	√	√	√	√	√	√	√	√	√
Collamus spp. (Phaar)	√	√	√	√	√	√	√	√	√	√	√	√
Collamus spp. (Phdao)	√	√	√	√	√	√	√	√	√	√	√	√
Bamboo shoots					√	√						
Leaves of *Nephelium lappaceum*	√	√	√	√	√						√	√
Leaves of *Willughbeia edulis*		√										
Wild Cabbage	√	√	√	√	√	√	√	√	√	√	√	√
Honey collection	√	√	√	√	√						√	√
Fuelwood	√	√	√	√	√	√	√	√	√	√	√	√
Rasin tapping and collection	√	√	√	√	√	√	√	√	√	√	√	√
Timber products	√	√	√	√	√	√	√	√	√	√	√	√

Wild Vegetables and Fruits: In addition to the more common non-timber forest products that are collected, there are also several subsidiary wild fruits and vegetables, including the fruits of *Eugenia sp.* and *Nypa fruticans*, as well as wild medical plants, including *Pouzulzia zeylanica*, *Phyllanthus emblica*, *Tetracera indica*, *Willughbeia edulis Roxb*., *Holarrhena pubescens*, amd *Prismatomeris tetrandra*, which are collected seasonally by villagers. Wildlife species, including wild pig (*Sus scrofa*), Red muntjac (*Muntiacus muntjak*), East

Asian porcupine (*Hystrix brachyuran*), and Lesser Mousedeer (*Tragulus kanchil*) are also occasionally collected.

There are approximately 20% of local people who earn their income from selling those wild fruits and vegetables every year. Of those individuals, about 45% earn incomes that range from 100,000-430,000 Riel (US $*25.00 - US $107.50*) during the wild fruit and vegetable harvesting season. The wild fruit is harvested by both young and old, most of whom are men. Women assume the role of marketing and selling the wild products in local villages and communes. The wild vegetables are more preferable to families than are the wild fruits. Sometimes, some wild vegetables, such as bamboo shoots, mushrooms, *Collamus spp*. (the inside stem of rattan) and *Korthalsia lacinosa* are sold in village markets when surpluses are collected from the forest. Some 80% of local people use those wild vegetables as food when they collect them from the nearby forest. Honey produces much more income than wild fruits and vegetables and approximately 18% of the local inhabitants earn incomes of 120,000-800,000 Riel (US $*30 - US $200*) during the honey collecting season every year.

Fuelwood and poles: Interviewees indicated that fuelwood is used for cooking and burning to maintain warmth during the cold season and poles may be used to fence residential land, rice fields, and home gardens. Poles and fuelwood may also be sold elsewhere in the province, but local use predominates. The average use of fuelwood in a family ranges from 2-3 carts/month for fuelwood that must be collected in the forest at a distance of at least 0.5 to 2 km from their homes. Since the current market price is 30,000-50,000 Riel/cart, or about $ US7.50 - $ US12.50/cart, collecting fuelwood is very advantageous and reduces daily expenses for its purchase. This use is considered to be a part of the indirect income provided by forest resources.

Timber and wood for construction: When a villager decides to build a house, he has to submit a request form to local authorities and Forestry Administration officials stipulating the amount of wood that will be required and the location in the forest where the timber will be collected. There are some villagers who enter the forest to harvest trees to sell them to increase their incomes, however, and these activities are considered to be illegal and are treated as such by authorities.

While the income emanating from forest resources provides but a small part of their income, it is still very useful to community members, especially for the poor and traditional communities. Those resources will sustain the livelihoods of local communities if primarily collected for domestic use. The availability of natural resources has been decreasing for several years, however. Those declines have resulted from the actions of various internal and external factors, including meeting the requirements of an expanding population and competition between livelihood strategies of different community members that lead in some instances to over-exploitation.

B. Land resources and land tenure

Land is of critical importance to local communities. They live on it and they farm it. The initial management plan of the Preah Vihear Protected Forest indicates that there are five principal types of soil, including grey hydromorphics, which make up 39% of the soils in the Preah Vihear Protected Forest, acid lithosols, which make up 23%, alluvial lithosols, which

make up 20%, red-yellow podzols, which make up 14%, and phinthite podzols, which make up 4%. Of those soil types, 39% have high productivity, while 58% have low productivity and 4% have medium productivity. There is, thus, a recognizable gap between the lower and higher productivities of soil types in the Preah Vihear Protected Forest.

There are two principal types of formal land occupied by local people - residential land and farmland. Prior to the arrival of the recent immigrants, traditional communities possessed a small piece of residential land and a larger area of farmland because shifting cultivation was no longer available as the result of limited resources. The residential lands occupied by local traditional communities are still comparatively smaller than those of new inhabitants, but their farmland may be somewhat larger because the government allocated 2 hectares of farmland to new residents and residential land with dimensions of 30 m x 150 m, representing 4,500m,^{2} or 0.45 ha, or in some instances 0.30 ha (Table 6.5). The survey results indicated that 11% of the people are fairly wealthy families that commonly have four family members earning incomes, with 1-2 hectares of their farmland completely cultivated with paddy rice or cassava. They may also have a farm vehicle or an automobile. This suggests that these families use both their residential land and farmland to plant rice and other crops and that their incomes are higher than those families who have not yet farmed all of their lands. Those who have farmed 0.1 - 0.5 ha, or who have only farmed their residential land of 0.30 ha, account for the highest proportion of farmers (39%). These families have two 'breadwinners.' Families that have 2 to 3 earners account for 25% of the families. They use 0.67 ha of their land to grow rice and vegetables (0.37 ha of their farmland and 0.30 ha of their residential land). The last group, representing about 26% of residents, have not farmed their residential land and because they have several small children do not use their farmland.

Table 6.5. Farmland size and average yield of paddy rice.

Farmland and Residential Land Planted with Crops and Paddy Rice				**Average Rice Yield (mt/year)**
No.	**Farmed Land Size**	**No. of Families**	**%**	
1	2-3 ha	0	0%	0
2	1-2 ha	5	11%	3.00
3	0.5-1 ha	21	25%	1.25
4	0.1-0.5 ha	33	39%	0.57
5	0 ha	22	26%	0
	Total	**85**	**100%**	

Rice yields are 1.5 -2.0 mt/ha, on average, but this depends on the varieties that are planted, the uses of agricultural techniques, sufficient watering, and other factors, including soil fertility and fertilization. Those who have farmed on 1-2 ha of land may achieve rice yields that vary between 1.5 to 4 mt/ha, but those yields are usually about 3 mt/ha. This means that the more they expand their farmed land, the higher will be the amount of rice produced and there are many families able to expand farmed land based on their officially allocated land.

There are about 95% of households who grow some kinds of edible fruit crops, such as *mango, sugar cane, banana, coconut, sour fruit, cashew apples, guava, or jujube trees,* during the dry season. The cash crops that are available include vegetables such as cabbage, cucumbers, eggplant, taro, tomato, bitter gourd, papaya, chines radishes, potatoes, and some types of climbing vegetables. These may be used daily for cooking to ensure household food

security. There are also many types of vegetables, or even some fruit crops, except paddy rice, that cannot be planted during the wet season because the soil is too wet for those vegetables to grow.

Since the initial establishment of new inhabitant communities, land allocation has been accomplished in the form of Social Land Concessions requested by military brigades. The rule is strictly applied, however, that while they may use the land for farming, they cannot sell it during the succeeding five years. That is, they may occupy and use the land, but without a legal right to sell it, although they may submit a request for land tenure after five years. Nonetheless, some people are unable to locate their land even though they have received the authorized letter of land occupation. Thus, nothing is produced on their farmland. Those who know the locations of their farmlands, moreover, sometimes lack the means and the capital to initiate farming activities.

6.4.3.4 Physical assets

Physical resources refer to physical infrastructure, including houses, roads, streams, lakes, ponds, irrigation systems, and sources of drinking water and energy. It is very important that local communities have access to such infrastructure to allow them to transport their products to markets, ensure they have enough clean drinking water and water for irrigation, live in a secure house, and have access to reliable energy supplies and means of communication.

Preah Vihear province has a fairly low annual rainfall since it is in the rain shadow of the Dangrek Mountains, which trend east-west along the Cambodia-Thailand border. It provides vital livelihood support through the provision of drinking water, as well as water for agriculture and fisheries. The forested watershed reduces wet season flooding and provides opportunities for rice growing and other agricultural activities in downstream areas. The maintenance of forest cover regulates annual flow regimes of the rivers into reservoirs and reduces sedimentation to decrease the dredging of those reservoirs.

There are more than 30 large streams connected to each other in and around the Preah Vihear Protected Forest and some 10 large ponds that provide fish and a watering system for agriculture. Without such a system, agricultural development would be obstructed and people would not have access to water. In addition to those natural water bodies, the government has provided a large artificial pond in Teuk Krahum commune that may be used as a source of clean water. There are approximately 150 pumping wells within the Preah Vihear Protected Forest and, of those, 115 are located in Teuk Krahum and Morokot communes. During the dry season, water resources are seemingly insufficient for people to use and water continues to be a constraint. Further investment is, therefore, required to ensure clean water and agricultural irrigation supplies.

Local villagers have been primarily using batteries for running electrical devices such as televisions, solar energy panels to secure electricity and charging phone batteries, fuelwood for cooking and heating, oil for lighting, and generators by those villagers who are able to afford those sources of electricity, but there is often not enough energy available for daily use.

The main road has been built to connect one village to another, as well as to commune and district centers. In some places, the government has expanded the irrigation system along the

road to reduce costs of infrastructure development and design and maintenance costs. There are many small roads that should be extended, nevertheless, and for which maintenance is required. When international checkpoints are officially opened, investments may reveal infrastructure that has to be developed to promote commercial exports and ease the business environment along the trans-boundary region. The main road in the Preah Vihear Protected Forest is usually only available in the dry season because it is degraded in many places during the wet season and it is relatively expensive for people to travel or to transport their goods to markets. Sustainable livelihoods cannot, therefore, be overlooked with regard to these concerns about physical assets.

Shelters are considered the most important basic necessity that people require to live. Traditional communities live in small houses, although there are a few who have large houses. In contrast, most recent inhabitants generally live in a model wooden house that has been funded by the government, which is 6 m in width by 8 m in length. These families have their own houses, which facilitates their secure living and welfare. Nevertheless, the project team has observed that there are no toilets for many families, which may affect the state of their health.

There are two health care centers in Chaom Ksant and Chheb districts and a few health posts at Chaom Ksant district that serve the new immigrants. While villagers have access to health centers and posts, though, they still have to go to hospitals in the provincial town because there are no urgent 'save and surgery' services for such small health care offices at the district level.

Properties, other than fixed assets, are also the principal tangible assets that may be used to identify each family's class, whether poor, medium, or wealthy. In interviews conducted with commune councils, it was determined that there are approximately 3% of the people who are wealthy in Teuk Krahum and Morokot communes, while the poor and the middle class predominate. The wealthy are seen to have automobiles, motorcycles, and bicycles, and some have farming vehicles (Kouyon), raise animals, and have other assets, as well (Figure 6.3).

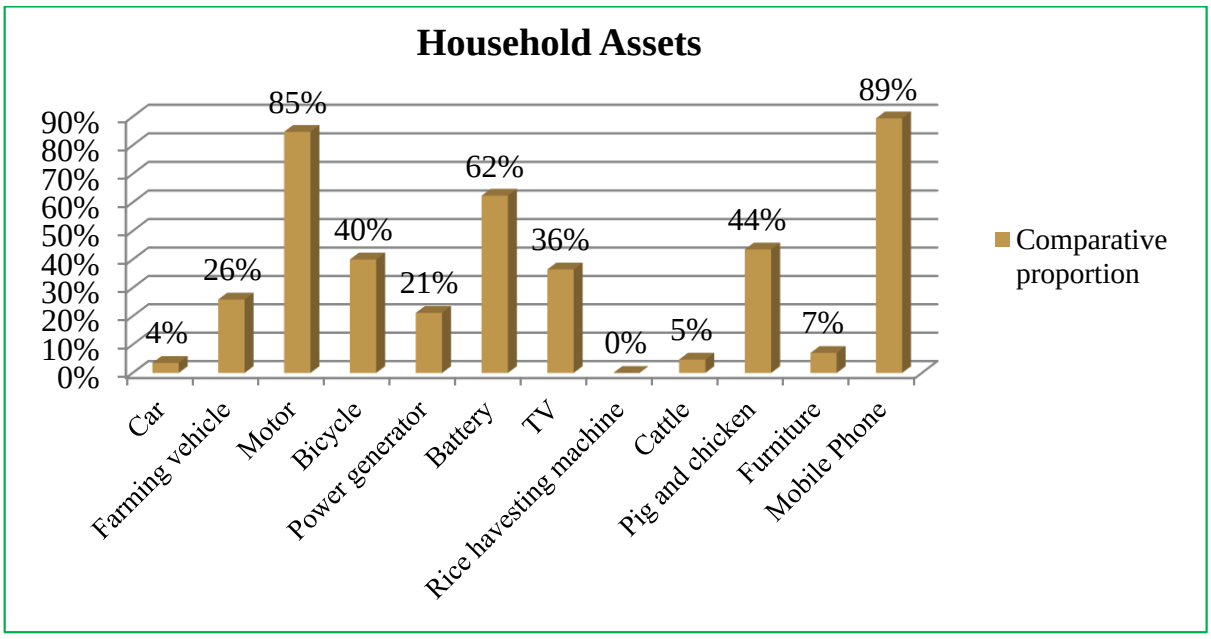


Figure 6.3. Relative proportions of household assets.

There are two types of assets, one that refers to those active assets that generate income and the other that refers to those inactive properties that do not produce further income. Of 85 families interviewed regarding their inactive properties, 4% had their own car, 85% their own motorcycles, 40% their own bicycles, 62% their own batteries, 36% their own televisions, 7% their own furniture, and 89% their own mobile phones. Of the assets that produce further income, 26% of interviewees stated their ownership of farming vehicles, 21% of power generators, 0% of rice harvesting vehicles, 5% of cattle, and 44% of pigs and chickens. It is understandable that local people purchase these inactive assets, but it is also understood that these do not improve their livelihoods as rapidly as do more active assets. Consequently, most of these families do not have sufficient access to technology and equipment to ensure efficient production.

6.4.3.5 Financial assets

"Financial capital denotes the financial resources that people use to achieve their livelihood objectives" (DFID 1999). These resources provide start-up capital to establish small businesses or support other investments in the form of loans, savings, joint-stock investments, or other forms of cash flow. There are three financial institutions - ACELEDA, AMK, and Vision Fund - that have been providing financial support and cash-flow transfers, but these are private sector financial institutions that, from the perspective of the local people, have relatively high rates of interest that deter the poor, especially those who are unable to afford either small investments or urgent loans. In some instances, moreover, a poor person might be assuming too much risk because they might have to bring an official letter of land tenure to the bank and their land might later be bid on by prospective purchasers if they have assumed too heavy a debt burden. This illustrates the vulnerability context of these actions. There are also many small savings groups of local people established by NGOs and other projects that are able to fill the gap of urgent needs among the poor by providing loans at relatively lower rates. This suggests that while the more well-to-do are able to access financial capital, the loans available to the poor may not be sustainable and will not be enough to support their livelihoods if there are not enough available at lower rates of financing. Nevertheless, we found that the poor were going to banks and microfinance institutions more often than the well-to-do, which indicates that the poor were accessing financial capital more than were the others. That capital and their savings are stored in their houses, which can be very risky.

Sometimes loans are linked to products or product exchanges in which poor farmers request loans from banks or from more well-to-do villagers to spend on their daily food or to purchase fertilizer for their paddy rice that will be repaid at the requested rates of the bank or the owner 'in kind,' i.e., in either cash or in bags of rice or other agricultural products, or even exchanged in products that are considered to be 'exchangeable.' Other projects support the poor through the provision of animal banks of cows, pigs, or hens, as well as rice banks. The output products of these animal and rice banks may be sold for income during the harvesting season. These exchanges represent different aspects of securing food security.

6.4.4 Vulnerability context

The vulnerability context examines conditions and external forces that may influence the availability and accessibility of a community's resources and assets.

The low population density, which is less than 8 persons/km^2 in the planning area, is primarily due to the inaccessibility resulting from flooding in the rainy season, the lack of water in the dry season, the inadequacy of roads, and the limited amount of land suitable for intensive agriculture. It is the result of this poor infrastructure that there is a low level of development and few employment opportunities. Many villagers depend to a considerable extent on natural resources and without greater employment opportunities for youth, there will be increasing pressure on the natural environment as expanding households clear forestland for agriculture and forage for forest products. Rapid population growth in rural areas often results in deforestation, forest degradation, depletion of water resources, and reductions in biodiversity (Forestry Administration 2010).

With reference to the livelihood asset assessment, about 87% of villagers have limited education, i.e., they have completed secondary school, but there are no high schools, which constrains opportunities for education. Consequently, they have bought many inactive assets rather than active assets that would increase their incomes because they do not consider those assets that would generate more income. Population growth is approximately 1.16% a year, which is higher than that in other areas around the Preah Vihear Protected Forest and this requires employment opportunities for those entering the workforce. There are generally two breadwinners, who receive some form of salary, in each household, which, on average, has four people. Since there has been no close reciprocal relationships between institutions, the provisions of stakeholders do not often match with the requirements of the people.

The poor depend to a considerable extent (12%-30%) on natural resources for their incomes since those assets gradually deteriorate and require replacement. The income available from agricultural sources accounts for from 16% to 46% because farming may only be conducted during the rainy season, there is not enough irrigation during the dry season, and lower productivity soils cover 58% of the project area. The dry season lasts very long, moreover, and can extend up to 6 months, in which case people do not have a water system or artificial channels to irrigate their crops and paddy rice. Agricultural production, moreover, is usually reserved for domestic use and there is very little available to sell for income. Most of the people, especially the more recent inhabitants, cannot access many assets, including farmland and land tenure, intensive and diversified agricultural techniques, markets for agricultural products, toilet and sanitation facilities, materials for preventing malaria infection, or lower rates of loans. The variations in seasonal prices and market demand fluctuations also cause lower prices of agricultural products and discourage community members from improving their livelihood strategies, which may increase vulnerabilities associated with food security and sustainable livelihoods.

6.4.5 Structures and processes

This factor examines the roles of institutions and social and political structures on community access and use of its assets. It examines responsibilities, rights, and relations.

The government has established forest and land use policies to promote the rights of local communities to obtain benefits, participate in natural forest management, and ensure their land tenure with regard to access to their fixed assets through which the Forestry Law and the Land

Law are in effect. This is the process through which institutions assist communities in their efforts to obtain access to assets.

In order to achieve its objectives of sustainable forest management and natural resources conservation, the Royal Government of Cambodia issued Sub-decree No. 76 on 30 July 2002 to establish the Preah Vihear Protected Forest for Plant and Wildlife Genetic Resources Conservation. Since 2008, the Forestry Administration, in cooperation with the International Tropical Timber Organization (ITTO) and the Thailand Royal Forestry Department,, has been implementing the 'Management of the Emerald Triangle Protected Forests Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation' project between Thailand, Cambodia and Laos. That project in its most recent third phase has had several important components, including forest law enforcement, community support, and the production of the revised and updated PFPV Management Plan. Livelihood strategies have, thus, been assessed through which community members must obey the law and divert their living strategies to sustainable agricultural improvement instead of forest resources, while their right to have access to their assets is still ensured, including access to land and human resources.

The project in each of its phases has continued to provide its support to improve the livelihoods of communities residing in the Preah Vihear Protected Forest. There have been Integrated Conservation and Development Projects (ICDP) established in three communities in three different villages that have included four principal activities - Rice Banks, Cow Banks, Microcredit Facilities, and Chicken Raising. The construction of community infrastructure, including 8 community pumping wells, 12 community ponds, and three primary school buildings equipped with school tables and educational materials, as well as 8 sets of community solar panels, has also been supported under the project. These initiatives have been linked to livelihood improvement to reduce local dependence on forest resources. The project has been supporting communities continuously and there are now more than 2,000 families in 8 local communities in the two communes with ICDP activities.

Over the course of Phase III project implementation activities, the number of cows in cow banks increased from 13 at the end of Phase II of the project to 69, with 8 other cows sold to generate cash to support construction activities in the two villages that share a cow bank and 1 cow reported to have died; the amount of rice in rice banks increased from 16.50 tons to 27.13 tons, with an additional 4 tons of rice sold to generate cash to maintain the rice bank, and two other rice banks in other villages established; and the availability of credit increased from US $1,000.00 to US $1,780, with US $300 of that amount withdrawn for management coordination activities and maintenance costs. The project also delivered 91,500 native commercial trees and fruit trees to local communities, military families, and other local people living in and around the Preah Vihear Protected Forest to promote reforestation and agroforestry during that period.

Designing commune investment projects is a participatory process in which those who represent their part of the village introduce their concerns and state their requirements to the village chief, who is responsible for village administration, to prepare a prioritized list of those requirements. The process culminates with the development of commune investment plans that are integrated into district development plans during District Integration Workshops that are organized every year. Every development project, in association with

development partners, is subsequently evaluated and a decision is made whether a particular project should be implemented on the basis of the objectives or concerns of each commune. With regard to sustainable livelihood approaches through agriculture-oriented and small business strategies, there are many activities that have been established and supported by development partners. Those activities have encompassed programs to enhance community livelihoods, ensure sustainable forest and land management, and reduce dependence on forest resources, and forestland encroachment. Survey results, however, indicate that there have been no effective reciprocal relationships and information exchanges that have been established with these institutions. That will require more effective facilitation and establishment of network partnerships.

Highlights of Community Livelihood Development Interventions
ITTO PD577/10 Rev.1(F) project




The monitoring of Community Livelihood Enhancement activities involving the establishment of rice banks and the installation of solar panels.


Demonstration of the planting of luxury tree species and fruit trees to improve land cover, reduce soil erosion, and increase adaptation to climate change around the community pond constructed under the project at O Chunh primary school.

Training provided on home garden preparation, animal raising, and integrated agroforestry systems to local communities and military families.

Exchange visit of Teuk Krahum and Morokot commune councils, village chiefs and local communities to the multi-agricultural and fish farming and rice and cow bank development activities implemented through the Tbeng lech Community Forestry Committee in Banteay Srey district and the manufacture of souvenirs and furniture from NTFPs by local communities in Sot Nikum district, Siem Reap province.


The monitoring of Community Livelihood Enhancement activities involving the establishment of cow banks.


Provision of study materials and commercial tree seedlings to local primary schools and the organization of question and answer sessions on forest conservation.




Collaboration with the Seoul National University team and interacting with community students at O' Chunh Primary School to provide a new classroom, table, chairs, and study materials, install solar panels, and provide study materials and commercial tree seedlings to local primary schools in the Preah Vihear Protected Forest.

The distribution of seedlings of high value commercial timber species, as well as fruit trees, to military families and local communities from the Morokot Nursery at the O Chunh project office in the Preah Vihear Protected Forest.

The distribution of seedlings of high value commercial timber species, as well as fruit trees, to military families and local communities from the Morokot Nursery at the O Chunh project office in the Preah Vihear Protected Forest.

6.4.6 Sources of income generation

Livelihood strategies are the ways in which community members have been using and combining their assets to meet their needs and attain their goals.

There are four principal livelihood strategies that local communities have been using to meet their requirements and attain their goals. These are: (1) salary-paid employment; (2) farming; (3) collecting forest resources; and (4) businesses.

While only more recent inhabitants pursue livelihood strategy 1 (salary-paid employment), traditional communities consider strategy 3 (collecting forest resources) to be the second most important strategy after farming. That is the reason that traditional communities do not seem to achieve their current livelihood strategies. They collect forest resources almost year-round, but their annual income using that strategy is still relatively low compared to their annual income from farming.

In the rapid assessment that was conducted in the project sites, two principal groups of local people who have been extracting and using products collected from the forest were defined on the basis of their primary incomes. The first group referred primarily to indigenous people, or traditional communities. The more recent inhabitants, who are primarily immigrants of military families, were considered to be the second group, which was officially provided with land tenure through Social Land Concessions. Comparisons of those two groups in the forest-based livelihood assessment were made to evaluate the extent to which forest resources contribute to their incomes, as well as to determine their other sources of income (Figure 6.4).

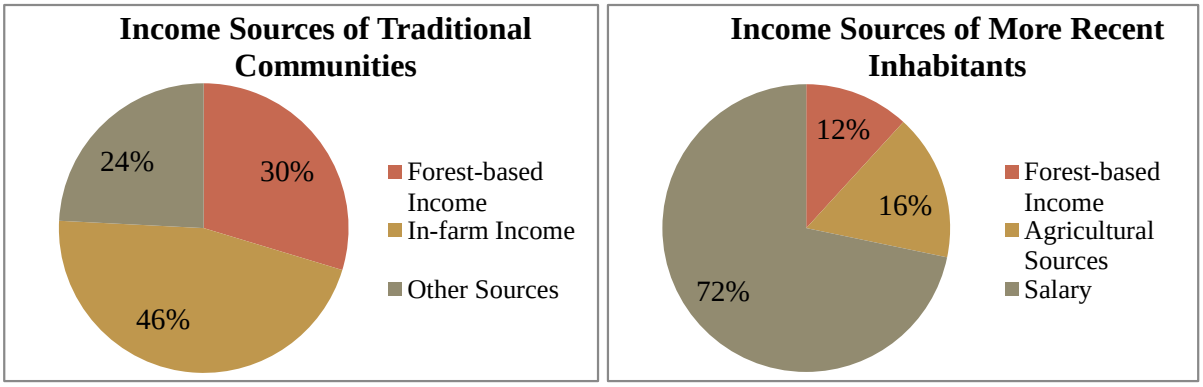


Figure 6.4. Comparison of income sources between traditional and more recent inhabitants.

The results indicated that the annual incomes contributed from forest resources were approximately US $460.00 (*Standard deviation: $13.80; minimum income: $404.80; maximum income: $515.02)*, which accounted for 30% of the income of traditional communities and about US $236.75 (*Standard deviation: $6.25; minimum income: $211.00; maximum income: $261.75)*, which accounted for 12% of the income of more recent inhabitants. The income composition of the traditional communities of primarily indigenous people included in-farm employment and other sources, which accounted for 46% and 25%, respectively, of income. In contrast, the more recent inhabitants depended on salaries and in-farm incomes, which accounted for 72% and 16%, respectively, of their income. This comparison suggests that sustainable livelihood improvement opportunities may be more associated with salary-based income and in-farm employment, while nature-based tourism development may provide less opportunities for increasing incomes.

The annual income of indigenous people, which is about US $1,550, is lower than that of more recent inhabitants, which is about US $2,007 per year. The income earned from forest resources represents 12% of the income of new residents and 30% of the income of local indigenous people. This may account for the underlying reasons that local communities have been so dependent on forest resources. The survey suggests that a vast majority of local people have been using forest ecosystem goods and services to a considerable extent every year—not only as a source of income, but also for domestic uses and extracted services such as the use of forestland and its products and forest-related employment.

Table 6.6. Primary sources of income from agricultural activities

No.	Income Sources	Income		
		Riels/year	USD/year	%
1	Rice	1,069,000.00	267.25	67
2	Vegetables	58,000.00	14.50	4
3	Fruit Crops	112,000.00	28.00	7
4	Raising animals	284,000.00	71.00	18
5	On-farm labor	83,000.00	20.75	5
	Total	**1,523,000.00**	**401.50**	**100**

Note: US $1.00 = 4000 Riel.

Agricultural activities have been considered to be the principal component providing annual incomes of those families that have extended their efforts into the establishment of productive agricultural practices and closed the gap of their daily food requirements through agriculture instead of by purchasing products from the market. Paddy rice provides the most income of agriculture-sourced earnings, representing 67% of income, followed by animal raising, which represents 18%, and fruit crops, which represents 7% (Table 6.6; Figure 6.5). The remaining income is from on-farm labor, which accounts for about 5% of income and vegetables, which accounts for about 4%. Growing vegetables is, nevertheless, considered by most families to be essential in meeting their daily food requirements.

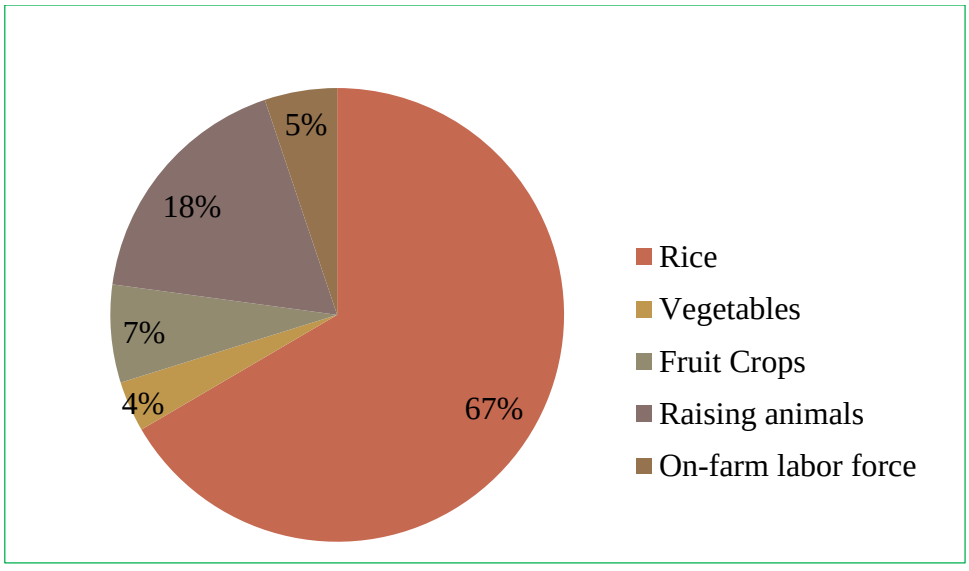


Figure 6.5. Relative earnings of agricultural sources.

The proportion of incomes from forest resources has been decreasing, while those of agriculture-sourced earnings and salary-paid employment have been increasing. There are only a few individuals who make long-term investments in their livelihoods through which there is consideration of improving agricultural production on their land. Others have to combine assets to increase agricultural productivities to meet household requirements and livelihood objectives and ensure the wellbeing of their children.

6.4.7 Livelihood options

"The livelihood options that appear in the generic framework are effectively categories introduced to make the use of the framework more manageable. Each one may or may not be relevant in a particular situation, which may only be established through participatory enquiry." The five primary indicators of livelihood options are: (1) increased income; (2) improved wellbeing; (3) reduced vulnerability; (4) enhanced food security; and (5) more sustainable use of natural resources.

Participatory assessments were conducted with many local community members on several occasions to assess the manner in which livelihood strategies are used to meet their needs and achieve their goals. SWOT analyses of livelihood options opportunities and challenges were also organized (Table 6.8). The purposes of the meetings with villagers were to define their principal livelihood strategies, the contributions to incomes associated with those strategies, and the extent to which those options matched with their livelihood requirements and goals. The assessment facilitated the determination of the most effective options and increased the understanding of the manner in which assets are combined. There was a matrix of livelihood options and outcome indicators that was established to analyze the results of existing livelihoods options according to the criteria of sustainable livelihoods (Table 6.7). The rankings of the options in the matrix used a three-year timescale to measure the constraints that obstruct individuals from accessing assets.

Table 6.7. Matching livelihood options with outcome indicators.

Options	More income	Improved wellbeing	Reduced vulnerability	Enhanced food security	More sustainable use of natural resources
Option 1: salary-paid employment	4	3	3	3	3
Option 2: farming	4	4	4	4	3
Option 3: collecting forest resources	4	2	2	2	1
Option 4: businesses.	3	1	1	1	1

Note: The participatory responses were scored in the following manner:

5. *Yes, it (livelihood strategy) has contributed consistently.*
4. *Yes, it has contributed, but not consistently.*
3. *Yes, it has started to contribute this year.*
2. *No, it has not contributed this year.*
1. *No, it has not contributed in the past three years.*

The matrix illustrates that livelihood option 2 (farming) received the best score for ensuring the livelihood option, although the share of its contribution to income was much smaller than that of option 1 (salary-paid employment). Option 2 would not be a good choice to sustain forest resources, however, since people encroach on forestland to establish agricultural crops, burn forestland, and hunt wildlife around farmlands. That is, forest capital cannot combine best for sustainable livelihood options because the process of increasing access to those assets is not the best. The second best ranking of livelihood options was option 1 (salary-paid employment) and the third best was option 3 (collecting forest resources). The businesses strategy was the last choice because there are only a small number of people who have been receiving benefits using this option.

Table 6.8. SWOT analysis of livelihood strategies and opportunities.

Strengths	**Weaknesses**
• There are many assets, especially forest resources (timber and NTFPs), for developing livelihood strategies and providing safety nets and acting as gap fillers when there are urgent needs. • Soils with moderate productivity coves 43% of the area. • People raise cattle and poultry. • Villagers have their own farmland. • The soils are suitable for home gardens. • There are many varieties of fruit trees planted. • Water is plentiful in the rainy season. • Salaries are the primary source of income. • There are many ancient temples to enhance nature-based tourism strategies.	• Forest resources are overexploited and there are many illegal forest activities. • Land encroachment leads to negative forest cover changes and destruction of biodiversity. • There is a limited variety of skills, knowledge, and agricultural techniques, such as animal raising, intensive rice production, selection of varieties of rice and animals, and growing home vegetable gardens. • Soils with low productivity cover 57% of the area and there is some soil erosion. • The dry season is long-lasting (6 months). • There is no irrigation in the dry season. • There is no suitable land use planning. • There are overlapping responsibilities of institutions.
Opportunities	**Threats**
• There are many supportive institutions. • Commune councils are attempting to improve participatory primary needs assessments of communities. • There are financial assets and support from other development partners and private institutions to start up or scale-up small business activities, especially to assist the poor. • People have spacious courtyards to use to expand their incomes from farm production through intensive rice	• Drought sometimes occurs during the rainy season, resulting in the destruction of rice crops. • Market prices and demand fluctuate. • Pests and insects destroy rice fields. • There are animal diseases. • Forest fires occur every year. • There is illegal logging and fishing. • The population and local market demand are small. • There is a lack of start-up capital to expand existing farmland.

cultivation, animal raising, and aquaculture. • Irrigation and soil fertility have been improved through support from military brigades, government, and other development partners.	• Infrastructure, transportation, and irrigation are poor. • There is a lack of sanitation and a high risk of disease infection affecting humans, animals, and crops.

6.5. Conclusions and recommendations

6.5.1 Conclusions

Sustainable livelihood assessments are very useful to assess the strategies that local communities use by combining their assets to make a living. These assessments contribute to efforts to improve those strategies in order to support people to expand their access to assets and resources to increase their earnings. Most of the villagers in the project sites, especially more recent inhabitants, do not have access to many assets, including farmland and land tenure, intensive and diversified agricultural techniques, or markets for agricultural products because of the low population and high costs of transportation in the rainy season. There are restrictions in their access to toilets and the means to improve sanitation, reduce malaria infection, and experience lower loan rates and risks, as well. Seasonal price and market demand fluctuations also result in lower prices of agricultural products and discourage community members from overcoming their livelihood limitations. These effects may result in increased vulnerabilities experienced with regard to food security and sustainable livelihoods.

In order to improve livelihoods to reduce dependence on forest resources, sustainable livelihood approaches must be used to supplement forest-based livelihood development. In this context, agricultural diversification, intensification and extensification, agroforestry and home gardens, and small enterprise development should be recognized as livelihood strategies that provide opportunities, in association with existing capital of local communities, to improve living conditions. Increasing the use of these approaches will require that vocational training and other support continues to be provided through this project, as well as by other stakeholders and development partners. Land use planning must be accomplished according to prevailing policies and legislation, as well as with regard to soil productivities and the rights to secure access to capital assets, including farmland, must be ensured. In so doing, agriculture-based approaches will provide effective means to improve livelihoods through which agricultural skills, agroforestry-oriented diversification, and breeding techniques, especially for wild plants and fruit trees, are introduced to support community development. These strategic activities are recognized as the implementing forms that are gradually adopted by local communities and adapted to the local environment and resources available to support efforts to alleviate poverty.

The income strategies and outcome indicators matrix analysis used in this study revealed that there are four principal types of livelihood strategies: (1) salary-paid employment; (2) farming; (3) collecting forest resources; and (4) businesses. Of those strategies, farming, including on-farm employment, and businesses have been considered to be the most important approaches to use to improve community access to capital to meet living requirements. The matching of those approaches with the five principal indicators of livelihood strategies - (1)

increased income; (2) improved wellbeing; (3) reduced vulnerability; (4) enhanced food security; and (5) more sustainable of natural resources - suggests that every institution, including development partners, local authorities, and the private sector, is in a position to contribute to community efforts to achieve those assets that are lacking according to the matrix analysis.

Overall, agricultural intensification and agroforestry provide the best options to increase economic opportunities for increasing incomes since the incomes from forest resources have been gradually deteriorating. The next best option may be business development supported by private microfinance services, but those would also require the enhancement of human capital, including expanding the skills and knowledge of community members. The nature-based tourism development appears to be the least desirable choice under current conditions because of the relatively large requirements associated with infrastructure development, although the riverside in the northeastern part of the Preah Vihear Protected Forest is considered to be an important site for nature-based tourism development.

6.5.2 Recommendations

- Promote sustainable agriculture and agroforestry in agricultural use zones and community forests in and around the Preah Vihear Protected Forest.
- Collaborate with local authorities, nongovernmental organizations, and other development partners to establish community enterprises to increase alternative income earning opportunities for local communities and provide training to local communities to increase participation in these, as well as other, sustainable livelihood development programs.
- Encourage the planting of trees and other plants that support local livelihoods, such as bamboo, and the cultivation of edible plants, such as mushrooms, to reduce local people's use of wild forest plants.
- Establish and enforce resource use regulations to control access to non-timber forest products used to support the sustainable development of local livelihoods and increase local incomes while maintaining natural resources in the Preah Vihear Protected Forest.
- Support community-based natural resources management in and around the Preah Vihear Protected Forest to reduce the unsustainable utilization of forest resources.
- Institutionalize the use of social instruments that encourage the participation of local communities in the management of the Preah Vihear Protected Forest, such as through the establishment of local advisory boards or committees to ensure local participation in management decisions affecting local communities.
- Organize workshops, meetings, and training programs involving local communities to enhance the understanding of the contributions to local livelihoods associated with sustainable forest management, biodiversity conservation, and community forestry programs in accordance with national forest development policies and plans.

- Develop environmental education programs that explain the purposes of the Preah Vihear Protected Forest and incorporate information on the environmental effects associated with the unsustainable use of natural resources and the rights and responsibilities of local people with regard to the management of natural resources.
- Strengthen mutually beneficial working relationships by extending outreach and information exchange initiatives with local communities.
- Organize periodic surveys to monitor variations in the socio-economic characteristics of local communities living in and around the Preah Vihear Protected Forest.
- Conduct periodic surveys of the attitudes of local communities toward protected forests, natural resource conservation, and biodiversity and use the results in environmental education and public outreach programs.
- Promote networking and exchange visits with cross-border local community livelihood improvement programs in adjoining communities of Thailand and Lao PDR.

6.6 References

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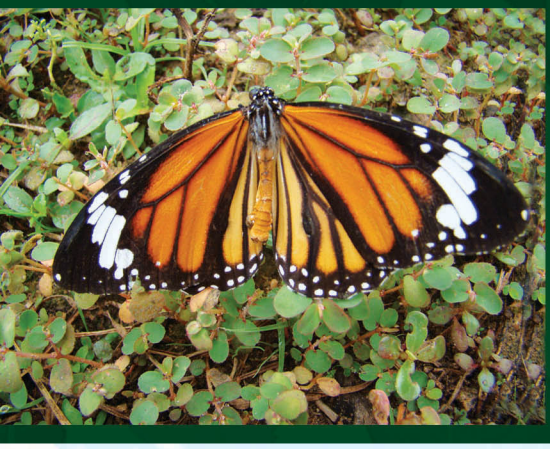
The Preah Vihear Protected Forest of Cambodia is a component of the Indo-Burma Biodiversity Hotspot, which is one of 35 Global Hotspots, and part of the Indochinese Dry Forest. This Technical Report on 'Integrating Forest Biodiversity Resource Management and Sustainable Community Livelihood Development in the Preah Vihear Protected Forest' supplements the Mangement Plan and contains chapters on several issues of critical concern intended to provide suport to the efforts to ensure the sustainable management of the forests and forest resources of the Preah Vihear Protected Forest. Those issues include assessments of forest cover trends, carbon stocks, land use and land cover change scenarios, floral diversity, the distribution of landscape wild species, and sustainable livelihoods.



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